Egyptian Clover

(Trifolium alexandrinum)

King of Forage Crops

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By

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FOREWORD

Production of green herbage is attaining enormous importance, the world over, since demand for livestock products is increasing. Livestock production is substantially supported by seasonally available green forage available from a number of cultivated crops. Berseem, Egyptian clover (*Trifolium alexandrinum*) has achieved the distinction of being designated "king of forages". Wild in the Levant and domesticated in Egypt in antiquity it has been a base of Egyptian farming, both as fodder and for soil fertility maintenance, for centuries. Berseem was introduced to many countries in the late nineteenth and early twentieth centuries. Because of its high production potential, easy cultivation, capacity to fix enormous amounts of atmospheric nitrogen and quick growth, it is grown on millions of hectares. Its production potential, easy cultivation and wide adaptability led to widespread use in mild, humid temperate and sub-tropical areas. Its spread was spectacular in Northern India, now including Pakistan, where farming systems are similar to those in Egypt: wheat-rice rotations, irrigation, smallholder farms with cattle and buffaloes reared on cut fodder and crop residues. Now India has by far the greatest area under berseem; Pakistan comes third with somewhat less than Egypt.

To improve exchange of information between berseem-growing countries with smallholder farming, FAO organised an Expert Consultation Workshop on "Forage Production Potential of Egyptian Clover and its Role in Sustainable Intensification of Agriculture in the Near East Countries" on 6-7 November 2012 in Cairo, Egypt. This publication presents reviews of the main themes of berseem agronomy, summaries of the plethoric Egyptian literature on the subject which is not easily available to outsiders, and Country Reports from participants.

The contributions of authors are much appreciated by FAO in its efforts to disseminate information on berseem production, particularly in the smallholder sector. The Expert Consultation was organised by Dost Muhammad, Regional Plant Production Officer, FAO Regional office for Near East and North Africa who also brought this book to publication; Bimal Misri provided assistance with technical editing.

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Acronyms used in the text

ARC	Agricultural Research Council
ADO	Agriculture Development Officer
DOAD	Department of Agriculture Development
FLD	Front Line Demonstration
FCRI	Forage Crop Research Institute
ICAR	Indian Council of Agricultural Research
IGFRI	Indian Grassland and Fodder Research Institute
KVK	Krishi Vigyan Kendra (Agricultural Science Centre)
LDD	Livestock Development Department
LDP	Livestock Development Project
NFCRP	National Forage crop Research Programme
NARC	National Agricultural Research Centre
TLDP	Third livestock Development Project

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EXECUTIVE SUMMARY

Egyptian clover, or berseem, Trifolium alexandrinum, a very important crop, for fodder and soil fertility maintenance, was domesticated in Egypt and is now widespread in irrigated cropping systems in west and south Asia and used in commercial farming in many countries with mild winters; India is now the largest producer. Because of its regional importance FAO RNE organised an Expert Consultation Workshop on "Forage Production Potential of Egyptian Clover and its Role in Sustainable Intensification of Agriculture in the Near East Countries" on 6-7 November 2012 in Cairo, Egypt", to facilitate exchange of information between agronomists, livestock and fodder specialists in the region. This publication brings together the outputs of the Expert Consultation. Berseem is also widely used in large-scale livestock systems in areas of mild winters in Europe, America and Australia but these cases are not discussed here.

Agriculture in Egypt is more than 5 000 years old; the Nile and berseem are two main reasons for its high productivity and sustainability. Berseem fixes huge quantities of atmospheric nitrogen, sustains animal husbandry and raises fertility for following crops. As a green manure on newly reclaimed or worn out soils, it is a boon to farmers. Traditional cultivation methods in Egypt were excellent and in balance with the environment and farming systems. New varieties have enhanced herbage and seed production and now Egypt is the largest exporter of berseem seed. Research on its cultivation and improvement has increased manifold. The results of this work are summarised in this publication. A consolidated summary of these results makes them more readily available the world over and a large bibliography is provided.

The publication is in nine chapters. After an Introduction there are chapters on: The Crop and its Growth; Agronomy; Crop Improvement; Seed Production; Chemical Composition and New Vistas in Berseem Research. These are followed by a series of country papers from Afghanistan, Egypt, India, Iran, Nepal, Pakistan and Turkey. These describe the state of cultivation and research on the crop in each country.

Notwithstanding the great flourishing of academic research, notably in Egypt, the impact of its results are not very obvious on the farms of smallholders. The country studies show clearly that most smallholders sow dirty seed of unimproved landraces, contaminated by weeds and parasites. Berseem gives high seed yields and its seed is easy to clean, very simple machinery suffices - Egypt exports large quantities which meet the quality and phytosanitary requirements of international trade. Countries where berseem is important should support seed improvement infrastructure and follow by extension of improved cultivars and agronomic techniques. The end use of berseem, fertility maintenance apart, is livestock production; it is especially associated with dairy production and buffaloes. Unfortunately it is difficult to conserve so has to be involved in year-round fodder production systems and improvement of dairy stock and livestock management.

Chapter I. INTRODUCTION

Introduction

Egyptian clover, or berseem, *Trifolium alexandrinum*, a very important crop, for fodder and soil fertility maintenance, was domesticated in Egypt and is now widespread in irrigated cropping systems in west and south Asia. Because of its regional importance, FAO Regional Office for Near East and North Africa (RNE) organised an Expert Consultation Workshop on “Forage Production Potential of Egyptian Clover and its Role in Sustainable Intensification of Agriculture in the Near East Countries” on 6 -7 November 2012 in Cairo, Egypt, to facilitate exchange of information between agronomists and fodder specialists in the region. This publication brings together the outputs of the Expert Consultation as well as providing summaries of much of the, mainly Egyptian literature on berseem. It comprises chapters on: The crop and its growth; Agronomy; Crop improvement; Seed production; Chemical composition; Berseem cultivation; New vistas in berseem research - a series of essays and themes by Egyptian authors; and Country Papers from participating countries describing their berseem crop: Afghanistan, Egypt, India, Iran, Nepal, Pakistan and Turkey. There is an extensive bibliography.

Berseem is a crop for mild climates and neutral to alkaline soils; in its area of origin it is grown as a winter annual. It was domesticated in Egypt in antiquity and is the oldest cultivated clover. It is uncommon in the wild and there are differences of opinion on its exact origin but it probably came from what is now Syria. Frame (2005) states that it originated in the eastern, Mediterranean; Knight 1985 gives Syria as its origin and the date of its introduction to Egypt as the sixth century AD; the Turkey study in this publication states that *T. alexandrinum* is found in the wild there. It was a major crop in Egypt for centuries and quickly became widespread after introduction to many countries in the late nineteenth and early twentieth centuries. In addition to the countries involved in this consultation, it is now grown as a winter crop in areas such as eastern Australia, South Africa, Southern Europe and the southeast USA; these are not a subject for our study and are discussed in another FAO publication (Frame 2005). It is grown as a summer annual in the Midwest USA (Sheaffer and Evers 2007).

The spread of berseem was spectacular in northern India, now including Pakistan, where farming systems are similar to those in Egypt: wheat-rice rotations, irrigation, smallholder farms with cattle and buffaloes reared on cut fodder and crop residues. Now India has by far the greatest area under berseem - 2 000 000 ha; Pakistan comes third - 710 000 ha with somewhat less than Egypt 1 175 000 ha according to the respective country studies. Berseem is well-suited to small farms and non-mechanised harvesting; the multicut cultivars can give their full potential when hand-harvested in cut-and-carry systems since the crop does not tolerate close or frequent grazing.

Farmers are slow to take up the results of research. Seed quality is noted as a problem in most country studies although rational production techniques are well known; much of the seed is produced on-farm from local landraces and does not pass through controlled marketing channels. A form of cleaning by flotation is frequently recommended. Seed quality, for both variety and purity should be simple to improve but has not been seriously addressed in smallholder systems. The main countries posess improved cultivars which could be multiplied. Berseem has a regularly shaped seed which can be cleaned by simple equipment. Egyptian seed merchants export considerable quantities of berseem seed to Europe and meet the high quality standards required there.

In the cooler parts of its range, the northern parts of India and Pakistan, mixtures of berseem with brassicas or oats are popular 1) to provide early bulk and 2) since the clover’s growth is very slow in mid-winter, to provide fodder at that difficult season. The use of oats as fodder, including in mixtures, is dealt with in another FAO publication (Suttie and Reynolds 2004).

The papers and country reports concentrate on the growing and improvement of berseem; little is said about its utilisation; this reflects the make-up of the Consultation. In its main areas there is little or no grazing. Berseem is generally fed green to stall-fed stock (cattle and buffaloes) to crop residues. It is difficult to dry under smallholder conditions. The Indian paper touches on this and mentions the use of chaffers which is so widespread there; not only the clover but straws, summer fodders and stovers are chaffed and mixed for more economical feeding; only rice straw is fed long. Berseem, and all green fodders, are also grown as cash-crops in Southern Asia where landless cattle-owners and peri-urban dairies are widespread and need a regular supply of green fodder. Professional fodder growers grow berseem, and other crops in season, to supply urban needs, there are fodder markets as for horticultural crops, and professional chaffers for those who need their services.

Egyptian clover is renowned in Egypt as a source of soil fertility, originally in systems based on inundation and cotton as a cash crop. In its new lands , while its role in fertility maintenance is recognised, more emphasis is put on its importance as a major cool-season source of high-quality fodder to supplement straw. The papers concentrate on the residual effect of clover on soil fertility but the role of animal dejections is usually a major means of fertility transfer. On much of the region dung, instead of being returned to the field and to the cycle of fertility, is mixed with chopped straw, dried and used as fuel in the vast areas with no firewood nor access to gas or kerosene. In monsoonal areas dung-cakes are stored in plastered stacks. Fodders provide much fuel, the economics are not clear, but all the organic matter and many nutrients are lost (Figure-1).

Figure 1. Animal manure dried for using as fuel in cooking

The Egyptian perspective

Egypt had organized agriculture by 5 500 BC. The Egyptians are the earliest people to practice large scale agriculture (Julie, 2011); the Nile which made this possible brought massive floods to Egypt which were fairly predictable. Water level usually increase in late August and September and eventually covered the flood plain and delta by a layer of water as deep as 1.5m. Inundation ended by October with soils rich in moisture and fertility for crops which ripen between March and May. This traditional primitive agriculture was supplemented by efforts since the early nineteenth century. Irrigation projects were established along with a network of canal systems. Initiatives continue unabated and have resulted in the establishment of Aswan, Damietta and Esna reservoirs.

Besides crops, livestock was there since ancient times. Pastures and grazing lands are meagre and crop wastes were major feed sources. This was changed by farmers who discovered, grew and established Egyptian clover. E. L. Nahrawy (2005) has given an excellent account of the contribution of berseem to Egypt.

Egyptian clover or berseem (*Trifolium alexandrinum L.*) is the main winter forage in Egypt and is a basic component of a sustainable cropping system. It has sustained livestock and crop production for centuries in situations where natural pasture is scarce. It provides high forage yields of exceptional value whether consumed directly as pasturage, green-chop, conserved as hay or silage or manufactured into pellets and cubes or other feed stuffs. Berseem occupies about a third of the cultivated area in Egypt during winter as full season and short season crop as well as an area devoted to seed production. The area under full season berseem is relatively stable varying between 745 039 ha in 1978 and 664 682. ha in 2000. However, the area increased suddenly to 836 309 ha in 2001 (11% increase)

Given the shortage of agricultural land in Egypt, competition between wheat (to feed humans) and berseem (to feed cattle) requires important policy choices. Increasing wheat area at the expense of berseem could lead to a major rise in prices of animal products, in particular meat and milk and even their import may become necessary. There can be no short or medium term solution to this problem. In view of the major constraint, the shortage of agricultural land, developing and increasing production of winter crops (especially wheat and berseem) can only be by increasing productivity.

Recently berseem yields have changed least in relation to other field crops. From 1978 to 1997 yields remained around 59.52 t/ha, and then increased from 1998 up to 71.14 t/ha in 2004. This was due to the spread of certified seeds of high yielding cultivars developed since the early eighties. The lowest annual production of berseem was 40,699,000 tons in 1981; the highest was 58,666,000 t in 2002.

Berseem is a vital component of the agricultural systems of the Nile Valley and Delta. David Fairchild (1902) stated that it is the great forage and soiling crop of the Nile Valley. Throughout his assessment of the evolution of Egyptian agriculture, Fairchild considered berseem to be indispensable as a rotation crop over centuries of cotton production. Graves *et al* (1996) concluded that it is difficult to imagine a greater honour to be bestowed on a crop than to give it credit for sustaining agricultural production in such an ancient land. Berseem has been called "The magic crop" in California due to its multiple advantages and rare or no disadvantages compared to crops like alfalfa. In addition berseem has enabled livestock to be closely integrated with cropping for many centuries it is:

- A better choice for soil improvement with its ability to add nitrogen up to 297-400 kg /ha (Graves *et al* 1996). Every year more than 714 000 tonnes of nitrogen are fixed (Abd Elhady, 1993, Graves *et al* 1996) in Egypt
- Cut several times for forage, then ploughed in, berseem is a green manure which decomposes rapidly and fertilizer for the succeeding crop . Higher cereal yield and quality has been observed in cereals on land where berseem had been used as green manure or planted for forage.
- Berseem in rotation helps to conserve the soil and prevents wind and water erosion and increases the organic matter content of the soil especially in newly reclaimed lands as well as improving soil structure and physical and chemical properties. It provides a cereal disease break in cropping rotations.
- The berseem canopy is the best shelter for beneficial insects which help control deleterious ones biologically. No pesticides are used during the lifetime of the berseem crop except when necessary in establishment stage.
- It is the best crop for applying no-till concept especially when sown in standing rice. Soil preparation after rice would cause a lot of disturbance to soil structure and micro flora as well as soil conservation due to increased probability of wind and water erosion as well as soil compaction.
- Berseem is a major seed export crop (7 400 tonnes) representing 86 % of Egypt's seed exports in 1989 (Egyptian Financial Group 1991). There are always high demands for berseem seed from East Asian and South European countries. Egypt's annual exports of berseem seed rose to over 120 00 tons in 2004. The demand is increasing every year.
- Berseem is the best crop for sustainable rotation with rice on salt affected soils. Graves *et al* (1996) reported that it is well known for reclamation of salty lands in Egypt. It is described by Lauchli (1984) and Winter and Lauchli (1982) as moderately tolerant of salinity more so than wheat and strawberry clover but less than barley.
- It is a suitable companion crop. Barley, annual rye grass, triticale and oats (Rammah and Radwan, 1977; Haggag *et al* 1995). A companion grass reduces the risk of bloat especially in initial harvests
- Berseem is very rich in protein and low in energy. Therefore, mixing it with grasses can lead to balanced feeding.
- It is a major crop for bees. Most Egyptian honey is from berseem which must be cross pollinated, primarily by bees, to produce seed.
- It is a suitable cover crop in orchards for controlling weeds and enriching the soil with nitrogen and organic matter.
- It is the foundation crop for land reclamation, especially, desert or marginal sites which can easily be achieved by establishing a livestock cropping system.

Berseem cultivation is a most viable way, economically and environmentally, of controlling all kinds of weeds especially wild oats. (Tables 2 & 3). Successive cultivation of wheat for four seasons resulted in low productivity (309.52 kg/ ha) while rotating it with berseem for three successive seasons gave up to 3 928.57 and 4 523.80 kg/ha of grain, respectively (Table 1). Rotation helps control wheat diseases . Comparing crop sequence for four successive seasons from 1991-92 to 1994-95, continuous wheat resulted in increase in number of spikes of wild oats by more than 16 times and decrease in productivity of wheat by about 12.6 times in comparison with rotation with berseem.

Table 1. Incidence of wild oat spikes in wheat-berseem

Crop Sequence				Wild Oats Spikes/m²	Wheat production kg/ha
91/92	92/93	93/94	94/95		
Wheat	Wheat	Wheat	Wheat	227	309.52
Berseem	Berseem	Berseem	Wheat	14.1	4523.80
Berseem	wheat	Berseem	Wheat	33.2	3890.47
Faba bean	Berseem	Wheat	Wheat	129.5	1178.57

Table 2. Wild oat seed bank in crop rotations

Crop sequence				Wild oat seed per 500g soil		
91/92	92/93	93/94	94/95	At planting	At harvest	Difference
Wheat	Wheat	Wheat	Wheat	22.9	98.3	75.3
Berseem	Berseem	Berseem	Wheat	0.3	11.0	10.7
Berseem	wheat	Berseem	Wheat	0.8	8.4	7.6
Faba bean	Berseem	Wheat	Wheat	1.8	60.0	58.2

In Egypt forage is mainly irrigated and many fodders are used; a comparison of their performances reveals the superiority of berseem in winter (Table 3)

Table 3. Comparison of production of various forage crops of Egypt.

Crop	Area under crop (ha)	Productivity (Fresh t/ha	Production t
Berseem (multicut)	783,000	70.0	54,810,000
Berseem (Single cut)	197,345	59.0	5,723,005
Alfalfa	35,923	94.5	3,394,723
Fodder maize (Darwa)	87,923	28.6	2,514,598
Sudan grass	3,503	54.0	1,90,913
Elephant grass	2,150	52.2	112,230
Hybrid grass	3,330	78.4	258,720
Echinochloa	4,550	39.0	177,450
Barnyard grass	3,000	30.8	92,400
Cowpea	500	33.6	16,800
Pearl millet	1,120	74.0	82,880
Fodder Beet	30	152.4	4,572
Rough pea	4	6.0	24

Trifolium alexandrinum is an annual, 30-60 cm tall, with erect hairy, stems and branches. The leaves are trifoliate, alternate, and membranous with visible green nerves. Leaflets are 1.5-3.5 x 0.6x 1.5 cm oblong, elliptical to oblong lanceolate. Leaflets are mucronate at the apex and denticulate in. Flower heads are creamish white, terminal and pedunculate. There is a small involucre at the base of the head. Calyx tube displays ten prominent nerves while the corolla is almost double the height of the calyx. Seeds are solitary and small. *Trifolium alexandrinum* is an entomophilous, cross pollinated plant. Honey bees are the most important agents of cross fertilization. Under Egyptian conditions cross-pollination in traditional cultivars, Meskawi and Fahl was up to 82 percent in the presence of bees. Under uncaged conditions seed set was 51.9% while under caged conditions seed set was only 0.96% confirming its cross pollinated character. However, studies in India suggest that the population of Egyptian clover grown there is predominantly self pollinated but requires tripping for better seed production.

Egyptian clover is commonly known as berseem which has been derived from Arabic Bersym or Berzym which notifies the branching behaviour and regeneration potential of plants. It has now become a widespread crop in areas with mild winters. It requires a dry, cool climate for best growth and is grown in most countries during winter. It needs mild temperature to grow well. It grows on wide ranges of soils. However, well drained medium loamy soils rich in lime are preferred. It does not withstand acidic soils but grows well in alkaline and saline situations.

The soil is ploughed thoroughly and planked to make it uniform. Farm yard manure is generally added. The plot is flooded and the seed broadcast. Seed rate is 20-25 kg/ha; seed is soaked overnight and mixed with dry soil at sowing to assure uniform spread. Sometimes seed is broadcast in standing paddy just before harvest. Phosphatic fertilizer P_2O_5 up to 125 kg/ha can be applied. Mustard, oats or Lolium multiflorum are sometimes mixed with berseem. 10-15 irrigations are required during the life of the crop.

Agricultural institutions and universities in Egypt have undertaken extensive work on berseem, its cultivation, improvement, agronomy etc. Results, confined to journals and official reports, are diffuse and scattered so it was important to consolidate them. An effort is made in the following pages to present consolidated information on various aspects of berseem crop in Egypt and other major berseem countries. A few papers on the use of latest technology in crop improvement have also been added.

Chapter II. THE CROP AND ITS GROWTH

Crop growth aspects

There has been much research on berseem in Egypt and a multitude of papers produced. Kirwan *et al* (1977) studied berseem + grass mixtures. Four mixtures tested were berseem + barley, ryegrass, berseem + timothy + rye grass, berseem + canary grass. Mixtures significantly outyielded pure berseem in the first cut in first season only. In second and third cut, solo berseem outyielded all mixtures in both years. In first year berseem produced 3.37 t/ha in first cut which was less than the mixtures M_1, M_2, M_3, and M_4 but in second and third cut pure berseem outyielded mixtures. Total forage yield (dry) obtained was berseem 9.28 t/ha, M_1 9.22 t/ha, M_2 8.75 t/ha and M_3 9.51 t/ha. In the second year the cumulative dry forage yield was 9.87t/ha, M_1 10.95t/ha, M_2 10.2 3 t/ha, M_3 10.29 t/ha and M_4 10.54t/ ha.

Younis *et al* (1986) studied the performance of mixing barley with berseem (Fahl and Meskawi), Vicia and Lathyrus increased forage yield by 18.91%, 17.85% 39.4% and 7.58% than the yield of legumes in pure stand, respectively. The protein content of the pure stand legumes was much higher than the mixtures.

Nasr *et al* (1989) evaluated the effect of seed rates of berseem and ryegrass on fresh and dry yield of mixtures of berseem cv. Sakha 3. During the first year of experimentation, three seed rates of cv Sakha 3, 15, 20 and 35 kg were mixed with four seed rates of ryegrass, 8, 10, 12 and 14 kg. In the second year, three additional treatments of pure berseem were added with 15, 20 and 25 kg seed rate. During both years highest fresh and dry yield was obtained when 20 kg of berseem was mixed with 14 kg of ryegrass. Lowest green forage yield was obtained by mixing 20 kg of berseem with 8 kg of ryegrass seed in the first year and 15 kg of berseem with 10 kg of rye grass during second year.

Sarhan and El– Maksoud (2002) investigated the response of berseem cultivars to seed rates. Response to growth, forage yield and quality of four cultivars (Giza 6, Gemmiza 1, Serw 1 and local) to three seed rates (35, 53 and 71 kg/ha) were studied. Giza 6 produced the tallest plants and most leaves per plant. It outyielded the other three significantly in fresh and dry forage as well as total digestible nutrients (TDN). The local cultivar was inferior to others.

Kandil *et al* (2004) investigated seed rates and cutting schedules on cv. Meskawi. Three seed rates of 35, 71 and 107 kg/ha were adopted. Cutting schedules were 30, 40, and 50 cm height; cutting intervals were fixed at 25, 35, 45 and 55 days. In both years the first cut was 60 days from sowing. 50 cm height cut provided maximum fresh forage yield of 27.08 t/ha in first year while in second year maximum yield of 25.53 t/ha was achieved in 3rd cut under 50 days cutting. Fresh yield of 28.35 t/ha was obtained under 45 days interval in first year while in second year it was 26.43 t/ha in second cut under 45 days. Kandil *et al* (2005) continued this study and later studied the chemical composition of the dry matter obtained from the treatments. Maximum crude protein. crude fibre, ash, and ether extract for blades and stems was 69.04 (2nd cut), 26.5 (1st cut), 44.47 (second cut), 8.30 (1st cut) and 5.33 (3rd cut) respectively. Maximum combined protein yield (kg/ha), crude fibre (kg/ha) ash (kg/ha), and ether expect (kg/ha) for blades and stems were 502.23 (2nd cut), 712.52 (3rd cut), 560.5 (2nd cut) and 71-176 (4th cut) respectively. Under different seed rates maximum combined protein, crude fibre, ash and ether extract (kg/ha) for blades and stems (combined) were 185.44 kg (71 kg/ha), 303.99 (71 kg/ha), 210.71 kg (107 kg/ha), and 36.59 kg (71 kg/ha) respectively.

El-Zanaty (2005) investigated the influence of sowing dates on forage and seed yield of new varieties over two years. Four varieties were sown on four dates: 15 October, 1 November, 15 November and 1 December. The highest fresh and dry yields were obtained by sowing 1st November in both years. Sowing cvs. Ahaly and Khadrawi on 1st November gave significantly highest dry forage field in both first and second year. Highest seed yields were from sowings on 1st December during first year and 15 November in second year. Cultivar Synthetic 79 and Serw 1 sown on 1st December provided the highest seed yield in the first season; during second year cv. Giza on 15 November provided the highest seed yield.

Influence of external factors on initial growth

Radwan *et al* (1972) studied the influence of seed size and source on germination and seedling vigour of berseem; 32 lots of Fahl seed were evaluated. Samples were graded by sieving.; seeds were designated as large, medium large, medium and small. Hundred seed weight, determined by weighing four samples of 100 seeds from every lot, was 198, 255, 328 and 403 mgms for small, medium, medium large and large respectively. Germination and seedling emergence were significantly influenced by seed source (lots) and seed size (classes). Except for first emergence count, both factors showed a highly significant interaction. This indicates that seed source factors, not related to seed size, are important in germination and emergence. Germination percentage ranged between 61.6 to 85.6 while germination recorded by classes was 83.7, 83.5, 79.8 and 74.7 percent in case of large, medium large, medium and small seeds. Seed size is not a major factor controlling seedling vigour during germination; it appears to be conditioned by intrinsic lot differences unrelated to seed size.

Kandil and Shalaby (1985) studied the effect of cultural practices on germination and seed characters of berseem and alfalfa. Average percentage of germinated seedlings appeared significantly higher in early sowings compared to late ones. Drilling gave a higher percentage compared to broadcasting in the second season. Plant densities failed to exert any significance on average percentages. Number of seedlings per unit area decreased as planting dates were delayed.

Two cultivars, multi-cut Gemmiza and single-cut Fahl were exposed to six treatments of non thermal plasma pulse by Tarrad *et al* (2010). These treatments were compared to an untreated control. Treatments were 1, 3, 5, 7, 9 and 11 pulses exposure to the seeds. There was a marked impact on morphological characters as well as herbage yield. The impact was well observed in both cultivars.

Genotype x environment interaction is of great importance in the development and evaluation of cultivars. Seven new varieties and some commercial ones (total 8) were evaluated for fresh and dry forage yield at six sites by Abd Elgalil *et al* (1998). Fresh and dry yields differed significantly between varieties within and among sites. The mean square deviation from regression indicated that all varieties tested were stable for dry yield performance.

Zayed (2011) evaluated six cultivars for performance under high temperatures. Helaly, Serw 1, Gemmiza 1, Giza 6, Sakha 4 and Fahl were evaluated in a randomized complete block design with four replications. Temperatures of air and soil were 18.5 and 40.8 C° with a mean of 31.4 C°. Giza 6 and Helaly yielded 11.28 and 11.57 t/ha respectively.

Mohammed and Fahmy (1988) studied the effect of Alar, Gibberellic acid (GA) and Morphactin on Egyptian clover. Alar (100-1622 ppm), Gibberellic acid (50 ppm) and Morphactin (1.20 ppm) were sprayed alone and in combinations on berseem varieties Meskawi and Fahl. In the single cut variety, Fahl, no branches were observed on plants sprayed with Gibberellic acid (GA) and Morphactin alone or in combination. Branches increased significantly by spray of Alar (200-800 ppm). Under spray of GA, plants grew tallest. In the multi-cut variety Meskawi almost the same trend was observed. GA (50 ppm) and or Alar spray produced the tallest plants. The number of branches on the main stem increased significantly by the spray of GA and Alar. Morphactin (1-8 ppm) increased the number of branches and significantly reduced plant height in both varieties; Alar alone or in combination with GA gave the best results. Alar (100-800 ppm) alone or in combination with 50 ppm of GA significantly increased fresh and dry weight of plants which was positively correlated with plant height, stem diameter, number of branches and total leaf area.

Dodder

In Egypt infestation by *Cuscuta planiflora* and *C. pedicellata* is widespread. and cause significant damage because of contaminated seed. Farmers produce and use their own seed.

Abdel-Hamid and El-Khanagry (2006) studied this menace in three governorates of the Nile Delta: Kafr El-Sheikh, Gharbia and Menoufia. Field, laboratory and farm studies were integrated to find the magnitude of dodder infestations and control measures. Germination studies on dodder seeds were made, to find the optimum temperature range for its spread. 200 seed samples were tested for dodder contamination with adulterants. 150 samples were collected from seed companies. A questionnaire to collect information from farmers revealed that Cuscuta seed, germinated in the temperature range of 10 – 20 °C and the optimum temperature for germination was 15°C. Some 86.7 % of farmers' samples were infected by dodder but seeds from certified sellers were clean. Contamination was higher in Kafr El-Sheikh (92.5%) while in Ghabia it was 80%. Most contaminated samples (62.7%) occurred in the range 1-5, 6-10, and 11-15g/kg of clover seed. 12.7% of contaminated samples occurred in the range of more than 30g / kg of clover.

Fungal infestations and their control

Foliar diseases caused by fungi, bacteria and viruses are very common in clovers and Egyptian clover is no exception. Black stem and leaf spots are very common. Shaat (2003) studied these diseases in Minia. Isolation and pathogenicity tests revealed two genera of fungi identified as Phoma and Epicoccum. Two isolates viz, Phoma medicaginis and Epicoccum spp. were identified as the cause. The former causes spotting of the foliage and black stem while the latter caused limited, small and dark brown spots mainly on leaves and at times on stem. Younger plants were more susceptible to fungal infections. Hundred percent incidence of disease was found on 25 day old plants while 35 and 45 day old plants recorded 87.0 and 66.0% of disease with 66% and 40% severity. Disease incidence was more severe in early cuts and declined in later ones. Disease incidence after first cut was 53% with 34% severity. In second and third cut the incidence was 36% and 26% with 20% and 10% severity respectively. Similarly, early irrigation caused more disease while late irrigation reduced these significantly. Irrigation after 14 days caused 100% incidence with 54% severity while irrigation after intervals of 21 and 35 days caused 70% and 23% incidence with 24% and 14% severity respectively. Spray of antioxidants to 25 days old stands resulted in protection against *P. medicaginis* infection. Ascorbic acid provided the highest protection when applied 24 hours before inoculation followed by salicylic acid.

Allelopathic effects of berseem

Crop competition is a natural phenomenon. Besides the inherent characters of plants to compete, chemical exudates from them are toxic or harmful to others and do not let these grow, or hamper their growth. This is known as allelopathy; it occurs in berseem and Toaima *et al* (1999) studied the allelopathic effects of two cultivars. Root extracts of Giza 15 and Helaly were prepared and their effects on germination, seedling length and fresh weight/10 seedlings of succeeding summer crops after seven days of sowing were studied. Summer crops tested were maize, soybean, berseem and sunflower. Germination in all crops except maize was reduced considerably by root extracts of Giza 15. Reduction in germination was 57.0 and 66.67% with 20 and 10% concentration extract respectively in case of soybean. In sunflower germination was almost completely inhibited by root extract of Giza 15. With application of 20% concentration of this root extract germination was reduced by 87.67% in sunflower. Similarly, seedling length of soybean and berseem was reduced considerably with 20% root extract of Giza 15. As far as the antitoxic effect of Giza 15 root extract is concerned, it reduced germination of berseem by 77.0% and 82.09% with application of 20% and 10% concentration extracts of Giza 15. The root extract of Helaly reduced germination in all crops except maize. These detrimental effects of allelopathic constituents of two cultivars are visible only under experimental conditions. The compounds in due time get degraded by soil micro organisms or get transformed and cause no significant effect on succeeding crops.

Multifoliate strains of berseem

Aberrant, abnormal or unique plant types can be found in any plant population. At times these abnormalities are caused by edaphic or climatic factors but they may be because of changes at gene level and such plants may in fact be mutants. It is difficult to designate a plant as a mutant by only visual observations; detailed studies are required. Trifoliate leaf is an inherent and diagnostic character of the genus Trifolium but multi-foliate leaves have been reported in *Trifolium pratense* and many other species.

In *Trifolium alexandrinum* multi-foliate plants occur commonly; many geneticists have designated them as mutants and used them to produce multi-foliate generations by hybridization. Bakheit and El- Nehrawy (1997) found a mutant of monocut Fahl and used it to create a multi-foliate strain of berseem. This mutant, having multi-foliate leaves, was crossed with the trifoliate, multicut cultivar Meskawi. The multicut, multi-foliate strain was developed after eleven generations of rigid selection of the progeny for highly productive multi-foliate plants. The new multi-foliate plants were evaluated along with eleven cultivars. There were significant differences among varieties for fresh and dry forage yield. The new multi-foliate strain gave highest fresh and dry forage yield at first cut. Also the new strain gave higher seasonal dry forage yields as compared to established varieties like Sakha 3, Sakha 4M, Sarol, Geminza 1, Helaly, Sakha 6M and Sakha 2.

The multi-foliate strain was evaluated with five cultivars by Bakheit (1998). There were significant differences for fresh and dry forage yields and protein content at first cut. The multi-foliate strain gave significantly higher dry forage yield than commercial varieties Giza 10, Sakha 4,Giza 15, Helaly and Giza 6 by 22.1, 22.5, 24.8, 29.9 and

36.7% respectively. Bakheit (2001) further evaluated this strain along with commercial varieties Giza 10, Sakha 4, Giza 15, Helaly and Giza 6. The first cut dry forage yield provided by the new strain was higher. Even the leaf stem ratio averaged over cuts was 18.3% higher than five commercial varieties. This strain gave higher seasonal protein yields than other cultivars. It has been suggested that this multi-foliate strain could be useful for forage production before sowing cotton or other early summer crops. The multi-foliate trait can serve as a genetic marker for breeders. Increase in leaf area certainly enhances the biomass and Radwan (1973) has given the methodology for leaf area estimation in berseem.

Tolerance of soil salinity

Berseem is fairly resistant to soil salinity which renders large tracts of land unsuitable for crops. Bakheit and Abd El-Rahim (1983) tested the response of four forages to salinity in their germination and initial growth. Seeds of berseem (cv. Meskawi), alfalfa, forage sorghum (Sordan-Northking), Sweet sorghum and millet were tested in two saline solutions of NaCl and NaCl+ CaC_{12}. Six concentrations of both solutions were tested with, control (distilled water), 4 000, 8 000, 12 000, 16 000 and 20 000 ppm. Germination tests recorded, 1) germination percentage after 10 days, 2) germination rate index, 3) radical and plumule length after 10 days, and 4) fresh weight of seedlings after 10 days.

In case of sodium chloride salinity, germination percentage and index descended in this order: forage sorghum- alfalfa- millet- berseem and sweet sorghum. In case of NaCl _ CaC_{12} salinity crops recorded germination percentage and index as (in descending order) alfalfa- Northking- sorghum, millet, berseem– sweet sorghum. This investigation reveals that berseem at germination has very little resistance to salinity. In case of seedling vigour and its resistance to salinity, only NaCl salinity was more toxic than NaCl+ CaC_{12} salinity. This was true for berseem. In a study by El- Nahrawy *et al* (1998), nine cultivars were evaluated at three sites with salt affected soils with a salinity level of 2.5, 5.5 and 8.5 mmohs/cm respectively. Three cuts were taken on Jan 25, March 22 and April 27. In the second season, cuts were taken on Dec 20, Jan 21 and March 2. Increasing levels of salinity caused detrimental effects on plants height, fresh and dry forage yields at all cuts in both seasons. Increasing salinity had detrimental effects. Genetic variability for salinity tolerance and forage quality seems to exist. Crude protein, ash and crude fibre percentage varied according to cultivar, cut, year and salinity level.

Drought tolerance

Egyptian clover is a moisture loving crop which requires frequent irrigation. Bakheit and El Hinnawy (1993) subjected 32 accessions to drought conditions throughout their growth till cutting and compared their performance with the same accessions under normal irrigation. There was considerable variations amongst accessions for fresh and dry forage field. Growth under drought conditions gave decreased yields. Fresh forage yields under normal irrigation ranged between 6.91 to 11.22 kg / m^2; under stress it was 3.80-6.06 kg / m^2.

Chapter III. AGRONOMY

Biological nitrogen fixation

Berseem's greatest contribution to Egyptian agriculture is its ability to fix atmospheric nitrogen and increase soil fertility, which may be the main reason for its adoption by farmers. The Agriculture Research Council began producing inoculants in 1950 and their efforts to find and produce more compatible and efficient rhizobia continue. Three local rhizobium isolates were compared with a reference strain and control. The number of nodules per 10 plants and their dry weight was recorded after 45 days from sowing. Dry weight of plants was recorded and plants analyzed for N content after 45 days from sowing. Fresh and dry weight/ha were recorded in all treatments. Samples were analyzed for chemical constituents, total digestible protein and digestible nutrients. Native rhizobia can be very effective. Uninoculated plants produced up to 110 nodules per 10 plants while inoculated plants showed significant increases in nodule numbers and dry weight. Local strains surpassed the reference strain significantly in increasing nodule number and biomass. Significant differences due to both inoculation and cultivars were observed .

Irrigation regimes

Berseem requires intensive irrigation. With the construction of dams on the Nile, irrigation is widely available, but there are areas where it is scarce. Investigations have studied the impact of irrigation regimes and the potential of drought resistance in Egyptian clover. Kandil *et al* (1983) evaluated irrigation methods and quantities of water for forage and seed yield. Sprinkler irrigation promoted longer and deeper roots than surface irrigation. Surface irrigation with large quantities of water produced shortest roots. Maximum seed production of 340 kg/ha was achieved under spraying of 4 200 m^3 water/ha in four irrigations and a seed rate of 28 kg/ha.

Belal *et al* (1998) studied the effect of water stress on photosynthetic rate, osmotic potential and yield. The main objectives were to investigate morphological and physiological parameters related to drought tolerance among eleven accessions. Severe drought reduced stem/root length ratio, crown diameter and number of branches for all accessions compared with moderate drought and control. All accessions recorded higher fresh and dry yield under control (irrigation every 15 days) than every 30 days. Photosynthetic rates declined in all accessions under irrigation every 15 days.

Gaballah (2001) studied the effect of irrigation frequency on forage yield and quality of four cultivars. Multi-cut Meskawi, Sakha 4, Helaly 4, Synthetic Sids 6 and Giza 15 were exposed to three irrigation frequencies after 15, 20 and 25 days. Three cuts were taken during first year. Irrigation frequency of 15 days displayed highest average plant height in all three cuts at 52.96 cm, 60.57 cm and 68.69 cm respectively. Similarly maximum protein kg/ha (combined) was achieved under 15 days frequency and highest yield of protein was 1 010 kg/ha under 15 days irrigation. Fresh forage yield displayed the same trend and highest yields were achieved under 15 days irrigation frequency in both years.

Rizk *et al* (2005) investigated the effect of irrigation regimes and mixing ratios on forage yield of berseem mixed with barley and annual ryegrass. The experiments were repeated over two years with a total of 21 treatments. Three water regimes of 738 (A) 561 (B) and 257 (C) m^3/ha of water which amount to 100, 75 and 50 % of actual irrigation were provided. Crop combinations were, berseem (pure) ryegrass pure, barley pure; barley+berseem (75:25) barley+ berseem (50:50) rye grass + berseem (75:25) rye grass+ berseem (50:50). At first cut the highest accumulated forage yield (fresh) was 21.90 t/ha, 5.83t/ha and 18.02t/ha under A, B and C irrigation treatments respectively. A similar trend was found under second and third cut when accumulated forage yields obtained were 18.02, 15.59, 13.92 and 17.76, 15.73 and 11.76 t/ha under A, B & C irrigation regimes. A similar trend was exhibited during second year but forage yields were higher.

Productivity as influenced by irrigation and nitrogen foliar application was studied by El-Sabbagh *et al* (2005). Two experiments were repeated for two years. Irrigation treatments comprised of 1, 2 and 3 irrigations after each cut. Nitrogen foliar spray was applied as urea (46.5% N) at rates of 0.0, 0.25 and 0.50%. Crops were sprayed four times at 35 days after flowering and 20 days after each cut using 952 litres of water/ha. Optimum fresh and dry forage yields were obtained from irrigations thrice after each cut. Urea foliar spray in concentration up to 0.50% significantly increased fresh and dry forage fields by 47.53 and 61.94% respectively compared to untreated plants.

Water requirement values were 64.75 cm (6475 m^3/ ha), 75.92 cm (7 592 m^3 / ha) and 85.77 cm (8577 m^3 / ha) for 1, 2 and 3 irrigations at each cut respectively. Water consumptive use values increased as available soil moisture increased in the root zone. Foliar application with urea had a slight increment on this trait.

Abouenein (2010) *et al* studied a water saving method for increasing yield of berseem by cultivation on raised beds. Treatments included, 1) growing berseem on raised beds; growing it in basins, 2) farmer's basin irrigation, 3) dry and wet sowing were tested, 4) deficit and farmer irrigation practices were tested. Growing berseem on raised beds revealed an increase in green (fresh) yield ranged from 20 to 26% being 34-38.3 t/ha and increase in dry yield ranged from 23 to 28% being 5.2 to 7.94 t/ha as compared to farmer's practice. Growing berseem on raised beds saved water which amounted to 104 mm (18%).

Ali Mohamed and Ahmed (1995) studied effect of water salinity on agronomic traits of five berseem genotypes. NaCl concentrations in irrigation were, 500, 1000, 1 500 and 2 000 ppm added to tap water. Plants were irrigated with these salinity concentrations in the whole season and cut four times per year. Maximum plant height of 46.3 cm was achieved in first year by cv. Serw 1 in fourth cut under control (tap water). Under salinity treatments maximum plant height of 45.2 cm was achieved in second cut by cv. Serw 1 under 1 000 ppm salinity. Minimum plant height of 33.3 cm was achieved by cv. Helaly under 2 000 ppm. During second year cv. Serw 1 achieved maximum plant height of 46.9 cm in 2^{nd} cut under no salinity. Maximum plant height of 44.4 cm was achieved in cv. Serw 1 under 500 ppm. In the first year the highest dry matter yield of 0.42 gm / plant was achieved by cvs Serw 1 and Helaly under no salinity; during second year these cultivars attained maximum dry weight of 0.52 gm/ plant without any salinity.

Mady and Meleha (2007) studied water use efficiency of berseem as affected by methods of sowing and nitrogen fertilization. Two sowing methods were used. W1 involved broadcasting seed on wet soil after flooding. In W2 seeds were sown on dry levelled soil and then irrigated. Nitrogen was provided in three regimes 0, 35 and 70 kg/ ha. There were no significant differences in fresh and dry yield and crude protein percentage in the two treatments. Sowing on dry, levelled soil and provision of irrigation after sowing gave the highest value of water saving.

Response to fertilization

A number of studies have been undertaken on these aspects in Egypt

Abdallah *et al* (1981) studied the effect of phosphorus fertilization and seed rate on forage and seed yield of berseem cv. El-Miskawi. Seed rates were 28, 56 and 85 kg/ha. Phosphorus was applied at 0, 35, 70 and 107 kg P_2O_5/ha in the form of calcium superphosphate (15% P_2O_5). Half of the fertilizer was broadcast at sowing and half after first cut. Irrigation was provided at intervals of three weeks. Fresh and dry forage yield was significantly affected by phosphorus application. Yields increased with increasing phosphorus up to 107 kg/ha P_2O_5. Of seed rates, 56 kg/ha significantly increased seasonal forage yield. Maximum fresh yield of 51.07 t/ha was obtained by application of 107 kg P_2O_5 and 56 kg /ha seed rate. Maximum dry forage yield of 9.42t /ha was obtained under this treatment.

El Hamdi *et al* (1981) studied the effects of nitrogen, phosphate and potash on yield and chemical composition of berseem. Five levels of N (0, 59, 119, 178 and 238 kg/ha) two levels of P_2O_5 71 and 142 kg / ha and two levels of K_2O 35 and 71 kg/ha were applied. There was a gradual increase in green and dry forage yields as more nitrogen was applied. Highest yields were obtained by addition of 119 kg/ha N in both seasons. Dry forage yield from this treatment was 7.14 and 3.57 t/ha during 1^{st} and 2^{nd} year respectively, to 143 and 150 percent higher yield than control. Highest seed yields of 1 269 and 1 559 kg/ha were achieved by application of 178 and 119 kg. N/ha. Application of potash had no significant effect on forage yield.

Kandil and Shalaby (1983) studied factors that may affect N, P and K uptake by Egyptian clover. Total nitrogen in dry matter of blades and petioles tended to increase as sowing dates were delayed or more cuttings taken. Mean percentage of total nitrogen in dry matter was higher in Meskawi than Waffer. Mean percentage of total nitrogen in dry matter of stem and sheaths showed the same pattern. Mean amounts of total phosphorus uptake in dry matter of blades plus petioles tended to increase as more cuttings were taken. The nitrogen in dry matter of sheaths increased in the second planting season (2^{nd} year) with more cuts. The mean amounts of total potassium uptake in dry matter of blades plus petioles decreased by delaying planting dates and this increased when more cuts were taken. In case of dry mater of stems plus sheaths the mean percentage of potassium increased in second planting and it tended to increase by more frequent cutting.

Haggag and El-Kholy (1998) investigated the effect of potassium forms and rates of application on yield and quality. Two forms and three rates of potassium fertilizer were tested. Fertilizer rates were 0, 71 and 142 kg/ha as potassium sulphate (48% K_2O) and potassium chloride (60% P_2O_5). Potassium sources and rates significantly affected green and dry matter yield for all cuts (3 cuts taken) in both seasons. Potassium sulphate provided the highest green and dry matter yields (92.73, 15.47, 101.52, 16.90 t/ha) at 142 kg. K_2O/ha for the 1st and 2nd season respectively. Highest crude protein percentage of 23-28 percent was achieved in second cut during 1st season with 60 kg K_2O as K_2SO4. The situation was similar in second season when the crude protein percentage was 22.48. Highest quantity of seed at 454.28 kg /ha and 620.95 kg/ha was achieved under application of 60 kg P_2O_5 as K_2SO_4 respectively during first and second season of experimentation.

Abdallah *et al* (1988) studied the effect of phosphorus fertilization and seed rate on forage and seed yield of berseem. Three seed rates of 28, 56 and 102 kg/ha were applied while phosphorus was applied at 0, 15, 35 and 107 kg/ha P_2O_5. Half of the phosphorus was applied at sowing and the rest after first cut. Two cuts were taken and then the crop was left to seed. First cut was 80 days after sowing and the first highest fresh fodder yield of 51.07 t/ha was achieved by application of 107 kg/ha of P_2O_5 and a seed rate of 57 kg /ha. The highest dry fodder yield of 9.42 t/ha was achieved under this treatment. The same trend was repeated in the second season when the lowest green yield was 42.26 and dry forage yield was 6.88 t/ha. In the first season highest seed yield of 237.85 kg/ha was achieved under 107 kg /ha P_2O_5 and seed rate of 57 kg/ha. During second season highest seed yield was with no P_2O_5 with seed rate of 85 kg/ha.

Abou Deya and Kandil (1993) studied the response of barley to N and P fertilization and grown mixed with berseem. Egyptian clover and barley were sown alone as well as mixtures of 1:1, 2:1 and 1:2 ratios respectively at a rate of 45 kg seeds /ha. Seed of both crops were thoroughly mixed and line sown 20 cm apart. N and P fertilizers were used at rates of 50 N + 50 kg P_2O_5 and 75 N + 75 P_2O_5 kg per ha. Two cuts were taken in December (1st season) and November (2nd season) sown crops. Mixing barley with berseem in a ratio of 1:2 (M_4 treatment) produced the highest forage yield in the second season and barley in both seasons. The inverse pattern of 2:1 (M_5 treatment) was favourable with berseem, adding 75 kg of both N and P/ha to the mixture of barley and berseem in 2:1 ratio resulted in highest forage production.

Nor El-Din and Haggag (1993) studied the effect of mineral nutrition on Egyptian clover on saline soils; phosphorus and potassium were provided as soil and foliar applications. Besides the control, P_2O_5 was applied at 107, 142 and 178 kg/ha as soil application. Similarly K_2O was applied at 114, 171 and 228 kg /ha. Calcium as calcium tetrahydrogen diorthophosphate was used as a foliar spray at 476 g/ha. Similarly $P_2O_5 + K_2O$ and Ca at 107 kg. 114 kg and 476 g /ha respectively were applied as foliar spray. There were no significant differences in plant height as affected by the nutritional treatments during 1st and second cuts in both seasons. However, plant height increased during third cut in both seasons. In first season maximum plant height was achieved in 1st, 2nd and 3rdcut at 50 cm, 76.67 cm and 76.67 cm respectively under P_2O_5 application of 142 and 178 kg /ha, P_2O_5 application of 178 kg / ha and 142 kg P_2O_5 /ha respectively. Total fresh forage yield of 117 t/ha during first season was achieved under 114 kg K_2O/ha application, while during second season maximum fresh forage yield of 190 t/ha was achieved by application of 107 kg P_2O_5/ha. Highest seed production of 1 500 kg /ha was achieved with application of 107 kg P_2O_5 ,114 kg K_2O and 47 kg Ca/ha during first season.

Four varieties of Egyptian clover, Ahaly, Khadrawi, Synthetic 79 and Giza Gammah were evaluated for response to N fertilization by El-Zanatay (2005). During the second season of evaluation two more varieties, Giza 6 and Serw 1 were added. Three nitrogen levels O, 40 kg/ha N as basal dose and 40 kg/ha N after every cut were applied. During first season five cuts were taken; during second season only four cuts were taken. No significant differences were observed in N levels on fresh and dry forage yield at each cut and total yield in both seasons, except at first cut in first season when fresh forage yield increased significantly with addition of basal dose of 40 kg N/ha.

Kandil and Abo Deya (1994) investigated the response of barley in pure stand to N and in combination with berseem in sandy soil. Egyptian clover var. Meskawi and barley var. Gustoen were sown in December and November during first and second season respectively. Mixtures were sown under the treatments of berseem solo, barley solo and mixtures of berseem + barley at the rate of 50 + 50%, and 33 + 67%. Two N and P fertilizer treatments were also applied at 50 kg/ha N + 50 kg/ha P_2O_5 and 75 kg/ha N + 75 kg/ha P_2O_5 kg. Two cuts were taken during each season. Land equivalent ratio (LER), relative crowding coefficient (RCC) and aggressivity (A) of berseem and barley were estimated on dry matter basis as affected by intercropping systems and different levels of N-P fertilization. LER values decreased and increased by increasing N-P added to solo berseem or solo barley respectively. Increasing berseem or barley component in mixture increased LER value. RCC values of berseem and barley increased by increasing N-P levels to berseem and increasing the ratio of any of them in the mixture. Increasing any of berseem or barley component in mixture resulted in corresponding increase in aggressivity.

Chapter IV. CROP IMPROVEMENT

Evaluation of genetic resources

Berseem has undergone a lot of improvement and a number of cultivars have been developed which have been evaluated under various climatic conditions and other parameters.

Abd El-Halim *et al* (1993) evaluated five cultivars of Egyptian clover under Ismailia conditions. Cultivars Sakha 3, Sakha 4, Giza 6, Giza 10 and Giza 15 were evaluated for two successive years and the studies identified cultivars for cultivation on newly reclaimed soils in Ismailia. During two years of evaluation 1990-91 and 1991-92, Sakha 3, Sakha 4, Giza 6, Giza 10, and Giza 15, produced cumulative dry matter yield of 5.47, 7.30, 6.61, 6.61 and 7.07 t/ha respectively. Productivity, however, differed at individual cuts. The interaction of variety x year was significant. Sakha 4 and Giza 15 were the best cultivars for newly reclaimed soils of Ismailia.

Haggag *et al* (1995) compared the performance of ten ryegrass varieties in pure and mixed stands with berseem at four sites, Ismailia, Gimmeza, Sakha and Nubaria during 1993-94 and 1994-95. All mixtures and berseem in pure stand produced higher forage yield than all ryegrass varieties alone. Mixtures of berseem and rye grass yielded more than pure berseem. Rye grass varieties Torero, Wosley and Primora were superior to other ryegrasses.

Sarhan *et al* (2002) studied the response of forage yield and quality of some berseem varieties to the interaction with mineral and bio-phosphate fertilization. Two field experiments were conducted at Sids during 1999-2000 and 2000-2001. The trial consisted of 15 treatments on 3 varieties. Varieties Giza 6, Sakha 4 and Helaly were allocated at random to the main plots and five rates of phosphorine inoculation in combination with 35 kg/ha P_20_5, 17 kg/ha P_2O_5 and phosphorine inoculation alone were tested and compared with untreated soil and recommended phosphorus fertilization dose of 71 kg/ha P_2O_5/ha which were randomly distributed in the sub plots with four replicates. The bio-phosphate fertilization with phosphorine inoculation had a significant influence on fresh and dry matter yields as well as protein, phosphorus and potassium yields. The highest values were obtained from plants fertilized with half the recommended dose of mineral phosphorus combined with phosphorine inoculation for all varieties studied. Variety Helaly achieved highest values for all the parameters while Giza 6 achieved the lowest.

Abdel-Galil et al (2007) studied the yield and stability of sixteen Egyptian clover genotypes under different environments. Field experiments were laid out at four sites, Sakha, Gemmiza, Serw and Sids representing the delta and middle Egypt during two successive seasons, 2003-2004 and 2004-2005. The genotypes tested comprised of 10 released cultivars, Sakha 3, Sakha 4, Sakha 96, Hellaly, Giza 6, Giza 15, Gemmeza 1, Serw 1, Serw 2 and Sids Syn. Along with these, six promising genotypes Cairo 1, Cairo 2, Cairo 3, Narmer, Hatour and Assiut populations were also tested. The highest mean fresh forage yield at four sites was achieved by genotype Hatour (113 t/ha) while the lowest fresh forage yield (mean of four sites) was achieved by genotype Cairo 3 at 103.95 t/ha. The highest dry matter yield was achieved by cv. Gammeza 1 at 14.76 t/ha (mean of four sites) while minimum dry forage yield was achieved by genotype Cairo 3 at 13.52 t/ha (mean of four sites).

Rizk *et al* (2002) studied the effect of various treatments of NaCl (saline water) on germination, seedling growth, development, accumulative forage yields and chemical composition on cultivars Giza, Ismaelia 1, Helaly, Sakha 4, Serw 1, and Gemmeza 1. Germination percentage, germination rate index, radical and plumule length were significantly influenced by NaCl concentrations and clover varieties. Increased levels of NaCl concentration up to 4 000 ppm significantly depressed germination percentage, germination rate index and plumule length. Seeds of Sakha 4 and Gemmeza 1 were comparatively more tolerant to NaCl. In case of forage yield cv. Ismaelia 1, was superior in fresh and dry forage yield over Giza 1, but its dry forage yield does not reach the significant level.

Kandil and Shalaby (1985) studied a new approach to growing Egyptian clover and Alfalfa. Cultivar Giza 1, of Egyptian clover and cv. Sonora of Alfalfa were compared. Sowings were made in mid August, mid September and mid October. Five cuts were taken from each sowing. Mean fresh weight per plant was found to be between 1.38-5.22 g, in mid September. It ranged between 1.01-6.00 g in mid October and in mid August it ranged between 0.74-1.85 g. Two more cuts were taken after 5th cut but their yields were low and ranged between 1.59-3.03 g/plant. Drilling was found to be a better method for increasing forage yield. The combined analysis indicated that averages of green yield per plant for the five cuts was significantly higher in pure berseem, followed by mixture with alfalfa followed by pure alfalfa.

Helmy *et al* (2011) evaluated forage production potential of barley and ryegrass grown alone or with berseem. In case of berseem, cv Giza 123 and cv. Giza 2000 produced a total of 47.38 and 44 t/ha respectively. Ryegrass produced 79.78 t/ha., berseem + barley Giza 123 produced 127.28 t/ha while berseem Giza 2000 + barley produced 114.83 t/ha., berseem + ryegrass produced 117.85 t/ha while Berseem solo produced 114.30 t/ha.

Abbas *et al* (2005) studied the negative relationship between number of berseem cuts and yield of cotton as a following crop. The aim was to study the effect of organic manure and number of berseem cuts on cotton yield and its components and fibre traits. Only plant height at harvest, number of fruiting branches/plant and the height of the first fruiting branch were significantly affected by organic matter application which did not affect cotton yield, yield components and fibre quality traits significantly.

Biotechnology in crop improvement

Egyptian clover has many inbuilt problems which perhaps, cannot be corrected by traditional technologies alone. Some characteristics cannot yet be explained since information at molecular level is not available. This information base can be very useful in programmes of plant improvement. Biotechnology could be amply used for plant improvement in the case of berseem. Aspects of Egyptian clover which have been studied under biotechnological regimes in Egypt include morphological, biochemical and molecular characterization of two varieties. Five Egyptian clover varieties were studied. Polyacrylamide gel electrophoresis (PAGE) was done on native SDS protein and isozyme variations. RAPD was conducted using 8 arbitrary 10 rule primers. Combined analyses based on four isozymes page protein electrophoresis and RAPD analyses revealed highest similarity of 0.85 between the two varieties Sakha 4 and Gemnuiza 1, while the lowest similarity (0.53) was observed between Giza 6 and Helaly. The investigation revealed variations amongst cultivars in their morphological characters.

Detailed cytological studies were undertaken on Helaly and Fahl. The somatic chromosomes of both were 2n=16. The karyotype exhibited differences in chromosome morphology. Chromosomes nsm (+) were observed in Helaly. The karyotype formula for which was 2 wm (+) +2 sm (-) +12 nm while for Fahl it was 6 nsm (-) +10 nm. Karyotype studies show that Helaly is advanced whereas Fahl is primitive.

Molecular characterization of Fahl and Helaly has been studied on the basis of seed soluble protein pattern as well as RAPD, ISSR and AFLP generated DNA profiles. Among molecular markers used, ISSR showed highest level of molecular variance (24.5%). In terms of allele frequency (p) level of difference between two cultivars was variable. Based on SPSS analysis, a high correlation coefficient (0.9) indicated a strong correlation and direct relationship between Fahl and Helaly.

Comparison of cytological and biochemical studies was undertaken on four cultivars. Serw 1, Gemmiza 1, Giza 6 and Fahl. All were diploid with chromosome number 2n=16. Five isozymes and proteins produced 28 different bands in peroxides, 7 bands in esterase, 2 bands in acid phosphates, 4 bands in alkaline phosphates and 3 bands in superoxide dismutase. It was found that 11 bands were produced from four Egyptian clover which ranged from 120 to 144 KDa.

Plant improvement

Zayed *et al* (2012) compared cytological and biochemical studies among four clover cultivars referring to cutting type, were based on cytology, isozymes and seed protein. Seeds of four varieties, Serw-1, Gemmiza – 1, Giza -6 and Fahl were sown in Petri dishes in six replicates. Studies were undertaken on seedlings after 10, 15 and 20 days. Three cells of each seedling were used for constructing the karyotype. Isozymes and protein pattern variation among cultivars were studied through native polyacrylamide gel electrophoresis (PAGE) and SDS- Polyacrylamide gel electrophoresis (SDS-PAGE) respectively. The cultivars were diploid (2n=16). The highest significant value (4.65) in single cut Fahl while Gemmiza-1 exhibited significant value (2.45) in shoot length Serw-1 gave highest significant value (5.20 cm) While Gemmiza-1 showed significant value (3.30 cm) in radial length. Five isozymes and proteins exhibited different total bands 28 (42.9% polymorphism, pol) in peroxides 7 bands (28.6% pol) esterase 2 bands (0% pol) in acid phosphates 4 bands (25% pol) in alkaline phosphates 3 bands (66.7% pol) in superoxide dismutase (SOD) I band (0% pol) and in protein II bands (53.2% pol). The protein bands ranged from 120 to 14.4 K Da. Isozyme and protein analysis using PAGE are suitable for maintaining and determining the genetic relationship in Egyptian clover cultivars.

Soliman *et al* (2010) compared two cultivars of Egyptian clover, Helaly and Fahl cytologically; studies including chromosome number and karyotype analysis. The somatic chromosome number of both was 2n = 16, karyotype analysis showed differences in chromosome morphology. Chromosome nsm (+) were observed in Helaly. The karyotype formula for Helaly was 2 nsm (+) + 2 nsm (-) + 12 nm. For Fahl 6 nsm (-) + 10 nm were recorded. Helaly had highest A1 and A2 whereas Fahl had highest TF %, S%, Syl index and Rec index. Karyotype analysis revealed that Helaly is advanced whereas Fahl is primitive. Chromosomal abnormalities were observed at mitotic division which was higher in Fahl.

El–Shawareb (1971) investigated the comparative efficiency of mass and recurrent selection in Egyptian clover on variety Meskawi. Seed composites were obtained by bulking equal quantities from seed lots sampled from three different regions. A spaced nursery of 3 600 plants was established in 36 plots. For mass selection the top ten percent of all plants, in green yield and number of tillers, were always selected. Five grams of open pollinated seeds from these selected plants were bulked to maintain the seed required for the subsequent cycle. For the modified main selection method the highest yielding ten plants were selected from each plot. Five grams of seeds from the selected plants were bulked for future use. For recurrent selection method, seeds were collected from best yielding 50 plants from open pollinated and selfed seeds. The first year revealed that first cut recorded the lowest coefficient of variability (54.3 percent) subsequent cuts values ranging between 71.0 to 72.5 percent. In the second year modified mass selection showed superiority in the field of each cut except the third in which both methods were similar.

Radwan *et al* (1983) studied the possibilities of improving forage yield in berseem through selection from farmers' seed lots. The material comprised of 58 lots selected for seasonal green forage yield from a population of 331 farmers. Two more lots were added; an Indian introduction and a FAO strain M. 38086. Each lot and its open pollinated progenies was grown in adjacent rows. Local cultivar Giza-1 of Meskawi was sown as a check. Sowing was made at 33 kg seed /ha. Three cuts were taken at each site. At Giza differences among sub groups and within groups were significant indicating significant differences among selected lots. Orthogonal comparisons showed that differences between performance of original seed lots and seed produced by open pollination were highly significant. The orthogonal comparisons indicated that the performance of the progeny of 331 farmers' seed lots was highly different from original seed lots in one location and in the combined analysis. Consequently, the location of lots interaction was also significant. There was only one group of the six evaluated lots that showed consistency between predicted and realized genetic gain combining ability index for lots selected at Giza ranged from 3.8 to 11.2 and at Gimmeza location ranged from 5.9 to 15.0 percent. Selection from farmers' seed lots and testing for combining ability seems a good approach to the improvement of forage yield of Egyptian clover.

Bakheit (1985) studied the effect of mass and family selection on productivity of Egyptian clover. Effectiveness of mass and family selection for fresh forage yield was determined for two generations. The gains of the first and second cycles of mass selection for the fresh forage yield were 8.43 and 10.71% of the original population, respectively. The realized heritability and expected selection advance for 1st and second cycles of mass selection were 0.38, 0.04, 31.8 and 3.94% respectively. Family selection was more rewarding than mass selection and produced a response of 15.5% of the unselected base family mean after one cycle of selection. The differences between the two methods of estimating heritability, parent – progeny regression (0.484) and variance component (0.57) was not great. Bakheit (1989) further studied the effect of recurrent selection and performance of seed synthetics in berseem. The objective was to examine the response of forage yield to methods of breeding recurrent selection and synthetic varieties. Two cycles of recurrent selection in the cultivar Giza–1 for increasing forage yield were compared to the base population. Also, two generations of a synthetic variety made by compositing six accessions selected for both high forage yield and combining ability were compared to the commercial cultivar and their parents. The realized gains were 13.9 and 21.7 percent for fresh forage yield, 14.8 and 23.8 percent for dry forage yield and 14.0 and 22.9 percent for protein yield in the first and second cycle of recurrent selection respectively, over the base population. The first generation of the synthetic (F1) showed an increase over parents of 3.7 percent in forage yield, 4.4 percent in dry yield and 6.3 percent in protein yield compared to the check Giza-1. Means in synthetic F2 were not different.

Younis *et al* (1986) studied the efficiency of visual selection under competitive conditions in five berseem populations. Results on green and dry yield, leaf/stem ratio, plant height, crude protein percentage, crude fibre percentage, oil and fat percentage concluded that visual selection was more effective in increasing green and dry yield in single cut than multicut berseem. Improved population of (single cut) increased dry yield by 31.7

percent over initial populations: the improved multicut population increased dry yield from 17.7 percent to 23.9 percent over initial populations. Similarly, in improved populations, crude protein percentage increased and fibre percentage decreased.

El-Tawab *et al* (1997) undertook in vitro selections in berseem for drought tolerance on six accessions. Seed were surface sterilized by immersion in ethanol 95% for one minute and rinsed in double distilled water, then germinated in culture jars containing 250 ml MS basal medium. 21 days old shoot tips were cut into small segments and planted in culture tubes containing 20 ml of MS media supplemented with napthaleneacetic acid, Kinetine, 2.40 and dichlorophenoxy acetic acid and Difco agar. callus growth declined sharply because of elevation of water stress. Final fresh and dry callus weight among accessions responded differently to water stress levels. Drought tolerant accessions (11, 26, 66) were sensitive to higher levels of water stress, exhibiting growth inhibition but their growth was better than the sensitive accessions (1, 6) and 27). Detailed studies revealed that accessions 11 and 26 showed drought tolerance in-vitro and field evaluation while accessions 6 and 27 were intolerant to drought in-vitro as well as under field evaluation. This suggests the possible use of cell culture as a useful tool for identifying drought tolerant accessions.

Fahmy *et al* (1997) undertook marker assisted selection for drought tolerance in berseem. Molecular markers such as SPS – protein, esterase, peroxidase and acid phosphatase isozymes and randomly amplified polymorphic DNA (RAPD) were used to determine the genetic variations among six accessions under two levels of drought stress i.e, control and severe drought (irrigation after every 30 days). SDS – PAGE of water soluble protein showed 30 bands which were not necessarily present in all accession. Some bands were more informative as indicators for drought tolerance. The esterase isozymes revealed a total of eight bands which were not necessarily present in all accessions. The esterase system was effective in distinguishing between tolerant and sensitive accession. A total of five acid phosphatase bands identified the profiles of six berseem accessions for three cuts under the two treatments with a wide variation in their densities and intensities. This system provides good markers for the discrimination among drought tolerant and sensitive accessions. The peroxidase isozyme patterns showed a maximum of four bands among the profiles of the studied accessions. The peroxidase isozyme patterns showed a maximum of four bands among the profiles of the studied accessions. The peroxidase system was far less effective than either esterase or acid phosphatase in discrimination between drought tolerant and sensitive accessions.

Ahmed (2000) made a comparison of single trait with multiple trait selection in berseem. Comparison of single trait of selection (total green forage yield) via combining ability test with multiple trait selection (total green forage yield, dry weight of root nodules and seed yield) by using independent culling levels of index selection for the improvement of berseem were obtained from 100 polycrosses isolated from a base population represented the second generation of random mating for a seed synthetic composed from 23 farmers seed lots of Meskawi. Selection for multiple traits was significantly more rewarding than single trait selection. The gains of 12.20, 17.40, 17.20, 28.50, 14.10, 17.90 and 8.55 percent from index selection were vs. 6.58, 5.96, 3.79, 10.27, 7.87, 5.05 and 4.47 percent from single trait recurrent selection for total green forage, dry forage, protein and seed yields, seed index, dry weight of nodules and leaf/stem ratio relative to the base population. The efforts required for index selection are somewhat higher, besides, the breeder has to wait till all the observations are recorded to construct an index. These are not essential with independent culling.

Radwan *et al* (2006) made selections for self fertility. Open pollinated (OP) and S1 progenies of the relatively more self fertile So plants from two varieties responded to selection for self–fertility SF (percentage seed set under selfing) determined by manual tripping (MT-fertility) but not for SF from spontaneous tripping (ST fertility). Selection for MT-fertility decreased ST-fertility while selection for ST fertility increased MT-fertility as much as direct selection. Synthetic populations combining S1 or S2 lines selected for SF showed no increase in SF but S2 synthetics showed higher fertility under open pollination (OP fertility) over OP progenies and S1 synthetic. Under the same conditions, inbred populations representing S1 to S5 generations of selfing and selection for SF from one variety exhibited a significant linear increase in MT-fertility and OP-fertility with generation of selfing. OP-sib-populations, formed by compositing OP seed of plants selected for SF from each selfing generation exhibited linear increase in OP fertility. Results suggest that 1) genotypes of more self-fertile plants in a population have a low genetic load and their progenies contain a higher frequency of SF genes than progenies of random So plants, 2) fertility and mode of tripping seem to be under independent genetic control and 3) genetic variation in MT-fertility (agent-tripping) was present in the varieties studied.

Ahmed (2006) investigated the response of three methods of recurrent selection to three selection methods. One cycle of selection was conducted for each method: half – sib with S1 as recombiners (H.S), S1 families (S1) and S2 families selection. Selection for all parameters was based on protein yield (t/ha). A 20 percent selection intensity was common in the three methods. Response to selection was measured for protein yield and correlated responses on fresh forage, dry forage, seed yield and leaf/stem ratio. All methods were successful in improving the population performance for protein yield significantly; family selection had the highest magnitude of response of 0.145 t/ha, per cycle (37.32%) but was not significantly different from the realized response for S1 family selection of 0.805 t/ha per cycle (34.74%). H.S family selection gave the lowest gain of 0.392 t/ha per cycle (16.94%). Taking into account both cost/unit gain and length of time required S1 families selection had the highest rate of gain per season and highest returns on investment.

Radwan *et al* (1971) undertook progeny testing in berseem, aiming to create synthetic varieties with better forage and seed yields. Plants used in these synthetics must represent genotypes high in combining ability. To find such genotypes, tests involving open pollinated progenies of phenotypically desirable So plants were regularly conducted. Data obtained provides information pertaining to the heritability of forage yield variation in combining ability among the plant and parent progeny relationships. Implications of these findings on berseem breeding are discussed in detail.

Mahdy and Bakheit (1985) studied inheritance of forage yield. Quantitative genetic action controlling forage yield was analysed. A proposed model of Eberhart and Gardner (1966) was used on the parents, Fahl and Meskawi and their S1, S2, F1, Bc and F2 populations. An inbreeding depression on selfing of parents was noticed. The inbreeding depression of Fahl was more pronounced than that of Meskawi. Moreover, the superiority of the F1 hybrid over the mid-parent and high parent was 30.77 and 23.71% respectively. Genetic analysis revealed that additive dominance and epistatic gene action were significant, while heterosis parameters were not significant. Accordingly, the superiority of the F1 hybrid over the mid- parent and high parent could be due to the combined effects of dominance and epistatic gene action.

Bakheit and Mahdy (1988) investigated improvement of berseem through pedigree selection among and with farmer's seed lots. Thirty-three collections of Meskawi were scanned for variability among collections over two seasons. The efficiency of pedigree selection for fresh forage yield in six superior accessions was also studied. There were significant variations in fresh forage yield among accessions. Six were stable and insignificantly outyielded the check variety Giza-1 over two years. Phenotypic and genotypic co-efficient of variation over two seasons were 12.00 and 13.1% respectively. 15 selected families significantly outyielded their respective base population. Seventeen selected families significantly outyield the check variety Giza–1. The estimated gains from selection over all families as a percent increase from the base population mean and check amounted to 14.14 and 13.77% respectively. The broad sense heritability estimates of fresh forage yield differed among accessions and ranged from 44.81 to 87.38 percent.

Abou–Fateih *et al* (2010) studied the performance of F1, F2, and BC generations of inter-varietal hybrids between multicut and monocut Egyptian clover. Performance was recorded in relation to agronomic traits and hybrid vigour. Crosses between multi and monocut genotypes showed better agronomic characters compared to their parents. Multi-cut Sakha I was reciprocally crossed with single cut Fahl (P-2) to study the performance of F1, F2, and Bc compared with the same parents in advanced generations from two directions. The F1, F2 and Bc and reciprocals along with two parents were evaluated in RCBD with four replications. Three cuts were taken during the season for multi-cut variety and only one cut for mono-cut variety. Analysis of variance showed high, significant differences for plant height, number of tillers and total fresh and dry yield of both varieties. Maternal effects demonstrated the same performance of traits related to the female characters in both directions of F2 cross and Bc of Meskawi and Fahl female. Heterosis over better parent (Hp) showed high performance for total cuts of fresh and dry fodder but Hp heterosis of F2, Fahl female recorded opposite performance for all traits. Performance of individual morphological characters, heritability and genetic advance have been discussed in detail.

Abdalla *et al* (2008) studied inbreeding and fertility in Egyptian clover and explained the enigma of compatibility and selection for fertility. The investigations were conducted on two varieties 579 and Ahaly and their derivative populations. Selection was done on manually tripped (MT) plant flowers with 25% SF (seeds per 100 flowers). Data were collected on (MT) and spontaneous seed set (ST) of bagged flowers and open pollinated (OP) seeds on same plant. Selection for (MT) was effective in SF in all populations in all generations over original parents and 4 check varieties. Advanced inbreeding generations were more fertile than early ones. Selection for (MT) was accompanied by improving fertility of (OP) population. Seed set was highest under (OP) followed by MT but seed set (ST) was very poor. Some individual plants set seeds up to 88% in (MT) materials. Self-sterile plants were found only in (OP) and the four check varieties. The materials used may be considered self - Compatible but cross-fertilized and requiring tripping to result in self seed set. Berseem was assumed to be a self-incompatible species that has been forced to inbreed. The enigma of fertility and sterility in berseem has been discussed and several explanations and hypotheses presented in an effort to understand controversial results in the literature. Different genes for self-compatibility, self-incompatibility, unilateral incompatibility, female rejection and floral structures may be operating and affecting seed set.

Abdalla and Zeinab (2012) reported that selection for manual tripping (MT) was effective in improving self-fertility (SF) in all populations and generations over original parents. Selection for MT was accompanied by open pollinated (OP) populations. Self seed set (ST) was very poor. Some individual selections set seeds up to 88% in MT materials. The enigma of fertility, sterility and absence of inbreeding depressions in berseem has been discussed. This was explained as inbreeding tolerance, due to selection for good vigour accompanying inbreeding. Selection for high MT seed set could be accompanied by selections for good forage yield. An approach has been suggested to develop new composite varieties characterized by high seed fertility and high forage yield. Improved selection for seed production was mainly due to more tillers/plant and to less degree, plant height. An approach has been outlined to produce new composites with high seed setting and good forage yields. Berseem is self–compatible but needs tripping to stimulate self seeding. This is mainly due to the relative position of male and female organs and the presence of bubbles on stigma. Molecular characterization revealed polymorphic differences between 1^{o} and selected inbred.

Chapter V. SEED PRODUCTION

An adequate supply of quality seeds has to be assured to make any agricultural system a success. Seed production in agricultural crops and other plants is an inherent character, but maximum production is not always assured and may require interventions for optimum pollination, fertilization and seed production. At the same time, physiological, cytological, environmental and other factors may hamper normal seed production. Farmers, usually, produce small quantities of crop seeds for their own use but for large scale production well organized seed production systems have to be established. The seed production of most crops demands longer than farmers cannot wait since they lose time for sowing a second crop.

Berseem is an unusual crop since its vegetative growth is the part used. Its foliage and tender stems of the plants are fed to animals. During its vegetative phase the crop is harvested several times and used as forage. In order to get the maximum cuts farmers try to prolong its growth and some use last phase for seed production. To obtain a good seed crop, berseem fields have to be uncut after February-March to let it produce seed which is available by mid June. By this time it is too late to sow the next crop so few farmers produce their own seed. Berseem grows during the entire winter from October to May; it is rarely grown with the intention of seed production. Sometimes farmer leave crop for seed. Increasing exports of berseem seed has changed this and the seed is now produced by many farmers but production, storage and marketing are still not very well organized.

Kandil and Shalaby (1983) studied the effect of some cultural practices on berseem seed yields of cultivars Wafeer and Meskawi. Sowing dates during first year were 20th September, 10th October, 30th October and 20th November and for second year 20th September, 10th October and 20th November. Three seed rates of 28, 57 and 85 kg/ha were adopted. Four N and P fertilizer combinations were tested and these were N0 + 71 kg P_2O_5/ha, N0+142 kg/ha P_2O_5, 47 kg N/ha +71 kg P_2O_5/ha and 111 kg N/ha + 338 kg P_2O_5/ha. Average percentages of germination tended to decline in later planting dates. The average number of seed per seed head increased marginally under increased seed rates. Similarly increasing N+P application increased the number of seeds per head. 20th September sown crop yielded a seed production of 361.61 kg/ha and 352.11 kg/ha in case of Wafeer and Meskawi respectively during the first year. In case of 20th November sown crop seed production of 145.09 kg/ha and 145.69 kg/ha was recorded in case of cvs. Wafeer and Meskawi respectively, during first year. The trend was similar in the second year when Wafeer produced highest seed yield of 295.38 kg/ha in 20th September sowing date. Maximum seed yield of 357.02 kg/ha was achieved in 10th October sown crop under N 0 and 71 kg P_2O_5.

Radwan *et al* (1983) investigated the seed production of berseem cv. Fahl intercropped with barely. Two seed rates of barley, 71.42 and 119.04 kg /ha and four seed rates of Fahl 0, 22, 45 and 67 kg ha were combined and used for the study, Two levels of phosphorus, 15 and 30 kg P_2O_5/ha were applied. Barley grain yield/ha was not significantly affected by berseem intercropping. The seed rates had no significant effect on production traits. Phosphorus application reduced barely grain production. Berseem seed yield components i.e, number of seeds/ head, seed index and seed yield /ha increased with increasing phosphorus levels. Intercropping of berseem with barely has no negative effects on grain yield of barley.

Abdallah Hussein *et al* (1983) studied the effect on berseem of phosphorus fertilization and seed rate on forage and seed yield. Four phosphorus levels applied were 0, 35, 71 and 107 kg P_2O_5 /ha and three seed rates adopted were 28, 56 and 8 kg/ha. Fresh and dry forage yields increased significantly with increasing phosphorus application up to 107 kg/ha. However the difference between application of 71 and 107 kg P_2O_5/ha was not significant. The seed rate of 56 kg/ha gave the best fresh and dry forage yields. Total digestible nutrients also increased with increasing P_2O_5 application up to 107 kg /ha. Seed yield and its components like number of seed heads, seed weight and number of seed per head increased by increasing P_2O_5 application up to 71 kg/ha.

Kandil and Shalaby (1985) investigated the effect of planting dates, sowing methods and plant density on Egyptian clover seed yield. Three planting dates, mid August, mid September and mid October were adopted. Sowing was done in two methods, broadcast and in rows 40 cm apart. Sowing was done for solo berseem and barley and a 50:50 mixture of both. Forage yield under different methods was not stable being higher in drilling during first year while during second year it was higher in broadcast sowing; no particular trend was exhibited. Average number of stems/ plant was significantly affected by mixtures but again there was no definite trend visible. The average number of seed heads/plant was significantly affected by sowing date and these were significantly lower in broadcasting. The average number of seeds/head tended to be higher in early sown crops. The number of seed/head was higher in drilled crop during the second part of this study. Kandil and Shalaby (1985) evaluated the effects of planting dates, seeding methods and plant density on seed and straw yields. The treatments were the same as for 1st study. Average seed yield was significantly higher in case of early plantings. The highest seed yield amounting to 268.61 and 256.11 kg/ha during 1st and 2nd year was obtained from mid August planting. Mid September and October sowings provided 12.3 and 28.5 % lower seed yields. Seed yield was significantly higher in broadcast during 1st year while it was highest in drilling during 2nd year, in both years Egyptian clover produced most seed when grown alone.

Bakheit (1989) made an interesting study on pollination and seed setting in different genotypes. Three experiments were laid. In experiment 1, two varieties, Meskawi and Fahl, were sown in alternate rows under natural open pollination conditions (un-caged) and the difference in flowering dates between varieties was taken into consideration. At harvest only the seeds from individual Fahl plants were collected. During second year the progeny of Fahl plants was sown. At harvest time the developing plants were scored for multi cut or single cut trait. This indicated whether seed had been derived from selfing (single cut) or cross fertilization (multi-cut). In experiment II, 29 seed lots of multi-cut Meskawi type seeds collected from different governorates and two varieties Meskawi and Fahl from the Forage Crops Institute, Giza were used. Each entry was grown in single row plots and replicated thrice in a randomized complete block design. Five plants were earmarked from each plot at random and each plot was divided into three sectors and each sector was subjected to one of these treatments, 1) natural open pollination (un-caged), 2) caged with fine muslin before blooming followed by hand tripping at flowering, 3) self pollination by bagging with fine muslin before blooming. At harvest, 10 inflorescences per plant for each sector were used for estimating the number of seeds/inflorescence, percentage seed set and fertility index. In experiment III, one plant each of Meskawi and Fahl was set out in two sites isolated from other berseem. The percentage seed set in presence of only bees was determined for these two plants. Their progeny was tested in next season for single or multi-cut trait. The percentage of cross pollination in Egyptian clover under open pollination conditions was 82.1%. In a population of 520 plants only 93 exhibited single cut trait of Fahl cultivar which meant that only 17.9% of plants were self pollinated. Experiment II showed that years, mode of pollination, genotypes and first and second order interactions were all highly significant for number of seeds/inflorescence and percentage of seed set. Number of seeds/inflorescence and percentage of seed set in all genotypes were significantly higher under natural open pollinated conditions (34.2% and 51.9%). Experiment III indicated that seed set in all genotypes under natural open pollinated conditions was more than twice the seed set under caged and hand tripping conditions.

Geweifel and Rammah (1990) undertook a study on seed production of six Egyptian clover cultivars as influenced by cutting system and potassium fertilization. The experiment included 36 treatments which were a combination of 2 cutting systems. Six cultivars of Berseem (Sakha 3, Giza 6, Giza 15, Sakha 4, Giza 10 and local) were tested. Potassium fertilization was applied under three regimes (control, 119 kg and 238 kg K_2O/ha.). Cultivars Sakha 4 and Giza 15 produced much higher seed/ha and was better in seed production attributes compared to other cultivars. In the first season both cultivars produced 43.6 % and 29.37 % more seed respectively compared to the local variety. 119 kg. of K_2O/ha application increased seed yield by 35.37% and 24.57% over control during 1st and second year respectively. Cultivar Sakha 4 harvested after 3 cuts produced the highest amount of seed, 713.61 kg/ha.

Gaballah (2001) combined number of cuts and phosphorus fertilization and observed their effect on some cultivars of Egyptian clover. Four cultivars, Sakha 4, Synthetic Sids 6, Giza 15 and a local cultivar were tested. Seed production was allowed after 3rd and 4thcut. Three phosphorus levels of 36.90, 75.71 and 110.7 kg./ha P_2O_5 were provided. There were significant differences in all cultivars exhibiting these in all morphological and production traits. As far as seed yield is concerned, Synthetic Sids 6, cultivar was superior over Sakha 4, Giza 15 and local cultivar by 18.26, 14.90 and 19.39% during first year and by 17.04, 14.18 and 16.45% during next year. Seed yields were higher after imposition of three cuts. The highest application of 110.7 P_2O_5kg/ha produced the highest amount of seed. Synthetic Sids 6, Sakha 4, Giza 15 and local cv. produced 606.90, 553.57, 567.61 and 559.76 kg seed /ha after 3rd cut. Gaballah and Kotb, M, (2006) further continued their study and observed the effects of sowing dates, phosphorus application and bio-fertilization on seed yield of Egyptian clover under sprinkler irrigation. Treatments imposed included three sowing dates (Oct 5, 20 and Nov. 4), three phosphorus fertilization levels, (36.90, 73.80 and 110.71 kg/ha P_2O_5) and bio-fertilization (untreated and treated with phosphorus). Seed rate of 71 kg/ha was used under broadcast regime. In each treatment, berseem was cut twice in each season after 60 and 105 days after sowing. Early sowing (Oct. 5) increased significantly the number of stems /plant, number of heads /10 plants, seed weight/10 plants, 1 000 seed weight and straw and seed yield. The superiority of early sowing in seed yield was 8.19% and 14.74% over late (20 Oct & 4 Nov.) sowing during first year and 8.19% and 14.74% during second year. Higher P_2O_5application (75.71 and 110.7 kg / ha) provided higher seed yields by 19.79 and 26.12% during first year and 20.20% and 26.28% during the second year. The combination of 110.7 kg/ha P_2O_5 and phosphorus increased seed yield by 31.92 and 32.77% during two succeeding years respectively.

Azab *et al* (2010) studied the effect of different rates of phosphorus and potassium fertilizers on seed production of two Egyptian clover (Fahl) cultivars. Treatments included four phosphorus rates (0, 238, 357 and 476 kg/ha P_2O_5 and four rates of potassium 0, 119, 178 and 238 kg ha K_2O. One local and one collected cultivar were used as test crops and seeds were sown at 47 kg ha on 15th and 17th November. Both cultivars exhibited significant differences during first year but during second year the differences were significant only in number of branches and flowering heads. Phosphorus fertilization up to 357 kg/ha P_2O_5 increased seed yield by 23.55 and 14.62 percent in first and second year respectively.

Bakheit *et al* (2012) investigated the influence of temperature, genotype and genotype x temperature interaction on seed yield of berseem. Treatments involved three sowing dates (1st Oct, 1st Nov and 1st Dec) and five varieties. There were significant differences between planting dates and among varieties for all traits. The highest number of florets (55.9) and seeds/head (49.9) seed set (778%) 1 000 seed weight (338 g) and seed yield (1.23 t /ha) were obtained from sowing on the 1st October. The Giza 15 cultivar outyielded (1.10 t /ha) other varieties over both seasons. The estimates of phenotypic stability parameters for seed yield showed that the highest seed yielding varieties Giza 15 and Giza 6 exhibited less instability in seed yield while the Assiut population used for testing was more stable.

Chapter VI. CHEMICAL COMPOSITION

The chemical composition of a crop determines its suitability for consumption by humans and animals. It includes various components but the nutritional and digestible components are of prime importance. It is dynamic and depends upon cultivar, climatic conditions, soil nutrients, age of crop, crop management and various other factors. Chemical analyses is also helpful in the classification of various cultivars and the establishment of phyllogenetic relationships amongst plant groups.

Kandil and Shalaby (1985) studied the variation in chemical composition of Egyptian clover due to cultural practices. Early sown clover provided higher percentages of protein compared to later sown crops. The first cut provided only 19.47% crude protein. This trend was correlated to the accumulation of higher dry matter in earlier sown and cut crop. The differences in the nutritive value of first, second and subsequent cuts showed a progressive fall with increasing plant maturity. Sowing method too had a significant impact on crude protein. Two sowing methods were used: drill and broadcast. Crude protein increased progressively from 21.51% in first cut to 25.70% in the 7th cut when the crop was drilled. In the broadcast crop crude protein increased from 20.39% (first cut) to 23.26% (7th cut).

Nabila and Mahmoud (1995) studied the effect of water salinity on chemical composition of five varieties of Egyptian clover: Giza 15, Sakha 4, Helaly, Serw 1 and Gemmaize. 500, 1 000, 1 500 and 2 000 ppm of NaCl were used in irrigation and four cuts were taken on all varieties. Crude protein, crude fibre, ash and ether extracts were determined in all the four cuts using the Infra Red Reflectance Spectroscopy (NIRS). Crude protein percentage was significantly affected by salinity levels, varieties and their interactions. Similarly crude fibre, ash and oil (ether extracts) were also significantly affected. The third cut contained the highest crude protein while the 4th cut contained minimum protein. Sakha 4 yielded maximum protein while Helaly yielded the least. Higher salinity levels yielded higher crude protein percentages and cut four provided maximum crude fibre. Giza 15 provided crude protein (CP) percentage of 22.76% in first cut under maximum salinity, in second cut maximum CP was provided under 1500 ppm salinity in 3rd cut 23.59% CP was provided under maximum salinity while in 4th cut the maximum CP was provided under 1500 ppm salinity. The crude protein availability pattern was almost similar in other cultivars. However, maximum crude protein i.e, 23.95% was provided by Sakha under maximum salinity of 2 000 ppm. The crude fibre (CF) yield exhibited maximum percentages in 4th cut. Cultivar Giza 15 contained minimum CF as compared to other cuts. The crude fibre content in cultivars Giza 15, Sakha 4, Helaly, Serw 1 and Gammaiza 1 was 26.11, 28.40, 27.31, 28.58 and 22.50 respectively in 4th cut. Total ash declined at higher salinity levels and it ranged from 7.32 to 11.04 percent in cultivars under maximum salinity of 2 000 ppm.

Tag El-Din *et al* (2001) undertook studies on protein analyses on 5 cultivars of Egyptian clover which would identify these cultivars and classify them. A greenhouse experiment studied the possible use of protein analysis and SDS PAGE of proteins from the seeds to classify the cultivars Giza 15, Sakha 4, Helaly, Serw 1 and Gemmaiza 1. In the first cut after 50 days protein profiles showed certain affinities and Gemmaiza 1 and Serw were placed in one cluster while Helaly, Giza 15 and Sakha 4 were placed in another. During the studies in second cut after 80 days, Gemmaiza 1 and Sakha were placed in one cluster while Giza 15, Helaly and Serw 1 were placed in another. Under 3rd cut which was after 110 days the affinities had changed and Serw 1 was separated as a single cluster and Giza 15, Helaly and Gemmaiza 1 were grouped together. The fourth cut after 140 days exhibited an identical affinity pattern with cut 3. Crude protein percentage ranged from 16-23% in different cuts. Correlations of similarity co-efficient matrix of crude protein percentage of different cuts were used to group cultivars.

Etman *et al* (1995) profiled the nutritional status of silage made from Egyptian clover with or without additives. Three types of silage was made, 1) without additives, 2) with 0.4% Formic acid and, 3) with 3% molasses. Besides chemical and nutritional evaluation, digestibility trials were also undertaken. The pH values were 4.85, 3.90, and 4.62 in case of silage made without additives, made with formic acid and made with molasses respectively. The dry matter (DM) losses were greater in silage with additives. DM loss was 18.64% in silage without additives while it was 19.26 and 21.84% with formic acid and molasses. Chemical composition, digestibility and nutritive value of silage with or without additives are presented in Table 1

Table 1. Chemical composition, digestibility and nutritive value of silage made from Egyptian Clover

Aspect	Different Silages		
	Without additive	With Formic Acid	With Molasses
Dry matter %	18.47	21.40	16.79
DM Composition (%)			
EE	14.0	14.66	14.94
CF	2.38	1.66	2.53
NFE	17.59	19.19	26.14
OM	49.16	50.74	45.33
Digestibility Coefficients (%)	83.21	86.25	88.94
DM			
CP	60.42	62.85	58.28
EE	67.70	63.66	56.63
CF	40.62	65.95	34.71
NFE	46.50	48.78	40.22
OM	68.84	63.95	44.82
	62.38	64.86	60.04
Nutritive Value (%)			
TDN	53.73	53.59	41.27
SV	42.46	41.53	25.30
DCP	9.53	9.33	8.46

Ali Mohamed and Mahmoud (1995) studied the effect of varieties and cuts on dry yield and chemical composition of Egyptian clover. They evaluated 18 varieties and selections for their dry fodder yield (t/ha) in two seasons and chemical composition in the second season only. Highly significant differences were observed in dry yield among cultivars and populations. Varieties x cuts interaction were significant. During first year dry yields (mean of four cuts) ranged between 4.09-4.73 t/ha while during second year the mean yield of four cuts ranged between 5.71-7.45 t/ha. Highly significant differences were observed in CP%, CF%, ASH% and EE% among cultivars and populations. The crude protein percentages (mean of three cuts) ranged between 17.09-19.94, crude fibre ranged between 24.01 -26.71%, ash percentage ranged between 13.21-14.66 and EE percentage ranged between 2.13-2.56. Correlation coefficients between dry yield (t/ha) and CP%, CF%, ASH% and EE% were not significant.

Chapter VII. BERSEEM CULTIVATION

Forages are as important as any other agricultural crop and require as much inputs, care, and management. Livestock products are as important in our food chain as cereals. Still, forage crops have never received priority attention from farmers, planners and extension workers. The incredible increase in human population, the un-natural and unscientific land use, un-planned urbanization and ecological degradation have diminished grazing resources to such an extent that they are no more a livestock rearing base and the alternative is forage cultivation as an important and integral component of agricultural systems. It is not possible to increase the area under fodder so it is imperative that forage crops become an important component of cropping systems. Integration will add to the availability of fodder but help the alternative crops if leguminous forages are grown.

Egyptian clover has proved its suitability as a forage in crop production systems, the world over. It is easy to grow, provides bulk forage of very high quality and improves the soil by fixing large quantities of nitrogen.

Berseem was domesticated in Egypt where it has been a major winter crop for thousands of years. The exact origin of berseem is lost in antiquity. A school of thought postulates that this crop originated in Syria and was introduced to Egypt in about 6th century. In 1896 it was introduced to the USA and was successfully grown in California in 1918. It was planted in Texas in 1916 and Florida around 1950.

Berseem plants are erect, rather hairy annual with a deep root system and trifoliate, elongated and oblong leaflets. This cool season fodder crop is now widely spread in the Mediterranean and has truly become global. In some European countries it is grown as a summer crop and similarly in some areas of Afghanistan it has been recently introduced as a summer crop. During the early twentieth century it was introduced to Sindh (then India) where it adapted to conditions and farming systems so well that it spread rapidly throughout the irrigated tracts of northern India and has, now, spread over almost half of India and has become the preferred winter fodder in Pakistan. Now it is a major cultivated fodder crop on millions of hectares around the world.

The important cultivation practices of the crop are described below

Climatic Requirements

Egyptian clover requires mild summer, as well as, mild winter to grow well. It should not be grown in areas with less than 6-7 °C in winter. The autumn sown crops withstand subsequent frost well. Irrigated Egyptian clover does best below 650 m of elevation with an annual rainfall of 300 mm or less, Temperature range of 18-25 ˚C has been found to be most suitable for optimum growth. However, in India and Pakistan temperatures up to 35°C may not damage the crop immensely but production of biomass is adversely affected. It can tolerate shade and is grown under orchards in Egypt. It is believed that high soil phosphorus levels enable it to withstand shade.

Soils

Berseem grows extremely well in fertile and well drained soils. It can grow on a variety of soils except very light sands. It can grow well on loam or clay soils provided they are not waterlogged. Medium to heavy loams are preferred. For best growth soils should contain adequate quantities of phosphorus, calcium and potash. Generally, berseem does not grow well on acidic soils but can perform well on alkaline soils which have good moisture retention capacity. It, generally, grows well in soils having pH between 7-8. Egyptian studies found populations growing well in light-medium acidic conditions. This crop performs poorly on compact, heavy soils.

Land preparation

The land must be prepared properly and put into a suitable state for sowing and establishment of the crop. Stones, stumps, old vegetation and termite mounds should be removed. Land should be properly levelled to facilitate operations like sowing and harvesting. Proper levelling is essential for uniform distribution of irrigation water. During land preparation, laying out of irrigation channels etc should be done. The land should be ploughed 3-4 times with proper inversion of the soil and thereafter planking should be carried out to break clods and level the land.

Sowing time

Generally berseem crop should be sown from late September to the end of October; however, this may vary with location and climate. At higher altitudes it is grown in summer and sown in March-April. Under sub-tropical and tropical condition, autumn sowing is best. Neither early nor late sowing is suitable for the crop. Early sowing can lead to problems like high rainfall, high temperature and weed infestation while late sowing, may face problems of low temperature. Under most climatic conditions, farmers have their own crop calendars based on experience.

Seed rate

The seed rate depends upon factors like the type of land, soil texture, soil fertility, seed size etc. However, 20-25 kg/ha is the most suitable rate for Berseem. The seed should be absolutely weed free. The seeds may be immersed in 5% salt solution before sowing. Light seeds float on the surface. These should be removed and only heavy seeds which have settled should be sown.

Seed treatment

Farmers growing this crop in fields which have never been under berseem should treat seeds with rhizobium, *Rhizobium trifolli.* This can be done by soaking seed in water overnight. After soaking, spread the seed on floor to drain off the water. Take out the rhizobium from its container and mix with 10% of jaggery. Mix it well with the seeds. Let it semi dry for about an hour and the seed is ready for sowing. If rhizobium is not available, soil from a field previously berseem should be added to the new field. For uniform spread seed may be mixed with sand and soil.

Sowing

Egyptian clover performs best if sown in a well-prepared and levelled seedbed that has a good depth of subsoil. Seeds should be sown at a depth of 1.5 to 2.5 cm with a light soil covering. There are several methods of sowing and the method has to be chosen according to terrain, topography and resource availability. These methods are described below:

Broadcasting in a soft puddled field

This is best suited for a small farming system in loamy or sandy soils and most farmers in berseem growing areas have adopted it. Fields are ploughed and harrowed to achieve the required tilth. Farmyard manure is uniformly spread and mixed into the soil. The land should be levelled and border bunds established. The plot is heavily irrigated and the seed is broadcast directly on the puddled muddy surface. This method eradicates many weeds which are uprooted or buried during puddling. The crop canopy is uniform.

Dry sowing in borders

Dry broadcasting can be used in small farming systems where soils are clay or clay-loam. The fields are ploughed and harrowed to achieve the required tilth and farmyard manure is uniformly spread and mixed with soil. Seed is then broadcast directly into the field and covered with a thin layer of soil. The field needs a heavily but soft irrigation.

Dry drilling in rows

This is most suitable for large fields where manual operations are not possible. Fields are ploughed and levelled, farm yard manure is mixed and seeds are drilled in lines 10-15 cm apart.

Sowing in standing rice

Berseem can be directly broadcast over rice without ploughing. However, a good irrigation should be provided for uniform spread and embedding of seed into the soil. The seed can also be sown after rice harvest. The field is irrigated and seed spread over the stubble.

Mixtures:

Farmers in most berseem growing countries have shifted to mixed sowing. The favourite crop companions are mustard, annual ryegrass and oats. Triticale and barley are also used. These crops provide a number of benefits like physical support to berseem which makes the crop grow erect; they provide early bulk and improve cool-season yield. During initial cuts these crops provide higher quantities of forage and suppress weed. They also reduce the chances of bloat in animals. 1.5-2 kg/ha of mustard seeds can be mixed with berseem for sowing the crop mixture. Similarly 2-3 kg/ha seeds of annual ryegrass may be mixed. In case of oats and barley 15-20 kg seed/ha may be mixed.

Fertilizer

At field preparation well decomposed farm yard manure should be applied at 20 t /ha. This is essential on fields being used first time for berseem. Thereafter, a basal dose of 20 kg Nitrogen+ 60 kg Phosphorus+ 40 kg Potash/ha should be applied to achieve a very good crop. Some farmers, according to their experience, add these fertilizers in split doses as and when they feel the need to do so.

Irrigation

Irrigation depends on climatic and soil conditions and recommended schedules may change at times. However, it is recommended that the first irrigation reaching 4-6 cm of the soil depth should be provided 4-6 days after sowing. The general pattern of irrigation may be after 10 days interval in October, 12-15 days interval during November-January, 10-12 days during February-March and 8-10 days during April- May. Thus 12-15 irrigations are required during the life of a crop.

Harvesting; schedules largely depend on the cropping pattern and livestock needs. It is recommended that first harvest be taken 50-55 days from sowing and subsequent cuts taken at intervals of 25-30 days.

Chapter VIII. NEW VISTAS IN BERSEEM

RESEARCH

The Role of Egyptian clover (Trifolium alexandrinum L.) in agriculture development in desert lands, North Sinai-Governorate, Egypt.

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North Sinai-Governorate is in north-eastern Egypt between 30.5 N° 33.6 E°. The population is 395 000 and density is about 14/km^2. The ever-increasing human population, concomitant with loss of crop land (due to urbanization) and diminishing water availability pose serious challenges to agriculture (Mittler and Blumwald, 2010). Water stress due to drought and/or salinity is probably the most significant abiotic factor limiting plant growth and development. So, drought and salinity are the most important environmental factors inhibiting photosynthesis and decreasing growth and productivity of plants. These factors are the major causes of crop loss worldwide, reducing average yields for most major crops by more than 50% (Wang *et al*, 2001; Ashraf, 2004; Qadir *et al.* 2008; Naz *et al*, 2010).

Increasing water productivity is an important strategy to increase food production (Rosegrant *et al*. 2002a) under conditions of limited supply. Increases in energy prices need better management of inputs to maximize efficiency of their water resources. It is crucial that growers get the most out of every litre of available water whether it comes from underground water, rainfall, or both. Rainfall has decreased in recent years and this has led to a fodder deficit. Graves *et al*. (1987) report that Egyptian clover tolerates moderate salinity.

Estimation of production costs in north Sinai farms is difficult due to structural farm problems and cost calculation methodology. Therefore, district to district or even from farm to farm, production costs and profitability of forage crops can vary significantly depending on changes in yields and input use levels (KARA *et al*, 2008).

The objectives of this study were: (i) to investigate the role of Egyptian clover in agriculture development in desert lands and explore the possibility of providing higher quantity and quality feed with high palatability under sandy soils and saline water in north Sinai, (ii) to estimate water use efficiency for berseem comapred with other forage, (iii) to determine the nutritive value of fodder and (iv) to calculate forage production costs and their net profit / ha for determining the competitiveness and preferences for studied crops.

Material and methods

The investigation was carried out during two successive years; (summer; 2010, winter; 2010-11, summer; 2011 and winter season; 2012) to investigate the role of Egyptian clover in agriculture in desert lands in north Sinai. 523 fields were used. The area of each field was 0.56 ha divided into five plots. Two plots were seeded to perennial forage crops; alfalfa and Rhodes grass and three plots were sown to summer crops; cowpea, Sudan Grass and pearl millet follwed by Egyptian clover, barley, oat and fodder beet in winter. The plot area was 1 050 sq m. The description of the area is presented in table 1.

Table 1. Range of electrical Conductivity (Ecw) and TDS, total dissolved salts (ppm) for used Underground water in north Sinai.

S.no	North Sinai - District	Ecw	Ppm*
1	Rafah	2.20 – 3.60	1408 - 2304
2	El-Sheik Zewayed	3.30 – 4.20	2112 - 2688
3	Al-Arish	3.80 – 4.50	2432 – 2880
4	Bir Al-Abed		
A	Bir Al-Abed	4.80 – 6.20	3072 - 4960
B	Rummana	6.60 – 8.40	5280 - 6720

Table 1. Range of electrical Conductivity (Ecw) and TDS, total dissolved salts (ppm) for used Underground water in north Sinai.			
5	El-Hasana	10.80–12.60	8640 - 10080
6	Nekhel	11.20–12.80	8960 – 10240
*ppm = (Ecw X 640; EC: 0.1 to 5.0 dS/m) *ppm = (Ecw X 800; EC: > 5.0 dS/m)			

Seed was broadcast over 30 to 50 cm on both sides of the irrigation lines. The number of fields was very high (523-fields), so data were collected from some fields which continued for two successive years. The number of cuts differed from district to district as presented in Table 2.

Table 2. Number of cut /season over two years for cultivated forage crops in north Sinai-districts, Egypt

Sites	Alfalfa*	Rhodes Grass*	Cowpea	Pearl Millet	Sudan Grass	Egyptian Clover	Barley	Oats
Rafah	4.0	4.0	3.2	4.1	3.3	4.2	2.0	3.2
El-Sheik Zewayed	4.3	4.2	3.0	4.0	3.0	4.0	2.0	3.0
Al-Arish	5.3	5.1	4.0	5.0	5.0	5.0	2.0	4.1
Bir Al-Abed	5.5	5.3	4.0	5.0	5.0	6.1	2.0	4.0
Rummana	6.3	6.0	4.0	5.6	5.0	6.5	2.0	4.3
El-Hasana	3.0	2.0	1.0	2.0	2.0	3.0	1.0	2.0
Nekhel	3.0	3.0	1.0	2.0	2.0	3.0	1.0	2.0

*: The number of cuts for alfalfa and Rhodes grass was calculated as average mean for two season; summer and winter for each year.

Experimental design

A three factor experiment in a randomized complete block design in split-split-plots and four replications. The factors were: two years as main plots, seven sites as sub-plots and nine forages as sub-sub plots. Fresh yield was estimated by harvest of fixed plot area (1 m x 10 m) and four replications through both weighed. Subsamples were air dried then oven dried at 105 ^{o}C for 48 hours and weighed.

Water Use Efficiency (WUED)

was based on dry weight and calculated according to Ehdaie and Waines (1993) formula as a ratio of dry yield (kg/m^3) to total water consumed (TWC) by the forages as follows: WUE kg•m^{-3}) = Y/TWC. For determining quality parameters, samples were oven dried at 70˚C for 72 hours. Analysis followed A.O.A.C. (1980) methods.

Analysis was carried out by standard analysis of variance (ANOVA) of the split-split-plot design. Means were compared by the L.S.D. values at 1% and 5% levels (Snedecor and Cochran, 1968) using MSTAT-C Computer Program V.4 (1986). Distribution of forage production costs and their net profit /ha was estimated according to El-Shorbagey (1992).

Results and discussion

Forage yield and quality

The forage yields and quality for Egyptian clover compared with eight forage crops were recorded over two seasons from north Sinai. Statistical analysis revealed that, with exception of dry matter percent (DM %) and digestible crude protein (DCP) traits, highly significant ($P \leq 0.01$) differences were detected among years (Y), districts (D) and investigated forage crops (C) for the quantitative forage yields and their quality under investigation. Likewise, highly significant ($P \leq 0.01$) differences effects of Y x C and D x C interactions were noted for studied forage yields traits (FFY and FDY) and WUED-water use efficiency based on dry matter. In addition, Y x D interaction was, also, highly significant ($P \leq 0.01$) difference effects for FDY, WUED, crude protein (CP), total digestible nutrients (TDN) and digestible crude protein (DCP) characters. On the contrary, this interaction was insignificant for FFY, DM % and CF traits. Abreast, the Y x D x C interaction had non-significant effects for all forage quality traits under investigation i.e, CP, CF, TDN and DCP, as well as, FDY and DM percentage.

Significant mean square values obtained for years (Y), districts (D) and forage crops (C) indicated that, conditions among the two years, in seven sites using nine forage crops were not similar in many ramifications and forage crops did not perform similarly in all districts. There was enough variation between forage crops as well as environments. The significant effects of Y x D interaction mean squares that were observed in five characters (FDY, WUED, CP, TDN and DCP) suggest that environmental conditions in the seven sites influenced the values of the above mentioned traits. This emphasizes the importance of evaluating forage crops in different sites over the years to ascertain their stability for use.

Regarding mean performances, the contrast reality in the salinity levels of the used irrigation water from one district to another (Table 1) accompanied with lowest rate of total rainfall impacted the performances of forage crops and this was also affected by environmental condition and their interactions. Therefore, the comparative performances of nine forage crops across seven sites for twelve characters studied provide a clear indication of the superiority of some of the forage crops over others. These twelve characters involving distribution of forage production costs and their net profit / ha and other parameters were used; there was considerable variability present in the forage crops investigated. These results would be useful in choosing forage crops to use and improve their productivity for animal feeding under north Sinai-condition. On the basis of fresh and dry forage yield, Egyptian clover was ranked the second winter forage crop after fodder beet among other forage crops in various sites or districts during two seasons. On the basis of mean values of fresh and dry yield berseem was highest in Rummana-district (147.38 and 27.38 t /ha respectively) and lowest in Nekhel-district (15.71 and 4.28 t /ha respectively). This means that the response of forage crops varied from location to another due to, mainly, the level of salinity in irrigation water (Table 1). In addition, the level of soil fertility added to this variation in production. Fodder beet recorded 265.23 and 33.57 t / ha respectively in Rummana-district and 28.57 and 5 t /ha respectively in Nekhel-district. Furthermore, and in the same trend, the Egyptian clover produced 4.60 kg of DM m^{-3} in Rummana-district, while the water use efficiency based on dry matter in Nekhel-district was 0.70 kg/m^3.

From previous results we can conclude that water use efficiency based on dry matter (WUED) are suitable criteria for screening drought and salinity tolerant forage crops under north Sinai-conditions. This seems logical based on its positive and highly significant correlation with forage yields and TDN-total digestible nutrients (Table 3) and its ability to select forage crops according to drought and salinity stresses resistance. This is very clear in case of Egyptian clover and fodder beet. Both produced highest values of forage yields and TDN. Generally, a reduction was evident for forage yields and water use efficiency with increased salinity levels in used irrigation water in north Sinai-districts as shown in Table 1. Zeng and Shannon (2000) attributed this reduction to crop sensitivity to increased salinity and this has been regarded as a chronic factor in displaying poor growth and uneconomic yields.

In term of forage quality for berseem, the crude protein (CP) ranged from 19.30% in Rafah-district to 26.60% in Nekhel-district. Equivalently, the crude fibre (CF) ranged from 23.10% in Rafah-district to 27.00% in Nekhel-district. Rafah-district recorded highest value of TDN for Egyptian clover (63.30%) and lowest value of DCP (14.50%). In contrast, Bir-Al-Abd-district recorded lowest value of TDN (62.00%) and Nekhel-district recorded highest value of DCP (21.20%). The same conclusion was outlined by Nadaf *et al*. (1998b) who reported that the calculated energy content of fodder beet (tubers and leaves) was about 61.00%, TDN and CP content of the leaves ranged between 11.40 and 15.80%, while, the tubers contained between 4.50 and 9.80%. In addition El-Bably (2002) found that three irrigation applications between cuts significantly increased fresh (Fy) and dry yields (Dy) to 104.14 and 19.48 t /ha^1 respectively. On the other hand, it decreased water use efficiency (WUE). He added that, water consumptive use values were 59.62, 48.98, and 37.98 cm, over both seasons, for three, two, and one irrigation time(s) between cuttings, respectively. Under shortage of irrigation water, single irrigation between cuttings could be useful, because, it produced 91.97 and 16.75 t /ha^1 FY and DY, respectively, consumed 37.98 cm $(170\ d)^{-1}$; and gave higher WUE of 440.9 kg of dry matter ha^{-1} cm^{-1} water consumed compared with irrigation three times, which produced 104.14 and 19.48 t /ha^1 FY and DY, respectively consumed 59.62 cm $(170\ d)^{-1}$; and gave lower WUE of 326.5 kg of DM ha^{-1} cm^{-1} water consumed over both seasons.

Table 3. Phenotypic Correlation Coefficient and Standard Error (in brackets) for Eight Forage crops' Yield and its Quality over Two Years in North Sinai-Governorate, Egypt								
	FFY	FDY	DM%	WUED	CP	CF	TDN	DCP
FFY	--	0.948** (±0.002)	-0.517** (±0.009)	0.856** (±0.002)	-0.022 (±0.015)	-0.325** (±0.014)	0.117 (±0.007)	-0.001 (±0.033)
FDY		---	-0.371** (±0.061)	0.956** (±0.008)	0.066 (±0.088)	-0.199 (±0.090)	0.235* (±0.042)	0.063 (±0.200)
DM%			----	-0.293** (±0.017)	0.099 (±0.059)	0.397** (±0.057)	0.145 (±0.029)	0.102 (±0.135)
WUED				-----	0.090 (±0.151)	-0.058 (±0.158)	0.312** (±0.070)	0.064 (±0.345)
CP					-----	0.064 (±0.046)	0.623** (±0.017)	0.510** (±0.087)
CF						----	0.238* (±0.020)	0.012 (±0.098)
TDN							---	0.291** (±0.200)
DCP								

*and **: Significant at 0.05 and 0.01, respectively.

Table 3 indicates that some characters or aspects of these crops affect other characters. Each of these characters has its own optimal mean value which is commensurate with the adaptive fitness of the genotype under stress condition. So, the interrelationships between characters are expressed in statistical term, as phenotypic correlation coefficients, which show how one variable changes as the other changes. Therefore, positive correlations show that as breeders change the mean of one character towards the higher side, the other also goes up with it, while, in the negative as the mean value of one character goes up, the value for the other character goes down. Consequently, the water use efficiency (WUED) had highest positive correlation with fresh and dry forage yields as shown in Table 3. On the contrary, WUED had negative and highly significant correlation with dry matter percent (DM %). The existing negative correlation between the dry matter (%), forage yields and WUED (Table 3) makes it difficult to perform selection in the direction of a simultaneous increase in DM%, forage yields and WUED. Commendable total digestible nutrients (TDN) were positively and strongly correlated with WUED and crude protein (CP). Likewise, phenotypic correlations were positive and significant between digestible crude protein (DCP) and CP and TDN. Whilst, negative and significant correlation was detected between CP and FFY.

Economic evaluation

Economic returns of any crop depend on factors such as price expectations, labour and input availability, soil structure and crop rotation. The feasibility study supports the fact that growing forage crops under north Sinai-conditions is advisable economically in some districts such as Rummana. This district earns maximum per ton profits. It was noticed that, among winter forage crops, the cost per ton for Egyptian clover ranged from 1101.20 L.E. (Egyptian pounds: $1 = 6.5 - 7 LE June 2013) in Nekhel district to 168.20 L.E. in Rummana district and the net profit /ha, ranged from 595.23 L.E in Nekhel-district to 28 452.00 L.E in Rummana-district. Based on previous estimates, the profit from per ton production and investor pound were 98.80 L.E. and 0.14 L.E respectively in Nekhel-district and 1031.80 L.E and 6.50 L.E. respectively in Rummana district. Furthermore these factors as stable for all crops and so it should hold true for Egyptian clover also. Considering a optimum production among winter forage crops, Egyptian clover and fodder beet are the two best options for supporting animal production under north Sinai-condition. Similarly, taking into consideration the extremely increasing fodder prices during summer season, it is clear enough that pearl millet production is the most important and profitable forage crop because it recorded the lowest per ton cost among summer forage crops and ranged from 107.20 L.E in Rummana district to 648.50 L.E in Nekhel-district. In this study, the impact of these forage crops and their importance for livestock production, as well as, their positive impact on the environment were not taken into account in calculations. It may be concluded that profitability of forage crops production is higher than presented.

Anatomical mechanisms of resistance/tolerance to dodder (Cuscuta spp.) of Egyptian clover.

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Egyptian clover or berseem (*Trifolium alexandrinum L.*) is a widely grown fodder, hay and silage. Unfortunately, uncertified and uncontrolled local seeds contaminated with dodder (Cuscuta spp.) affect productivity and quality of forage negatively. Anatomically, resistance/tolerance to dodder could be attributed to a number of factors, viz, initiation of cambial cells in China rose (Dorr, 1987); hypersensitive reaction in tomato (Al-Menoufi and Ashton, 1991), lignified cells unsheathing the vascular bundle in grasses (Joel *et al*, 1996) and thickened epidermal cells and lignified hypodermal cells (Farah and El-Hassan, 2002) in grasses. The haustorium contact with the host is formed by the expansion of the epidermis and cortex of the stem at the contact side and a group of meristematic cells remains within the haustorial cortex (Lee, 1985).Dodder adheres its host with a cementing layer of pectin and develops haustoria within a few days due to thigmotropic responses and chemical recognition of the host plant to the haustoria (Press *et al*; 1990). This investigation added that a single cell hyphen elongates within the host tissue and meets the vascular bundles. In chickpea Abd El-Wahed (1996) found that the haustoria of Cuscuta spp. expanded to the cortex, whilst, in Egyptian clover the expansion was evident in the vascular cylinder. Hegazy *et al* (2005) found that the ratios of palisade to spongy tissue were significantly higher in control than in treated plants reaching 5.36 in Diplotaxis acris control plants. Moreover, the influence of mulching on the hydraulic conductance of the petiole became more obvious when the leaf area was involved in leaf specific conductance (LSC) and significantly higher LSC in treated than in control plants were obtained in D. acris, Plantago phaeostoma and Tricodesma africanum reaching 9.56 m^2 Mpa^{-1} s^{-1} $x10^{-20}$ and 0.82 m^2 MPa^{-1} s^{-1} x 10^{-20} in treated and control plants of D. acris. Furthermore, Rasmussen *et al*, (2004) explained that the root tip cells subjected to the alkaloids gramine and hordenine caused damages to the cell walls, disorganization of organelles, increase cell vacuoles and the appearance of lipid and globules, showing food reserves. Leather and Einhellig (1985) stated that the common allele-chemicals include phenolics like cinnamic, benzoic acids, coumarines, tannins, flavonoids, terpenoids, a few alkaloids, steroids, and quinones. Also, among the natural products, Liu and Lovett (1993) have reported the phenolic acids, flavonoids, tannins, alkaloids, terpenoids and glucosinolates present in allelopathic interactions. Kim and Shin (2003) reported that until recently, many studies verified the mechanisms of a self-defence system, including allelopathy in plants, particularly phenylpropanoid and isoterpenoid metabolism. The increase of allelopathic phenolic and terpenoid compounds under environmental stresses have been well documented, for example, enhanced UV-B- light induces the accumulation of phenylpropanoids and flavanoids in different plant species, such as bean, parsley, potato, tomato, maize, rye, barley and rice. In addition, Khan *et al*. (2007) found numerous phytotoxins such as cytokinins, diterpenoids, fatty acids, flavones, glucopyranosides, indoles, momilactones (A and B), oryzalexins, phenols, phenolic acids, resorcinols and stigmastanols in rice and considered these as growth inhibitors in rice. Through laboratory studies, Hall and Henderlong (1989) found that the auto-toxic compound contained within the water-extractable alfalfa fraction was not the direct result of microbial activity. Ascending paper chromatographic separation indicated that the auto-toxic compound had reading fraction (RF) characterization similar to phenolic acids. Also, water-soluble auto-toxic compound had characteristics indicative of phenolic compounds. Also, Mattic *et al*. (1997) showed significantly higher levels of 3-hydroxy benzoic acid (3 HBA), 4-hydroxy benzoic acid (4 HBA), and 3.4-dihydroxyhydro-cinamic acid (3.4 DHHCA) and tentatively identified 4-hydroxy phenyl acetic acid (4 HPAA) in water from allelopathic rice cultivars when compared with water from the non-allelopathic cultivar Rexmund. All these chemicals are phenolic acids which have been described as allele-chemicals in many plant species. Kim *et al*. (2000) identified several compounds by Gc/Ms analysis from rice cultivar Kouketsumochi such as sterols, benzaldehydes, benzene derivatives, long-chain fatty acid, esters, aldehydes, ketones and amines with biological activity. Whereas, Rimando et al. (2001) found that Taichung Native 1, allelopathic rice; have been identified by the bioassay-guided isolation method. Its allele-chemicals are azelaic acid, P-coumaric acid, 1 H-indole-carboxaldehyde, 1 H-indole-3-carboxylic acid, 1 H-indole-5- carboxylic acid and 1, 2- benzenedicarboxylic acid bis (2- ethylhexyl) ester. Also, Chung *et al* (2002) demonstrated that p-hydroxybenzoic, p-coumaric acids were the most active compounds in rice hull extracts which have inhibitory effect on the growth of barnyard grass seedlings. High-performance liquid chromatography, chlorogenic acid and trans-cinnamic acid were quantified as having the highest amounts in the water and EtOAc fractions, respectively (Chon, 2004). In nutgrass (Cyperus rotundus), Ali (2005) mentioned that tuber and foliage contained different flavonoids and phenolic compounds such as rutin, kaempferol, quercetin, myricetin, p-hydroxybenzoic, chlorogenic acid and ferulic acids. While, in rice, Noguchi and Ino (2005) found the putative compound causing the inhibitory effect of rice seedlings isolated from their culture solution and purified with several chromatographies. The chemical structure of the inhibitor was determined by spectral data as 3, 20-epoxy-3 alpha -hydroxy-9 beta -pimara-7, 15-dien-19, 6 beta-olide (momilactone B). Momilactone B inhibited the root and shoot growth of cress seedlings at concentrations greater than 3 nmol mL^{-1}. The inhibition increased with increasing concentrations of momilactone B. Momilactone B when released into the neighbouring environment from rice roots throughout its life cycle. Therefore, the objective of the study was to investigate into the cellular and biochemical events involved in the resistance/tolerance of berseem (*Trifolium alexandrinum L.*) to a parasitic higher plant (Cuscuta spp.).

Material and methods

Three field experiments were carried out at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate (FCRD), Field Crops Research Institute (FCRI), Agricultural Research Center (ARC), Egypt, during three successive winter seasons; 2008/09, 2009/10 and 2010/11 to investigate the performance of some Egyptian clover genotypes for forage yield and its tolerance to dodder infestation (Cuscuta planiflora) as described by El-Nahrawy (2012).

Stem samples were taken from 2ndcut in 2ndseason (1.00 cm long) from the sub apical part of moderate stem tip of berseem plants. The samples were fixed for 48 hours in FAA (10.00 ml formalin, 5.00 ml glacial acid, 50.00 ml ethyl alcohol absolute and 35.00 ml distilled water). Samples were washed twice in 70% ethyl alcohol. Dehydration was done by passing the samples in a series of the following ethyl alcohol concentration (75-100%) followed by three changes of absolute alcohol for four hours and each sample was passed through a mixture of xylol and absolute alcohol in the percentage of 25%, 50% and 75%. Paraffin shavings reagent contained the samples until saturation within 12 hours, two changes of Paraffin were done to get rid of all traces of xylol. Samples were taken, embedded in melted Paraffin in embedding paper trays, and then cooled rapidly with cold water. Sections (10-12 microns thick) were done with Rotary Microtome (Leica RM 2125 apparatus). Paraffin sections were affixed to slides with albumin. Slides were completely dried for 24 hours at 50˚C. Before staining, slides were placed in two changes of xylol 10 times, and transferred to a jar containing equal parts of absolute alcohol and xylol for 5 minutes. Sections were plunged in close series of descending dilutions of ethyl alcohol ranging from absolute to 5% for 5 minutes. Then were stained for 10 minutes in a jar containing 1% Safranin and the excess stain was washed. Sections were stained for 1 minute in a jar containing 1% light green; they were cleared in xylol, mounted in Canada Balsam and prepared for microscopic examination (Ruzin, 1991). Five readings for each slide were taken with electric microscope (Leica DM LS) with digital camera (Leica DC300) and then photographed.

Dry samples of clover plants at 40 days age from the 1st cut were taken to determine total soluble phenols and phenol acids. Total phenolic compounds were determined calorimetrically according to the method reported by Snell and Snell (1953) using Folin-Ciocalteau phenol reagent. For estimation, 1 ml of ethanol extract was mixed with 10 drops of concentrated hydrochloric acid, heated rapidly in boiling water bath for 10 minutes, cooling, then 1 ml of Folin-Ciocalteau reagent and 1.5 ml of 14% sodium carbonate were added. The mixture was made up to 5 ml by adding distilled water, shaken well, and then kept in a boiling water bath for 5 minutes. The developed colour was measured at 650 nm against a reagent blank using SHIMADZU 240 UV/VIS spectrophotometer. Total soluble phenolic compounds were calculated as mg/g fresh weight using standard curve with pyrogallol. Vanillic, ferulic, syrungic, p-coumaric, p-hydroxypenzoic, caffic, gaalic acid and protocatoic were subsequently checked for purity by high pressure liquid chromatography (HPLC). HPLC grade water and MeOH were used for all analyses. Phosphoric acid buffer was made using HPLC grade $NH_4H_2PO_4$ and H_3PO_4.

Water extract of each donor plant shoot was prepared, then phenolic extraction of phenolics in the water extract which found in glycon form were extracted as described by Mckeehen *et al* (1999)with some modifications. Approximately, 15 ml of 4N NaOH was added for 200 ml of each concentration of water extract in 50 ml Pyrex centrifuge tube purged with nitrogen and shaken for 2 h in dark with a wrist – action shaker.

After phenolic acids liberated by alkaline hydrolysis, samples were acidified with ice cold 6 N HCl to reduce pH to between 1 and 2. Samples were centrifuged at 3 000 g and the supernatant was decanted into a 250 ml separator funnel. The supernatant was extracted with ethyl acetate (3 × 50 ml) with shaking for 10 s and the mixture was allowed to settle for 5 min between extractions. Ethyl acetate fractions were collected and pooled. The remaining pellet was diluted with 15 ml of distilled water, vortex distributed and re-centrifuged at 3 000 g. The second supernatant was re-extracted with ethyl acetate (30 × 50 ml) as before and all ethyl acetate fractions were pooled. The phenolic acids rich ethyl acetate fraction was dried by addition of anhydrous sodium sulphate and concentrated using a rotary vacuum evaporator at 35 °C to dryness. The phenolic acids rich residue was re-solubilized in 2.5 ml of MeOH and stored in dark prior to separation and quantification by HPLC within 24 hours of extraction.

Phenolic acids were separated by Shimaduz (Kyoto, Japan) HPLC apparatus (model, LC-4A) equipped with visible/UV detector (model, SPD-2AS) at 280 nm and stainless steel column (25.0 cm × 4.6 mm i.d.) (Phenomenex Co, USA) coated with ODS, (RP-18). An aliquot of the sample suspended in MeOH was diluted with 10 mM phosphoric acid buffer (pH 3.5) to the same concentration as initial mobile phase (15% MeOH). Samples were next filtered through a 0.2 µm poly (tetrafluoroethylene) (PTFE) filter prior to injection. The two solvent systems consisted of MeOH (A) and 10 mM phosphoric acid buffer, PH 3.5 (B), operated at following rate of 1.50 ml/min. The phosphoric acid buffer consisted of 10 mM $NH_4H_2PO_4$ adjusted to PH 3.5 with 10 mM H_3PO.

Results and discussion

Histological studies on berseem genotypes attached with dodder

The experiment aimed to identify the site of parasitism of Cuscuta planiflora on nine berseem genotypes; (Helali and Genotypes no. 51, 35, 74, 65, 66, 14, 95 and 29) and investigate if there are any histological differences which could be associated to specific berseem genotype. Cuscuta planiflora coils around the stems of its hosts. Its haustorium contacts the stem sides then penetrates and expands and sends minute haustorium suckers into host tissues which draw nutrients.

Different reactions of histological studies performed on sections of infested stems of berseem genotypes were illustrated (Fig. 1 and 2). These sections include accumulation of a brown substance that was observed around the penetration pathway of abortive haustoria in both the cortex and the vascular cylinder of the host stem. The substance covered the whole tissue and looked dark brown, almost black in thick sections, resembling the appearance of necrotic tissue.

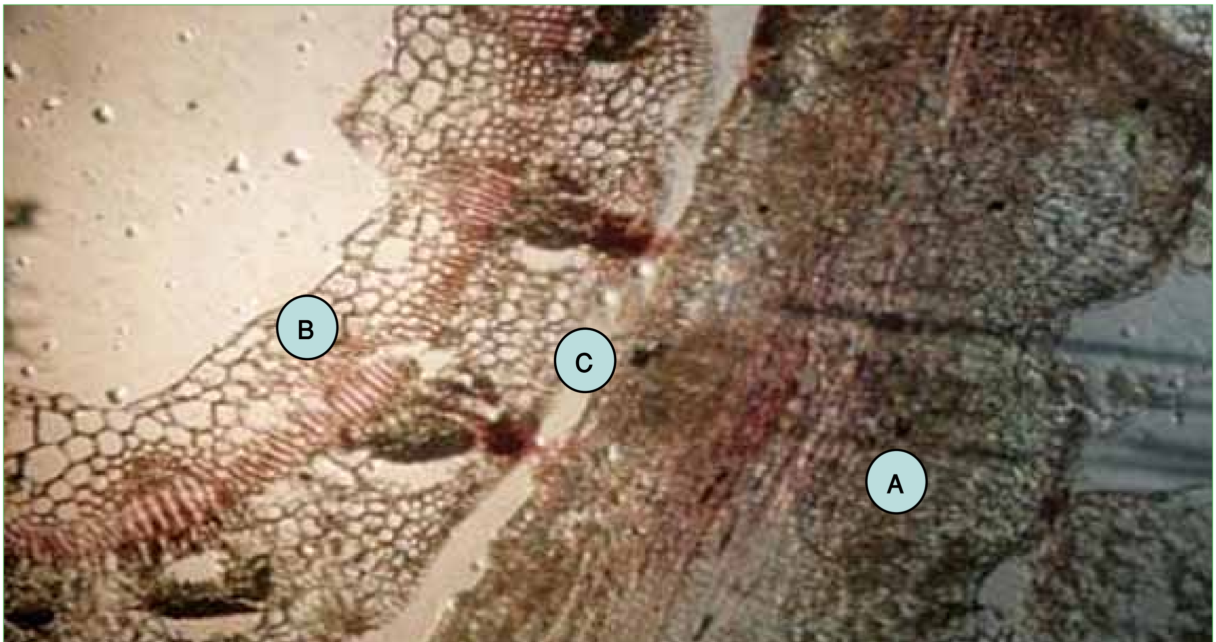


Fig 1. Histological reaction to Cuscuta planiflora of berseem (Helali cv.).
A: Haustorium of the dodder. B: The host tissues.

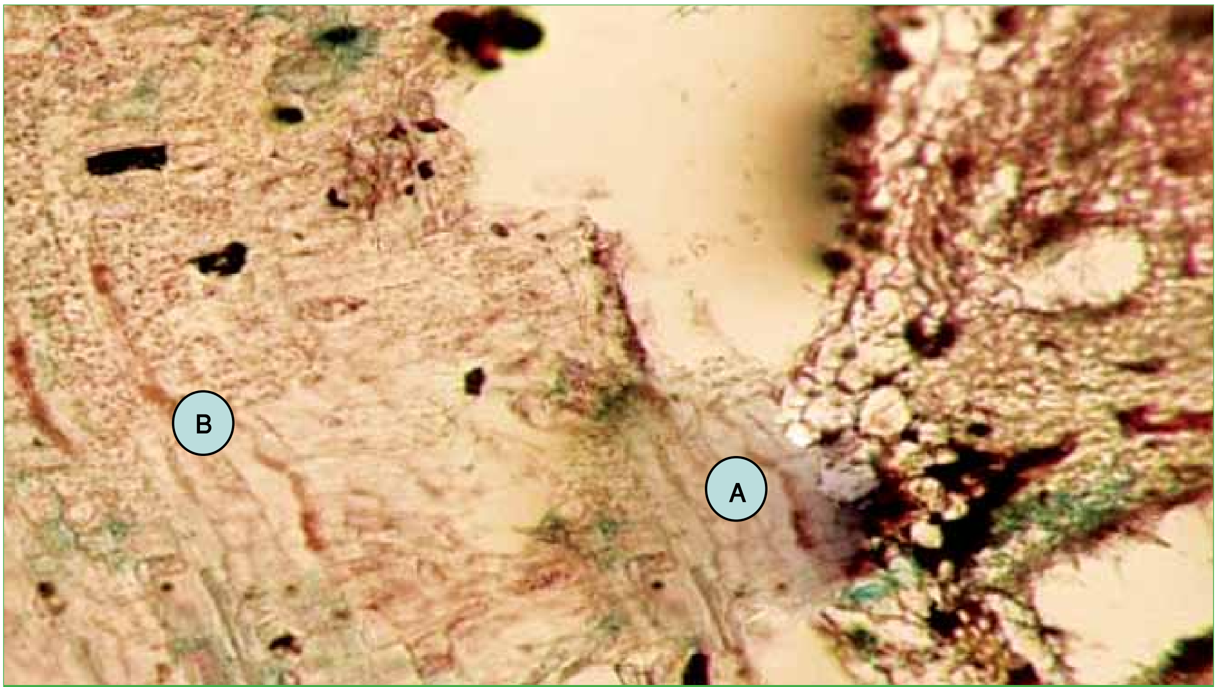


Fig. 2 Histological reaction to Cuscuta planiflora of berseem (Genotype no. 51).

A: Haustorium of dodder. B: The host tissues.

The data indicates that different mechanisms existed and it is suggested that the darkening of the tissue is a secondary symptom. This gets developed as a result of various operations of different type of resistance/tolerance mechanisms that stop or block the development of the parasite. With more detailed observations during the incompatible interaction of Cuscuta plantiflora with the tolerant berseem genotypes (Helali and Genotype no. 51), the intrusive cells of the parasite are stopped in the host cortex, before reaching the starch sheath which is evident from Fig. 1 and 2.

In some cases, the parasite is scarcely able to pierce the epidermis, but lignifications of host pericycle and starch sheath have been observed in incompatible interactions between berseem genotypes and Cuscuta planiflora, which seemed to prevent penetration of the parasite to the stem vascular cylinder (Fig. 3 and 4).

In contrast, on the stems of the susceptible berseem genotypes, the infestation developed normally, with the intrusive cells reached the centre cylinder and the host vascular tissue (Fig. 5 and 6) in comparison with the control (Fig. 7).

Fig 3. Histological reaction to Cuscuta planiflora of berseem (Genotype no. 35)A: Haustorium of dodder B: The host tissue

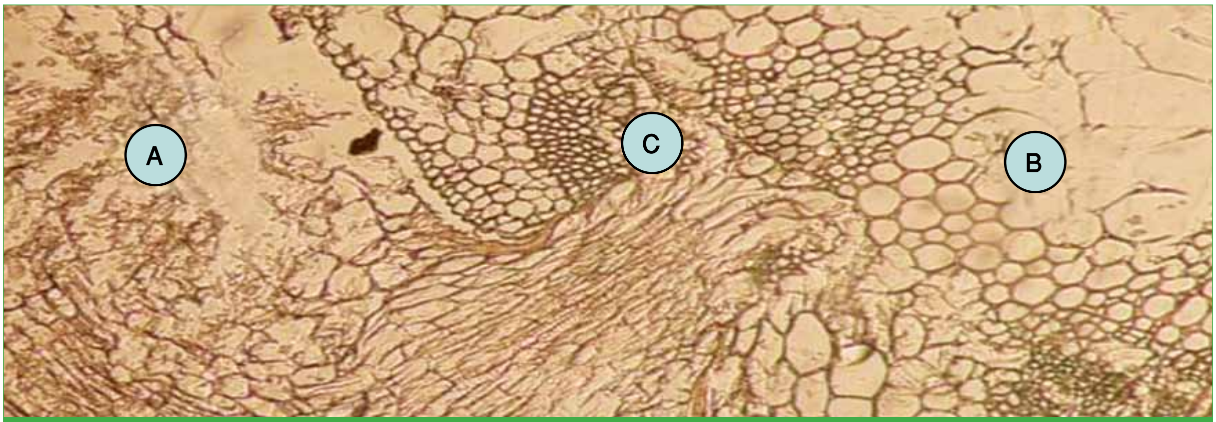


Fig 4. Histological reaction to C. plantiflora of berseem (Genotype no. 74). A: Haustorium of dodder. B: The host tissue.

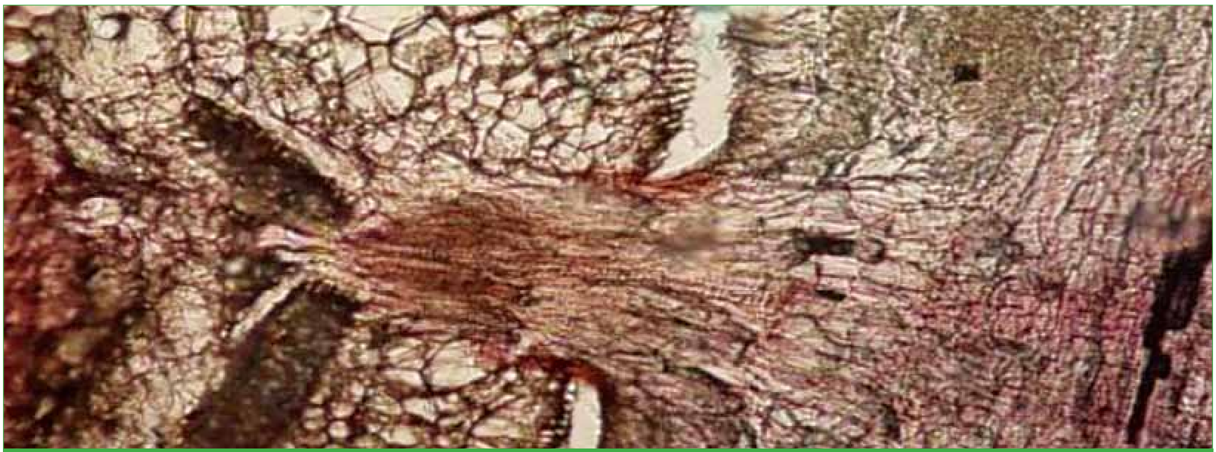


Fig 5. Histological reaction to C. planiflora of berseem (Genotype no. 94).A: Haustorium of dodder B: The host tissue.

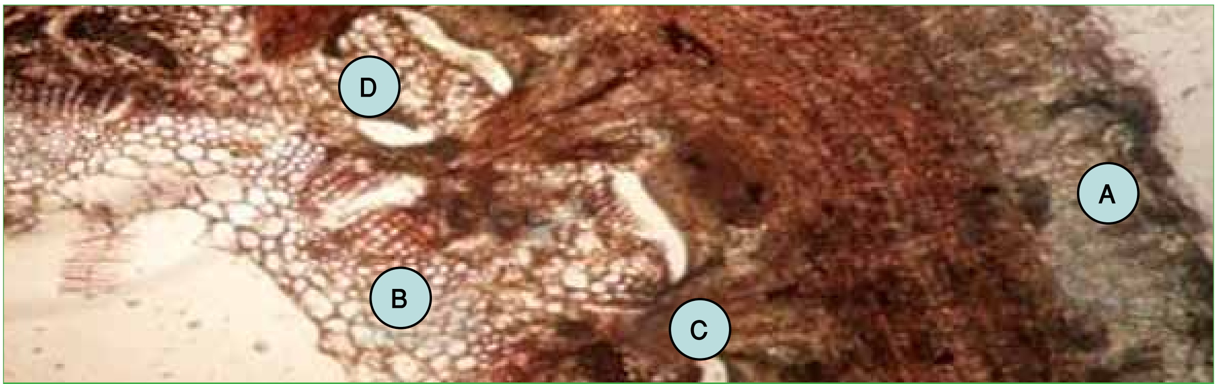


Fig 6. Histological reaction to C. planiflora of berseem (Genotype no. 29).A: Haustorium of dodder. B: The host tissue.

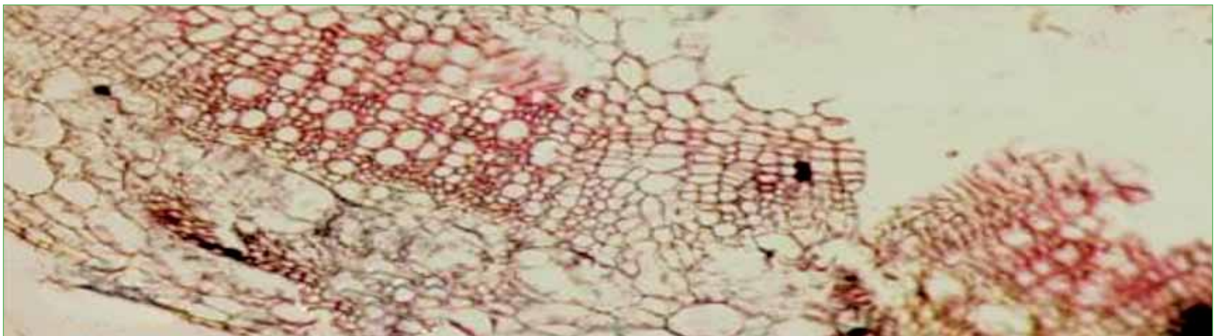


Fig 7. Histological reaction to C. planiflora of berseem (Control/non-infested)

Usually, these substances are regarded as defensive materials or mechanisms for the host, but it would be possible to differentiate several substances in the C. planiflora berseem genotypes interaction that may play different roles and seem to originate from both the host and the parasite. The haustorium stem at the side of the host contacts while the host expanded the epidermis in tolerant varieties (Helali and Genotype no. 51), the cortex in moderate tolerant varieties (Genotypes no. 35 and 74) and the vascular cylinder in susceptible varieties (Genotypes no. 94 and 29).

Allelo-chemical compounds in berseem genotypes

Chemical analyses of eight Berseem genotypes; Helali, Genotype no. 51, Genotype no. 35, Genotype no. 74, Genotype no. 65, Genotype no. 14, Genotype no. 94 and Genotype no. 29, for phenolic compounds are presented in table 1. It could be deduced that the amount of phenolic acids were relatively high; 1111.65 and 965.24 µg/100 mg of foliage dry weight for genotypes (Helali and no.51. Therefore, these varieties could retain some tolerance to the infestation of C. planiflora. The phenolic acids in the genotypes no. 35 and 74, to some extent, retain moderate tolerance to infestation with dodder and these were present in lesser concentration (784.6 and 735.38 µg/100 mg). While in Genotypes no. 94 and 29 which could be considered susceptible varieties to infestation with dodder phenolic acids these were found in trace amounts (385.42 and 419.46 µg/100 mg dry weight, respectively). Also, it could be shown from the data that the amount of ferules acid, and P-coumaric acid is relatively high which was represented by 864.65 and 191.35 µg/100 mg in Helali cv. and 782.91 and 130.25 µg/100 mg foliar dry weight, respectively. The amount of syringic, protecatechic and vanilic acids are present in lesser amounts. However, the other two P-hydroxyl benzoic acid and caffeic acid were present in trace amount.

Genotypes no. 35 and 74 which are considered to retain moderate tolerance to dodder had sufficient ferulic acid which was relatively high (784.60 and 735.38 µg/100 mg) as foliage dry weight of berseem associated with a lesser amount of P-coumaric and syringic acids, Vanillic, P-hydroxyl benzoic, caffeic and protocatechuic acids were present in trace amounts as foliar dry weight.

Concerning susceptible varieties (Genotypes no. 94 and 29), in all five phenolic acids were present in trace amounts in a descending order; ferulic acid (1.22 and 1.56 µg/100 mg), P-coumaric acid (2.68 and 3.58 µg/100 g), syringic acid (10.99 and 9.56 µg/100 mg), vanillic acid (4.71 and 7.82 µg/100 mg) and P-hydroxyl benzoic acid (14.67 and 9.50 µg/100 mg) foliar dry weight, respectively. The two phenolic acids i.e. caffeic and protocatechuic were present in high amounts as foliar dry weight.

Table 1. Phenolic compounds in berseem varieties

Phenolic compounds	Concentration (µg/100 mg) foliar dry weight							
	Helali	Gen. no. 51	Gen. no. 35	Gen . no. 74	Gen. no. 65	Gen. no. 14	Gen. no. 94	Gen. no. 29
Protocatechuic acid	16.32	11.05	12.32	2.52	24.13	32.32	210.47	240.11
Caffeic acid	3.18	2.67	15.05	3.40	9.58	6.14	141.90	150.89
P-hydroxyl benzoic acid	8.58	10.32	13.30	9.15	12.46	6.32	14.67	9.50
Vanillic acid	10.77	11.80	13.34	6.34	34.46	48.22	4.71	7.82
Syringic acid	16.40	16.24	25.75	18.64	13.75	11.66	10.99	9.56
Coumaric acid	191.75	130.25	58.40	83.68	54.23	73.47	2.68	3.58
Ferulic acid	864.65	282.91	636.44	611.65	411.53	401.77	1.22	1.56
Total	1111.65	965.24	784.6	735.38	560.14	579.90	386.64	423.02

HPLC analysis revealed the presence of protocatechuic acid, caffeic acid, P-hydroxyl benzoic acid, coumaric acid, ferulic acid, vanillic acid and syringic acid; their concentrations differed from one genotype to another. Chung and Miller (1995) mentioned that water–soluble chemicals in alfalfa are mainly cinnamic acid and its derivatives such as ferulic acid, vanillic, hydrorybenzic, P-coumaric, trans-cinnamic acid, caffeic acid. Ali (2005) stated that tuber and foliar parts of Cyperus rotundus contained different flavonoids and phenolic compounds such as rutin, kaempforol, quercetin, myricatin, P-hydroxybenzoic acid, chlorogenic acid and ferulic acids. Inam *et al*. (1987) proved that inhibitors identified in Xanthium strumarium shoots were caffeic acid, P-coumaric acid, P-hydroxy benzoic acid and ellagic acid.

Even though resistance and/or tolerance among-and-within crop plants to pests, especially for parasitic weeds is difficult to obtain, highly significant differences among the evaluated berseem genotypes for fresh and dry forage yield reduction due to dodder in all cuts and seasonal yield during the three seasons were detected. These differences are highly supported with obtaining less reduction percentages of fresh as well as dry forage yields for the tolerant genotypes due to infestation with dodder. Indicator's traits which are highly associated i.e, different histological structures among the susceptible and tolerant Berseem genotypes and allelo-chemical compounds which existed in different concentrations well performed for tolerant genotypes in comparison with the sensitive ones were evident in this study.

Biological nitrogen fixation in Egyptian clover

Abotaleb, H. H and Nassef, M. A

Investigations on the berseem-rhizobia association over many years reflect its importance to enhance growth and increase yield of Egyptian clover. Berseem is ancient in Egypt; presence of many strains of rhizobia with high efficiency is known. Inoculation of berseem with specific rhizobia leads to maintaining soil fertility, increasing yield, reducing the amount of fertilizer and increasing farmers income.

Successful inoculation requires 1) highly efficient and competitive strains of rhizobia, 2) compatibility between the plant and rhizobia, 3) suitable environmental conditions. Production of highly efficient and specific rhizobium started in the 1950's in ARC Production of Biofertilizers Unit.

Nodulation status

The presence of native rhizobia in Egyptian soils is abundant as shown in Table 1. Uninoculated plants formed up to 110 nodules per 10 plants and inoculated plants recorded significant increase in both nodule number and nodule dry weight. Moreover, the 3 local rhizobia isolates (Re2, Re3 and Re4) surpassed the reference strain used (Re1).

Biomass production

Significant differences due to rhizobia inoculation and cultivar were observed and presented in Table 2. Inoculated plants significantly recorded higher values for both plant dry weight (g $plant^{-1}$) and plant N-content (mg $plant^{-1}$) compared to un-inoculated plants. Generally, local isolate (Re4) gave the highest fresh and dry yields among 3 berseem cultivars tested.

Chemical constituents

Crude protein (CP), Crude fibre (CF), Ether extract (EE), Nitrogen Free Extract (NFE) and ash components obtained are shown in Table 3. Variation in chemical constituents among cultivars tends to fluctuate in response to type of inoculation. Generally, inoculation gave higher values for chemical constituents as compared to un-inoculated treatment. All local isolates tested recorded higher values of both DCP and TDN compared to the reference strain used. Generally, inoculation recorded higher percentage increase up to 35 and 29% for DCP and TDN respectively, as compared to uninoculated treatments.

Summary

Application of highly efficient rhizobia has benefits for both crop yield and soil fertility. Several studies in Egypt on berseem– rhizobia inoculation clearly showed that inoculation with rhizobia leads to increase in the yield which ranged between 29 - 66% as compared to un-inoculated, and reduced the amount of mineral N-fertilizer application by about 75% of the recommended dose.

Conclusion

Inoculation with rhizobia supports growth, yield and yield components of Egyptian clover and recorded significant increases in productivity of different cultivars. Local isolates gave the best results.

Table 1. Number of nodules and nodules dry weight (g/10 plants) of Berseem cultivars 45 days after sowing as affected by inoculation with various rhizobia strains

Parameter	V1 (Sakha-4)			V2 (Helai)			V3 (Sids)		
Rhizobia strain	S1	S2	$\bar{X}$	S1	S2	$\bar{X}$	S1	S2	$\bar{X}$
Control no. nodules	105	116	111	111	108	110	100	113	107

Table 1. Number of nodules and nodules dry weight (g/10 plants) of Berseem cultivars 45 days after sowing as affected by inoculation with various rhizobia strains

Parameter	V1 (Sakha-4)			V2 (Helai)			V3 (Sids)		
D.W. of nodules Re1 (reference)	139.1	153.6	146.5	147.0	143.1	145.1	132.5	142.7	141.1
no. nodules	175	183	179	163	174	169	158	177	168
D.W. of nodules Re2 (reference)	231.8	242.4	237.1	215.9	230.5	223.2	209.3	234.5	221.9
no. nodules	192	203	198	188	193	191	191	224	208
D.W. of nodules Re3 (local)	254.3	268.9	261.6	249.0	255.6	252.3	268.9	296.7	272.8
no. nodules	181	193	187	196	207	202	235	227	231
D.W. of nodules Re4 (local)	239.8	255.6	247.7	259.6	274.2	266.9	311.3	300.7	306.0
no. nodules	189	215	202	211	217	214	219	222	221
D.W. of nodules	250.3	284.8	267.6	249.5	287.4	268.5	290.1	294.1	292.1

LSD 0.05 (Cultivar) V = (9 no. nodules) (Re) T =13 (V x Re) =23 CV% 17%	V = 12.2 D.W. of nodules T = 17 V x T = 29.1 18%

Table 2. Plant dry weigh and plant Nitrogen content as affected by inoculation with various rhizobia strains at 45 days after sowing

Parameter	V1 (Sakha-4)			V2 (Helai)			V3 (Sids)		
Rhizobia strain	S1	S2	X̄	S1	S2	X̄	S1	S2	X̄
Control PDW	12.6	13.0	12.8	13.1	13.2	13.1	13.0	13.1	13.0
PN-Content	18.9	20.5	19.7	19.9	20.0	19.9	18.7	19.7	19.2
Re1 (reference) PDW	14.2	14.8	14.5	14.2	14.9	14.6	14.4	15.0	14.7
PN-Content	20.1	20.9	20.5	22.3	20.2	21.2	20.1	21.4	20.8
Re2 (local) PDW	13.9	14.7	14.3	14.2	14.8	14.5	14.9	15.2	15.1
PN-Content	19.2	20.4	19.8	20.0	20.3	20.1	21.1	21.8	21.5
Re3 (local) PDW	14.7	15.1	14.92	15.3	15.8	15.6	15.1	15.6	15.4
PN-Content	20.0	21.4	20.7	21.1	19.9	20.5	20.1	21.0	20.6
Re4 (local) PDW	13.8	14.9	14.4	15.0	14.9	14.9	15.7	16.0	15.9
PN-Content	19.0	19.4	19.2	20.1	20.2	20.2	21.1	21.3	21.4

LSD 0.05 (Cultivar) V = 0.23 PDW (Re) T =0.7 (V x Re) =1.0 CV% 16%	V = 0.4 PN-Content T = 0.8 V x T = 1.1 18%

Table 3. Chemical constituent percentage of three berseem cultivars as affected by bacterial inoculation (average over cutting and seasons)															
Parameter						V1 (Sakha-4)					V3 (Sids)				
Rhizobia strain	CP %	CF %	EE %	NFE %	Ash %	CP %	CF %	EE %	NFE %	Ash %	CP %	CF %	EE %	NFE %	Ash %
Control	15.7	38.6	1.6	27.8	17.0	15.5	39.9	1.8	26.3	17.1	15.3	40.2	1.8	26.3	17.1
Re1 (reference)	15.7	39.0	1.7	26.6	17.3	15.5	40.0	1.6	25.9	17.7	15.6	39.7	1.6	26.0	17.7
Re 2 (local)	15.9	38.3	1.6	27.3	17.4	15.2	39.3	1.8	26.7	17.7	15.1	39.8	1.7	26.4	17.5
Red (local)	15.3	39.8	1.7	26.7	17.4	15.2	39.8	1.5	26.4	17.8	14.6	40.6	1.8	26.2	17.2
Red (local)	15.4	38.8	1.7	27.3	17.6	15.0	39.4	1.7	27.2	17.9	15.2	40.6	1.8	26.3	17.8

Factors affecting the productivity of berseem in Egypt

M. S. Radwan, K. I. Abdel-Gnawed and R. I. El-Zanaty

Berseem, Egypt's main winter forage is grown on about one million hectares of which about half is sown for a catch crop before summer crops, and the rest is a full- season winter crop for soiling, silage and hay.

In 1969 the major factor limiting the productivity of berseem was identified as the slow rate of growth of 5.6 g/m^2/day during a growing season of about 175 days. This rate represents less than 10% of the theoretical daily growth rate of 77 g/m^2 expected from a standard crop canopy. The low efficiency of berseem in dry matter production was ascribed to the following factors (Radwan, 1969):

1) The slow rate of leaf area development before the first cut.

2) The use of seed rates which lead to leaf area indices lower or higher than optimum for maximum forage production. Farad *et al* (1968) showed that increasing the seed rate of Meskawi berseem above the recommended 47 kg/ha rate gives lower forage yield.

3) The low quality of berseem seed also plays a major role in limiting forage production. This is evidenced by the large variation in productivity between farmer's seed lots.

Forage yield of 37 commercial seed lots of Fahl varied from 17.14 to 32.14 t/ha when compared at Giza and from 19.28 to 47.38 t/ha when compared at Sakha. Wide variation in productivity was also noted among seed lots of the multi-cut types of berseem (El-Nahrawy, 1994).

Nitrogen fixation

Berseem hosts Rhizobium bacteria in roots which fix atmospheric N and make it available to the plant. N fixation by Rhizobium is dependent upon 1) Presence of effective strains of bacteria in soil and 2) the ability of berseem to furnish the required carbohydrates for the multiplication of Rhizobium. Farmers do not usually inoculate berseem seed although inoculants are available at a low price with seed dealers.

Adding a starting dose of 40.47 kg N/ha was found to increase forage yield of the first cut (El-Zanaty, 2005). Forage yield and protein content were also significantly increased at each cut by increasing added N level up to 242 kg/ha. However, an earlier study (El-Zanaty, 1996) showed no significant effect on protein yield of berseem from the application of N at rates from 119 to 476 g/ha. These observations suggest that the efficiency of the Rhizobium bacteria may differ with soil conditions and perhaps with the variety.

Effect of management

Sowing date

El-Zanaty (2005) found that the highest fresh and dry forage yields of berseem were obtained from seeding during the first two weeks of November under Giza conditions. However, in one year the highest seed yield was obtained from sowing on the first of December, and on the middle of November in another year. Sowing the Synthetic 79 variety of Meskawi on the first of December gave the highest seed yield in another season. The Giza Gammah cultivar, a new synthetic variety, produced the highest seed yield when sown in the middle of November.

Ramadan *et al* (1994) reported that seed production was affected by sowing date and number of cuttings but mainly by the date of the last cut. They also reported that seed yield was highest when berseem is sown on the first of October. Seed yield decreased when sowing was later than December 20 and the last harvest was after March 20. Seed production is affected by the date of the last cutting and seed yield is highest when only two cuts are taken. Taking two and three cuts gave the highest seed yield (Radwan *et al*, 1983, Geweifel and Rammah, 1990). Shabban *et al* (1984) reported that seed yield was highest when was sown on the first of October; yield decreased when sown later than December 20 and the last cut was after March 20. Seed production is affected by the date of the last cutting and yield is highest when only two cuts were taken (Radwan *et al*, 1983). Seed and straw yield were highest when berseem was sown on 1st October (Shaaban *et al*, 1984). Seed yield decreased when sowing was later than December 20 and the last cut taken after March 20.

Soil fertility and foliar nutrition

Gupta and Dabas (1983) found that spraying berseem with a solution containing 5 ppm Zinc in the form of Zinc sulphate maximized yield. Sorour (1994) found that foliar spray with micronutrients significantly increased berseem forage yield. El-Zanaty and Ibrahim (1993) reported that soil application of 20 kg zinc sulphate increased the protein content of berseem leaves while spraying with 0.6 % Zinc sulphate resulted in the greatest protein content of stems at all cuts.

Nitrogen fertilizer

Many farmers add nitrogen fertilizer after cutting during the growth cycle of berseem. Such applications gave some improvements in the fresh yield. However, they seldom add to the quality and dry yield (El-Zanaty, 1996). It is well known that adding a small dose of nitrogen (35-54 kg N /ha.) to berseem at sowing improves seedling growth (Tisdale & Nelson, 1975), because it seldom responds to N fertilization except at the beginning when nodules may not yet have been formed.

In Egypt, adding 23-95 kg N/ha caused an increase in plant height (Hefni and Zeidan 1976, Nor-El Din *et al* 1986, Ibrahim and Abdel-Aal, 1990 and Abo-Zeid, 1993). However, Mahmoud *et al* (1984) and Abdel-Gawad (1993) noticed insignificant differences in plant height of some cultivars. Similar results were reported by El-Zanaty (1996). Adding 23-95 kg/ha N , caused a significant increase in fresh forage yield (Hefni and Zeidan, 1976; Mahmoud *et al* 1984, Maatouk, *et al* 1986, Nor-El Din *et al* 1986; Ibrahim and Abdel-Aal 1990, Sinha and Rai, 1993, Abou- Khadrah *et al* 1994). However, adding 142-357 kg/ha N caused a significant decrease in fresh forage yield (Ibrahim *et al* 1983; Maliwal *et al* 1986, El-Zanaty, 1996). Total fresh yield increased by raising nitrogen from 47 to 238 kg/ha. (Shaaban *et al* 1984, Nor-El Din *et al*, 1986, Abo-Zeid, 1993, Abou- Khadrah *et al* 1994 and El-Zanaty, 1996). Dry forage and total yields of Egyptian clover increased by adding 47 to 119 kg /ha N (Shalaby *et al*, 1983, Mahmoud *et al* 1984, Shaaban *et al* 1984, Taneja *et al* 1991, Abdel-Gawad, 1993, Abdel-Halim *et al* 1993, Abo-Zeid, 1993, Abou- Khadrah *et al* 1994 and El-Zanaty, 1996).

Adding N fertilizer almost doubled protein yield of berseem. Adding 47 to 119 kg N /ha. gave the highest crude protein percentage and protein yield of berseem (Mahmoud *et al* 1984, Taneja *et al* 1991, Abo-Zeid, 1993 and Abou- Khadrah *et al* 1994). However, El-Zanaty (1996) found no significant differences between all N rates from 119 to 476 kg/ha N on protein yield of berseem. No significant differences were observed by adding 95 to 119 kg/ha N for heads/m^2 and seed index (Abo-Zeid, 1993 and El-Zanaty, 1996). Insignificant differences were observed by adding 119 to 47 kg/ha N on number of seeds/head and seed weight/10 heads (El-Zanaty, 1996). Adding nitrogen at the rate of 89.28 to 357.14 kg N/ha gave the highest seed and straw yields (Taneja *et al* 1991 and El-Zanaty, 1996). However, Abo-Zeid (1993) noticed significant increase in seed yield by adding 95 kg/ha N. The highest seed yield was attained by Giza 15 followed by Ahoy (Abdel-Gawad, 1993)

Cutting management

The highest total fresh and dry forage yield of berseem was obtained by delaying growth period up to 160- 165 days (Abdel-Gawad, 1993 a), to 175 days (Geri and Bose, 1975 and Radwan *et al* 1975) and to 220 days (Abou Saied *et al* 1963). The highest protein yield was obtained by taking four cuts (Shaaban, 1975 and Abdel-Gawad, 1993 b). Sakha 87 variety gave the highest protein yield followed by the Hardaway and Synthetic 79 varieties in one season, whereas, Khadrawi gave the best protein yield followed by Ahaly in another season (Abdel-Gawad, 1993 a). Plant height at harvest decreased by taking three cuts (Geweifel and Rammah, 1990) and by cutting the sixth internode and at early flowering but was increased by cutting at physiological maturity of seeds (Iannucci *et al* 2000).

Variation among seed lots

Variation in productivity among farmers' seed lots of berseem is commonly observed. Radwan (1970) reported wide variation in plant height, leafiness and forage yield among commercial lots of the single cut (Fahl) variety.

Seed production

El-Bulkeiny (1959) pointed out that seed of the Fahl and Saidi types of berseem could be produced by interseeding with grain barley or wheat. However, Moursi and Abdel-Gawad (1967) reported that berseem seed yield slightly decreased in this case. In contrast, Sarkiayan and Bakhalbashyan (1969) demonstrated that seed yield of pure berseem is lower than berseem sown in mixture with barley, rye or ryegrass. One of the major difficulties facing berseem cultivation is the low productivity of seed at the end of the growing season. The number of cuts and the length of the growth period before flowering and seed harvest and the availability of pollinators are important factors affecting seed production. The highest seed yield was obtained by taking two or three cuts (Kassem and Aboul-Ela, 1963; Hassan, *et al* 1968; Radwan, *et al* 1983; Abdel-Rahim, *et al* 1984 and Geweifel and Rammah, 1990). However, Abdel-Gawad (1993 b) obtained the highest seed yield after taking four cuts from Giza 15 variety followed by the Ahaly variety. Seed production after two or three cuts resulted in the highest number of heads / m^2 and the highest seed index (Radwan *et al* 1983; Geweifel and Rammah, 1990). Taking two or three cuts gave the highest values for number of heads/m^2 and seed index (Radwan, *et al* 1983), increased number of heads/plant (Abdel-Rahim, *et al* 1984) and increase in the number of stems/plant, number of heads/plant and seed weight/ plant(Geweifel and Rammah, 1990).

Ramadan *et al* (1994) found that berseem seed production was affected by sowing date, number of cuts, but mainly by the date of the last cut. Taking two or three cuts resulted in the highest number of heads per m^2, the highest seed index and the highest seed yield (Radwan *et al* 1983 and Geweifel and Rammah, 1990). El-Zanaty (2005) found that the highest seed yield from the synthetic 79 var. was obtained by seeding on the first of December in 1999 and on November 15 in 2000. it was indicated that the highest forage and seed yields are obtained from sowing berseem during the first two weeks of November.

Mixtures with other crops

Because of the low dry matter content in forage of the first cut of berseem, studies have been carried out growing it in mixture with forage grasses and other non-legume forage crops. Several studies showed that berseem /grass mixtures may produce higher forage yield with better and balanced nutritional quality than either pure berseem or pure grass (Raafat *et al*, 1963; Ibrahim, 1969; Abou –Raya and Shehab El-Din 1971; Rammah and Radwan, 1971; Hefni *et al*, 1978; Sourer, 1984). Khafagi *et al* (1984) showed that mixtures with barley, ryegrass or cabbage x rape hybrid produce higher yields than pure berseem with improved nutritional value. Radwan *et al* (1983) reported that seed of Fahl berseem can be produced by inter-seeding with grain barley without reducing grain yield. Sharaan *et al* (1988) reported that the highest forage yield, especially at first cut was from pure stands of berseem followed by the mixtures of 3 parts berseem to 1 part rape.

Breeding for salt tolerance and karyotyping characterization in Egyptian clover

Abdel-Galil M. M, R. M. Khalaf, H. O. Sakr, Abo-Elgoud S. A. and S. S. M. Abo-Feteih

Berseem fits well into crop rotations and improves the soil for subsequent crops (Graves *et al*, 1996, El-Nahrawy 2008). As it is essential for the cropping pattern, it is grown in areas characterized by high level of salinity in soil and irrigated water which strongly affect the yield and yield components. Consequently, attention should be given to establish a breeding programme to produce varieties tolerant to high level of salinity or populations distinguished with stable performance under different environments.

Plant breeding should be directed to identify germplasm that withstands stress, especially saline areas, through collecting farmer seed lots from different environments. Plant breeding should evaluate and improve the quantity and quality of selected populations Younis *et al* (1986) and Michael (1987) reported that mass selection was effective for improving forage yield in multi-cut Egyptian clover. Johnson and Gosforth (1953) reported that four cycles of selection increased yield by 11% in sweet clover. Selection in cross pollinated crops increases the frequency of desirable alleles and genotypes and leads to produce new genotypes.

Two cycles of selection and cross pollination directed effective gain in forage yield by 20.58% and 5.11% as reported by Omara and Hussein (1982).Abdel-Galil *et al* (2008) reported that selection and cross pollination procedures in isolation seem to be a helpful technique to develop a high productive population out of selected genotypes. El-Nahrawy (2001), reported that the growing demand on existing water resources, enforces Egypt to reuse drainage and recycled water. In drainage water, salinity is increased from 1 000 mg/l in southern Delta to more than 6 000 mg/l in some parts of northern Delta due to the sea water intrusion.

Studying chromosomal characterization is an important tool, as it helps to identify the magnitude of cell activity and its ability of adaptation for biotic and abiotic stresses. Breeders get acquainted with the ability of such variety or population to tolerate nematode and soil born diseases. Chromosomal aberration information gives an idea about the cytological stability of the tested germplasm. This paper includes the results of a breeding programme for producing a salt tolerant base population of Egyptian clover in addition to the results of karyotype characterization of five registered varieties and the tolerant base population of Egyptian clover.

Material and methods

The breeding programme was established at Serw Research Station in 2006-2007 winter season, where 39 seed lots and two varieties (Serw 1 and Serw 2) were evaluated under high level of salinity (6 000 ppm) and eight populations were selected. A self pollinated generation was produced for each selected population and three cycles of mass selection in isolation were carried out. The improved populations were evaluated against the original parents and the registered varieties and the highest yielding population was selected and multiplied to be registered as a new variety (Serw 3) tolerant to salinity and exceeding Serw1 and Serw 2 varieties in withstanding such stress conditions. Cytological investigation was carried out to study the karyotype characterization of the promising population (Serw 3) and the registered varieties (Serw 1, Gemmeza 1, Giza 6, Sakha 4 and Hillaly) to get acquainted with the area, length, long and short arm chromosome, determining centromeric index and centromeric position of chromosome. In addition mitotic cell divisions determined as an indication for the adaptability for Egyptian conditions were also studied. Determination of chromosomal aberration as an indication for cytological stability in the tested entries of berseem varieties were also studied.

Results and discussion

Analysis of variance indicated that selected seed lot No. 108 (Serw 3) after a selfed generation and three cycles of mass selection surpassed other selected populations and the local variety (Serw 1) and recorded 74.06 and 11.73 tons/ha for fresh and dry yields which are significantly higher than other entries. Breeder seed was propagated in 2011-2012 season to be registered as a new salt tolerant variety (Serw3).

Table 1. Means of fresh and dry yields (tons/ha) for selected populations and registered variety		
Populations	Fresh yield	Dry yield
114	64.17	9.89
108 Serw3	74.06	11.73
120	57.73	9.43
113	51.75	8.74
106	47.84	5.52
85	56.35	9.66
Serw1	60.49	9.66
LSD at 5%	1.8	0.560

Chromosome area

Variety Serw1 recorded the highest value (46 um) and Sakha 4 the lowest (43.71 um) indicating that Serw 1 contains the highest quantity of DNA meaning that high number of genes and their frequency is available and mechanical repair genes of DNA are found in this variety indicating that Serw 1 is more adaptable to stress condition. This is expected as Serw 1 was produced to be cultivated under high salinity with high yield.

Chromosome length

The selected population (Serw3) recorded the highest chromosome length so it is a good source of genes which control the characters like yield and it could be used to obtain high genetic variability in the subsequent generations as a parent with other entries.

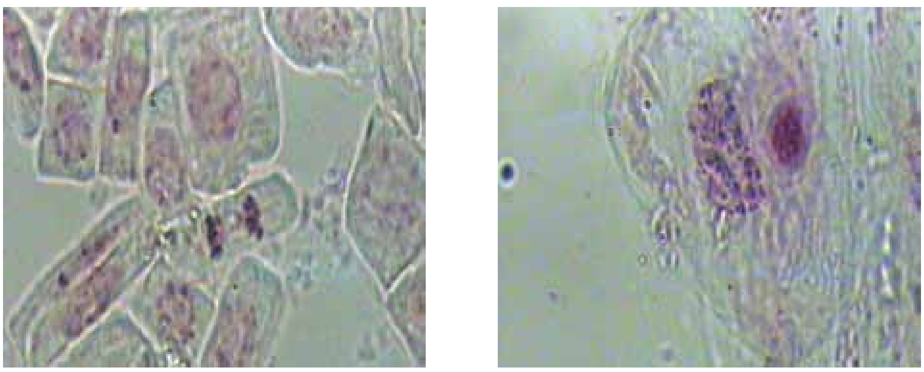
Mitotic index

Serw1 and the selected population (Serw 3) were the highest entries in mitotic index indicating that they have very active cells with ability to adapt to stress and tolerate nematode and soil born diseases, whereas, high level of mitotic division points out to the ability to renew damaged cells when infected with disease or exposure to severe environment.

Chromosomal aberration

Chromosomal aberrations were not observed in the varieties; Giza 6, Sakha 4, Serw1 the selected population Serw 3 indicating these entries are cytologicaly stable and could be grown in different environments. Meanwhile, stickiness, non compact micronuclei and satellite chromosomes were found in Gemmeza1 var. and non compact micronuclei was found in Helalli.

Figure 1

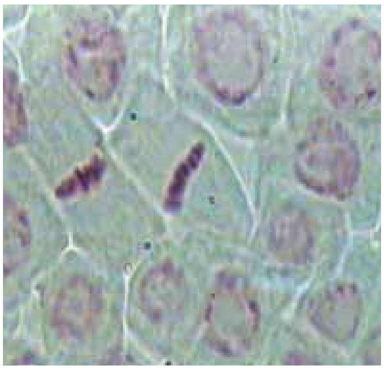


A.Chromosome Fragment

B. Compact micronuclei

C. Non compact micronuclei

D. Binucleate Cells



E. Chromosome Stikiness

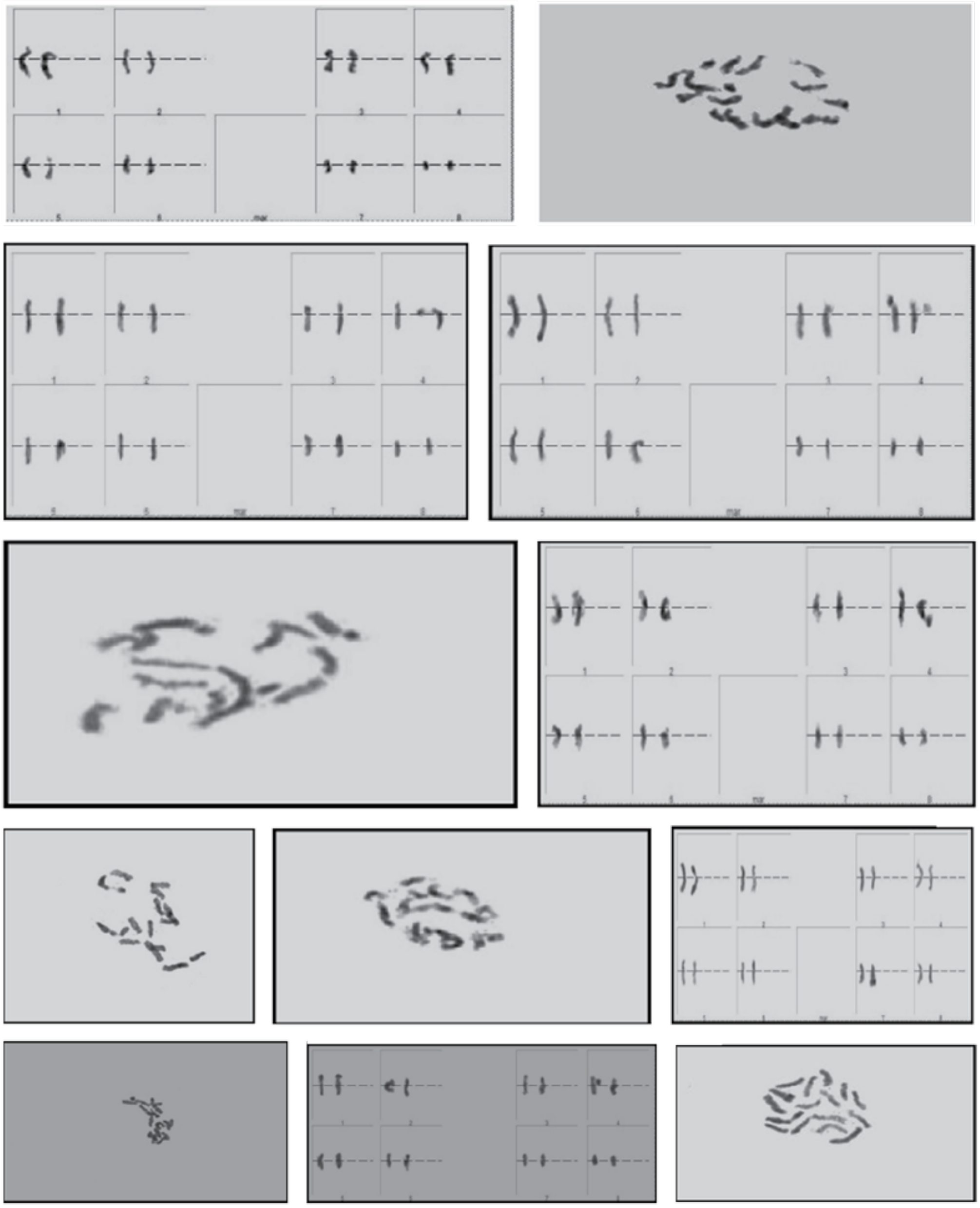


Figure 2. Types of chromosomal aberration in Berseem Clover

Relative tolerance of Egyptian clover genotypes to dodder infestation

Shereen M. El-Nahrawy, R. A. El-Refaey and E. H. El-Seidy

Berseem occupies about 1.5 million ha (El-Nahrawy, 2009b). Livestock development is mainly dependent on berseem in winter because it satisfies most of the animal protein needs (ACSAD, 2008). It is the fertility foundation of agriculture in the Nile Delta and the valley playing a vital role in sustaining Egyptian agriculture (El-Nahrawy, 2009a). Berseem is indispensable in rotation with cotton and other crops due to its high nitrogen fixation potential since it fixes more than 714 000 tons of atmospheric N annually in Egypt (Kennedy & Mackie, 1925; Abd EL-Hady, 1993; Graves *et al*, 1996). Berseem is an important sources of honey but has not received much attention compared to cereals (The Strategy for Sustainable Agricultural Development Towards; 2030). The remarkable increase in cereal productivity in the last two decades (from 8 million MT in 1980 to more than 22 million MT in 2009) is mainly due to the development of high-yielding cultivars and making certified seed available to growers. Unfortunately, this is not the case for berseem. Farmers traditionally produced their own seed or purchased their needs from local markets, local seed is uncertified and uncontrolled, its quality is poor and most of it is contaminated with weed seeds, especially, dodder (Cuscuta spp.).

Recently, an increasing number of farmers (85%) have been reporting trouble due to dodder in berseem which affects both productivity and quality of produced forage. Dodder affects the growth and yield of infested plants and causes losses to the crop. Berseem infested with dodder leads to reduced protein content, fresh as well as dry forage yield and nutritive value. Dodder can germinate alone if the weather is conducive but, it cannot survive alone without attachment to a host. It must attach itself with a host plant by its suckers. Hard seeds of dodder can remain viable in the soil for many years (Abd El–Wahed, 1996). Dodder species are distributed worldwide and attack many different hosts. International trade, mainly with contaminated crop seeds, has led to the wide distribution of this parasite (Parker & Riches, 1993). It lives entirely on the host thereby reducing growth and yield. Several herbicides have successfully shown selective suppression of attached dodder but complete control is rarely obtained. Dodder control will require an integrated approach conducted over a period of many years (Lanini & Kogan, 2005). The main goals of this study were to assess the effect of dodder on growth and development of available berseem germplasm; commercial and high-yielding developed cultivars as well as farmers' seed lots. In addition, it was envisaged to estimate the losses occurring due to dodder infestation and to identify the most tolerant genotypes under artificial infestation.

Material and methods

Three field experiments were carried out at Sakha Agricultural Research Station Farm, Kafr El-Sheikh-Governorate, Forage Crops Research Department (FCRD), Field Crops Research Institute (FCRI), Agricultural Research Center (ARC), Egypt, during three successive winter seasons of 2008-09, 2009-10 and 2010-11 to investigate the performance of some Egyptian clover genotypes for forage yield and their tolerance to dodder infestation. One hundred genotypes were used in this investigation. Ninety six genotypes were chosen randomly from a wide collection of farmers' seed lots (landraces) through a survey carried out over most of the country and the other four were commercial cultivars; Helali, Sakha-4, Sids-1 and Serw-1.

Season 1 (2008-2009)

Simultaneously, two adjacent as well as similar layouts were conducted. Recommended cultural practices such as preparing good seed bed, adding NPK fertilizers, cutting and irrigation were applied. The first layout accommodated the 100 genotypes, divided into five sets and each containing 20 genotypes. Genotypes were randomly distributed within each set and sets were randomly distributed within each replicate of the four replicates in in-complete block design without infestation of dodder seed. The second layout was carried out in a similar way to the first one but berseem seeds of each plot were mixed with dodder seeds in rate of 5% berseem seeds (Soliman, 2002) to achieve the artificial infestation. Plot size was 1.2 x 2.0 m which contained four rows. The seeds of each genotype were sown within four rows. Row spacing was 30 cm with 1.50 m between plots. The sowing dates of the experiments were October 20, 15 and 18 for the three seasons, respectively. Four cuts were taken. Fresh forage yield/plot was weighted in the non-infested experiment and after separating dodder material from forage in the infested experiment. Percentage of reduction (R %) in forage yield due to dodder infestation was calculated according to Topps & Wain (1957) formula as R% = (A – B / A) x 100. Where A: Fresh forage weight on non-infested, B: Fresh forage weight on infested crop.

At the end of 1st season, 25 genotypes were selected based on the least value of reduction in descending order of the fresh forage yield out of the 100 genotypes under evaluation. After the 4th cut, the 25 genotypes selected were left for open cross-pollination and the rest of genotypes were discarded to eliminate the possibility of producing pollen and providing good isolated area for the selected genotypes. Three hives of honey bees were provided during the flowering period to ensure intercross pollination among the selected genotypes. Seed of each of the 25 selected genotypes was harvested, separately, at maturity.

Season 2 (2009-2010)

Seeds of the selected 25 genotypes along with two lots; genotypes nos. 29 and 94, which were identified to be very sensitive to dodder in the 1st season were evaluated in a randomized complete block design with four replicates. The plot size, number of rows within the plot, the distance between plots and number of cuts were similar to that in the 1st season. At the end of 2ndseason, selection was conducted for the genotypes that had the least percent of reduction in descending order. Six genotypes were selected based on the least value of reduction of the fresh and dry forage yield out of the 25 genotypes under evaluation. Seeds of each genotype of the six selected genotypes were harvested, separately. Reduction percentages for fresh and dry forage yield were estimated. Total chlorophyll content was determined from 10 fresh berseem plants mechanically by using chlorophyll meter content (spade value) for 10 genotypes which represent four degrees of dodder infestation tolerance; high, medium, low tolerance and sensitive. Also, percentage of reduction for total chlorophyll was estimated.

Season 3 (2010-2011)

Seeds of the selected six genotypes which represent the parents as well as seeds of the same genotypes which were selected in the 2ndseason representing the progenies of these parents and two check commercial varieties Giza-6 and Gemmiza-1 were evaluated on a RCDB with four replicates as in the 2ndseason. The materials were left for seed production in isolated area and honey beehives were provided during flowering. Percentages of reduction for fresh as well as dry forage yield were estimated. Analysis of variance was carried out according to Snedecor & Cochran (1971) for each experiment (infested and non-infested). Variance components were calculated according to Comstock &Robinson (1952).

Results and discussion

1st season (2008-2009)

Highly significant differences among the 100 genotypes under evaluation, interaction between the sets and genotypes for all cuts and seasonal yield were obtained Table 1. FFY R % ranged from 4.75 for genotype no. 111 to about 54.0 for genotype no. 108 at the 1st cut. Moreover, FFY R % ranged from 10.2 for genotype no. 51 to 54.6 for genotype no. 32 at the 2ndcut. In addition, FFY R % ranged from 8.93 for genotype no. 51 to about 46.35 for genotype no. 70 at the 3rd cut. While, FFY R % ranged from 14.03 for genotype no. 51 to 61.9 for genotype no. 13 in the 4th cut. Regarding seasonal forage yield, R% value ranged from 11.44 for genotype no. 51 to 47.9 for genotype no. 32. In general, genotype no. 51 has the least reduction value (R %) among all the genotypes at all cuts and seasonal yield except at 1st cut, where, it is preceded by genotype no. 111 which gave 4.75% for FFY then followed by genotype no. 74, where, it gave 5.26%. Moreover, the average of FFY R % across the cuts increased in ascending order i.e. R % at 4th cut< 3rd cut < 2ndcut <1st cut. However, the highest FFY R % value was manifested by genotype no. 13, where, it gave 61.9 at 4th cut and genotype no. 94 where it gave 50.56 regarding the seasonal yield.

Table 1. Mean squares of FFY R % for Egyptian clover genotypes infested by dodder at different cuts and seasonal yield in 1st season (2008/09).

S. O.V	d. f.	Mean squares				
		Cut 1	Cut 2	Cut 3	Cut 4	Seasonal yield
Sets (S)	4	104.118	333.257	847.456	1309.798	341.716
Reps/S	7	120.271	353.056	868.245	1331.266	353.217
Genotypes(G)	19	961.623**	388.440**	292.503**	864.297**	411.520**
S x G	76	538.991**	274.575**	252.966**	461.00**	283.900**
Error	258	8.485	10.870	10.877	3.920	4.768

**: Significant at the 0.01 level of probability.

Genotype no. 111 is a commercial cultivar. Helali cv. has high potential and high-yielding ability compares to other cultivars. It was bred for relatively high ability for rapid re-growth which may be associated with good tolerance to biotic and abiotic stresses. Therefore, to be less affected due to dodder infestation it could be expected in comparison with other materials under evaluation. Moreover, it is reported (Abd El-Hamid & El-Khanagry, 2006) that about 85% of farmers fields are infested with dodder in their study area. Presence of genotype no. 51 among farmers seed lots which retains some tolerance to dodder infestation is also expected due to co-evolution among parasite-host relationships.

2ndseason (2009-2010)

The mean squares of fresh as well as dry forage yield reduction percentages at different cuts and seasonal yield in the 2ndseason (2009 -2010) are presented Table 2.

Table 2. Mean squares of fresh and dry forage yields reduction percent of Egyptian clover-genotypes infested by dodder at different cuts and seasonal yield in 2ndseason (2009 - 2010).

S. O.V	d. f.	Mean squares of reduction of fresh forage yield (FFY R %)				
		1st Cut	2nd Cut	3rd Cu3	4th Cut	Seasonal yield
Genotypes	26	216.47**	200.41**	581.65**	650.92**	269.5**
Error	78	2.88	2.23	2.03	3.50	0.776
Genotypes(G)	19	961.623**	388.440**	292.503**	864.297**	411.520**
Mean squares of reduction of dry forage yield (DFY R %)						
Genotypes	26	277.81**	129.88**	608.31**	720.17**	365.91**
Error	78	11.92	12.99	17.73	15.88	4.47

**: Significant at the 0.01 levels of probability.

Highly significant differences are shown (Table 2) among evaluated genotypes at all cuts and the seasonal yield for R% due to dodder infestation of both fresh and dry forage yields in 2ndseason (2009 -10).

It is evident from the recorded data that genotype no. 29 had the highest FFY R% (44.0%) due to dodder infestation for the seasonal yield in 2ndseason (2009-10). On the other hand, genotype no. 111 had the least R% (10.1%) followed by genotype no. 51 where R % = 10.3 for the same trait and it is shown to retain good tolerance to dodder infestation.

It is evident that genotype no. 29 had the highest DFY R% (50.90%). While genotype no. 11 had the least R% (14.5%) and it may be considered most tolerant genotype under the dodder infestation among the tested genotypes. Likewise, genotype no. 111 was followed by genotype no. 51 which had R% = 14.6% of DFY. In general, berseem genotypes under investigation manifested highly significant differences at all cuts and seasonal dry yield for R% due to dodder infestation. Similarly, the DFY R % by dodder infestation existed. Its grand mean increased from the 1st cut to 2ndcut then decreased in the 3rd cut and start to increase again in the 4thcut starting with R % = 20.1%, 41.5%, 29.8%, and 31.1%, respectively, while, R % for seasonal yield are 32.4%.

Mean squares of R% of total chlorophyll content due to dodder infestation at different cuts and their mean in 2ndseason (2009-2010) and 3rd season (2010-2011) are presented in Table 4. Highly significant differences existed among the evaluated genotypes at all cuts and their mean for R % of total chlorophyll content in 2ndseason (2009-2010) and 3rd season (2010-2011).

Table 3. Mean squares of total chlorophyll reduction percent (R %) of Egyptian clover-genotypes infested by dodder at different cuts and their means in 2ndseason (2009/10) and 3rd season (2010/2011).

S. O.V	d. f.	1st Cut	2nd Cut	3rd Cu3	4th Cut	Seasonal yield
		2nd season (2009/10)				
Replications	3	0.539	2.650	1.139	0.593	0.793
Genotypes	26	65.80**	69.56**	111.56**	82.29**	65.12**
Error	78	4.91	6.22	5.07	6.99	1.43
3rdseason (2010/2011)						
Replications	3	0.548	2.340	1.138	0.459	0.835
Genotypes	26	13.07**	15.29**	27.62**	21.88**	9.77**
Error	78	1.731	1.631	1.009	1.553	0.164

**: Significant at the 0.01 levels of probability.

Genotype no. 29 had the highest R% (22.3%) of total chlorophyll by dodder infestation while genotype no. 111 had the lowest R % (7.2%) and it was followed by the genotype no. 35 and 51, where they had 7.9% and 8.7% of reduction for the total chlorophyll content .

3rd Season (2010-11)

Mean squares of fresh and dry forage yield R % due to dodder infestation in 3rd season (2010 - 2011) are presented in Table -6. Highly significant differences among evaluated genotypes at all cuts and seasonal yield for fresh as well as dry forage yield R % due to dodder infestation in 3rd season (2010 - 2011) have been recorded.

Table 4. Mean squares of fresh and dry forage yield reduction (R %) of berseem genotypes infested by dodder at different cuts and seasonal yield in 3rd season (2010/11).

S. O.V	d. f.	Reduction of Fresh Forage Yield (R %)				
		1st Cut	2nd Cut	3rd Cut	4th Cut	Seasonal yield
Replication	3	8.373	10.611	1.824	46.285	7.710
Genotypes	13	345.61**	301.32**	294.76**	547.40**	327.47**
Error	39	3.67	6.54	4.54	8.87	1.86
Reduction of Dry Forage Yield (R %)						

Table 4. Mean squares of fresh and dry forage yield reduction (R %) of berseem genotypes infested by dodder at different cuts and seasonal yield in 3rd season (2010/11).						
S. O.V	d. f.	Reduction of Fresh Forage Yield (R %)				
		1st Cut	2nd Cut	3rd Cut	4th Cut	Seasonal yield
Replication	3	17.70	23.68	5.70	53.42	7.59
Genotypes	13	327.81**	332.21**	317.85**	573.62**	355.90**
Error	39	5.32	7.11	5.62	8.87	2.40

**: significant at the 0.01 levels of probability

Genotype (Giza 6) had the highest R% (43.3%) of the seasonal yield. On the other hand, the lowest R% (11.1%) was recorded for genotype no. 111 (parent) which is followed by genotype no. 111 (progeny) where R % = 11.3% for FFY were recorded in 3rd season (2010-11). Genotype no. 51 had the lowest R% (11.9%) among the 14 under evaluation followed by no. 111 where its R % is 12.4%. However, the highest R % (46.5%) was obtained by Giza-6. Highly significant differences of R % among genotypes at all cuts and the seasonal yield in 3rd season (2010 -2011) were detected.

Highly significant differences among all the genotypes under evaluation at all the cuts and their mean are manifested. Giza 6 had the highest (9.4) total chlorophyll R %, while, genotype no. 111 had the least (4.8) total chlorophyll R % then followed by genotype no. 1110 and genotype no. 510 where R % values were 5.2 and 5.5, respectively.

To conclude, even though resistance/tolerance among and within crop plants to pests, especially for parasitic weed like dodder is difficult to obtain, highly significant differences among the berseem genotypes evaluated for fresh and dry forage yield reduction due to dodder in all cuts and seasonal yield during the study were obtained.

Biochemical genetic fingerprinting and effect of water stress on Egyptian clover (*Trifolium alexandrinum L.*)

Wafaa M. Sharawy, F. M. Abdel-Tawab, Eman M. Fahmy; A. M. Rammah and A. H. Belal

Water stress is major harmful factor in arid and semi-arid regions worldwide (Roy *et al,* 2006). Success in the development of drought tolerance in berseem will lead to the expansion of its cultivation in marginal and sandy regions where irrigation water is scarce. With the development of molecular marker techniques, DNA polymorphisms have been used to measure genetic diversity. Electrophoretic analyses of proteins, isozymes and RAPD as genetic markers are quite useful in plant breeding programs, in studies of development and taxonomic relationships. They are also considered reliable methods for cultivar identification (Barratt, 1980 and Williams, *et al*. 1990).

Material and methods

Experiment 1. Identification of twenty nine genotypes of berseem according to their electrophoretic patterns on saline protein fractions, esterase and peroxidase isozymes was carried out to contribute a national index of some major Egypt genotypes.

Experiment 2. Field experiments were conducted during three successive winter seasons to investigate some morphological and physiological parameters related to drought tolerance among eleven accessions selected from 72 farmer seed lots collected from different governorates. Three treatments were applied as follows: irrigation every 15 days as control (C), irrigated every 21 days as moderate drought (MD) and irrigated every 30 days as severe drought (SD). Leaf samples of six berseem accessions were chosen according to their performance for yield-related traits and some physiological parameters under control and treatments were taken for SDS-protein, isozymes and RAPD analyses.

In drought stress studies, the effect of water stress on the growth of the callus was studied by adding mannitol with different concentrations (0, 5, 7.5 and 10 bar) to the media. The dried calli tissue was prepared for cation determination. Potassium, sodium, calcium and magnesium were measured. The proline contents were determined in seedlings and calli tissue.

Results and discussion

In experiment 1, it was noticed that 29 berseem genotypes were classified into 14 genetic similarity groups based on three systems together (saline protein fractions, esterase and peroxidase). Eleven groups of them involved 19 genotypes according to the similarity in two or three systems. However, the other three groups involved 10 genotypes showed similarity in only one system among the studied genotypes (Abdel-Tawab, *et al*. 1990).

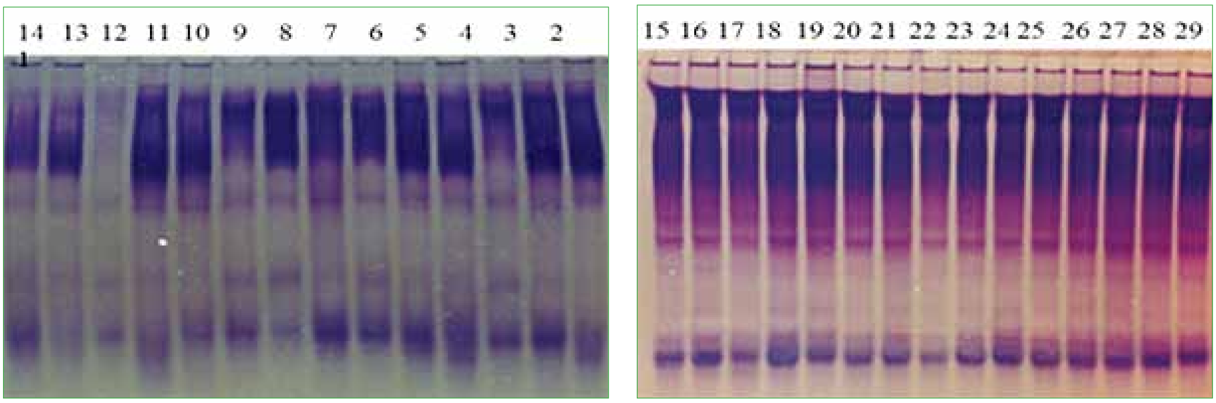
In experiment 2, data of morphological and physiological parameters related to drought tolerance revealed significant differences among accessions and between treatments. In (SD) treatment data showed lower stem/root ratio, crown diameter and number of branches for all accessions, while leaves/stem ratio were relatively higher. Generally, all accessions recorded higher fresh and dry yields under the control than at drought treatments. MD and SD treatments reduced the dry yield by about 15% and 28%, respectively. Photosynthetic rates declined with increasing water stress in all accessions compared with control. The reduction of MD and SD were about 18% and 31%, respectively. There were differences among accessions and treatments in stomatal conductance as water stress reduced stomatal conductance but osmotic potential increased with increasing the water stress. The increased osmotic potential for water stress treatments was due to the high accumulation of solute concentration within cells. Solute accumulation and ionic contents absorbed by large and longer root system assisted these drought-tolerant accessions to withstand water stress (Belal, *et al*. 1998).

Six accessions were chosen and classified into a relatively tolerant group and sensitive group based on the combined performance of the studied accessions regarding yield and its related traits, photosynthesis parameters and osmotic potential. Furthermore, final fresh and dry callus weights of these accessions responded differently to water stress levels, and the growth of callus sharply declined as a result of the elevation of water stress in the medium up to 1.0 MPa. Data under stress for these accessions might be related to tissue culture as an early screening technique for drought tolerance to select among a large number of genotypes under water stress.

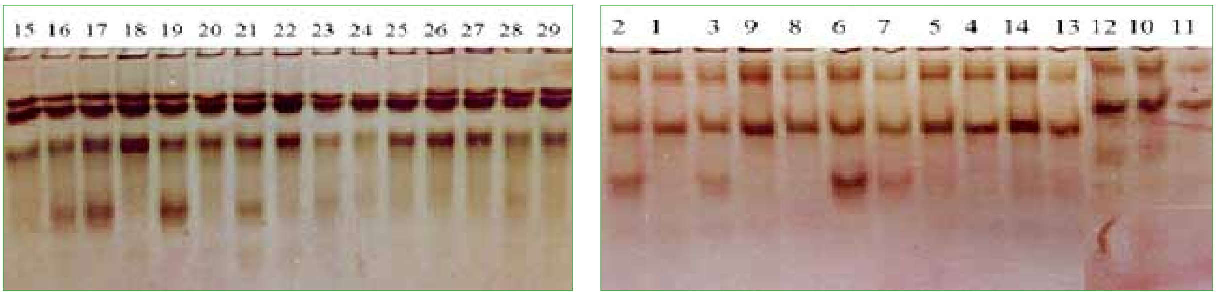
Both seedling and callus tissue recorded higher proline content under water stress compared to the control for all accessions. However, proline accumulation was relatively higher in seedlings than callus tissue. SDS-protein, esterase and acid phosphatase provide good markers for discrimination among drought-tolerant and sensitive accessions. Also, RAPDs generated by six 10-mer primers were successfully used to differentiate between bulked DNAs from drought-tolerant and drought-sensitive accessions (Fahmy, *et al*. 1997).

Conclusion

Drought-tolerant and sensitive berseem accessions could be differentiated based on morphological and physiological characters. Furthermore, Biochemical and molecular markers are useful in genotype fingerprinting and discriminating between sensitive and tolerant accessions under drought stress. These data will be used in improving Egyptian clover to withstand water stress and its production ability.

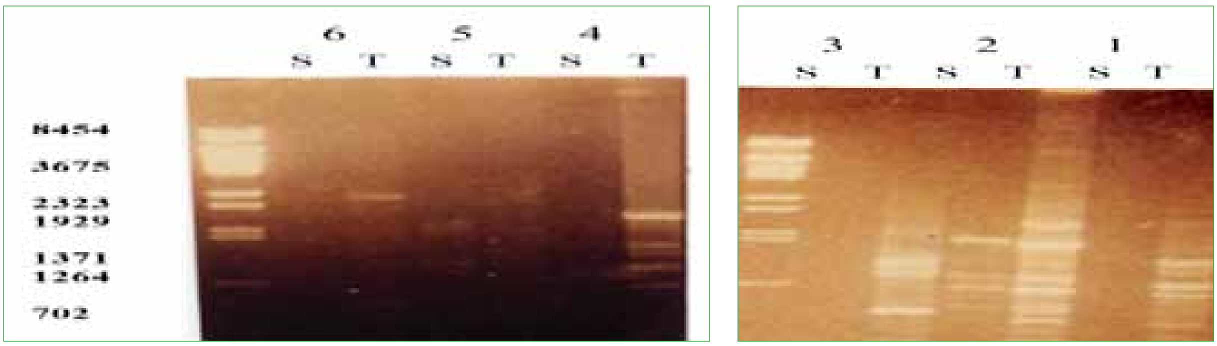


Electrophoretio patterns of seed protein fractions for 29 *Trifolium alexandrinum* L.



Esterase isozyme profiles for *Trifolium alexandrinum* L.cultivars

DNA polymorphism using random amplified polymorphic DNA lines from right to left



represent bulk of tolerants (T) and sensitives (S) parents, respectively
1=C 18 primer 2= C 19 primer 3= C 20 primer
4= D 3 primer 5= D 7 primer 6= D 10 primer

Chapter IX. COUNTRY PAPERS

AFGHANISTAN

Fodder production in Afghanistan.

Mir Mohammad Bashir

Afghanistan lies between 29° and 38° N and 61° and 75° E, is landlocked and is bound on the north by Turkmenistan, Uzbekistan and Tajikistan; on the east by China and Pakistan (including the disputed territory of Kashmir), on the south by Pakistan and on the west by Iran. It has an area of 645 500 km^2 of extremely steep, rugged and mountainous land. The arable area is about 7 900 km^2, about 50 percent is cultivated. Permanent pasture covers 290 000 km^2 and the forested area 13 000 km^2. Afghanistan is semi-arid to desert and most farming is in pockets of irrigable land, with some rain-fed areas in the north and at high-altitudes. Crops cover less than 10% of the land; the rest is grazed extensively, is desert or under permanent ice. Some 85% of the population is engaged in agriculture (livestock and crops), with livestock making a contribution to livelihoods of about 80% of households. Crop production, livestock rearing; horticulture and forestry are the major farming activities. Crop and livestock production systems vary through the country's wide range of altitudes and climates

Crop sector

Crop production is limited to irrigated lands, except in the northern plains where there is just enough precipitation for very extensive cereal growing. Most traditional irrigation systems have a sporadic supply - either spate irrigation fed by rain or snowmelt from far off hills, or Karez systems. Most arable land can only be watered for part of the year. When a limited supply of permanent water is available it is used for home gardens, orchards and other high-value crops near the homestead. The primary crops are wheat, maize, barley, rice, cotton, sugarcane, sugar beet, oil seeds, vegetable, fruits and fodders. Apricots, mulberry, pomegranate, grapes, apples, plums, peaches, pears, pistachio, walnuts, and chilghoza (pine nut) are the most important horticultural crops. Dried fruit, mainly raisins, constitutes about 40% of agricultural exports. Vegetables are grown everywhere for subsistence and near towns, for sale; melons are a major summer crop. Fodders, mostly clover (*Trifolium resupinatum*) and lucerne (*Medicago sativa*) are an important component of most production systems.

Livestock

Livestock plays an important role in the national economy by supporting domestic income generation (milk and dairy products) for both the urban and rural population. There are two livestock production systems, those of sedentary villagers and transhumant (Kuchi) systems. Cattle, sheep and goats are the main livestock, camels, asses and horses are also important; there are a few yaks and buffalo in suitable climatic environments. Cattle are the main source of farm power and provide subsistence dairy needs.

Most small ruminants are raised in mobile systems with regular movements between summer and winter grazing sites. In the north there are five million Karakul sheep in a specialized system. Cattle are the main source of farm draught (but tractor ploughing is increasing rapidly on suitable terrain) and milk is important for both subsistence and income. Most livestock are indigenous breeds; some exotic blood has been introduced in commercial dairy cattle.

Livestock production suffers from many problems such as poor health, shortage of feed and poor nutrition, lack of access to credit and other essential services. Sufficient quality feed is not available during the bitterly cold winter and many animals become weak, which affects milk and meat production as well as birth rates. Poor calving rates are also due to a lack of bulls. Livestock owners lack information and knowledge about improved methods of feeding, vaccination, and signs of illness or epidemics. Poor nutrition is a chronic problem for achieving quantity and quality in livestock production, especially in winter.

Feeding system

Much of the livestock diet is rough grazing and coarse crop residues. In agricultural areas some cultivated fodder is used to supplement straws and stovers. Transhumant herders buy grain, mainly maize and barley as winter feed, however, feed is deficient in quantity and quality. Sown fodder from legumes is very traditional throughout the country and is usually grown close to the homestead. The proportion of fodder in the rotation varies; it is probably between 3% and 10% according to local conditions and farmers' needs. Fodder is partly fed fresh and partly made into hay to supplement crop residues. Lucerne (*Medicago sativa*) is the most widespread but can only be grown where there is year-round irrigation. Persian clover or shaftal (*Trifolium resupinatum*) is a winter annual which gives two hay cuts in spring. Excellent landraces of shaftal are available, suitable for both low and high areas; it is also used as a vegetable. Vetch (Vicia spp) and grass pea (*Lathyrus sativus*) are grown as rain fed crops in some high altitude areas. Berseem (*T. alexandrinum*) is grown in a few relatively frost-free areas and has become more popular in recent years due to its higher production; however, unlike shaftal, it is neither suitable for hay nor as a vegetable. There are large areas of commercial fodder near Jalalabad and Kandahar. In summer maize is sown very densely and thinned for stock feed, a practice that is very widespread in most of the country.

Intercropping of orchards with fodders is common and is particularly useful during the establishment years where cropping with field crops could have a deleterious effect on young trees through disturbance of their superficial root system

Most fodder seed in Afghanistan probably comes from on-farm production or farmer-to-farmer exchange but seed of traditional fodders is of inferior quality and contaminated with weeds. There are numerous constraints in extensive forage production and these constraints like shortage of land, irrigation, seed and ignorance about the technology always lead to an imbalance between demand and supply.

FAO fodder development programme implementation

Demonstrations of new crops and new varieties of established fodders were carried out with selected farmers who provided land and labour while the project provided seeds and fertilizer. Direct training of selected farmers and field days ensured the successes of the demonstrations and a wide dissemination of the results. In all selected sites fodder demonstration were carried out during two seasons with the same farmers and the farmers in the old villages were supported with the improved seed against cash payments, if requested. As far as possible fodder development activities were coordinated with those on cattle production, especially for members of the integrated milk schemes in Kandahar, Kabul, Mazar, Kunduz, Herat and Nangarhar provinces. The number of farmers covered by the fodder programme was in most sites larger than for cattle extension.

New varieties were tested by staff on experimental fields in Farah, Kandahar, Kabul, Jalalalabd, Mazar, Kunduz and Badakhshan. Testing of 20 varieties of lucerne, 5 varieties of berseem, 7 varieties of oats, 4 varieties of sorghum, 3 varieties of hybrid sorghum, 6 varieties of millet and materials of shaftal, fodder beet, red clover, vetch, sainfoin & Mott grass were carried out.

Introduction of berseem

Berseem, as an alternative to local shaftal for warmer sites, was introduced through demonstrations with farmers; shaftal is very slow in early growth and provides only 1-3 cuts hence, produces less fodder. On the other hand, shaftal resists cold weather, soil salinity, grazing and provides excellent hay. Green fodder production from demonstrations of berseem was in the range from 52.0 t/ha in Paktia up to 105.0 t/ha in Balkh. Seed of the Pakistani cultivar Agaiti was available in large quantities and was therefore, tested in all sites. Agaiti as an early maturing variety was grown successfully in all the tested sites (Figure-1).

Figure-1. Berseem Variety Agaiti

The “newer” cultivar S2 provided by the Fodder Research Institute Sargodha, Pakistan is a late variety which was supposed to grow longer into summer, a characteristic that was especially requested by farmers in Nangarhar and Balkh provinces. Productive performance and the late characteristic however, were less than expected and S2 could therefore, not be considered as an alternative to Agaiti (Figure-2).

Figure-2. Berseem variety S2

A local variety “Khewa” purchased from a district in Nangarhar produced similar results to Agaiti under field conditions although slightly less in controlled trials. Berseem seed from Australia produced well for the early cuts, but stopped growth when the weather warmed up and did not produce more than Agaiti (Figure-3 and 4).

Figure-3. Australian demonstration plot in Balkh Province

Figure- 4. Berseem (Agaiti) seed multiplication plots on farmers lands

Conclusion

- The overall results from field trials and farmers demonstration plots clearly indicated that berseem can be grown very successfully in most of the sites in Afghanistan.
- Berseem "Agaiti" is an early variety, fast growing during the entire growth seasons.
- Berseem "S2" also grew fast at the beginning and Berseem "Australian" was medium late variety.
- Comments from some farmers in Nangarhar, Farah and Balkh provinces indicated that availability of late producing varieties might be better to cover feed shortage periods.
- Green matter production from berseem demonstration plots was mainly influenced by the length of growing season and number of cuts. The lower production was clearly a result of the short production periods and fewer cuts.
- Comments from farmers in some cold areas like Paktia, Logar, Maidanshar and Kabul provinces is that they prefer mixed cropping of berseem and oats which grew very well and evaded frost injury and bird attacks, especially, at the early growth stage and also produced higher green fodder yield.
- Availability of good quality seed is a major constraint for the continuation of the programme. The project therefore, started seed production of the "Agaiti" variety in Jalalabad, Farah and Balkh province through contract farmers.

Berseem in Afghanistan- Country report.

Hamdy Oushy

In the early years of the twentieth century berseem was introduced to Sindh, Pakistan, where it adapted to the conditions and farming systems so well that it rapidly spread throughout the irrigated tracts of northern India (Roberts & Singh, 1951). It is now the major cultivated fodder on millions of hectares around the world, which may make it the most rapid spread of a crop in recent times, this is all the more notable for its being cultivated primarily by smallholders. It is also grown in the U.S, and in southern Europe as both a winter and summer crop. Egyptian clover is a fast-growing winter annual. In Afghanistan, it can produce up to 90 tons/ha fresh green forage from five cuts under irrigation. It is a heavy nitrogen producer and the least winter-hardy of all true annual clovers. Egyptian clover draws down soil nitrogen early in its cycle. Once soil reserves are used up, it can fix 115 to 225 kg or more of nitrogen per hectare.

In Afghanistan, if it establishes well, Egyptian clover can make an excellent cover for crop rotation with wheat and barley in winter; and with maize, cotton, pearl millet, vegetables, and Sudan grass in summer. FAO (2000) reported that the most important fodder crop in the hotter areas of eastern Afghanistan is Egyptian clover (*Trifolium alexandrinum*) or berseem, a crop of recent introduction, via Pakistan. It is grown in some of the lower areas, such as Khost and Nangarhar, where winters are sufficiently mild since it only withstands light frost.

Six Egyptian clover varieties (Hellaly, Sahk-4, Gemiza-1, Giza-6, Serw-1, and Fahl) have been introduced through the Ministry of Agricultural Irrigation and Livestock (MAIL) by the author to break the cycle of wheat/rice crop rotation, improve soil fertility, and provide high-quality feed for livestock.

Figure-1 (A & B). Six Egyptian clover varieties at MAIL/Shishem Bagh Agricultural Research Station in Jalalabad, Nangarhar Province, Afghanistan.

Egyptian clover does not withstand extreme heat or cold and is the least winter hardy of the cultivated clovers (McLeod, 1982). It should not be grown in areas where winter temperatures are commonly 6°C or lower. In general, Egyptian clover sown early in autumn resists frost much better than if it is sown late. Egyptian clover Miskawi does not do well with intense heat, and late sowing gives a reduced number of cuts due to injury from summer weather. However, Miskawi appears to be the most cold resistant of the varieties. It is a winter annual in some parts of the world and a summer annual in others. Most cultivars cannot stand frost. Egyptian clover does best below 750 m (2,500 ft) elevation. Miskawi is best adapted to regions with mild winters under irrigation. The optimal temperature for its growth ranges between 18-25 ˚C; germination is sharply reduced when temperatures reach 35 ˚C, and low temperatures can delay germination and result in weak growth.

Clover varieties

In Afghanistan, there are two local varieties; "Missry Shaftala". and "Peshawari" clover which was introduced to Nangarhar from neighbouring Peshawar in Pakistan. Both are similar in growth habits, structure, heights, number of tillers, and leaf features; they are short varieties with thin stems and very small dark seeds. Both varieties were evaluated in a comparison trial with the five introduced Egyptian clover varieties: Hellaly, Sahk-4, Gemiza-1, Giza-6, and Serw at Shishem Bagh Agricultural Research Station in Jalalabad, in the winter growing season of 2010 to 2011. The five introduced Egyptian clover varieties were significantly superior to the local Afghan varieties, in fresh yield, number of cuts, heights per cut, and overall plant vigour.

In addition, the establishment and adaptation of five introduced varieties have been outstanding in Jalalabad, Nangarhar, conditions in Afghanistan. These results indicate that there is a significant potential for improvement of the overall agricultural production system in Afghanistan through the replacement of the inferior local Afghan clover varieties by the high-yielding improved varieties of Egyptian clover (Figure-2).

Figure-2. Local Afghan clover "Missry Shaftala" is in front; and Egyptian clover Hellaly is shown in the back of the photo at Shishem Bagh Agricultural Research Station in Jalalabad, Nangarhar Province, Afghanistan.

Egyptian landraces of berseem include Miskawi, Saidi, and Fahl (Graves *et al*, 1989). Kennedy and Mackie (1925) reported that there are four distinct agricultural varieties; Miskawi, Khadrawi, Saidi, and Fahl.

Demonstration and seed production sites for the six Egyptian clover varieties were established at MAIL-Shishem Bagh Agricultural Research Station, Nangarhar University, Nangarhar Valley Development Authority (NVDA) in Jalalabad at 20 demonstration plots on 20 farms in four distracts - Kama, Behsood, Chaparhar, and Kewa in Nangarhar Province - in addition to a research site at Balkh University in Balkh Province (Figure-3 and 4).

Figure-3. (Left) A farmer in Behsood District, Nangarhar Province is happy with his improved Egyptian clover Hellaly variety. (Right) Data collection at other Egyptian clover demonstration plot in Kama District, Nangarhar province, Afghanistan .

Figure-4. Afghan workers carried out berseem trials at MAIL/Shishem Bagh in Jalalabad, Nangarhar Province.

Egyptian clover haymaking steps

- Use only the third and subsequent cuts for hay.
- Sun cure the harvested forage in rows in the field for one day only.
- Transfer the sun cured forage to the "Hay House" (see Figure 5).
- Keep the forage in the Hay House for four days.
- Turn the forage daily throughout four days to dry it out.
- Transfer the hay to a storage place when it reaches 25% moisture content.

Hay House

Figure 5. Egyptian clover haymaking, step-by-step in the "Hay House" (HH), developed for small farming systems in Afghanistan.

making hay from Egyptian clover is clean, fast, requires little labour, and results in low mechanical losses. The frame uses three triangle-shaped forms of different sizes. It also requires three wooden bars (each 4 m long) to build the skeleton and three wooden bars for each floor. The measurements of the three floors are as follows: 3 m long for the first floor, 2 m long for the second floor, and 1 m long for the third floor (see photo 2 in Figure 2). Plastic nets should be established on the three floors to hold the forage (see photo 8 in Figure 5). The Hay House should be connected using some tools, as in photo 3 in Figure 5.

In a large farming systems Egyptian clover hay can be produced using mechanical mowers, sun curing, and balers.

Figure 6. The old way of making hay from alfalfa and local clover by drying the forage plants on the walls of farms in Balkh Province, Afghanistan .

Summary of FAO fodder development programme in Afghanistan

In 1997 Egyptian clover was studied. FAO introduced three varieties: 1) Agaiti, Pakistani variety, 2) S2 from Sargodha-Pakistan, and 3) No one from Australia. For milder sites berseem is an alternative to shaftal which is slow in growth and provides only 2-3 but resists cold weather, soil salinity and grazing and provides excellent hay. Agaiti was grown in 1997 in Herat, Farah, Helmand, Kandahar, Bamayan, Logar, Wardak, Kabul, Pktia, Nangarhar, Laghman, Badkhshan, Kunduz and Balkh. The results of field trails and demonstrations clearly show that berseem can be grown very successfully in Afghanistan; mixed cultivation has the advantage that the fast growing cereal produces an early cut and protects the legumes from damage by frost and insects and suppress weeds. It seems that farmer' practices of mixed cultivation are well justified and well recommended; shaftal resists cold weather, soil salinity and grazing and provides excellent hay. Most farmers in lower areas of eastern, northern and western regions are replacing local shaftal with berseem which can significantly increase fodder production in double cropping regions.

Berseem produced twice the green fodder compared to shaftal. The first cut was obtained in December or January when no green fodder was available. Shaftal gave its first cut at the end of April. Berseem produced on the average 75-80 t/ha green fodder yield in 3-4 cuts as compared to 40 t /ha produced by shaftal in two cuts. The green fodder production from demonstrations for berseem was in the range from 52.0 t/ha in Paktia up to 105.0 t/ha in Balkh, the difference is mainly influenced by the length of the growing season and the number of cuts. Seed of the Pakistani cultivar Agaiti was available in large quantities and was therefore, tested in all sites. Agaiti as an early maturing variety was grown successfully in all the tested sites.

EGYPT

Egyptian clover and its vital role in Egyptian agriculture

Mohamed Abu-Zeid El-Nahrawy

Summary

Egyptian clover (Berseem) and wheat compete with each other for limited irrigated land. There is a consensus to expand area under wheat to increase self-sufficiency which can only be at the expense of berseem; the competition is exacerbated by rising livestock numbers. Berseem has enabled livestock to be closely integrated with cropping systems for many centuries; it plays a vital role in the sustainability of agriculture since it is the fertility foundation of farming in the Nile Delta. It is an excellent plant for controlling weeds, insects, pests, and diseases in crop rotations and is a major honey crop. Most farmer's plant berseem landraces but improved cultivars are available which could greatly increase productivity but little effort has been put into developing their seed supply. Increasing yield per unit area by using improved cultivars and better agronomic practices could reduce the competition for land with wheat; fodder research is grossly under-funded compared to other field crops. More than 30,000 tonnes of berseem seed was exported during 2009.

Egyptian clover or berseem (*Trifolium alexandrinum L.*), the main forage crop in Egypt, plays an important role in the agricultural system; it is an ancient crop and a basic component of sustainable cropping which has enhanced both livestock and crop production for centuries, in a situation where natural pasture is scarce.(Figure 1) It provides high forage yield of exceptional value whether consumed directly as pasturage or green-chop, conserved as hay or silage or made into pellets and cubes or other feedstuffs. (Figure 2) Berseem occupies about a third of the total cultivated area in Egypt in winter (between 84,000 to 1,260,000 hectares) as a full and short-season crop as well as the area devoted to seed production. The full-season berseem area is relatively stable, varying between 751,000 hectares in 1978 and 670,000 hectares in 2000 (Table 1). However, due to rapid growth in livestock numbers to meet the demand for animal products, the berseem area increased 12% during 2011. With limited agricultural land and scarce water, the competition between wheat and berseem requires rational decisions by policy makers. Increasing the area under wheat at the expense of berseem could result in a drastic reduction in feed production and rise in price of animal products with a consequent rise in imports.

Table 1. Trend in area cultivated, green forage yield/ha and total production of berseem

Year	Area under crop (ha)	Productivity (t ha^{-1})	Production (1000 t)
1978	751,000	57.60	43,256
1979	733,000	57.60	42,230
1980	723,000	56.31	40,699
1981	738,000	56.40	41,586
1982	752,000	57.60	43,281
1983	784,000	57.62	45,063
1984	828,000	55.00	45,514
1985	807,000	58.57	47,310
1986	784,000	58.33	45,685
1987	717,000	60.71	43,514
1988	678,000	61.31	41,555
1989	668,000	62.50	41,799
1990	692,000	62.14	42,985
1991	684,000	62.19	42,535

Table 1. Trend in area cultivated, green forage yield/ha and total production of berseem

Year	Area under crop (ha)	Productivity (t ha^{-1})	Production (1000 t)
1992	685,000	62.33	42,697
1993	690,000	62.43	43,078
1994	749,000	59.48	44,581
1995	740,000	59.76	44,214
1996	693,000	60.64	42,011
1997	666,000	61.33	40,860
1998	714,000	64.26	45,885
1999	774,000	66.43	51,392
2000	670,000	68.00	51,710
2001	843,000	67.26	54,655
2002	838,000	70.00	58,666
2003	825,000	70.24	57,916
2004	801,000	71.14	56,946
2005	695,907	71.17	49,530
2006	766,152	70.37	53,911
2007	680,672	71.35	48,555
2008	1175000	44.26	52,000
2009	1175000	44.26	52,000
2010	1175000	44.26	52,000
2011	1175000	44.26	52,000

There are no short or medium-term solutions to this problem. Land is limited, so production of winter crops, especially wheat and berseem, will be determined by improving yields through the use of high-yielding cultivars. Berseem yields are distinguished by their stability and fluctuate less than cereals. From 1987 to 1997, yields were around 59 tonnes ha^{-1}; then production increased from 1998 up to 71.35 tonnes ha^{-1} in 2007. This is mainly due to the availability of certified seed of high-yielding cultivars that were developed in the early eighties. The lowest annual production recorded was 40,699,000 tonnes in 1980; while the highest was 58,666,000 tonnes in 2002 (Table 1). The development of berseem production is determined by the competition with wheat and the production of food and commercial policy choices.

Berseem is the great forage and soiling crop of the Nile Valley and is indispensable as a rotation crop during centuries of cotton production (Fairchild, 1902). Fairchilds insight has been vindicated since the establishment of the High Dam which stopped silt and nutrients from enriching the Egyptian soil. The role of berseem in sustaining soil fertility could have been suspected or confounded with other causes before High Dam establishment. But once the High Dam stopped the silt and nutrients during flooding, there is no doubt that berseem is responsible for sustaining Egyptian lands. Moreover, Graves *et al*. (1996) concluded that it is difficult to imagine a greater honour being bestowed on a crop than to give it credit for sustaining agricultural production in such an ancient land.

Origin

Berseem is a true clover belonging to the genus Trifolium and somewhat resembles red clover (*T. pratense*); in growth habit, but has yellowish-white instead of red flower heads. DeCandolle (1886) reported that berseem is indigenous to Egypt and extensively cultivated as fodder and its Arab name is bersym or berzun and its name does not occur in Hebrew and Armenian botanical works. Bossier (1872) indicated that berseem is not wild in Egypt, but assured that it was wild in Syria and Asia Minor. On the other hand, Muschler (1912) reported that it is only known from Egypt and Cyrenaica and the true home is uncertain and it is cultivated everywhere in Egypt where it is also sub-spontaneous. Fairchild (1902) indicated that no picture, name or authentic seeds of berseem had ever been discovered in any of the tombs of Egypt and denied that the plant has been discovered wild.

Description

Berseem is an annual legume with oblong leaflets, hollow stems and upright growth habit which varies from erect to decumbent during winter and spring. Naturally growing Egyptian cultivars are diploid and have 16 chromosomes. It attains a height of 45 to 75 cm or more if not mown and has an upright growth habit. Plants develop short (60-90 cm) and thick tap roots from which emerge numerous fine lateral roots. Numerous small ovoid, pinkish white nodules are found on the lateral roots. Leaves are large, numerous, slightly hairy, succulent, consist of three leaflets on one petiole and very palatable to livestock. It produces round yellow-white flowers in elliptical heads at stem terminals. Flowers are predominantly self-incompatible and must be pollinated by bees to produce high seed yield. On average, there are about 100 flowers densely crowded in each ovoid head (raceme), subtended from an annual stem by a leaf-like bract. Petals are yellowish and form a long basal (corolla) tube. The seeds are about 2 mm long, somewhat larger than red clover and about the same size as crimson clover. They are egg-shaped and can vary from yellow to red-brown. Some seed may have a purple pigmentation. Number of seeds per gram could range from 400 to 500. The usual growing season in Egypt extends from early September to late July.

Distribution and adaptation

Berseem is widely grown for fodder and seed as well as in rotations for soil improvement. It is best adapted to areas where winter temperatures are moderately cool to warm and adequate moisture is available throughout the growing season. It dies when exposed to temperatures below 4 C° for several days. It is moderately tolerant of salinity but is not adapted to low, poorly drained soils; maximum yields are obtained when calcium (Ca) is adequate and the pH 6.5 or higher.

Soil requirements and seedbed preparation

Berseem can be grown on a wide range of soils, including calcareous and heavy ones. It is moderately tolerant to salinity, although sensitive at the germination stage. A pH of 6-7 is required for efficient nitrogen fixation. The seedbed should be firm and the optimal seeding depth is 1-2 cm, with a maximum of 4 cm. Cultivation of berseem on heavy soil that has a hard layer and/or high water table should be avoided.

Inoculation

Rhizobium bacteria create nodules on berseem roots and fixes nitrogen which becomes available to the plant. While many soils contain Rhizobium from previous crops, not all fields have adequate numbers; berseem seed should be inoculated with Rhizobium trifolii, especially on new lands. Effective bacteria should be present when the first roots develop, to begin fixing nitrogen immediately.

Fertilization

Berseem typically gets enough nitrogen from its symbiotic relationship with Rhizobium and from soil organic matter which releases nitrogen as it decomposes. On well-inoculated, established stands, top dressed nitrogen does not improve yields, quality, or stand vigour. Adding nitrogen may lower yield and/or quality by stimulating growth of grasses and weeds. But in some cases, soil poor in nitrogen should receive an encouraging dose around 50 - 75 kilograms of nitrogen per hectare to help seedlings develop healthy roots. These roots will ensure developing effective nodules.

Berseem needs relatively large amounts of phosphate and potash. Adequate phosphorous is important for successful establishment and good root development. Potash is essential for maintaining both forage and seed yields, reducing susceptibility to certain diseases and increasing persistence. Phosphate and potash are relatively immobile when added to the soil. Phosphate bonds tightly on acidic clayey soils (pH< 5.5) and on very high pH soils (pH> 7.5) making it unavailable to plants. Potash can leach on some extremely sandy and on organic soils.

Optimum date of sowing and ways of seeding

In Egypt farmers sow berseem from mid September till late November. Sowing before mid September results in poor stands as well as poor forage quality, due to high temperatures which cause seedling death and encourage summer weed invasion; early sowing has higher probability for cotton leaf worm infestation as well as less persistence. Sowing after mid November will cause slow growth due to cool weather and consequent poor growth, prolonged time before the first cut and fewer cuts. Studies by the National Forage Crops Research Program (NFCRP) indicate that forage yields increase by about 30% for planting on September 20th in comparison with planting on October 30th while planting on November 30th lead to a decrease by 62% as compared with planting on October 15th. Berseem is sown directly into flooded land with no-till (after rice) or after land preparation (after cotton and corn). It can be broadcast or drilled; it can be sown directly without flooding. Laser levelling increased berseem productivity by 15-20%; laser levelling and direct seeding without flooding could lead to increase productivity from 15-20 % and water saving about 20-30 %.

Water requirements

Berseem only reaches its full growth potential when not stressed for moisture. Compared to other forages it uses water efficiently. Williams *et al*. (1991) estimated water-use efficiency (WUE) to be about 175 to 280 kilograms of dry matter per acre-inch during the four cutting intervals. While WUE dropped to an average of 132 kg acre-inch during the last two harvests as evaporative demands increased during May and June.

Herbage production, storage, and utilization

Berseem can provide a large yield of nutritious forage with high intake. It is a palatable, high protein crop. For herbage it can be sown alone or in a mixture with grasses. A companion grass reduces the risk of bloat especially the forage from first harvest; in big farms grass will cushion the berseem crowns against wheel damage. Berseem should be cut when it reaches 45 to 55 cm; it may be used as green fodder, hay or silage. The nutritive value of berseem compared with alfalfa is presented in Table-2. During hay making, berseem leaves dry relatively quickly, become brittle and are prone to shattering before the stems are cured. A crimping or conditioning attachment should be used to hasten drying.

Table 2. The nutritive value of berseem and alfalfa

Forage	Cut	Percentage				
		Crude protein in DM	Crude fibre in DM	Ether Extract	Ash	Dry Matter
Berseem [1]	1	22.20	20.68	2.16	20.40	10.98
	2	21.95	20.30	2.90	15.81	12.58
	3	20.06	23.79	2.76	13.74	13.33
	4	16.13	29.64	1.83	12.01	20.83
	Ave.	20.08	23.60	2.41	15.43	14.43
Alfalfa [2]	Ave.	20.70	20.58	2.30	11.50	17.17

Figures [1]: averaged over 18 berseem cultivars and experimental strains. Figures [2]: averaged over 6 alfalfa cultivars and 17 cuts.
Source: NFCRP, FCRI, ARC, Giza, Egypt

Berseem can be ensiled but its high protein content presents problems; it is beneficial to wilt it to a dry matter content of 25-35% in the field to minimize undesirable fermentations. Additives such as organic acids may be particularly useful in ensuring a desirable pattern of fermentation. Berseem grown in a mixture is easier to ensile. Excellent results can be achieved by feeding berseem silage to dairy or beef cattle.

Seed production

Berseem can be a multiuse crop for both forage and seed production; it is self-incompatible and must be cross-pollinated to produce seed; this is done primarily by bees. Good seed yields are produced when honey bees, Apis mellifera, are introduced to the field at eight colonies per hectare. Unlike other legumes, the flower structure of berseem provides a greater opportunity for cross-pollination after each visit by a pollinator, the pistil and stamens move back to their original position. A second or third visit by an insect will have the same effect and the chances of the pistil being properly fertilized will last as long as it remains in a condition to receive pollen. Berseem should be cut and swathed when 80-90% of the heads are brown; the swaths are left to dry and may be threshed in 7-10 days. Seed should be dried if the moisture content exceeds 14%. Specialized machinery may be required for further processing. Average seed yield is about 750 kilograms per hectare in pure stands for seed production. However seed can be produced in faba bean (Vicia faba) and wheat fields as intercrops but seed yield are lower. Thousands of tonnes of berseem seed are produced in Egypt annually for export to Eastern Asian and Southern and Western European countries.

Weed control

In strong vigorous stands of berseem, annual weeds are not usually a problem because the crop can compete strongly with them and frequent cutting prevents the growth of winter weeds. Persistent perennials sometimes become a problem and can be isolated from the rest of the field and destroyed by cultural means or herbicides. Berseem is most susceptible to injury from weeds during establishment; seedlings are weak and poor competitors. Aggressive annuals can reduce the vigour of the crop during establishment, causing poor establishment of berseem seedlings, and reduced yields. To reduce losses from annual weeds, pedigree seed should be used and sown only on clean land. Herbicides can be useful in controlling weeds in seedling stands. One of the most devastating weeds is the parasite dodder, Cuscuta sp. which is becoming a widespread problem where seed is uncertified and uncontrolled.

Diseases and their management

Fungal diseases are the most important, because they attack foliage, roots, and crowns. Preventing or controlling diseases is more economical than curing them. Crop losses from most diseases can be reduced by proper management to maintain a vigorous stand. Using clean seed of recommended and resistant cultivars where available are highly recommended. Rotating with non-legumes is of mutual benefit. If serious diseases develop, professional diagnoses are recommended. Prolong the rotation interval between legumes. Avoid contaminating healthy fields by working diseased fields last, and/ or by disinfecting farm machinery after use on infected areas. Once berseem is established, cutting will take care of disease management; in most cases controlling diseases by pesticides is not economical.

Injurious insects

Insects that affect forage yield and quality, and seed yield are root borers, Lygus bugs, thrips, clover seed chalcids, Egyptian weevil, cotton worm, green worm, and clover seed midges. Treating the crop with specific insecticides when necessary is recommended especially in the establishment phase.

Varieties

A long history of cultivation in different regions of the country has led to the evolution of several ecotypes; most modern varieties have been developed from three distinct Egyptian landraces: the late flowering or multi-cut type, named Misckawi; the medium flowering or double-cut type, named Saidi; and the early flowering or single-cut type, named Fahl. These three types can also be identified on stem branching: Miskawi has basal or crown branching, it can be harvested five to seven times during the growing season and dominates in Lower Egypt. Fahl is a stem-branching type that can be cut only once and is dominant as a preceding crop to cotton and recently wheat following the early maturing rice cultivars and corn; Fahl is the most vigorous one. Saidi is both basal and stem branching; it can provide up to three cuts during the growing season and dominates in Upper Egypt.

Farmer-produced seed of landraces such as Miskawi, Saidi and Fahl comprises the majority of seed for both local use and export. High yielding varieties that have been developed through the National Forage Crops Breeding

Program are available. Performance of some licensed cultivars in comparison with farmers landraces is documented in Table -3, these have been developed for high yield and resistance or tolerance to biotic and abiotic stresses such as drought and salinity. Serw-1 was bred in Serw Agriculture Research Station, ARC, as a salt-tolerant variety; it was developed by recurrent selection among and within farmers landraces. Helalee as well as Sakha-3 varieties are characterized by longevity up to early August as long as high moisture is available. Sakha-4, Gimmiza-1 and Sakha-96 are characterized by high yielding ability in both Northern and Middle Delta. Giza-6, 10 and 15 varieties are highly adapted to Upper and Middle Egypt where high temperatures are common.

Table 3. Performance of some developed berseem cultivars averaged over 18 Provinces during 2008 - 2009 and 2009 - 2010 seasons

Cultivar	Number of data-years	Forage yield (tonnes/hectare		% superiority over farmers' cultivar.
		Mean	Range	
Farmers' cultivar	2	69.90	93.12-143.00	---
Hilali	2	130.29	100.83-153.76	10.89
Giza 15	2	127.57	97.69-164.95	8.58
Sakha 4	1	126.80	92.55-164.95	7.91
Gemmiza 1	1	128.69	93.50-163.93	9.54

Source: NFCRP- FCRI, ARC, Egypt

The nutritive value of berseem

Berseem forage quality is similar to alfalfa, perhaps a little higher in total digestible nutrients (TDN) and a little lower in crude protein (CP). Berseem hay is quite palatable and high in feeding value. It can give a large yield of nutritious feed with high intake characteristics. Table -4, illustrates the proximate analysis of seven high yielding berseem cultivars developed by the National Forage Crops Breeding Program averaged over five cuts.

Table 4. Quality parameters of seven developed high-yielding berseem cultivars on a dry matter basis

Cultivar	CP%	CF%	Ash%	EE%	NFE%
Helali	17.26	25.33	15.42	1.73	40.26
Sakha 4	17.54	25.02	15.43	1.94	40.07
Giza 6	16.81	25.87	15.54	1.73	41.01
Giza 15	17.13	25.80	15.56	1.73	40.21
Gemmiza 1	16.86	26.31	15.38	1.77	39.74
Sakha 3	17.24	25.92	15.51	1.75	39.62
Serw 1	17.47	25.53	15.40	1.88	39.71

Source: NFCRP, FCRI, ARC, Giza, Egypt.

Berseem in Egyptian agriculture

Berseem has enabled livestock to be closely integrated with cropping for many centuries, it is also:

- A better choice for soil improvement and increasing soil fertility with an ability to add high levels of nitrogen (298-400 kilograms ha^{-1}) (Graves *et al*. 1996); more than 714,000 tons of fixed nitrogen is added to Egyptian cultivated lands every year (Abd Elhady 1993; Graves *et al.* 1996). Berseem has, for centuries, been considered indispensable in rotation with cereals, cotton and other crops. Without growing berseem and other legumes, the high productivity of non-leguminous crops could not have been maintained.

- Mown several times for forage and then incorporated into the soil as green manure, sometimes referred to as plough-down. The crop is allowed to grow to approximately 4-10 cm and is then incorporated into the soil. Single or double-disk harrows followed or preceded by heavy-duty cultivators can effectively incorporate the green crop into the soil. Berseem green manure decomposes very rapidly and releases nitrogen as soon as it is turned under. Thus, the amount of commercial fertilizer added for a succeeding crop can be decreased. An increase in yield and quality has been observed in cereal crops that were grown where berseem had been used as green manure or even grown for forage.
- Berseem in a rotation helps to conserve the soil and prevents wind and water erosion and increases the soil organic matter content, especially in newly reclaimed lands and improves soil structure and physical and chemical properties. It provides a disease break in cereal rotations. It provides the best shelter for rearing beneficial insects, which helps control deleterious ones biologically. No pesticides are used during the lifetime of a berseem crop except when necessary at establishment so berseem is a very good place to harbour beneficial insects. It is the best crop for applying no-till concept, especially when it is grown after rice.
- Berseem is the best crop for sustainable rotation with rice for salt-affected soils. Graves *et al*. (1996) reported that it is well known for its use in reclamation of salty lands in Egypt. It is described by Lauchli (1984) and winter and Lauchli (1982) as moderately tolerant to salinity, more than wheat and strawberry but less than barley. It is suited for rotations with rice at Serw Research Station in Damietta Governorate where EC reaches up to 15 mmhos/cm. It is environmentally friendly crop where minimum or no pesticides are used in comparison with most if not all other crops. It converts cultivated fields immediately to green carpet which reflects pleasant view during the season. Berseem is a major seed export crop (7, 400 tons) representing 86% of Egypt's seed exports in 1989 (Egyptian Financial Group 1991). There is high demand for berseem seed from East Asian and South Europe countries. Egypt's annual exports of berseem seed rose to more than 29,000 tons in 2007 (figure 3) .
- Various berseem-grass mixtures have been tried; barley, annual ryegrass, triticale and oats in different proportions have been used as components of these mixtures (Rammah and Radwan, 1977; Haggag et al, 1995). Including ryegrass in mixture with berseem leads to an increase in dry matter content and intake especially in the first cut. Berseem is very rich in protein and poor in energy. Therefore, including it in mixtures with grasses will lead to a balanced ration and consequently will be reflected in animal performance. It is the major foraging crop for honeybees and the main honey source in Egypt. A decrease in the berseem area would affect honey production. It is well suited as a cover crop in orchards for controlling weeds as well as enriching the soil with nitrogen and organic matter.

It is the foundation crop for land reclamation, especially of desert or marginal land. A general rule for successful land reclamation is to establish an integrated livestock-crop system. Organic matter incorporated into the land from berseem as well as animal manure and fixed nitrogen by bacteria will convert the marginal and poor soil to fertile soil within three to five years. Manure is a complete nutrient source, containing almost all of the major nutrients, secondary nutrients, and micronutrients. In addition, manure promotes biological activity in the soil and enhances the soil physical properties.

The crop provides one of the most viable ways economically as well as environmentally of controlling weeds, especially wild oats which is a big problem in wheat. There is a national campaign to control wild oats and the only efficient and effective control method is growing berseem on the infested land and rotating berseem with wheat. Regardless of the important role of berseem in sustaining soil fertility for all crops in general (Tables 5 & 6). Successive cultivation of wheat for four seasons resulted in low productivity of wheat grain (310 kilograms ha^{-1}) while rotating wheat with berseem seasonally and three successive seasons of berseem followed by wheat gave higher productivity of grain wheat; 3,929 and 4,524 kilograms ha^{-1}, respectively (Table 5). Rotating berseem with wheat helps controlling wheat pests, especially wheat rusts. Comparing the crop sequence for four successive seasons from 1991/92 to 1994/95, continuous wheat growing resulted in increase in frequency of spikes of wild oats more than 16 times and a decrease in the productivity of wheat about 12.6 times in comparison with rotating berseem with wheat. Repeated cutting from five to seven times per season removes growing weeds and depletes the weed seed bank (Table 6). It is very common to see fields of wheat following berseem free of weeds without applying any kinds of weed control.

Table 5. Effect of crop rotation on wild-oats control in wheat fields (1995)					
Crop sequence				Wild oats # spikes m^{-2}	Wheat production kg ha^{-1}
91/92	92/93	93/94	94/95		
Wheat	Wheat	Wheat	Wheat	227	310
Berseem	Berseem	Berseem	Wheat	14.1	4524
Berseem	Wheat	Berseem	Wheat	33.2	3891
Faba bean	Berseem	Wheat	Wheat	129.5	1179
Adaptad from El Hasanan S. and EL H. 1996					

Table 6. Effect of crop rotation on the number of wild oats seeds in the soil (seed bank) in 1995						
Crop sequence				Wild oats seeds per 500g soil		
91/92	92/93	93/94	94/95	At planting	At harvest	Difference
Wheat	Wheat	Wheat	Wheat	22.9	98.3	75.3
Berseem	Berseem	Berseem	Wheat	0.3	11.0	10.7
Berseem	Wheat	Berseem	Wheat	0.8	8.4	7.6
Faba bean	Berseem	Wheat	Wheat	1.8	60.0	58.2
from El. Hasanan S. and EL H. 1996						

Despite the controversy, real opportunities exist for increasing wheat area without disturbing the ancient, integrated and sustainable cropping system. The main theme of these opportunities is directed to finding sources for increasing and or improving feed supply. The Wheat Research Department has developed high-yielding cultivars and optimum cultural packages which resulted in a noticeable increase in productivity. Self-sufficiency of wheat has been increased from 25% in 1980 to about 56% in 2007 despite the population increase from about 55 million in 1980 to 75 million in 2007. The major problem in resolving wheat self-sufficiency is thinking about increasing the wheat production and productivity through forcing farmers to increase their wheat area without fulfilling the feed shortages; this would be a waste of time and effort and could have bad consequences on the stability and sustainability of Egyptian agriculture. Berseem is the main as well as cheapest source of feed, especially for smallholders, for most of the year. Shortage of berseem will affect farmers' ability to keep livestock; over 80% of which are owned by landless and small-holding farmers.

Conclusion

Berseem in rotations with wheat guarantees high productivity. Increasing the area under wheat at the expense of berseem would not be viable as it would result in decline of soil fertility, reduction in overall productivity, infestation with insects, pests, diseases, and weeds. Systematic and conscious efforts are needed for the development, introduction, evaluation, and selection of high yielding varieties coupled with modern cultural and management practices to increase yields per unit area. New farming systems and cropping patterns should be investigated and developed so that both wheat and berseem complement rather than compete for land.

Figure 1. Goat fattening by stallfeeding feeding berseem in Upper Egypt (left) and berseem varieties comparison (right)

Figure 2. Berseem forage transportd for sale to feed urban dairy (Left) Provides job to family members (Right)

Figure 3. Seed production of berseem

INDIA

Evaluation of the performance of frontline demonstration of Berseem in District Jammu (J & K State, India)

Rakesh Nanda, Vinod Gupta and P. K. Rai

The concept of Front Line Demonstration (FLD) was introduced to improve the adoption behaviour of farmers to improved crop production technologies and to harvest the maximum yield potential in real farm conditions. To lay down FLD, free supply of all the critical farm inputs and timely guidance by scientific community to avoid partial and non adoption of recommended technologies are essential. Frequent monitoring of performance at critical stages to obtain the quality production and disease free seed makes FLD more result oriented. This exchange of improved seed in the village and thus popularizing the advantages of improved technologies, extending the cultivation of improved varieties and getting the feedback from farmers involved in FLD trials regarding constraints in adoption of recommended improved technologies are the basic requisites of an FLD. The feed back from FLD's becomes first hand information base for research systems to further improve and tailor farmer friendly activities.

Although the increase in production because of berseem cultivation has been spectacular, yet there is untapped yield potential of berseem due to partial and non adoption of improved technologies like best variety, time of sowing, seed rate, seed treatment, weed management, plant protection, etc. By popularizing the importance of complete adoption of improved technologies, yield barriers can be surpassed to meet the ever increasing demand of fodder and seed of berseem. FLDs are designed to get feedback on the performance of improved varieties and latest production technologies from the farmers for evolving new strategies to increase the productivity in the country as a whole.

Every year Krishi Vigyan Kendra (Agricultural knowledge centre), Jammu lays out frontline demonstration on fodder crops as one of its activities. This provides first hand knowledge about the impact of technology to allow researchers to modify their activities for a particular area of operation. In addition, administrative and extension workers can plan strategy for implementation of useful programmes of crop production. Frontline Demonstration (FLD) is a form of applied research under which latest notified/ recommended hybrids/ varieties along with full package of practices are carried to selected farm fields with a view to demonstrate the potentiality of the technologies to the:

1. Beneficiaries
2. Non beneficiaries of the neighbouring areas

The extension workers of the State Department of Agriculture and allied agencies to analyze the production constraints if any, and to assess the performance of the technologies for scientific feedback.

The demonstrations are to be conducted preferably by extensionists and agronomists. An active collaboration of the extension workers from the State Department of Agriculture is an essential requirement. While implementing the FLD's, scientists from the fields of agronomy, soil science, plant breeding, pathology, extension and entomology interact closely with farmers and extension workers. This provides the opportunity to assess the field situation and design location specific technology and strategy. In addition, this helps in evaluation of impact created by the FLDs under real farm situation and it can be used as feedback for further research.

The ultimate aim of this programme is to accelerate the adoption of berseem production technology by the farming community through multiplier effect generated by these demonstrations. Keeping this in view the study was designed with the following objectives.

1. To study the impact of berseem FLD on varietal adoption and farmers' economy
2. To know the shift in area of berseem with economic impact after KVK intervention.

Methodology

The KVK Jammu adopted the rotational policy of selecting villages by keeping on support to those villages for two years and later on KVK switches to other potential villages after a baseline survey. Follow-up consultations continue with the villages left by KVK. In 2009, KVK Jammu laid berseem FLDs on 10 acres at village Chak shain of block R. S. Pura of district Jammu. This village was selected because of its irrigated conditions and farmers grow berseem in winter in and around 40 acres. The list of all the FLD berseem growers was prepared for the study. The only drawback of the area was that the farmers were not aware of latest varieties and improved cultivation practices. For the study the personal characteristics of the respondents were also studied. Parameters like, age, land holding, extension participation, mass media and risk orientation (Biradhar 1997) were enumerated. Their relationship with the adoption level of respondents was also studied by correlation. The required data were collected by regular monitoring of demonstration fields and personal interaction with the farmers with the help of well structured schedule (proforma) developed for the purpose. The data on socio-economic status of berseem growers, perception of growers regarding berseem demonstration and performance for adoption and economy of berseem varieties in farmer's field were collected.

Results and discussion

The personal characteristics of the beneficiaries and non beneficiaries of FLD programme were analyzed. Six characteristics were identified such as age, education, land holding, mass media contact, extension participation and risk bearing ability of the respondents. The result in Table 1 indicated that 47.50 percent of the respondents were middle aged followed by old age (38.75%). It was evident from the Table -1, that 38.75 percent of the respondents were educated up to middle school, followed by 20 percent each in primary and high school. It was also found that 52.50 percent of the respondent families had land holding up to 2.5 acres of land (small farms). The results in Table 1 indicate that majority (77.50%) were aware of the training programme on fodder management given by KVK Jammu. Similarly, 71.25 percent of the respondents regularly listened to agricultural programmes on radio followed by 47.50 percent who saw television for such programmes. Some 63.75 percent of the respondents were average risk bearers and this indicated that the fodder production like Berseem has a greater scope in future also.

Table 2 shows that in 2005 farmers cultivated local berseem and obtained a yield of 4.10 t/ ha of fodder with the BC ratio of only 1.36. Whereas, in 2009-10 when demonstrations were laid down by KVK with the objective of implementing the complete technology recommended by Sher-e-Kashmir University of Agricultural Sciences and Technology-Jammu (SKUAST-J), the yield of berseem fodder of the demonstration plot was increased to 6.50 t/ ha as compared to local check found to be 4.25 t/ ha with an increase of 53 percent in yield.

Similarly, results from Table 2 reflect the comparison of data between beneficiaries and non beneficiaries in 2010-11. Beneficiaries obtained higher yields of 6.20 t/ha in 2009-10, where as yield of non beneficiaries was 5.50 t/ ha with an increase in yield of 39 per cent and 28 percent in the year respectively of beneficiaries and non beneficiaries. It was also evident from the Table - 2, that in the subsequent years from 2009-10 to 2010-11 the B:C ratio of the beneficiaries was 2.85 and 3.1 respectively, whereas, that of non beneficiaries also increased from 1.36 in 2008-09 to 2.7 in 2010-11 as multiplier effect of FLDs.

Intervention of the KVK was done at village chak shian with provision of critical inputs to the beneficiaries. It was found from the result of Table 2 that 25 kg/ ha of seed was given to beneficiaries, which otherwise farmers were using @ 40-50 kg/ ha. Seed treatment with berseem rhizobium (culture) was also recommended which the farmers were not practicing at all. Similarly, the balance dose of fertilizer (20-25 tonnes of FYM along with NPK of the ratio of 25:60:40) was provided to farmers. The most significant intervention of KVK Jammu, was treatment of seed with 5 to 10 percent salt solution before sowing of seed.

Further, Table 3 revealed that in 2010-11 all of the beneficiaries adopted practices like fertilizer application, broadcasting and weeding recommended by KVK. Similarly, adoption behaviour of non beneficiaries revealed the impact of KVK frontline demonstrations and it was evident from the Table 2 that 65 percent of non beneficiaries had adopted proper seed rate followed by 60.00 per cent who adopted the demonstrated variety JBL-146. More than half (58 percent) of non beneficiaries adopted proper dose and quantity of fertilizer followed by seed treatment by 55 percent of respondents.

While collecting data it was found that the farmers trained in cultivating berseem under improved technologies were now rendering their services to other areas and even KVK Jammu is using them as a paratechnician to provide training to other farmers of the area.

Perusal of Table 4 reveal that more than half of berseem growers (beneficiaries) had high (70 %) adoption while only 20 and 10 percent adopted new technologies at medium and low levels. In contrast, most non- beneficiaries were in medium (65 %) category and 20 percent and 15 percent each in high and low level of adoption respectively. The chi-square value indicated that adoption levels of beneficiaries of berseem was significantly different from that of non beneficiaries

Under berseem cultivation there was a significant increase in percentage of area under fodder as show in Table 5. In 2008-09 area under berseem of beneficiaries in chak shain village was 48 percent and after the intervention of KVK Jammu in 2009-10 the area under berseem cultivation increased to 69 percent of the total area during winter 2010-11. Similarly there was a switch over of non beneficiaries to grow demonstrated berseem variety and this switch over was 51 percent as revealed from Table 6.

A correlation between the personal characteristics of respondents and their adoption was found from Table 7 that personal characteristics like education, land holding, extension participation, mass media contacts and risk orientation were positively significant with the adoption level of respondents at 5 % level of significance, whereas, age had a non significant relation on the adoption level of respondents. Usually the farmers of the middle and young age are enthusiastic and have more working efficiency. Furthermore, young and middle aged farmers possess more physical vigour and have more receptivity towards new subjects and technology.

Table 1. Personal characteristics of berseem growers (n=80)

Characteristics	Categories	Respondents	
		Number	Per cent
Age	Young (up to 35 years)	11	13.75
	Middle (36 to 50 years)	38	47.50
	Old (more than 50)	31	38.75
Education	Illiterate	06	7.50
	Primary school	16	20.00
	Middle school	31	38.75
	High school	16	20.00
	Higher secondary	10	12.50
	Graduate	01	1.25
Land holding	Small farms (up to 2.5 acres)	42	52.50
	Medium Farms (2.5 to 7.5 acres)	36	45.00
	Big farms (above 7.5 acres)	02	2.50
Participation in extension activities	Field days	22	27.50
	Demonstrations	43	53.75
	Trainings	62	77.50
	Field visits	24	30.00
Mass media	Radio	57	71.25
	Television	38	47.50
	News paper	20	25.00
Risk Orientation	Low risk bearers < 9.1 (Mean-S.D)	18	22.50
	Average risk bearers 9.1-18.6 (Mean+_ S.D)	51	63.75
	High Risk bearers > 18.6 (Mean+ S.D)	11	13.75

Table 2. Performance of Berseem FLD in 2009-10						
Year		Variety	Yield of fodder (qtls/ acre)		Increase in fodder yield %	B/C ratio
			Demo	Local check		
2008		Local	-	410		1.25
2009-10 Beneficiaries		JBL 146	650	425	53.00	2.85
2010-11	Beneficiaries	JBL 146	620	445	39.00	3.1
	Non beneficiaries	JBL 146	550	430	28.00	2.7
Farming situation:irrigated.N=80 (beneficiaries 40, non-beneficiaries 40)						

Table 3. Intervention of KVK in laying Berseem FLD and its impact in subsequent years					
Intervention by KVK	Year 2009-10 n=40 (beneficiaries)		Year= 2010-11		Impact
	Farmers were Practicing	KVK recommendation	Beneficiaries (n=40)	Non–beneficiaries (n=40)	
Variety	Local	JBL-146	90.00	60.00	Now farmer is having a complete knowledge of all the improved cultural practices recommended by the KVK and farmers from the surrounding area are also taking their advice to reap maximum harvest. They are acting as paratechnicians for providing information to farmers.
Seed rate	40-50 kg/ha	20-25 kg/ha	75.00	65.00	
Seed treatment	No seed treatment	Seed treatment with the berseem culture is recommended	92.00	55.00	
Method of sowing	Broadcasting	Broadcasting	100	100	
Fertilizer quantity	Partially using FYM and urea at sowing	20-25 tonnes of FYM + N:P:K of the ratio of 25:60:40	60.00	58.00	
Fertilizer application	Only urea at sowing time	2/3rd of N and full quantity of P and K at the time of sowing and rest of N in two split doses	100	47.00	
Weeding	No weeding	Treatment of seed with 5 to 10 % of salt solution before sowing seed	100	36.00	
Plant protection measures	No plant protection measures	Attack of Grass hopper, Caterpillar and stem rot was found and accordingly plant protection measures were recommended	83.00	38.00	
No of Cuts	04	06	90.00	60.00	
Fodder	400 qtls/ha	610 qtls /ha	620 qtl	550 qtl	

Table 4. Overall adoption level of improved practices among beneficiaries and non beneficiaries in 2010-11 N= 80

S. No	Adoption Level	Beneficiaries		Non beneficiaries		Total	χ 2
		Number	Percent	Number	Percent		
1.	Low	4	10.00	6	15.00	10	32.00*
2.	Medium	8	20.00	26	65.00	34	
3.	High	28	70.00	8	20.00	36	
		40	100	40	100	80	

Table 5. Increase in area of beneficiaries of berseem cultivation from 2008-09 to 2010-11 n=40

Land Area (Acre)	Area under Berseem (%) before FLD was given (2008-09)	Area under FLD varieties (%) after FLD was given(2010-11)
Less than 1.0	12.00	24.00
1.0 -2.5	20.00	37.00
More than 2.5	16.00	18.00

Table 6. Switch over of non beneficiaries to grow berseem FLD variety n=40

Land Area (Acre)	(2008-09)	(2010-11)
Less than 1.0	5.00	17.00
1.0 -2.5	11.00	25.00
More than 2.5	2.00	9.00

Table 7. Relationship between personal characteristics and adoption of berseem cultivation practices

S.No	Personal characteristics	Correlation "r" value
1	Age	-0.172*
2	Education	0.385*
3	Land holding	0.242*
4	Extension Participation	0.279*
5	Mass media contact	0.371*
6	Risk orientation	0.402*

*Significant at 5% level

Berseem seed crop at flower initiation stage

Impact of integrated nutrient management on crop productivity, soil fertility and economics under a rice – berseem system

S. Karmakar, Rakesh Kumar, B. K. Agrawal and Devkant Prasad

In India about 8.3 million hectares are under forage and it is difficult to expand the area due to increasing demand for food and commercial crops. Growing a legume forage after cereal in rice based cropping systems enhances the total productivity and quality as well as improving soil fertility. Application of chemical fertilizer may increase crop yield substantially but cannot sustain the productivity as well as soil fertility. Therefore, the present situation necessitates the application of integrated nutrient management in rice-berseem system for higher net returns, maintenance of soil health and to meet daily requirements of human and animal population. Thus, not only the number of crops but the type of crops suitable under nutrient management programme is also important. It has been realized that combined application of chemical fertilizers, organic manure and biofertiliser are useful for meeting the economic needs of the farmers as well as for sustainability in term of crop productivity and soil fertility. Inclusion of berseem in the rice- fallow system is compatible and profitable (Shivey and Singh, 2000) and integration of chemical fertilizers along with organic manure and biofertilizers (phosphate solubilising bacteria, blue green algae or rhizobium) are the needs of the day to maintain the soil health and quality of produce (Dutta and Banik, 1992).

Material and methods

The experiment was conducted with transplanted rice in the rainy season and berseem in winter for three years from 2006-07 to 2008-09 at Forage Research Farm, Birsa Agricultural University, Ranchi, Jharkhand, situated at 27 13 N° and 85 19 E° with an average annual rainfall of 1 450 mm. The soil was sandy-loam with pH 6.15, low in organic carbon 3.2 g kg^{-1}, and available N (200 kg ha^{-1}), high in available P (20 kg ha^{-1}) status and medium in available K (154 kg ha^{-1}).

The experiment was laid out with seven treatments and three replications in randomized block. The treatments were T1 - Control, T2 - Recommended dose of chemical fertilizers (RDF), T3 - 50% RDF + 50% N through farmyard manure (FYM), T4 - 50% RDF + 25% N (FYM) + green manuring (GM), T5 - 50% RDF + 25% N (FYM) + GM + biofertilizer (blue green algae for rice and rhizobium for berseem) T6 - 50% N (FYM) + GM + biofertilizer and T7 - 50% N (FYM) + GM + biofertilizer + phosphate solubilising bacteria (PSB). Medium duration transplanted rice variety Lalat (June to October) and Berseem variety Wardan (October to March) were grown in the experiment. The recommended fertilizer dose of 100 kg N, 50 kg P_2O_5 and 30 kg K_2O ha^{-1} for rice and 20 kg N, 80 kg P_2O_5 and 20 kg K_2O ha^{-1} for Berseem were used. FYM was applied as per treatment and incorporated uniformly at 15 days before transplanting (DBT)/ sowing of crops. Green manuring of Crotalaria juncea was done in situ at 15 DBT of rice. Half amount of N as urea with full dose of P as single super phosphate (SSP) and K as muriate of potash (MOP) were applied as a basal dose and remaining N was split twice for rice while for berseem a full dose of NPK was applied at sowing as per treatment schedule. Standard agronomic practices were followed uniformly for all the treatments.

Data on grain and straw yields of rice were recorded. Similarly in berseem, green forage yield at different cuts was recorded and dry forage yield based on moisture content basis and protein yield was computed. Plant samples of rice and berseem were collected, oven dried, powdered and kept for nutrient uptake analysis (N, P and K). Nitrogen content in the plant samples was estimated after digestion in H_2SO_4 in automatic digestion system. Total P and K in the plant samples were estimated after digestion in di-acid mixture using standard methods. Total NPK uptake by each crop and protein yield of berseem were computed. Composite soil samples (0-15 cm) from each plots were collected after final harvest of the system and analysed using standard procedures as described for pH (Jackson, 1973), organic carbon (Walkley and Black, 1934), available N Subbiah and Asija, 1956), available P (Bray and Kurtz, 1945) and available K (Jackson, 1973). Microbial count was also recorded following standard procedure (Oblinger and Koburger, 1975).

Results and discussion

Crop yield

Integrated nutrient management practices (INMP) led to substantial increase in grain and straw yield of rice, green forage yield of Berseem and the system equivalent yield as a whole (Table 1 and Table 2). Combined application of 50% NPK through chemical fertilizers along with 25% N through FYM, green manure and blue green algae (T5) recorded the maximum grain (4.3 t ha^{-1}) and straw (6.0 t ha^{-1}) yield of rice followed by sole application of organic nutrient sources (T7) which was at par with other INM treatments. Such trend was exhibited during all the years except in 2006 where T5, T6 and T7 remained at par among themselves. In winter, the highest green forage yield (64.3 t ha^{-1}) of berseem recorded under combined application of 50% RDF and 50% N supplemented through FYM (T3) followed by T5 treatment (58.2 t ha^{-1}) was at par with the other treatments receiving INMP. The dry forage yield of berseem followed almost a similar trend as green forage yield. The protein yield of berseem also increased under combined application of FYM and CF. Under different INMP the yield of rice and berseem remained significantly higher than that of sole chemical fertilizer application during both the seasons.

In the rice- berseem system, berseem equivalent yield under T3 remained at par with T5 (Table 2). These two treatments recorded significantly higher Berseem equivalent yield as compared to sole application of chemical fertilizers or organic nutrient sources. The increase in yield might be due to effective utilization of nutrients under INM practices due to application of organic materials which acted as the source of slow nitrogen release and the green manure incorporation might have led to better P nutrition (Hundal *et al*, 1988). Organic manures also helped in improving physical, chemical and biological environment of soil and contributed towards higher yield (Singh *et al*, 1997). Sarwad *et al*. (2005) also opined regarding the yield advantage due to the addition of organic manures along with inorganic fertilizers.

Nutrient uptake

Total uptake of N, P and K by rice under the INM practices led to higher nutrient uptake over sole application of CF (Table 3). The N, P and K uptake by rice recorded under the treatment T5 (87.6, 31.7 and 94.2 kg ha^{-1}, respectively) remained at par with T3, and was significantly higher than that under sole chemically fertilized plot and control. The highest grain (4.33 t ha^{-1}) and straw yield (5.99 t ha^{-1}) were observed in T5. This might be due to easy and continuous availability of nutrients throughout the growing period resulting in improvement of physical, chemical and biological properties of soil (Mondal *et al*, 2004).

In general, the total N uptake by berseem was higher (Table 2) than rice, whereas the reverse trend was observed in case of the total P and K removal. The higher N uptake might be due to higher biomass yield and being rich in protein content which ultimately led to higher N removal. The total N uptake was found maximum in T3 treatment i.e, 227.0 kg ha^{-1} which was significantly higher than rest of the treatments except T5 where they remained at par. The total P and K uptake followed almost same pattern as found in the N uptake by berseem. Similar findings were reported earlier by Bhandari *et al*. (1992) and Sarwad *et al.* (2005).

Total N, P and K uptake by rice- berseem system under INM treated plot significantly increased under T3 and T5 treatments indicating better nutrient utilization under INM treatment combinations. Increase in the nutrient uptake from combined fertilizer application might be due to increased supply of nutrient through organic and inorganic sources and indirectly through minimizing the loss of nutrients from soil (Bindra and Thakur, 1996).

Nutrient use efficiency

Table 4 revealed that the combined application of 50% RDF and 50% N (FYM) recorded the highest N use efficiency which might be due to minimization of nutrient losses and steady supply of optimum nutrients throughout the crop growth period. The maximum P-use efficiency was recorded when phosphate solubilising bacteria was applied with organic nutrient sources. Congenial atmosphere was created for the bacteria under organic nutrient sources which increased P availability by reduction of P-fixation in acidic soil condition and this might have increased P-uptake and thereby increasing P-use efficiency. However, reasonable increase in N, P and K use efficiency was observed under T3 and T5. The saving of chemical fertilizers under these two treatments was to the extent of 60 kg N, 65 kg P_2O_5 and 25 kg K_2O ha^{-1} without impairing the crop yield and soil productivity in rice-Berseem system.

Soil fertility status

Analysis of Physico-chemical and biological properties of soil after 3 years of experimentation clearly indicated the effect of different treatment combinations on soil chemical properties (Table 5). The application of 50% RDF, 25% N through FYM, green manure and blue green algae (T5) increased the organic carbon, available N, P and K of soil. The highest values of available N (254.0 kg ha^{-1}), P (25.8 kg ha^{-1}) and K (159.0 kg ha^{-1}) were recorded in T5. There was not much variation in soil pH among treatments except in the chemically fertilized plot where a decrease in soil pH by 0.4 units from initial pH of 6.2 was noted. Available N, P and K content of soil increased in all treated plots which received nutrients through inorganic or combined sources as compared to their initial status. Such improvement in soil physico-chemical properties under integrated fertilizations might be due to minimization of nutrient losses and increased growth of the plant resulted in higher root biomass and its recycling. Similar effect of integrated nutrient management on soil properties was reported earlier by Sarwad et al. (2005).

The organic carbon content was found higher in INM treated plot as compared to control and chemically fertilized plot. The organic carbon was found maximum in T7 (5.1 g kg^{-1}) and lowest in control (3.5 g kg^{-1}). Population of bacteria and fungi also increased under combined application of nutrient sources. The increase in organic carbon content and microbial activity under INM treated plots indicated improvement of soil health which is important for maintaining sustainability of the system. The increased organic carbon content under INM treated plots might be due to incorporation of the organic manure and higher root biomass production in both the seasons which led to addition of more biomass to the soil. The findings are in agreement with the findings of Bindra and Thakur (1996).

Economics

Table 6 revealed that treatment T3 (50% RDF + 50% N FYM) recorded highest net return (Rs 136418 ha^{-1} yr^{-1}: US$ = Rs 59.7 in June 2013) followed by T5 (Rs 134460 ha^{-1} yr^{-1}). Combined application of nutrients from organic and inorganic sources received a higher benefit-cost ratio which ranged from 4.29 to 4.54 as compared to chemical fertilizations (4.09) and sole application of organic nutrient sources (3.37 to 3.65) indicating advantage of the INM over the sole inorganic or organic nutrient management practices. Thus, the combined application of 50% RDF + 50% N supplemented by FYM or 50 % RDF + 25% N (FYM) + GM + biofertilizer may be a suitable combination for receiving higher and sustained food- forage productivity, maintaining soil health with economic feasibility in plateau region of Jharkhand. Such integrated fertilization system can also be effective in saving chemical fertilizers to the extent of 60 kg N, 65 kg P_2O_5 and 25 kg K_2O ha^{-1} in rice-berseem system.

Table 1. Effect of integrated nutrient management on yield (t ha^{-1}) of rice

Treatments	2006		2007		2008		Pooled	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T1- Control	1.94	2.64	1.87	2.93	1.69	2.74	1.84	2.77
T2 – 100% NPK (RDF)	3.59	4.69	3.49	5.02	3.82	6.03	3.63	5.25
T3 – 50% RDF + 50% N (FYM)	3.42	4.11	3.80	5.18	4.04	5.98	3.75	5.09
T4 - 50% RDF + 25% N (FYM)+ GM	3.91	5.12	3.98	5.65	4.22	6.27	4.04	5.68
T5 - 50% RDF + 25% N (FYM) + GM + BGA	4.49	5.37	4.12	6.21	4.37	6.38	4.33	5.99
T6 - 50% N (FYM)+ GM + BGA	4.12	4.48	3.66	4.92	3.60	5.54	3.80	4.98
T7 - 50% N (FYM)+GM + BGA + PSB	4.23	4.52	3.74	5.42	3.78	5.69	3.91	5.22
C.D (P = 0.05)	0.47	0.71	0.39	0.82	0.42	0.70	0.41	0.79

RDF: Recommended fertilizer dose (100 kg N, 50 kg P_2O_5 and 30 kg K_2O ha^{-1} for rice and 20 kg N, 80 kg P_2O_5 and 20 kg K_2O ha^{-1} for berseem), FYM: Farmyard manure, GM: Green manuring, BGA: Blue green algae and PSB: Phosphate solubilising bacteria

Table 2. Effect of INM on yield (t ha^{-1}) of berseem (green forage) and rice-berseem system (berseem equivalent yield)

Treatments	Berseem Rice			-		berseem system		
	2006-07	2007-08	2008-09	Pooled	2006-07	2007-08	2008-09	Pooled
T1- Control	35.5	32.1	23.6	30.4	42.7	38.9	30.3	37.4
T2 – 100% NPK (RDF)	56.4	64.6	46.2	55.8	69.5	77.5	61.0	69.4
T3 – 50% RDF + 50% N (FYM)	64.3	78.6	61.4	68.1	76.5	92.7	76.8	82.0
T4 - 50% RDF + 25% N (FYM)+ GM	58.6	70.7	59.3	62.9	72.9	85.6	75.3	77.9
T5 - 50% RDF + 25% N (FYM)+GM+BGA	58.2	74.7	64.0	65.6	74.2	90.4	80.5	81.7
T6 - 50% N (FYM)+ GM + BGA	53.9	60.4	48.2	54.2	68.2	73.9	62.0	68.0
T7 - 50% N (FYM)+GM + BGA + PSB	56.4	64.8	53.9	58.4	71.2	78.9	68.4	72.8
C.D (P = 0.05)	5.8	7.4	3.7	5.5	10.2	12.5	5.9	7.5

RDF: Recommended fertilizer dose (100 kg N, 50 kg P_2O_5 and 30 kg K_2O ha^{-1} for rice and 20 kg N, 80 kg P_2O_5 and 20 kg K_2O ha^{-1} for berseem), FYM: Farmyard manure, GM: Green manuring, BGA: Blue green algae and PSB: Phosphate solubilising bacteria.

Table 3 Effect of INM on NPK (kg ha^{-1}) uptake by rice, berseem and rice-berseem system (pooled over three years)

Treatments	Rice			Berseem			berseem system		
	N	P	K	N	P	K	N	P	K
T1- Control	33.2	12.0	39.9	110.6	7.7	29.6	143.7	20.5	70.4
T2 – 100% NPK (RDF)	72.2	24.6	80.6	206.0	18.2	52.0	278.2	44.1	129.9
T3 – 50% RDF + 50% N (FYM)	84.4	27.6	88.4	270.0	21.9	72.9	354.3	51.3	161.3
T4 - 50% RDF + 25% N (FYM)+ GM	82.6	24.3	87.8	221.4	17.9	63.7	304.0	44.0	151.5
T5 - 50% RDF + 25% N (FYM)+GM+BGA	87.6	31.7	94.2	233.6	22.1	68.0	321.2	55.7	158.5
T6 - 50% N (FYM)+ GM + BGA	71.7	23.2	77.9	202.0	17.6	57.4	273.7	42.4	133.3
T7 - 50% N (FYM)+GM + BGA + PSB	76.4	25.1	76.5	219.4	21.0	65.5	295.8	48.2	141.7
C.D (P = 0.05)	10.2	2.2	8.6	25.6	2.1	9.6	34.7	3.5	14.4

RDF: Recommended fertilizer dose (100 kg N, 50 kg P_2O_5 and 30 kg K_2O ha^{-1} for rice and 20 kg N, 80 kg P_2O_5 and 20 kg K_2O ha^{-1} for berseem), FYM: Farmyard manure, GM: Green manuring, BGA: Blue green algae and PSB: Phosphate solubilising bacteria.

Table 4. Effect of INM on nutrient use efficiency (%) and saving of chemical fertilizers (kg ha^{-1}) under rice-berseem system

Treatments	Nutrient use efficiency			Saving of chemical fertilizers		
	N	P	K	N	P_2O_5	K_2O
T1- Control	-	-	-	-	-	-
T2 – 100% NPK (RDF)	112.1	18.2	119.0	-	-	-
T3 – 50% RDF + 50% N (FYM)	175.5	31.2	94.7	60	65	25
T4 - 50% RDF + 25% N (FYM)+ GM	93.7	23.3	96.5	60	65	25
T5 - 50% RDF + 25% N (FYM)+GM+BGA	103.8	34.9	104.9	60	65	25
T6 - 50% N (FYM)+ GM + BGA	92.2	41.6	64.2	120	130	50
T7 - 50% N (FYM)+GM + BGA + PSB	107.9	52.6	72.8	120	130	50

RDF: Recommended fertilizer dose (100 kg N, 50 kg P_2O_5 and 30 kg K_2O ha^{-1} for rice and 20 kg N, 80 kg P_2O_5 and 20 kg K_2O ha^{-1} for berseem), FYM: Farmyard manure, GM: Green manuring, BGA: Blue green algae and PSB: Phosphate solubilising bacteria.

Table 5. Effect of INM on soil fertility status and microbial population after completion of three crop-cycles

Treatments	pH	Organic C (g kg^{-1})	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})	Bacteria (x 106 g^{-1} soil)	Fungi (x 104 g^{-1} soil)
T1- Control	6.1	3.5	216	18.32	141.4	82.5	45.6
T2 – 100% NPK (RDF)	5.8	3.8	234	24.72	166.0	89.6	44.7
T3 – 50% RDF +50% N (FYM)	6.2	4.5	241	24.52	162.6	111.9	55.1
T4 - 50% RDF + 25% N (FYM)+ GM	5.9	4.7	245	23.84	164.2	116.5	59.2
T5 - 50% RDF + 25% N (FYM)+GM+BGA	6.2	4.9	251	25.48	161.8	89.6	45.6
T6 - 50% N (FYM)+ GM + BGA	6.1	4.8	249	24.91	157.1	150.1	73.3
T7 - 50% N (FYM)+GM + BGA + PSB	6.4	5.1	255	26.51	158.4	145.9	50.1
Initial	6.2	3.2	200	20.0	154.0	78.6	39.2

RDF: recommended fertilizer dose (100 kg N, 50 kg P_2O_5 and 30 kg K_2O ha^{-1} for rice and 20 kg N, 80 kg P_2O_5 and 20 kg K_2O ha^{-1} for berseem), FYM: Farmyard manure, GM: Green manuring, BGA: Blue green algae and PSB: Phosphate solubilising bacteria

Table 6. Effect of integrated plant nutrient management on economic return of rice (pooled over three years)

Treatments	Economic return (Rs ha^{-1} yr^{-1})			
	Gross return	Cost of cultivation	Net return	B:C ratio
T1- Control	76120	21304	54816	2.57
T2 – 100% NPK (RDF)	141346	27782	113564	4.09
T3 – 50% RDF + 50% N (FYM)	166461	30043	136418	4.54
T4 - 50% RDF + 25% N (FYM)+ GM	158497	29563	128934	4.36
T5 - 50% RDF + 25% N (FYM)+GM+BGA	165819	31359	134460	4.29
T6 - 50% N (FYM)+ GM + BGA	138207	31620	106587	3.37
T7 - 50% N (FYM)+GM + BGA + PSB	147970	31826	116144	3.65
C.D (P = 0.05)	17374	-	7252	-

RDF: Recommended fertilizer dose (100 kg N, 50 kg P_2O_5 and 30 kg K_2O ha^{-1} for rice and 20 kg N, 80 kg P_2O_5 and 20 kg K_2O ha^{-1} for berseem), FYM: Farmyard manure, GM: Green manuring, BGA: Blue green algae and PSB: Phosphate solubilising bacteria

Berseem production in India and its impact on livestock production

Bimal Misri

Berseem (*Trifolium alexandrinum*) has become a king of crops in India, particularly, in north India - the food bowl of the country - where it is now cultivated on an estimated 2 000 000 hectares. A common belief is that the Egyptian cultivars Mescavi and Fahl were introduced to India in 1903-4 but older farmers of Punjab, particularly, ones living near the Pakistan border insist that this crop was grown even earlier. Egypt and India had very old trade relations and traders from Sindh and Punjab are believed to have brought the seeds from Egypt to India. The crop remained confined to the northern parts of the country till a few years ago but has gradually spread up to central and western parts and become the commonest rabi (winter) fodder of these areas. The major trait of the crop, its potential to increase milk production in cattle and buffaloes has made it the first choice of the farmers. Because of its high nutritive value, farmers have devised their own methodologies to replace concentrate feeding by berseem. Small farmers in Himachal Pradesh grow very small areas because of land constraint and feed it to only lactating animals to save the cost on concentrate feeding. This cool season fodder is now widely spread in the Mediterranean and other regions and has truly become a global fodder. The multiple cuts (4-8), up to 20 percent protein availability, 60-70 percent digestibility of the fodder and high nitrogen fixation are the major factors which have led to its great acceptability by Indian farmers. Its cultivation is increasing day by day which is evident from the huge quantities of seed which are imported from Egypt

The crop and its management

Berseem requires a dry, cool climate. Mild temperatures are essential for germination and subsequent growth and establishment. The best temperature for sowing should be 13-15.5 °C. Optimum growth can be achieved between 18-21°C. However, some cultivars like BL-22 and BL-42 provide green fodder up to mid June in India when the temperature is around 40°C. This crop is generally suited to areas below 1 700 m altitude though the best growth is limited only up to an altitude of 1 100 m. Above this growth remains slow and dormant in winter and it picks up in spring only. It grows very well in medium to heavy soils and is fairly tolerant of alkalinity. The land has to be ploughed thoroughly 2-3 times and then planked to make it uniform. Best production figures have been achieved by basal application of 25 kg N+ 60 kg P_2O_5+ 50 cart loads of FYM/ha. Sowing time varies from place to place but generally coincides with the rice harvest. It is only in the hilly regions where the sowing date gets delayed considerably and at times the sowing is done in November-December. In plains the crop, is generally, sown between September-October. It is recommended that the seeds should be inoculated with Rhizobium trifolii, rhizobium culture. But farmers rarely use rhizobium since its availability is not easy and assured in rural and far flung areas. However, work on this aspect suggests that the rhizobium inoculated seeds produce 36-39 percent more fodder. Before sowing, well prepared fields are irrigated and a layer of standing water is retained in the plots. Seeds at 20-25 kg/ha are broadcast over this layer of water. Some farmers soak the seeds in water overnight and mix these with sand, for easy handling. Farmers in the northern areas have evolved many interesting crop combinations in case of berseem and all these combinations provide considerable increase in initial biomass availability. In Punjab the most common combination is berseem+ mustard but, of late, this is being replaced by berseem + Lolium multiflorum, though this combination is the best, seeds of Lolium are not easily available. Some farmers use oats as a combination. In central India chicory is the main, inadvertent, crop combination. Even if the purest seeds are used the fields get infested with chicory and the farmers feed it to the animals.

There are numerous findings on every aspect of this crop's cultivation but farmers have devised their own regimes and systems based on resource availability, local climatic conditions and their convenience. The recommended regime for irrigation is to provide first irrigation after seedling emergence and subsequent irrigations after 15-20 days depending on weather conditions. Farmers in hilly regions may irrigate their crop even after a gap of 40-50 days. However, for better production regular irrigation is essential. It is recommended that the first cut should be taken after 40-60 days of sowing and subsequent cuts may be taken at an interval of 25-30 days. But this also varies from place to place and farmer to farmer. The farmers have very efficiently combined the recommendations of researchers and their own experiences to achieve optimum production from the crop

This crop has achieved so much value for farmers that in some areas it is grown purely as a cash crop with immediate returns to farmers. In some areas of Jammu, Punjab and Haryana that large farmers cultivate the crop on large areas and sell it before the first cut. Sale is by unit area. For example, in Jammu a kanal of land with berseem will be sold. Kanal is the local unit of land measurement and it comprise of 5 400 sq. ft. The buyer harvests all the crop and use it for animal rearing. Some buyers have opened shops in periurban areas to sell berseem fodder. They have a chaff cutter and sell chaffed fodder by weight. Stem rot and root rot are two main diseases which afflict the crop.

Berseem and the Indian perspective

Berseem cultivation has greatly boosted livestock economy in India. Berseem is supplemented by kharif (summer) fodders, concentrates, optimum use of grazing and tree fodder. Establishment of milk co-operatives has greatly enhanced milk production and India continues to be the largest milk producing country in the World. There has been an increase of 13.6 percent area under non-food crop cultivation till 2003-2006 and most of the area is cultivated under fodders (Bhalla and Singh, 2010). In spite of the increase in area under fodder, the national fodder budget suggests a heavy imbalance (Table 1) and shortages in supply of green and dry fodder are increasing every year (ICAR, 2010). This imbalance is complementary with the increase in livestock numbers.

Berseem, the most suitable fodder for many Indian conditions, offers a great relief to Indian farmers, dairy-men and planning personnel and its cultivation is increasing regularly. Extensive R&D initiatives have been initiated in by various institutions and agricultural universities to develop area specific and national varieties and suitable package and practices. These efforts have already resulted in the release of varieties and regional packages of practices and these are helping farmers a great deal in solving problems of fodder shortages.

Table 1. Supply and demand scenario of fodder in India (million tonnes)

Year	Supply	Demand	Deficit	Supply	Demand	Deficit
	Dry	Green	Dry	Green	Dry	Green
1995	105	379.3	421	947	528	588
2000	121	384.5	428	999	549	604
2005	126	399.9	443	1025	569	635
2010	138	395.2	451	1061	589	666
2015	143	400.6	466	1097	609	696
2020	157	405.9	473	1134	630	728
2025	162	411.3	488	1170	650	759

The ever innovative Indian farmer is finding absolutely new areas for berseem cultivation without damaging his earnings in other pursuits. Farmers in Punjab have started growing this crop under Mango orchards. They have changed the irrigation schedules and brought irrigation to minimum. They believe that both mango and berseem are early summer crops so both should complement growth of each other. The shade of mango plantations conserves soil moisture which helps berseem which adds nitrogen to the soil for the mango crop. Similarly, farmers have sown berseem in the interspaces of Poplar plantations which have become very popular in Punjab and Haryana. Farmers in these plantations irrigate on the basis of their visual assessment of Berseem. If they feel that the crop might dry up, they irrigate otherwise they use very little irrigation, say, only 3-4 times instead of 6-8 times.

Research and development initiatives

India's National Agricultural Research System (NARS) comprise various institutes, national centres, central agricultural universities, state agricultural universities (largely funded by central Govt), all India co-ordinated projects, Krishi Vigyan Kendras (KVK, Agricultural Science Centres) are located in each district of the country and some affiliates. Each KVK has a toll free telephone number on which farmers can approach for advice. Similarly there are national toll free numbers available 24x7 to farmers for advice. This system is the backbone of the strides made in Indian agriculture. The NARS institutions are spread throughout the country which makes the job of identifying regional researchable issues easy. Forage crops, particularly, berseem, are no exception. However, Indian Grassland and Fodder Research Institute, Jhansi; Panjab Agricultural University, Haryana Agricultural University, Hissar and Jawahar Lal Nehru Krishi Vishwavidyalaya have emerged as the most advanced centres of research on berseem. Studies on different aspects in India have led to formulation of package of practices which are, generally, as follows:

Cultivation

Best soil for cultivation:	Loam to clay loam
Sowing time:	Mid October to Mid November
Manure	10-20 t FYM/ha
Seed rate:	20-25 kg/ha
Basal fertilization:	20-25 kg N + 60-80 kg P_2O_5
Inoc ulation of seed with Rhizobium trifollii	
Irrigation:	Essentially one after every cut, more on demand
Harvest:	40-45 days after sowing
Number of cuts available:	6-8

Disease and Pest management:

Stem rot: Spray with 0.1 percent solution of Bavistine twice during January and February at 15 days interval. Avoid frequent irrigation

Root rot: Seed needs to be treated with Thiram, Bavistin Carbofuran @ 2.5g/ kg.

Semilooper: Malathion or Endosulfan spray @ 0.75 %

Nematodes : Seed treatment with Carbofuran @ 2.5g/kg

The on-going initiatives and future thrust areas in case of berseem have been profiled elaborately by Malaviya *et al* (2010). According to them thrust areas of research are as follows:

- Germplasm collection from the area of origin and diversity like Egypt, Turkey, Iran, Iraq etc.
- Transfer of biotic and abiotic stress traits from wild taxa.
- Use of modern techniques like embryo rescue and tissue culture for generating variability and transfer of desirable traits.
- Breeding/screening for disease resistance, especially, stem and root rot
- Identification of long duration lines which have fast regeneration capacity.
- Identification/development of lines producing high dry matter in early cuts.
- Extending the crop to areas where it is not now cultivated.

The IGFRI (Indian Grassland and Fodder Research Institute) group has undertaken extensive studies on the genetic aspects of the crop for developing desirable varieties. 526 germplasm lines have been evaluated and a descriptor has already been published (Roy *et al,* 2009). This germplasm is being maintained at IGFRI and the gene bank of National Bureau of Plant Genetic Resources. Detailed studies on biochemical characterization of 25 related species and 65 accessions of berseem have been undertaken. Cytological studies on hybrid progenies and pollination behaviour have been completed. The crop has shown wide diversity for self fertility and self pollination, self compatibility requiring tripping, self incompatibility with broad genetic base and self incompatibility with narrow genetic base (Malavaya *et al* 2010). In vitro regeneration among 6 species of *Trifolium*, in vitro screening of ecotypes of Berseem for Salinity and alkalinity tolerance and development of three interspecific hybrids with berseem as female parent and three other species of *Trifolium* using embryo rescue technique have been developed. The R&D initiatives undertaken by various institutions have resulted in the development of various new varieties whose details are presented in Table 2.

Table 2. Various varieties of Berseem developed and released in India		
Variety	Year of Release	Agency
Mescavi	1975	CCS HAU, Hissar
BL-1	1980	PAU, Ludhiana
Wardan	1981	IGFRI, Jhansi
JB-1	1981	JNKVV, Jabalpur
JB-2	1982	JNKVV, Jabalpur
JB-3	1983	JNKVV, Jabalpur
BL-22	1987	PAU, Ludhiana
UPB-110	1993	GBPUA&T, Pantnagar
Bundel Berseem-2	1997	IGFRI, Jhansi
Bundel Berseem	2000	IGFRI, Jhansi
BL-42	2003	PAU, Ludhiana
HFB-600	2004	CCS HAU, Hissar
BL-180	2006	PAU, Ludhiana
Hisar Berseem	2006	CCS HAU, Hissar

Conclusion

Berseem is one of the most important crops in Indian agriculture. It has very positively helped small farmers to improve their livelihood and medium and large farmers have immensely benefitted by economic gains both by selling fodder or milk. R&D organizations have equally put in their efforts to develop high producing varieties and appropriate cultivation technologies. Consequently it is spread over an estimated area of 2 000 000 hectares (Malaviya *et al*, 2010). During 1950-51 the total milk production of India was 17.0 mt and per capita availability of milk per day was 130 gm. This has risen to total production of 116.2 mt and the per capita per day availability of 263 gm during 2011 (NDDB, 2011). Dairy co-operatives alone collected 9.6 million tones of milk during this year and India has retained its global position at number one in milk production. Berseem, it seems, has had a great bearing upon this achievement. Ever since its introduction in India, its seeds are imported from Egypt in large quantities. Some seed was and is being produced in India as well but this is not so well organized. The area under its cultivation has been increasing at an appreciable scale. During 2008, the Exim (export and import) committee of Government of India received 36 proposals to permit import of 24,756 t of berseem seed. The committee permitted import of only 1800 t.(G.O.I, 2008). The next year the committee was approached for import of 25,496 t of seeds and the import was allowed for the entire quantity (G.O.I, 2009).This, amply suggests that area under Berseem is increasing substantially in India and this crop has played a major role in sustaining the milk economy of the country.

IRAN

Forage in Iran with particular reference to berseem

Azizallah Shabani and Asadallah Sarshad

Agriculture has a long, traditional history in Iran going back 10,000 years. The goat was first domesticated on the Iranian plateau about 10,000 years back. This ancient agriculture continued evolving and as early as the seventh century the windmill was invented and put into use in Persia. Qanat, a subterranean aqueduct for irrigation was one of the greatest achievements of Persia's innovative farmers; these were in use millennia ago and are still used. Tulips, peach and spinach are significant contributions to world agriculture developed in Iran. Despite ecological factors never having been farmer and farming friendly, agriculture has made great strides in Iran. According to estimates one-third of Iran's surface area is suited for farming but, because of poor soils and lack of adequate irrigation facilities, only 12 percent is under cultivation. Western and north-western areas have very fertile soils. Both irrigated and rain-fed agriculture are practiced. The irrigated area is about 50.45 percent while the rain-fed area is spread over 49.55 percent.

Agriculture is a major economic sector with great potential for development and is a key strategic policy area. It contributes more than 25% of GDP and one-third of total employment. It also earns one-third of the total non-oil export revenue. The country has an arid and semi-arid climate except for Caspian Sea regions. The average precipitation is about one third compared to global precipitation. Sometimes the difference between the warmest and the coldest places is greater than 50 °C. Annual rainfall is low and rarely exceeds 250 mm. The spread of rainfall is not conducive to farming as only 25% falls during the cropping season. The evaporation rate is three times the global average.

Livestock and livestock production

Livestock is an important and essential component of farming systems. More than half of the rural population depends, at least partially, on livestock for livelihood. Livestock rearing can be the sole pursuit or an additional activity for extra cash generation. However, this activity plays a key role in the lives of rural people and generates about 80 percent of their cash income (Table -1) Animals are reared under three well established systems:

1. Migratory
2. Semi-migratory
3. Non-migratory (sedentary)

Under migratory systems, sheep and goat herds are taken, seasonally, to places where grazing is available, by transhumant herders. These herders are well trained in animal husbandry practices because of the experience gained through generations. However, forage on these well established and recognized transhumant routes is not always plentiful and acute shortages of herbage are very common. In the semi-migratory system herders are stationary and live at one place. Their livestock is taken seasonally for grazing to nearby areas and brought back at the end of the grazing season. In sedentary livestock rearing the animals get a little or no grazing and are fed cultivated green or dry fodder along with concentrates.

Table 1. Livestock production in Iran

Production	2002	2004	2006	2009	2011	Annual Growth (%)
Milk	5877	6720	7749	9556	10600	7.62
Red Meat	741.6	874.9	838.1	922	968	3.28
Poultry Meat	941.5	1171	1360	1605	1690	7.58
Eggs	547.03	645	676	789	790	4.7

Sheep and goats combined form the bulk of the livestock population, sheep being higher in numbers. The other components are cattle, buffalos, camels and others like horses etc. livestock numbers are presented in Table 2.

Table 2. Livestock population (1,000) in Iran during 2002-11

Species	Years				
	2002	2004	2006	20011	Annual Growth
Sheep	51701	52115	52271	51958	0.062
Goats	25551	25656	25883	25679	0.066
Cattle (PE)1	683	753	830	1009	4.99
Cattle (CB)2	2525	2839	3438	4690	8.59
Cattle (LB)3	4337	4039	3624	2711	-4.29
Buffalo	383	402	424	473	2.67
Camel	147	150	152	155	0.66
Other	1727	1727	1551	1817	0.054

1) PE=Pure Exotic, 2)Crossbreds, 3) Local Breeds

Poultry is very well developed in Iran and during 2010, a total of 1,600,000 t of poultry meat was produced in the country. The present poultry status of the country is presented in Table 3.

Table 3. Status of poultry sector

Category	Unit	Capacity (1000)	Remarks
Broiler	17814	301000	5.1/annum
Broiler breeder	583	21556	per 18 month
Layer	1483	73000	per 2 years
Pullet	207	14000	6 month
Layer breeder	19	1256	per 18 month
Broiler grand parents	12	500	per 18 month
Layer grand parents	1	10	per 18 month
Line	1	20	per 18 month

Feed supply, so important to maintain livestock production, is the major bottleneck. In spite of local production of feed, large quantities of feed grain are imported. About 60 % of the feed requirement is met by imports. Important feed resources are presented in Table 4 and Table 5

Table 4. Major Resources of Poultry Feeds in 2011 (1000 Ton)

Feed Sources	Domestic	Import	Total
Maize	2900	3324	6224
Soy Meal	194	1939	2133
Fish Meal	35	76	111
Others	135	-	135
Total	3264	5339	8603

Table 5. Major Resources of Ruminants feed (air dried, million Tons)			
Feed sources	Required	Consumed	Difference
Pastures	13.01 (allowed)	17.0	+4 (low quality)
Straw	9.78	15.0	+5.22 (low quality)
Forages	18.06	15.2	-3.04 (high quality)
Other resources	23.50	21.2	-2.3 (high quality)
Total	64.4	68.4	+4 (low quality)

Role and history of berseem clover introduction in Iran

Trifolium alexandrinum seeds were first imported by the Organization of the Jungles and Pastures in 1963 and sown in the north of Iran. The first studies on berseem introduction was at Amol's Rice Research Center. The initial introduction showed very encouraging results and detailed studies began during 1969-70. Berseem was successfully grown as a crop alternating with rice. *TrIfolium alexandrinum* grew well in north of Iran and the climate was found suitable for its cultivation. Berseem sown as the second crop after rice was found to be a profitable proposition. The crop played a significant role in reducing pest infestations of Chilo supperssalis from rice fields. As a result the area under its cultivation was increased. After a number of harvests it was found that berseem with its copious growth can be used as an obstacle to the growth of weed in rice fields which assured better rice crop in rotation. This crop was found to contain remarkably high and balanced nutritional value and did not differ much from lucerne. Nitrogen fixation by this plant provided half of the required nitrogen by productive and high N demanding varieties of rice. It was calculated that one season crop of berseem can fix about 80-200 kg/ha. The incorporation of berseem in the soil leads to increase in the level of soil humus and it improved the physical, chemical and biological status of the soils.

Research on berseem

Research on berseem in Iran indicated that the area under its cultivation has increased many fold in the north and it has become second most important crop after rice. Chemical analysis of its forage amply exhibit its high nutritive value, particularly protein. Feeding this herbage could compensate for concentrate feeding. This could also reduce the shortages of the fodder.

Berseem is now commonly grown in Golestan, Mazandaran, Gilan and Khuzestan provinces. An investigation in south of the country revealed that the herbage contains 18.8% and 0.24% crude protein in green and dry forage respectively. It was further revealed that crude protein content of berseem is more than alfalfa and it could be used as poultry feed as well. The comparison in nutritive value of berseem and alfalfa is given in Table 6.

Table 6. Chemical Composition of Berseem and alfalfa						
Feed	CP %	Crude fat %	CF %	Energy Kcal/kg	Ca%	P%
Berseem	22.4	2	21.3	4159	1.72	.34
Alfalfa	16.5	1.2	31.1	4230	1.23	.24

In a feeding trial on broilers with berseem and alfalfa 900 Aryan broiler chicks were distributed into 36 groups and fed diets containing 0, 1, 2, 3 and 4 percent of berseem and alfalfa meal. Performance parameters were recorded at starter (2 weeks), grower (3 weeks) and finishers (2 weeks). At the starter period body weight gain (g/chick/day) as compared to control was significantly higher (<0.05) and the feed contained 3 and 4 % of alfalfa meal. At the finishing period, the diets containing berseem meal resulted in higher performance (<0.05) as compared to the control. Feed intake did not vary significantly among the different diet groups excepting the diet containing 2% alfalfa meal and its intake was significantly higher ($p<0.05$) as compared to control. The alfalfa intake was 89.4 g as compared to control in which case it was only 82 g. However, berseem meal up to 3% of the diet resulted in a significant ($p<0.05$) of the feed intake as compared to the alfalfa contained diets.

Addition of 1, 2 and 3 percent of alfalfa or 1 to 2 % of berseem significantly improved ($p<0.05$) the feed efficiency when compared to the control diet. Economically no differences were observed among different diets with the exception of 1% berseem added diet which was more profitable than others. It can be concluded that alfalfa or Berseem meal (up to 4%) may be used but using a diet with only 1% of Berseem addition could be more economical.

The major benefits of berseem cultivation in Iran are summarized below

- Significant soil improvement takes place;
- There is a significant increment in humus and organic matter content of the soil;
- Nitrogen levels in soil increased significantly;
- There was a significant reduction in chemical nitrogen application;
- The next rotating crop of rice gave higher yields;
- Pests like Chilo supperssalis reduced significantly;
- The cost of cultivation and labour input decreased significantly ;
- Very high and frequent irrigation was not required ;
- Agricultural income and employment generation increased;
- The seasonal unemployment of rural people decreased;
- Very high quantities of forage were harvested ;
- The forage produced was equivalent to alfalfa forage ;
- An increment in livestock numbers took place ;
- Rice fields were more efficiently utilized ;
- Land preparation in advance could be avoided ;

Recommendations

1. Increase in berseem cultivation, a favourable crop highly recommended for Iran ;
2. A consortium on berseem should be established in middle and near-east countries;
3. More investigations and extension activities should be carried out.

Figure 1. A Berseem field

Figure 2. Sheep grazing on a productive pasture

Figure 3. Cattle grazing in an improved pasture

Figure 4. Cattle being stall fed on berseem forage

NEPAL

Berseem (*Trifolium alexandrinum*) seed production in Nepal

Rameshwar Singh Pande.

Nepal had no tradition of fodder cultivation; livestock were reared on grazing, crop residues and tree fodder. The increase in human population raised the demand for livestock products and the imbalance in demand and supply of fodder started telling upon the agricultural scenario and the economy. Land constraint initially did not permit farmers to grow fodder in their crop lands but eventually they understood the importance of fodder but there were no technologies available. Planners took this challenge seriously and a preliminary study was undertaken by FAO in 1952. This study was on various aspects of livestock rearing and dairying especially to meet the increasing demand of milk and milk products. Consequent on the recommendation of FAO, serious efforts on fodder production started and farmers in the Terai (foot hills) and the hills realized the importance of fodder and began stall feeding instead of open and indiscriminate grazing (Pande, Shrestha and Pradhan, 1994). Since 1970 efforts on fodder production were further strengthened and many productive forage species like oats, berseem, stylo and molasses grass etc, were introduced successfully (Pande 1994). In 1980 a livestock development project was initiated in two phases under a loan secured from the Asian Development Bank. Fodders like berseem oats, stylo, kudzu, desmodium etc, were popularized in different eco- zones (Pande 1994). Livestock development farms were established at Pokhara, Chitlang, JiIri, Jumla, Panchasa, Ykhola where feed and fodder activities were also started.

Berseem of all introduced forages became most popular with farmers because of its high nutritive value, multicut regime and ease of cultivation. The demand for berseem seed increased manifold and some had to be imported from Australia, New Zealand, India and Bhutan. Seed production of forages, especially, berseem was initiated by involving local farmers and became quite popular. Though most popular in the Terai, berseem is now cultivated extensively from Jhapaq district in the east to Kanchanpur in West; it is grown extensively in the hills as well. Seed production efforts are now showing results and a reasonable quantity of seed, especially, berseem is being produced locally. This paper aims to enumerate efforts put into berseem seed production.

Berseem in Nepal

Berseem is believed to be introduced from India by rich farmers of Janakpur around 1985. The livestock development project changed the situation; research and extension activities amply demonstrated the benefits of farm cultivation and farmers agreed to grow it and eventually even produced seed. The project introduced 10 cultivars which were tested at Janakpuri and elsewhere. Details of these cultivars are presented in Table 1.

Table 1. Berseem cultivars introduced and evaluated in Nepal

Cultivar	Origin
Giza	Egypt
Giza-10	Egypt
Giza-15	Egypt
Sakha 3	Egypt
Synthetic var-79	Egypt
Mewcawi	Australia
Wardan	India
UPB-103	India
BL-22	India
Local genotype	India

Of the cultivars evaluated Mescawi was the best since it produced 134 t ha (green fodder and its seed production was 240-783 kg/ ha (Khatri, 1989). Besides providing forage in winter, when nothing grows in hills, berseem enhanced subsequent paddy production at Janakpur and other farms. Farmers were more than happy to grow it.

Research on berseem

Extensive studies have been undertaken and continue at Janakpur, Pokhara, Ganghat, Tarahara and Dhankutta. Results are summarized below:

Methods of cultivation

Different methods of growing berseem have been studied such as: broadcasting on cultivated land, line sowing in the cultivated land, and relay cropping with rice (broadcasting in standing paddy without tilling the land).

At Janakpur farms line sowing gave higher yield but the difference was not significant. Fodder yields were 134, 110 and 107 t/ha and seed yield was 414, 370, and 240 kg /ha respectively in the above treatments. The seed rate in all cases was 21 kg /ha and fertilizer application was N: P: K @ 90:60:0 kg/ ha. Berseem as a relay crop with rice is quite popular. In this method, berseem is sown into standing paddy 2-3 weeks before harvest. As a leguminous crop, it does not require high doses of nitrogen fertilizer for normal production. However, for better production, a normal dose of phosphate fertilizer is recommended. The usual practices of fertilization are 15-20 kg of N and 60 kg P_2O_5/ha for better fodder and seed production. Various researchers have studied the response to fertilizer on fodder and seed yield of berseem like Khatri, (1989) and Pradhan and Silwal (1989). In normal Nepalese conditions, 12-15 irrigation may be required for the entire crop duration. Irrigation should be given at 15-20 days intervals. Seed production could not be obtained in Nepalgunj without irrigation (LDP, 1986). In usual conditions of Janakpur, after each cut, irrigation is essential for normal growth. Berseem requires inoculation with (*Trifolii rhizobium)* especially when sown first time in a field. If inoculum is not available, soil from a previous berseem field could be mixed with seed. Inoculum production division, Khumaltar produces packets (200 gm each) of Rhizobium trifolii for distribution to farmers.

Berseem seed production

Berseem is a high seed yielder. The seed multiplication ratio is about 25-30 times more than other forages. In Nepal seed yield ranges from 240-783 kg/ha under different doses of fertilizers and irrigation. In farm conditions seed production is about 100-120 kg/ ha after taking 2-3 cuts of fodder.

Affect of altitude on fodder yield

Berseem can be grown in the Terai and foot hills. The potential areas for berseem cultivation in the Terai are from east to west 1 400 m. Studies at PAC in 1991, in the eastern hills Koshi Zone at 1 010 to 1 650 m revealed that green fodder yield was affected by altitude. At altitudes below 1 400 m fodder yield was 11.7 t/ha from Mescawi. Average height was 17.7 cm at high altitude; at lower altitude it was 45.0 cm. Altitude not only affects fodder yield but also seed production. The best growth of berseem in the Terai is at 600 m.

Activities to promote berseem seed production and marketing

A Government resource centre for berseem seed has been established at Janakpur which grows berseem on more than 12 ha. It produces 1 500 -2 000 kg seed annually mainly for distribution to farmers. The private sector is not involved in production/marketing of forage seed in Nepal. Some private dealers at Bhairahaw import different kinds of forage seed from India according to the buyer’s demand.

Seed production through registered growers

To promote quality forage seed production at private level, the government “ under which farmers keen to grow quality seed are selected. An agreement between farmers and government agencies is signed regarding species/ cultivar, quality of seed, amount to be produced, price and the distribution mechanism. Foundation seeds and technology are provided by government. Many farmers are interested to grow berseem seed under this scheme. The main problem is an assured market for seeds. Farmers must limit seed production. Though, berseem seed is a high value crop and earns about Rs 69/kg (US$ 1.25/kg), if the seed can not be sold in the forthcoming season, it become worthless, neither it can be consumed nor it can be fed to the livestock /poultry.

Rural forage seed banks

Besides registration of seed growers, to promote forage seed production, a seed bank programme has been initiated by DOAD, Livestock Development Division under which interested farmers/groups involved in forage production form a group of 7-9 members. Seed producers' groups are technically supervised and assisted by the district agriculture officer. Producer groups have to contribute a nominal amount to create a revolving fund for the promotion of seed production and marketing. If group members deposit NR's 3000 (US $ 60.0) in the fund, the ADO has to contribute an equal amount. Besides, technical support and monitoring assistance to the rural seed bank, the DOAD and LDD provide support to members in the forms of facilitation for marketing, training, recommendations for agricultural loan, animal health facilities etc. However, organized efforts for marketing of berseem seed are lacking.

Estimated production of berseem seed

Now, berseem is no longer a new crop, farmers are well aware and acquainted with its cultivation and seed production. At present berseem seeds are produced in 11 different districts (Table 2).

Table 2. Berseem Seed Production at Government Farm Level

S.No	Farms/ Districts	Seed Production, kg	%
Government Sector			
1	PTSM farm, Janakpur	1500	19.4
2	LFTSM farms, Ranjitpur	1000	13.0
Sub Total		2500	32.4
Private Sector			
1	Dhanusha districts	1000	13.0
2	Mahotatri	1000	13.0
3	Sarlahi	500	6.5
4	Rautahat	500	6.5
5	Bara	10	0.1
6	Parsa	10	0.1
7	banke	500	6.5
8	Dang	1000	13.0
9	Surkhet	700	9.1
Sub total Grand Total		5220	67.6
		7720	100

Of a berseem seed production of 7 720 kg, about 68 percent (5 220 kg) is grown by the private sector and only 32 percent (2 500 kg) at government farms (Table 2).

Future prospects for berseem seed production

There is a tremendous potential to produce berseem seed in Nepal along the southern border: Dhanusha, Mahotatri, Sarlahi, Rautahat and Banke are suitable for seed production.In seed producing districts, out of 686 510 ha only about 52 percent is cultivable. About 61 percent is under paddy which could be used successfully for berseem. However, most of the land after paddy crop left fallow until the next season. A total of 77 000 ha i.e. 21.3 percent of all agricultural land including paddy fields has been brought under wheat. The remaining 10-20 percent is under winter crops such as barley, mustard, sugarcane etc. The remaining 50-60 percent could be used for berseem seed production which is about 20 000 ha in berseem seed producing districts. Under well managed systems this could easily produce 40 thousand tons of berseem seed. There is a vast potential for berseem seed production in Nepal.

Recommendations

- Immediate attention is required to replace existing seed stock available at government farms with high quality seed to maintain the varietal purity;
- Seed production of berseem should be well organized through a full fledged national level institute to look after production, processing, quality control and marketing;
- Berseem production (green fodder/ seed) should be promoted as a potential source of income generation especially for the rural farmers. In this regard, in berseem seed producing districts, quality seed production should be given high priority whereas in the fodder producing districts priority should be given to produce green fodder for silage, hay and leaf meal production etc. for all types of animal;
- Possibilities for the extension of berseem seed especially to the SAARC counties should be explored and a specialized quality seed farmers association should be formed for this purpose;
- Government/ non government efforts be directed towards the extensive use of fallow lands for the production of fodder crops like berseem to solve the winter feed deficit and also to improve the fertility status of soil;
- Farmers involved in forage seed production should be provided training/ skills in quality seed production and their processing. Farmers of the seed producing districts should be facilitated with necessary equipments for seed processing and quality control;
- Rules/ regulation to control the quality of produced seed should be strictly amended by concerned organization.

Consequence of number of irrigations and their interval on seed yield and biomass production of berseem in Nepal

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In Nepal farm land provide about 60% of annual feed supply, mainly in the form of low quality crop residues, whilst 40% comes from forest and grazing lands (TLDP, 2002). The fodder budget displays a dry and green matter deficit of 30.8% and 54.3% respectively (Pariyar, 1993, Pande, 1997 and Raut, 1998). Livestock face feed deficit of over three millions tons per annum (TLDP, 2002). Great efforts have to be made to provide adequate feed not only to increase the production but to lower the production costs. Government agencies such as Department of Livestock Services (DLS) have helped in production of forage seed and planting materials. DLS assists farmers in many ways for promotion of better forage production and feeding in Terai. But it is inadequate at the local levels. The major limitations and constraints in feed, fodder. pasture production and use are:

- Lack of adequate irrigation and rainfall at the forage growing time;
- Lack of quality fodder in required quantities;
- Forage seeds are expensive and local farmers can not afford to buy them, (Rs 400/kg for stylo seed, Annual Report PFSMF, 2006 - 2007);
- Lack of trained personnel for the production of quality feed and fodder;

Forage seed production has been increasing in the last few decades. Oat, berseem, winter vetch, teosinte, stylo, joint vetch and Napier are major forages in the Terai and mid hill districts. Among them, berseem has been rightly called the king of fodder crops due to high yields of succulent, palatable and nutritious fodder that it provides over a long season from November to May in five to six cuts. A cow yielding 7 to 8 litres of milk per day can easily be maintained on green berseem alone without any concentrate feeding. Berseem has a high nutritive value around 22% CP and 80% TDN.

Berseem is sown in October in Terai and hills. Sowing in November yielded low at Koshi hills (PAX Annual Report, 1990-1991). The easiest and quickest method at sowing is flooding to a depth of 4 to 5 cm in well levelled fields and broadcasting soaked seeds uniformly in a crosswise direction. The seeds should be inoculated with *Rhizobium trifolii* bacteria About 400-500 kg/ha of seed can be produced under good fertilizer and irrigation management.

Irrigation is essential for berseem seed and biomass production. Generally, it is applied at 10-15 days intervals according to the condition of soil, moisture and rainfall.

Material and methods

The study was carried out at the Pasture and Forage Seed Multiplication Farm, Gaughat which is about 12 km west of Nepalgunj, Banke district. It investigated the effect of number of irrigations and irrigation intervals on berseem seed yield and biomass production. The cultivar 'Wardan' was used and four different number of irrigation (0, 5, 10, 15 times) were applied at different intervals and it was replicated 3 times and managed in 4T × 3R Completely Randomized Design (Simple CRD. Test results showed pH level 7.0 and organic matter 1.95% of soil. Fertilizer was applied as NPK @ 25:60:30 NPK kg /ha equally in all plots. The different parameters during the experiment such as seed yield, biomass production at first cutting, second cutting and the dates of seed ripening etc. were recorded. Means were separated by using Least Significant Difference (LSD) at 5% level of significance.

Results and discussion

Berseem seed yield

Berseem seed yield is presented in Table 1. There were highly significant differences ($P<0.01$) in the seed yields among all treatments. Seed yield was observed significantly higher in T4 (393 kg/ha) followed by T3 (360 kg/ha), T2 (266 kg/ha) and T1 200 kg/ha).

Table 1. Berseem seed yield		
S. NO	Treatments	Seed yield (kg/ha)
1	T1	200d
2	T2	266c
3	T3	360b
4	T4	393a
5	Mean	305
6	Probability	0.00
7	CV%	3.14
8	SEm	0.05
9	LSD Value	0.24

Seed yield is significantly higher (96.65%) in T4. The number of irrigations directly affect seed yield. In farmers conditions the usual seed production is about 100-120 kg/ ha after taking 2-3 cuts of green fodder (Pande, 1995). It was reported that seed production could not be obtained at Nepalgunj without irrigations (LDP, 1986). But seed yield is significantly decreased (about 96.65%) in the drought condition or with no irrigation. Thus, irrigation is an important component to obtain the optimum seed yield.

Berseem forage production

The mean biomass production of berseem at first cutting at different number of irrigations and their intervals is presented in Table 2.

Table 2. Average biomass production of Berseem at first and second cutting			
S. No	Treatments	Average biomass production at first cutting (kg/m^2)	Average biomass production at Second cut (kg/m^2)
1	T1	1.10c	1.63d
2	T2	1.20bc	2.10c
3	T3	1.33b	2.93 b
4	T4	1.56a	3.26a
5	Mean	1.30	2.148
6	Probability	0.00	0.00
7	CV%	4.97	3.49
8	SEm	0.03	0.05
9	LSD Value	0.16	0.23

The effect of number of irrigations and intervals on biomass production at first cut was highly significant ($P<0.01$). Significantly ($P<0.01$) higher biomass production (1.56 kg /m^2) of berseem was taken in first cut in the treatment with 15 times of irrigations with 12 days interval followed by 1.33 kg/ m^2, 1.20 kg /m^2, and 1.10 kg /m^2 with T3, T2 and T1 treatments respectively.

Similarly, average biomass production of berseem at second cutting at different number of irrigations is presented in Table 3. Biomass production is highest (3.26 kg /m^2) in the second cut in T4 followed by treatments T3 (2.93 kg/m^2), T2 (2.10 kg/m^2) T1 (1.63 kg/m^2). The difference between the biomass production at first cut and second cut is 0.58 kg/m^2, 0.9 kg/m^2, 1.60 kg/m^2 and 1. kg/m^2 in T1, T2, T3 and T4 respectively. The number of irrigations applied to the berseem increased the biomass production at first and second cutting. 1m^2 area from each plot was taken for the calculation of its total biomass production. Only 3 cuts were taken at an interval of one month. The average biomass production is presented in Table 3.

Table 3. Biomass Production of Berseem (t/ha) fresh		
S.N.	Treatments	Avg Total Biomass
1	T1	64.00d
2	T2	81.06c
3	T3	89.03b
4	T4	98.83a
5	Mean	83.23
6	Probability	0.00
7	CV%	1.24
8	SEm	0.59
9	LSD Value	2.67

The effect of number of irrigation and irrigation intervals on the total biomass production were highly significant ($P<0.01$). Significantly higher average biomass production was recorded in T4 (98.83 t/ha) by three cuts at one month interval followed by T3 (89.03 t/ha), T2 (81.06 t/ha) and T1 (64.00 t/ha). The number of irrigations and their intervals are positively correlated with the biomass production etc.

PAKISTAN

Berseem Production in Pakistan

Sartaj Khan

Pakistan is in South Asia. Geographically the landscape spectrum consists of plains, forests, hills and plateaus ranging from the coastal areas of the Arabian sea in south to the mountains of the Karakorum in the north. Pakistan is bordered by Afghanistan to the north-west and Iran to the west while the people republic of China borders the country in the north and India to the east. Agriculture is the main livelihood of approximately 45 percent of the working population, it contributes about 21 percent to the Gross Domestic Product (GDP), and generates over 50 percent foreign exchange earnings (Economic Survey of Pakistan about 2010). Although crop sector is dominant in Pakistan agriculture, there is increasing recognition of the importance of livestock production.

Livestock is an integral part of mixed farming and provides draught power as well as milk and meat for both home consumption and sale. Although, during the last two decades, the area under fodder decreased by 11.6 percent, fodder production increased by 18.2 percent due to adoption of high yielding varieties; Livestock population increased by 71 percent. It is estimated that around 70 percent of dairy households in Pakistan still operate under subsistence conditions by maintaining herds of 3-4 animals (Bhatti and Khan 1996, Burki et al. 2005). Normally shortage of livestock feed in terms of green fodder occurs during May-June and December-January.

Production of sufficient quality forage is basic to the development of an efficient and productive livestock industry. Both small and large ruminants can make satisfactory gains and attain satisfactory productivity on good quality forage alone. Dairy animals can produce 10-12 kg of milk a day on good quality forage without concentrates. Unfortunately not enough good forage is available so considerable quantities of concentrates are often fed along with poor quality straw or other crop residues. Likewise no effort has been made to maximize forage feeding of the livestock. In fact it has been estimated that ruminants are only being fed about 50% of their dry matter requirements.

Introduction of Egyptian clover

Egyptian clover or berseem (*Trifolium alexandrinum*) is an annual multi-cut fodder crop grown at temperatures ranging from 0-35 C^{o}. It grows well on a wide variety of well drained soils ranging from sandy types to heavy loams. It belongs to the family Papilionaceae and order Leguminales. It was first introduced in Sindh in 1904. Later, its cultivation was started in Peshawar, Khyber Pakhtunkhwa region in 1924 from where its cultivation was extended to the irrigated tracts of Punjab. Now it is a major winter fodder grown on an area of 0.71 million hectares (Khan et. al, 2006, Bhatti and Khan, 1996).The merit of the crop lies in its multicut nature (4 -6 cuts), long duration of green fodder availability (November to May), high green fodder yield (>100 t/ha), good forage quality (20% crude protein), digestibility (up to 65%) and high palatability. Berseem has wide acceptability among farmers due to its merits over other winter forages since it's yield ranges from 100 to 120 t/ha. Berseem is known as milk multiplier. Yield of fodder crops can, no doubt be doubled by using improved varieties and methods. If this increase were achieved, either the number of livestock fed on berseem could be doubled or the acreage devoted to this crop could be cut in half releasing this acreage for the production of crops for human consumption.

Table 1. Crop-wise area and production of fodder crops in Pakistan

S. No.	Crop	Area (m ha)	Production (m tons)
Summer (Kharif) Fodder Crops			
1.	Sorghum	0.23	0.14
2.	Millet	0.55	0.35
3.	S.S. Hybrid	0.10	1.42
4.	Guar	0.21	3.05

Table 1. Crop-wise area and production of fodder crops in Pakistan			
S. No.	Crop	Area (m ha)	Production (m tons)
5.	Maize	0.97	3.71
6.	Other Kharif Crops	0.41	6.12
Winter (Rabi) Fodder Crops			
7.	Berseem	0.71	2.61
8.	Lucerne	0.13	5.32
9.	Shaftal	0.02	0.81
10.	Rape & Mustard	0.02	0.34
11.	Other Rabi Crops	0.10	4.22
Total		3.45	28.09
Khan *et. al,* (2010)			

Cultural practices

Unfortunately, crop management is always a weak point in Pakistan. Agronomic research and the application of results are extremely location specific so difficult to generalize. The land is ploughed four to six times to get a fine tilth and small beds are formed which are then flooded with about 5 cm of water and berseem seeds, soaked overnight are mixed with an equal quantity of fine earth and broadcast in the standing water to ensure uniform sowing. A seed rate of 20-25 kg per hectare suffices. Bright, yellow, plump seeds should be used, discarding all brown and immature ones.

Early sowings give better growth and higher yields, but there is a danger of caterpillar damage; late sowing gives stunted growth and poor yields. Care should be taken for proper sowing time as late sowing often hampers the fodder yield because the onset of winter interferes with the crop growth in early stages. As the water dries up in the beds, berseem seeds germinate in three to four days and as soon as they have struck root (in about a week's time) the beds should be irrigated once more. Sowing is to be done in mid September.

Berseem responds well to fertilizers and needs about 120 kg of P_2O_5 per hectare applied to the seed-bed. A small dose of nitrogen @ 25 kg N per hectare at sowing is very helpful in improving both the yields and forage quality. In addition to major nutrients, experiments indicate that micro-nutrients like boron, supplied as 6 to 11 kg of borax per hectare and molybdenum, in the form of sodium or ammonium molybdate at 10-12 kg per hectare can often increase yields considerably.

where berseem is grown for the first time, inoculation with the appropriate Rhizobia bacterial culture is necessary to ensure good growth. The culture may be smeared on seeds before sowing. Where cultures are not available, soil from an old Berseem field may be spread on the field before sowing. A total of 10 to 12 irrigations may be required for the entire crop duration. Irrigation should be given as per requirement depending on soil and climatic conditions.

It is good to grow a mixture of Brassica species, oats, barley or ryegrass with berseem since berseem has only a few shoots when the first cut is taken. Rape plants grow much quicker and this mixture provides a high fodder yield for the first cut when there is usually an acute scarcity of green fodder. Another advantage of mixing rape or winter cereals in berseem is that it protects berseem from frost; rape and winter cereals cover berseem. Surface caterpillars and cotton worms are widespread. Other common problems are berseem root rot, dodder and weed infested seeds. Effective methodologies are available to control these infestations and problems but the rate of their adoption by the farmers is very low.

Improved varieties

Improved cultivars are available at research level and have to be made available to farmers in order to exploit their full genetic potential and meet the requirements of our livestock. These varieties have the potential to increase fodder yields 2-3 times compared to local ones currently used. Some of these are Cv. Agaiti, Cv. Pachaiti, Cv. Peshawari, Cv. Super Late Faisalabad and Cv. Anmole (Figuer1).

For varietal release, National Uniform Fodder Yield Trials (NUFYT) under Fodder Research Program, National Agricultural Research Center (NARC) are undertaken under a range of ecological situations. Candidate lines of fodder crops from all over the country are contributed for testing. The best performing line is released for general cultivation or for a specific ecological condition. Seven different berseem lines (A-G) are currently under evaluation. Yield performance data so far collected (4 cuts) are given in the Table 3. A major objectives of the berseem breeding program is to select heat tolerant and late maturing lines. Line "Palosi -1" is late maturing among the lines under testing. The performance can be judged from the figures below.

Table 3. National Uniform Fodder Yield Trial (NUFYT) - 2011-12

Name of variety/line	Green fodder yield (t. ha^{-1}) during the growth period					Total green yield (t. ha^{-1})
	1st cut	2nd cut	3rd cut	4th cut	5th cut	
Chenab Berseem	8.44	17.33	25.11	32.64	12.52	96.04
Sandal Berseem	7.78	20.44	28.67	34.27	10.02	101.18
SG-07-1	6.44	16.22	28.67	33.27	10.02	94.62
SG-07-2	6.44	14.44	24.89	32.36	10.02	88.15
Super Late	7.56	16.00	27.56	35.82	6.68	93.62
Agaiti Berseem	7.44	16.67	24.22	32.49	7.51	88.33
Palosi-I (late maturing line)	8.22	14.89	26.67	34.67	36.74	121.19

Performance of berseem at higher altitudes

In The Northern Areas, local shaftal (*Trifolium resupinatum*) is grown on a large scale; improved varieties of berseem and shaftal were compared with local shaftal for green fodder production at agriculture farm Skardu more than 2 000 m asl in 1994-1995 and 1995-96. Total green fodder yield at different stages of harvest during the season obtained was higher from berseem cultivars compared to shaftal cultivars. Table 4 shows details of the performance of varieties of both species.

Table 4. Average green fodder yield (t. ha^{-1}) of berseem and shaftal cultivars

Species/Varieties	Green fodder under various cuts (t. ha^{-1})			Total green fodder yield (t. ha^{-1})
	1st cut	2nd cut	3rd cut	
Berseem Cv. Agaiti	14.70	12.60	5.70	33.00
Berseem Cv. Axi	10.20	11.60	5.30	27.10
Shaftal Cv. Shaftal	10.30	11.50	-	21.85
Shaftal Cv. Maral	10.50	11.75	-	22.25
Shaftal Cv. Local	9.00	10.80	-	19.80

Source Khan (1996)

Berseem in relay cropping with sunflower

Sunflower is an autumn cash crop in Pakistan. As there is an opportunity for relay cropping berseem, Hafiz *et. al,* (2004) studied its feasibility. They sowed sunflower in the first week of September and broadcast berseem in it during last week of September, at first irrigation of sunflower in Ayub Agriculture Research Institute, Faisalabad.

The study was conducted for three years (i.e. 1997-1998, 1998-1999 and 1999-2000). Average yields are given in Table 5, while economic analysis, Land Equivalent Ration (LER) and Benefit Cost Ration (BCR) in Table 6 & 7. Relay cropping of berseem with sunflower increased per unit area income of Rs. 44939 and net income of Rs. 27646 per ha. It increased per unit gross income by 71% as compared with sole crop of sunflower and 10% in comparison with sole conventional sown berseem crop. LER was increased to 1.66 in relay cropping over monoculture and the maximum LER of 1.73 was achieved in case of berseem relayed in sunflower sown at 90 cm row spacing. Moreover, the highest BCR of 2.60 was found from the same treatment.

Table 5. Sunflower seed and berseem fodder yield as affected by relay cropping

S. No	Treatments	Sunflower seed (kg ha^{-1})	Berseem fodder (kg ha^{-1})
1.	Sunflower alone at 75 cm row spacing	1064.69 a	-
2.	Sunflower alone at 90 cm row spacing	999.48 b	-
3.	Sunflower alone at 100 cm row spacing	903.47 c	-
4.	Sunflower at 75 cm apart row spacing + berseem	1042.09 a	30.56 c
5.	Sunflower at 75 cm apart row spacing + berseem	983.26 b	37.09 b
6.	Sunflower at 75 cm apart row spacing + berseem	904.08 c	37.98 b
7.	Berseem alone	-	45.21 a
8.	LSD %	17.872	7.459

Hafiz *et. al,* (2004)

Table 6. Economic analysis of sunflower and berseem relay cropping

S. No	Treatments	Gross returns (Rs. ha^{-1})	Expenditure (Rs. ha^{-1})			
			Sunflower	Berseem	Total	Net income
1.	Sunflower 75 cm row	1064.69 a	6795.60	-	6795.60	6496.97
2.	Sunflower 90 cm row	999.48 b	6795.60	-	6795.60	5639.34
3.	Sunflower at 100 cm row	903.47 c	6795.60	-	6795.60	4486.67
4.	Sunflower at 75 cm apart row spacing + berseem	1042.09 a	6795.60	10497.50	17293.10	22188.28
5.	Sunflower at 80 cm apart row spacing + berseem	983.26 b	6795.60	10497.50	17293.10	27645.98
6.	Sunflower at 100 cm apart row spacing + berseem	904.08 c	6795.60	10497.50	17293.10	27073.44
7.	Berseem alone	-	-	15338	15338	23842.17
8.	LSD %	17.872		-	-	-

Hafiz *et. al*, (2004); 1 US$ - 98 Rs June 2013

Table 7. LER and BCR of sunflower and berseem relay cropping

S. No	Treatments	Land equivalent ratio			BCR
		Sunflower	Berseem	Total	
1.	Sunflower at 75 cm row	1	-	1	1.96
2.	Sunflower at 90 cm row	0.94	-	0.94	1.83

Table 7. LER and BCR of sunflower and berseem relay cropping

3.	Sunflower at 100 cm row	0.85	-	0.85	1.66
4.	Sunflower at 75 cm row spacing + berseem	0.98	0.68	1.56	2.28
5.	Sunflower at 90 cm row spacing + berseem	0.92	0.82	1.73	2.60
6.	Sunflower at 100 cm row spacing + berseem	0.85	0.84	1.68	2.57
7.	Berseem alone	-	1	1	2.55

Hafiz *et. al,* (2004)

It can be concluded that berseem can successfully be relayed in autumn sown sunflower and it will ensure a considerable increase in per unit area income.

Berseem in rice-wheat cropping

Studies have been undertaken on comparative advantage and feasibility of different rice base cropping systems. Rice is a crop of great economic value in Pakistan, grown on 2.88 million hectares (Anonymous, 2009-2010). Wheat is commonly grown after rice but rice is grown in puddled soils to maintain submergence during the growing season; wheat grows better where soil allows deep root penetration (Hobs *et al,* 1987). Wheat is sown late due to late harvest of Basmati rice in plains. Furthermore, this rotation has resulted in stagnation of both rice and wheat yields. Berseem is a better choice. Rice Cv. 385 was planted in the third week of July and wheat, barley, chickpea, lentil and berseem were sown in the third week of November. The results indicate (Table 8) that rice-chickpea cropping system gave highest profit followed by rice-Berseem, rice-barley, rice-lentil and rice-wheat.

Table 8. Economics of Agronomic expression of different relay crops grown after rice

Crops	Grain yield (t ha^{-1})	Straw/forage yield t ha^{-1})	Gross Income (Rs. ha^{-1})	Total Expenditure (Rs. ha^{-1})	Net Income (Rs. ha^{-1})	B.C.R
Wheat	3.47	4.95	32212.50	13867.46	18345.04	1.32
Barley	4.46	7.69	44522.50	16105.95	28416.55	2.75
Chickpea	2.09	2.82	47730.00	11981.42	35748.58	3.98
Lentil	1.20	2.23	30557.50	11487.42	19070.08	2.66
Berseem	-	63.94	51152.00	13306.51	37845.49	3.84

Asghar *et. al,* (2002)

Future research areas

- Germplasm enrichment through exploration at centres of diversity such as Egypt, Turkey, Iran, Iraq etc;
- Breeding/screening for disease resistance especially root rot and stem rot;
- Long duration type varieties to cover fodder scarcity periods of May-June;
- Improved dry datter content and seed yield;
- Extending the crop to northern parts of the country;

Berseem variety Agaiti at Hafizabad (Left) and at Islamabad (right)

Figure1. High yielding varieties of berseem evaluation trials (left and right)

TURKEY

Berseem production in Turkey

Rustu Hatipoglu

Turkey lies between 36º- 42° N and 26°- 45° E forming a bridge between Europe and Asia divided by the Sea of Marmara (Figure 1); it covers 785 000 km^2 consisting of seven geographical regions and 37 ecologically homogenous areas (Figure 2). The land area is 769 630 km^2 (FAO, 2009). Total agricultural land area is 38,911 km^2 of which 213 510 km^2 are arable, 2 943 km^2 are permanent crop and 146 170 km^2 meadows and pastures. 15.2 million ha of the arable land is sown and 4.3 million ha lie fallow.

Average elevation is 1 100 m and annual precipitation 600 mm. Both the amount and distribution patterns of precipitation show great variation between regions, as the topographical features do. Turkey is subject to both a continental climate characterized by rainy weather throughout the year and to a subtropical climate distinguished by dry summers. Autumn is the start of the rainy season, which continues until late spring on the Marmara, Mediterranean and Aegean coasts. The Black Sea coasts receive rain throughout the year. In this region, the amount of rainfall steadily decreases in an east-west direction from 2 000 to 600 mm/year. In the interior and South-eastern Anatolia, rainfall occurs mostly in spring. Throughout much of the area snow lies in winter at and above 1 000 m. In the east rainfall is in spring; winter temperatures are much lower than the rest of the country, particularly in the highlands of this region. Almost the entire area is under snow from November to March or April. Although the west and south coasts are near the sea they receive less rainfall then the Black Sea coasts. These regions are very dry in summer but humidity is higher than inner and eastern parts of the country.

According to the Turkish Statistical Institute (TUIK), population was estimated as 74 724 000 in 2011 and population growth rate was 1.35 %. The agricultural population is declining. 46.5 % of the population was involved in agriculture in 1988, but this has declined to 25.5 % in 2011 (TUIK, 2012). There are 3 million agricultural enterprises in Turkey. The average farm size is 6.1 ha of land. Of those, 37.2 % are solely involved with plant production and since they raise no animals they produce very little or no forage crops (TUİK, 2012). About 62.3 % operate as crop-animal enterprises raising animals and crops together. They keep 1-2 cows and/or 4-5 sheep and goats. They live in the villages and their animals graze community pastures in a sedentary system. Finally, 0.5 % raise animals without any crop production. They are landless migratory families having large herds in a mobile grazing system.

Turkey's ruminant resources in 2011 were 12.4 million cattle, 25.0 million sheep and 7.1 million goats. Cattle numbers have not changed significantly in the last 30 years, while sheep, goat and buffalo numbers decreased steadily in the same period.

Forage production

Roughage needs of ruminants (about 11.2 million AU) are estimated to be 89.9 million tons (Alcicek *et al,* 2010). Quality roughage production is 32.9 million tons 11.7 million tons of which come from meadows and pastures and 21.2 million tons from forage crops grown for hay, green forage or silage. So there is a roughage deficit of about 57 million tons which is covered by straws and residues.

Animal husbandry is based on extensive grazing. This natural resource is public land owned by the state. The state has given the rights to use these lands to villagers but without regulations or technical enforcements for management. As a result, these lands are utilized at 90-92 percent (Tukel, 1984). Due to indiscriminate misuse, plant cover and biomass yields of these pastures are very low ranging from 10-30 % plant cover and biomass production of 0.5-1 t/ha (Altin *et al,* 2011).

Official statistics in 2011 showed a total of 1.5 million ha under forages, which is slightly over 6.9 % of all cropland and 9.9 % of the sown area every year. Over 78 % of enterprises have less than 10 hectares. Additionally, 63.2 % of enterprises have their land split in over four plots. Farmers with small farms unwilling to grow forages and prefer to grow crops for direct consumption or which they can sell easily.

Alfalfa (*Medicago sativa L.*) cultivated on 558 553 ha is the most important forage followed by common vetch

(*Vicia sativa L.*), maize (*Zea mays L.*), sainfoin, bitter vetch (*Vicia ervilia L. Willd.*) forage beet (*Beta vulgaris L. var. rapacea Koch.*) and clovers being cultivated at area of 475 476 ha, 312 795 ha, 153 645 ha, 6 903 ha, 2 540 ha and 434 ha respectively.

Berseem as a potential forage for Turkey

Berseem, is believed to have originated in Asia Minor (Genckan, 1985). Boeker (1963) reported that wild forms of berseem grow naturally along the rivers of Euphrates and Tigris. According to the Turkish Plant Data Service, berseem grows naturally in some areas of North and South Anatolia, around the provinces of Duzce and Antalya, (TUBIVES, 2012).

Many investigations have been conducted on different aspects of growing clover. According to these investigations, it could be grown in almost all parts of the country. Some of the results on hay yield of growing in different regions of Turkey are given in Table 1.

Table 1. Hay yields of berseem clover in different regions of Turkey

Region					
	Characteristics of location	Cultivar tested	Hay yield (t/ha)	Number of cutting	Reference
Erzurum	1 700 m ASL*, Continental climate with an annual total precipitation of 460 mm	Tetraploid (Portugal)	4.5-9.3	1	Tosun *et al,* 1979
		M-2746	5.5-6.6		
Ankara	860 m ASL, continental climate with an annual total precipitation of 435 mm	Carmel	5.7-6.5	3	Hakyemez and Sancak, 2005
		Lito	6.6-8.7		
		Castalia	6.2-7.7		
		Pinias	5.9-6.2		
		Meteor	5.1-5.4		
Adana	23 m ASL, typical Mediterranean climate with an annual total precipitation of 650 mm	L-1714 (USA)	5-9.6	1	Saglamtimur *et al*, 1986
Antalya	Mediterranean climate with an annual total precipitation of 1043 mm	Population	1.5-2.2	1	Cakmakcı and Cecen, 1999
Samsun	4 m ASL, Black Sea climate with an annual total precipitation of 692 mm	Population	6.2-6.4	1	Yavuz *et al*, 2006
İzmir	20 m ASL, Mediterranean climate an annual total precipitation of 630 mm	Kastilia	14.8	3	Celen and Soya, 1997
		Pinias	16.4	3	
		Tabor	7.1	1	
		Carmel	15.1	3	
		Meteor	15.3	3	
		Lito	15.2	3	
		L-1905	15.8	3	
Adana	23 m ASL, typical Mediterranean climate with a precipitation of 650 mm	Sac	13.9	3	Turkeri and Karakoy, 2011
		Lito	13.7	3	
		Tabor	12.9	3	
		Pinias	14.5	3	

Agronomy of berseem in Turkey

Berseem, a cool-season forage crop, is best adapted as a winter annual in regions with Mediterranean climate. Therefore, regions such as Aegean and Mediterranean with a Mediterranean climate as well as the Black Sea Region with a Black Sea climate are most suitable for berseem. In these regions, it can be grown as a winter crop without irrigation. Sowing time is generally 15 October-15 November. It must be harvested before the sowing of main summer crops such as corn, cotton, soybean, peanut, depending on region and crop rotation. Berseem can be harvested once or twice, and it can produce 1.5- 10 t/ha hay depending on cultivar and climatic conditions, especially the amount of precipitation (Table 1). If berseem is grown till the sowing of second crop of corn or soybean, it can be cut 3 times and a hay yield of 14-16 t/ha can be achieved. In the interior Anatolia and East Anatolia with a continental climate, it must be grown as summer crop under irrigation; sown in April. Under these conditions, it is grown as main crop and cut 3 times with a total hay yield of 5-9 t/ha (Table 1).

Sowing rate is at 30-40 kg seed/ha broadcast and at 25-30 kg/ha under row sowing (Soya, 2009). It is recommended that 80 kg/ha P_2O_5 and 120-150 kg/ha K_2O be provided at sowing. Recommended cutting time is at beginning of the flowering. In an investigation in Aegean region with the cultivar Tabor, cutting time affected both yield and quality of hay (Avcıoglu *et al,* 1999). Delaying cutting time increased hay yield but decreased the crude protein ratio of hay (Table 2).

Table 2. Effects of cutting time on the yield and quality of hay in berseem clover

Cutting time	Hay yield (t/ha)	Crude protein ratio (%)
At before flowering	1.69	28.4
At early flowering	3.64	16.3
At the end of flowering	9.63	14.4

According to research in different regions of Turkey, berseem can give as much as or higher hay yields and hay quality as other annual forage legumes (Table 3).

Table 3. Hay yields and crude protein ratios of some annual forage legumes under different sites of Turkey

Annual Legume Species	Hay Yield (t/ha)			Crude Protein Ratio (%)		
	Location			Location		
	Samsun(1)	İzmir 2)	Antalya(3)	Samsun(1)	İzmir(2)	Antalya(3)
Common vetch	5.8	6.28	2.86	19.37	23.66	-
Hairy vetch	5.05	6.27	2.46	18.6	21.09	-
Hungarian vetch	4.21	4.82	-	17.69	20.65	-
Narbonne vetch	3.26	-	3.6	16.97	-	-
Grass pea	2.93	-	4.04	17.72	-	-
Berseem clover	6.31	6.0	-	18.15	16.95	-
Gelemen clover	4.12	-	1.9	19.11	-	-
Persian clover	-	6.16	2.15	-	20.13	-
Pea	4.31		2.27	17.79	-	-

1)Yavuz *et al,* 2006; 2) Celen *et al,* 1997; 3) Cakmakcı and Cecen, 1999.

Intercropping

Berseem can be grown pure or in mixtures with annual ryegrass or cereals. Mixtures can provide more hay of better quality (Table 4).

Table 4. Hay and crude protein yields of mixtures of some annual forage legumes with cereals or annual ryegrass			
Mixture	Hay yield (t/ha)	Crude Protein (kg/ha)	Reference
Hairy vetch + oats	7.7	-	Tukel and Hatipoglu, 1987
Hungarian vetch+ oats	7.0	-	
Grass pea + oats	7.4	-	
Pea + oats	7.8	-	
Berseem clover + oats	7.7	-	
Cyprus vetch + barley	7.0	999	Degirmenci and Avcıoglu, 2011
Grass pea +barley	6.1	818	
Persian clover + barley	5.4	706	
Berseem clover+ barley	5.3	746	
Berseem clover (BC)	4.37	956	Silbir *et al*, 2000
Barley (B)	8.62	1196	Silbir *et al*, 2000
75 % BC+ 25 B	6.12	971	
50 % BC+ 50 B	6.70	977	
25 % BC+ 75 B	7.51	1019	
75 % BC+ 25 ARG	7.63	1342	
50 % BC+ 50 ARG	7.55	1274	
25 % BC+ 75 ARG	8.02	1251	

Berseem rotations

In Adana with Mediterranean climate, berseem Planted before maize provided nitrogen through harvest residues, and maize grown with or without N fertilization after berseem gave higher grain yield compared to other previous crops (Table 5).

Table 5. Grain yield of maize grain with or without N fertilization after some annual forage legumes (*)			
Previous crop	Maize yield without N fertilization	Maize yield with 120 kg N/ha (t/ha)	Maize yield with 240 kg N/ha (t/ha)
Horse bean (HB)	6.89	10.52	11.0
HB+ vetch	7.85	11.09	12.91
Berseem clover	9.07	11.47	12.16
Fenugreek	7.98	10.33	12.24
*) Anlarsal *et al,* 1996			

Berseem can be used as a green manure. In Adana, berseem green manure for maize resulted in higher grain yield as compared to other green manures (Table 6) (Figures 1 &2).

Table 6. Grain yield of maize grown after some of the green manure crops					
Green Manure Crop	Dried biomass of green manure (t/ha)	Provided total N from green manure (kg/ha)	Grain yield of maize without N fertilization	Grain yield of maize with 120 kg N/ha	Grain yield of maize with 240 kg N/ha
Horse bean (HB)	8.26	312	9.15	11.24	11.45
HB + common vetch	7.53	275	9.84	11.41	12.20

Table 6. Grain yield of maize grown after some of the green manure crops					
Berseem clover	10.41	338	9.29	12.07	13.15
Fenugreek	8.60	318	9.28	11.22	12.28

Seed yield of berseem

Seed yield of berseem increased from 252.3 to 700.2 kg/ha depending on the cultivar and location (Table 7).

Table 7. Seed yield of berseem in Turkey

Cultivar	Seed yield (kg/ha)	Reference
Population	430.0 - 700.2	Saglamtimur *et al,* 1986
Population	285.0 – 524.0	Cakmakci *et al,* 1999
Carmel	307.8	Deveci *et al,* 2009
Tabor	372.9	
Pinias	252.3	
Population	294.9	
Pinias	627.5	Silbir, 2001
Tabor	515.5	
Meteor	960.7	
Carmel	592.7	
Lito	588.0	
Sac	791.8	

Conclusion

Berseem has a great potential as an annual forage in Turkey. Due to structural problems of Turkish agriculture, growing of forage crops is far behind the desired level. However, the area of forages has increased significantly through governmental support in the last ten years. Most Turkish agricultural enterprises are still very small and just support the farmer's family needs. It is estimated that declining agricultural population will increase farm size in the next decade. Then, it is presumed, the agricultural enterprises will be economical units for supporting family needs and agricultural production. This might lead to farms specializing in livestock production. This diversification will result in the establishment of mixed farming systems for sustainable production of food for humans and feed for animals.

Figure 1. A view of a field experiment of berseem clover (cv. Alex) at Adana (Nedirli, 2010)

Figure 2. Harvesting of berseem clover (cv. Alex) in a field experiment at Adana (Nedirli, 2010)

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Annex 1

GLOSSARY OF CROPS MENTIONED IN THE TEXT

Botanical Name	Common Name	Common Synonym (s)
Avena	Oat	
Beta vulgaris L. var. rapacea Koch	Forage beet	
Brassica campestris L.	Mustard	Turnip and rape
Echinochloa crus gall	Barn yard grass	
Echinochloa frumentacea (Roxb.) L.	Barnyard millet grass	
Echinochloa frumentacea (Roxb.) L.	Barnyard millet grass	
Chenopodium quinoa Willd.	Quinones	
Cicer aritenum	chickpea	Black gram
Chloris gayana kunath	Rhodes grass	
Cuscuta planiflora	Dodder	
Desmodium gangeticum	Spanish clover	.
Helianthus annus	Sunflower	
Hordium vulgare L.	Barley	
Julgans nigra	Walnuts	
Lathyrus sativus L.	Chickling vetch, grass pea, Rough pea	
Lens culinaris	lentil	
Lolium multiflorum Lam.	Italian Rye grass	L. italicum
Malus pumila (sylvestris)	Apples	
Medicago sativa L.	Alfalfa	lucerne, alfalfa
Morus alba L.	Mulberry	
Onobrychis viciifolia Scop.	Sainfoin	
Oryza sativa L.	Rice	
Panicum americanum (L.) K. SCHUM.	Pearl millet	p. typhoides
Panicum purpuureum Schumach.	Elephant grass/ Mot grass	
Pinus gerardiana	Chilghoza	Pine nut
Pistacia vera L.	Pistachio	
Prunus americana	Plums	Malum
Prunus armeniaca	Apricots	
Prunus persica	Peaches	
Punica granatum	Pomegranate	
Pyrus calleryana	Pears	
Rhizobium trifolli	Berseem-rhizobia	
S. arundinaceum var.sudanense	Sudan grass	
S. bicolor (L.) Var. vulgare	Sorghum	

Botanical Name	Common Name	Common Synonym (s)
Triticum aestivum L. Thell.	Wheat	
Trifolium alexandrinum	Berseem	Egyptian clover
Trifolium fragiferum L.	Strawberry clover	
Trifolium lantago phaeostoma	Peshawari Shaftala	
Triticale (× Triticosecale), triti'keil:	Triticale	
Trifolium resipunatum	Missry Shaftala	
Vicia faba	Faba bean	
Vigna sinensis L.	Cowpea	Lobia
Vitis vinifera	Grapes	
Zea mays L.	Maize	Maize

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