EFFECT OF SOWING DATE AND FERTILIZER ON DRY MATTER, GRAIN NUTRITION LEVEL AND YIELD OF FABA BEAN (*Vicia faba cv. Kalimotor*)

BY

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CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF SOWING DATE AND FERTILIZER ON DRY MATTER, GRAIN NUTRITION LEVEL AND YIELD OF FABA BEAN** (*Vicia faba cv. Kalimotor*)" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY**, embodies the result of a piece of bonafide research work carried out by Md. Abu Kawochar, registration No. 27552/00718 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: 30-12-2007
Dhaka, Bangladesh

(Prof. Dr. Md. Jafar Ullah)
Supervisor

Dedicated to
My
Parents, Grandfather & Teachers
who laid the foundation of my success

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ABSTRACT

An experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of sowing date and fertilizer on the dry matter, grain nutrition level and yields of faba bean (*Vicia faba* L.) cv. Kalimotor during the period from October 2006 to March 2007. The trial comprised with three sowing dates (20 October, 15 November and 10 December) and four fertilizer treatments (6 kg N + 20 kg P_2O_5 + 20 kg K_2O + 15 kg S ha^{-1}; 12 kg N + 40 kg P_2O_5 + 40 kg K_2O + 30 kg S ha^{-1}; 18 kg N + 60 kg P_2O_5 + 60 kg K_2O + 45 kg S ha^{-1} and 24 kg N + 80 kg P_2O_5 + 80 kg K_2O + 60 kg S ha^{-1}) which were tested in a RCBD design with three replications. Fertilizers were applied during final land preparation. All data were recorded at harvest. Results showed that the highest values were attained with 15 November. There was a severe reduction in yield due to delay of sowing. The highest value of pods per plant (53.80), filled pods per plant (28.12), 1000-seeds weight (92.13g) and grain weight per plant (8.946g) were obtained with 18kg N + 60 kg P_2O_5 + 60kg K_2O + 45 kg S ha^{-1}. The interaction effect of date of sowing and fertilizer levels was also significant. Seed yield (1.454 t/ha) was the highest in 15 November sowing fertilized with 18 kg N + 60 kg P_2O_5 + 60 kg K_2O + 45 kg S ha^{-1}. Sowing dates and fertilizers also contributed on grain nutritional level. However, the effects were a bit inconsistent.

CONTENTS

LIST OF TABLES

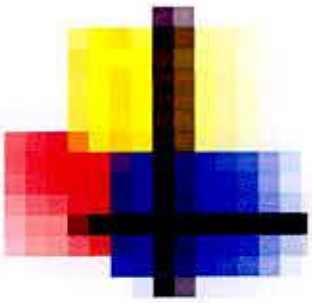
LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
FW	=	Fresh Weight
Fed	=	Feddan (1 fed = 0.42 ha)
Fed^{-1}	=	per feddan
ppm	=	Parts per million
N	=	Nitrogen
et al	=	And others
TSP	=	Triple super phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
g	=	gram(s)
Kg	=	Kilogram
m^2	=	square-meter
SRDI	=	Soil Resources and Development Institute
HI	=	Harvest Index
No.	=	Number
Wt.	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
mm	=	Millimeter
Max.	=	Maximum
Min.	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPKS	=	Nitrogen, Phosphorus, Potassium and Sulfur
CV%	=	Percentage of coefficient of variance
Hr	=	Hour



CHAPTER 1

Introdution

CHAPTER I

INTRODUCTION

Faba bean seed is used as human food in developing countries and as animal feed, mainly for pigs, horses, poultry and pigeons in industrialized countries. It also can be used as a vegetable, green or dried, fresh or canned. It is a common breakfast food in the middle east, mediterranean region, China and Ethiopia (Bond *et al.*, 1985).

Feeding value of faba bean is high, and is considered in some areas to be superior to field peas or other legumes. Sometimes it is grown for green manure, but more generally for stock feed. Large-seeded cultivars are used as vegetable. Roasted seeds are eaten like peanuts in India (Duke, 1981). Straw from faba bean harvest fetches a premium in Egypt and Sudan and is considered as a cash crop. The straw can also be used for brick making and as a fuel in parts of Sudan and Ethiopia (Bond *et al.*, 1985). Murinda and Saxena (1985) reported that faba bean fixes more nitrogen (135 kg N ha^{-1}) than lentil and chickpea.

It is grown as a winter annual in warm temperate and subtropical areas; hardier cultivars in the Mediterranean region tolerate winter temperatures of -10°C without serious injury whereas the hardiest European cultivars can tolerate up to -15°C. They are considered to be the least drought resistant of legume crops; however, cultivars with high water use efficiency have been developed at ICARDA (Robertson *et al.*,

1996). Optimum temperatures for production range from 18 to 27°C (65 - 85°F). It can tolerate nearly any soil type; grows best on rich loams. Some faba bean cultivars are reported to exhibit tolerance to high pH, insects, low pH, slope, and viruses (Duke, 1981). Rainfall of 650 - 1000 mm per annum evenly distributed is ideal (Kay, 1979). Thus, the crop is grown from the equator to almost all the areas of Arctic Circle and from sea level to very high altitude which demonstrates its wide genetic diversity (Bond *et al.*, 1985).

The whole dried seeds contain (per 100 g) 344 calories, 1.3 g fat, 59.4 g total carbohydrate, 6.8 g fiber, 3.0 g ash, 104 mg Ca, 301 mg P, 6.7 mg Fe, 8 mg Na under 10.1% moisture (Duke, 1981). The amino acid content except for methionine is reasonably well balanced in faba bean (Bond *et al.*, 1985).

Among the faba bean producer China was the largest producer with estimated annual production 2.4 - 2.6 million MT (1161 - 1447 kg/ha) and 60% of total world production comes from China. Argentina reported the highest yield of more than 9000 kg/ha from 1992 to 2004, followed by Switzerland (3350 - 4375 kg ha^{-1}), France (3000 - 3900 kg ha^{-1}) and Belgium (3350 - 3750 kg ha^{-1}) during the same years (FAO, 2005). Large seeded green types are canned. It is the second ranking food legume in Europe (Picard *et al.*, 1988). Faba bean production in the world is concentrated in nine major agroecological regions, namely; northern Europe, Mediterranean, the Nile valley, Ethiopia, Central Asia, East Asia, Oceana, Latin America, and North America (Bond

et al., 1985). There has been a 50,000 tons increase in production in Australia, a 50,000 tons increase in EEC, and a 210,000 tons increase in West Asia and North Africa (WANA) from 1982 to 1992 (Oram and Agcaoili, 1994).

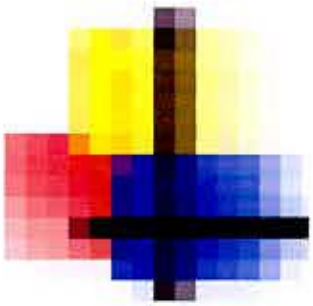
Faba beans are generally sown in October - November in Africa e.g. Egypt. It was reported that late sowing increased field emergence and reduced the number of days to flowering, fresh harvest and maturity, but suppressed vegetative growth as measured by plant height and number of primary branches and reduced green pod length and number of green seeds pod^{-1}. Whereas early sowing gave the highest FW and dry seed yields (7.5 - 9.7 and 1.57 - 1.79 ton $feddan^{-1}$, resp.). Late sowing reduced yields from 5.45 to 6.73 t FW and 0.83 - 1.58 t dry seeds $feddan^{-1}$. Dry seed protein content was lowest with the earliest sowing date (Murabaa *et al.*, 1987a).

In Mexico seeds was sown from June to December to evaluated the effects of 17 fertilizer rates of nitrogen (0 - 76 kg ha^{-1}), phosphorus (0 - 76 kg ha^{-1}) and potassium (0 - 57 kg ha^{-1}) on the growth and yield components of faba bean. Results showed that treatment with nitrogen, phosphorus and potassium increased the plant height but not the number of branches. The cultivar used had a positive response only for the yield components, 100-seed weight and yield per hectare. The optimum fertilization rate was found to be 00-76-57 kg NPK ha^{-1} (Hernandez *et al.*, 2001)

Faba bean (*Vicia faba*) has been being cultivated in Bangladesh for many years in some localities. However, in comparison to other grain legumes, the cultivation area

under ths crop is quite low and no statistical data regarding its area and production. But due to the ever increasing demand, Bangladesh has to import a lot of valuable foreign currency every year. Due to the population pressure, these are also tremendous pessure of growing food crops, especially cereals on our land. More commonly grown pulses such as lentil, grasspea, mungbean, peas, chickpea and blackgram are not so productive as we expect in relation to those of cereals. So, it is essential to find out ansd introduce some tother pulses in search of higher yield poenteials as welll as more nutritional aspects. In Bangladesh, one local cultivar of faba bean named 'kali motor' or 'Bakla kalai has been being grown in some areas, especially at manikgong. But, no information is available regarding its production practices. Considering the above facts this study was undertaken with the following objectives-

i. to find out the optimum sowing date of faba bean
ii. to find out the optimum doses of fertilizers for achieving higher productivity in faba bean, and
iii. to evaluate the nutritional quality of faba bean under different sowing dates and fertilizer levels



CHAPTER 2

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Many studies have been carried out in different parts of the world for the improvement of faba bean. However, there are evidences that the yield of faba bean can be increased substantially by using optimum sowing date and fertilizers. Information available, concerning to the present studies is cited below.

2.1 Effect of sowing date

Annicchiarico (2005) carried out a field experiment on 17 cultivars of faba bean (*Vicia faba*). Results indicated wide variation in the performance within species. Autumn and late winter sowing gave yield of 2.78 and 2.69 t/ha respectively.

Oweis *et al.* (2005) carried out an experiment in Northern Syria including three sowing dates (Early: early November; Normal: mid December, and Late: late January). Early sowing date of faba bean steadily increased grain yield of 1.73 t/ha. Yields were 1.60 t/ha for normal and 1.38 t/ha for late sowing. Overall mean water use efficiency was 0.59 kg m^{-3} for early; 0.61 kg m^{-3} for normal and 0.52 kg m^{-3} for late sowing indicating that the optimal sowing date was mid December.

Mekky *et al.* (2003) conducted an experiment on the effects of sowing date (1, 15, or 30 November) in Egypt, during the 1999 - 2000 and 2000 - 2001 winter seasons.

Sowing on 30 November resulted in the highest faba bean weight, pod number and weight, seed weight, and seed yield. Sowing on 1 November gave the tallest plants with the highest pigment (chlorophyll a, chlorophyll b, and carotenoid) content. Giza 429 recorded lower dry weight and population and higher pigment content, branch number, plant height and weight, pod weight and number, and seed yield and weight, branch number, pod weight and number, seed weight, and seed yield. Higher seed weight and yield were obtained when sown on 15 November.

Turk and Tawaha (2002a) conducted an experiment during 1998-99 and 1999-2000 in Jordan to investigate the effect of sowing date (20 and 30 November, 10 and 20 December) and seed size (small, medium and large) on the yield and yield components of a local cultivar of faba bean. Results revealed that seed yield was not significantly affected by both seed size and seasons. Results also showed that grain yield was reduced due to a delay in sowing. The highest grain yield (1035 kg ha^{-1}) was obtained in plants sown in 20 November.

Bakheit *et al.* (2001) conducted experiments in Egypt during 1998-99 and 1999-2000 seasons to study the effect of sowing dates (1 and 20 October, and 10 November) and population densities (66, 33 and 22 plants/m^2) on yield and its components of faba bean cultivars (Giza 402, Giza 2, Giza 429 and Giza 674). Results showed that early planting (1 October) produced the tallest plants in both locations, lower number of

branches plant^{-1}, highest straw yield and highest pod length compared to other planting dates. The number of pods/plant was highest with October 20 planting date.

Salman and Elhagag (2001) conducted an experiment on faba bean cv. Giza 2 under 4 sowing dates (20 October, 5 and 20 November, and 5 December) in Egypt during 1999 - 2000 and 2000 - 2001. They reported that the 1st sowing date (20 October) was the most favorable in producing more yield by reducing *T. tabaci* infestation on faba beans.

Sekara and Poniedziaek (2001) conducted a study during 1998 - 2000 to determine the effect of sowing dates (1, 7 and 14 April 1998; 15, 26 April and 5 May 1999; 1, 17 and 26 April, 2000) on the yield. In conditions typical for the region of Krakow, Poland, sowing in the first two weeks of April led to the achievement of a 3.5 - 7.1 t/ha yield while in the case of delayed sowing, the yield was considerably lower.

Sekara *et al.* (2001) carried out a field experiment in Poland, in 1998 - 2000 to study the effect of temperature and rainfall during the vegetation period on flowering and pod setting of faba bean cv. Gobik at three sowing terms through 1 April to 5 May. Results showed that the delay sowing date increased the number of flowers but decreased the level of pods and seeds.

Hatam *et al.* (1999) conducted an field experiment on faba bean (*Vicia faba*) cv. local in which seed was sown in 22 October and 7 January in Peshawar Valley, Pakistan. It

was seen that when sowing was delayed from 22 October to 7 January, days to 50% flowering decreased significantly from 61 to 56 days; days to maturity from 191 to 150 days. But plant height increased from 105 to 150cm due to delayed sowing. Reductions in biological and grain yields were 82 and 85% respectively. Hundred-seed weight was unaffected by sowing dates. Early sowing of faba bean exhibited higher grain yield under the climatic conditions of Peshawar Valley.

Saghin (1998) conducted an experiment on the effect of sowing date on biology and seed production of *Vicia faba* during 1993 - 94 at the Pojorita Agricultural Research Center (Suceava district). He reported that sowing in the first 2 weeks of spring was optimum. With a 10 days delay after that time leaded to a significant decrease of yield and yield components.

Adisarwanto and Knight (1997) carried out a field experiment on faba beans (*Vicia faba*) at the Waite Agricultural Research Institute, South Australia, at 3-week intervals between 24 April and 26 June. Results showed that later sowing drastically reduced yields. Variation in yield was largely determined by variation in the number of pods per unit area. Seeds per pod was constant across the treatments but weight per seed decreased when sowing was delayed beyond 10 June. With later sowing, the number of pod-bearing nodes on the main stems declined from 27 to 15. Early-sown plants at high density had fewer pods per node at the lower nodes and more pods per node at the higher nodes than plants at low density. This interaction was not evident at

the second sowing and the number of pods at each node was unaffected by density. For the sowings in June, all nodes of the low density plants bore more pods. The number of seeds per pod was smaller at the lowest and highest nodes, but as there were few pods at these nodes, this did not affect the mean number of seeds per pod when evaluated for all pods on a plant.

Abdalla (1995) conducted a field experiment at New Haifa Experiment Station, Sudan where *Vicia faba* was sown on 30 October, 1, 10, 20 or 30 November, 1993. Sowing between 25 October and 30 November did not show significant effect. Yields were highest with sowing on 25 October, 1 and 10 November.

McDonald *et al.* (1994) conducted a field experiment in 1986 - 90 at 2 sites in South Australia. Sequential sowings were conducted to examine the effect of sowing date and a vernalization treatment on the phenology of faba beans cv. Fiord and a range of accessions. Delayed sowing increased the time to establishment. The greatest response to vernalization occurred with early autumn (Apr.) sowing. When sown in late winter (Aug.), however, there was little response to vernalization.

Stutzel *et al.* (1994) carried out a field experiment on cultivar (Ticol and Herz Freya) of *V. faba* in 1989 and 1990 in South Germany. It was seen that delayed sowing reduced field emergence rates in both the years. Seed yields and DM production were generally higher in Herz Freya than in Ticol.

Elemery (1993) conducted laboratory and pot experiments in 1990 - 92 at Giza using sowing dates of 29 Oct., 13 or 28 Nov., or 14 Dec. Plant growth at 20 days after sowing was greater from larger seeds, but after 35 days differences were not significant. But with the 1st 2 sowing dates seed yield/plant was higher. Seed weight/plant in both growing seasons was decreased by sowing later than 13 Nov.

Kumar and Singh (1993) carried out a field experiments on *V. faba cv.* VH 82-1 and HB 180 at Hisar, Haryana sowing seeds on 1, 15 or 30 Oct. or 15 or 30 Nov., 1990 using 30, 45 or 60 cm row spacings. Seed yield was 3.26 t/ha from 1 Oct. sowing, decreasing with later sowing to 1.75 t/ha from the last sowing date.

Sliman (1993) conducted a field trial at Deirab Agricultural Experimental Station, Saudi Arabia in 1988-90 *V. faba* cv. Giza 3 and X77TA66 were sown on 15 Oct., 30 Oct., 15 Nov. or 1 Dec. Yields were highest at the earliest sowing date (4.09 and 3.61 t/ha in Giza 3 and X77TA66, respectively), decreasing to 1.54 and 1.94 t, respectively, with sowing on 1 Dec. Delayed sowing decreased both total DM production and harvest index.

Tay (1992) carried out rainfed field trials in Yungay in the Andes foothills and Chillan in the Central Valley region of Chile in 1990, Vicia faba was sown on 26 June, 19 July, 10 or 24 Aug. At Yungay, green pod, DM and seed yields were highest with sowing on 26 June (21.4, 8.3 and 5.2 ton ha^{-1}, respectively) while at Chillan, green pod and seed yields were highest with sowing on 26 June (12.0 and 2.3 ton ha^{-1})

and DM yield was highest with sowing on 19 July (3.6 ton ha^{-1}). Number of pods/plant and 1000-seed weight were also highest at earlier sowing dates at both locations.

Hebblethwaite *et al.* (1991) conducted an experiment in Leicester, UK on sowing date, irrigation, plant growth regulator, and the problems of establishing white flowered faba beans. For each week's delay in sowing after the 1st week in Mar. for spring beans, and the 1st week in Oct. for winter beans, yield decreased by 72 and 68 kg ha^{-1} respectively.

Pilbeam *et al.* (1990) conducted a field trial at Sutton Bonington in 1985-87 using *V. faba* cv. Bourdon (indeterminate) which was sown in early-mid Oct., late Oct. early Nov. or late Nov.-early Dec. Av. seed yield was highest for Bourdon at all sowing dates but seed yield in all cultivars decreased with delayed sowing.

Herzog (1989) conducted field trials near Kiel. The winter *Vicia faba* cv. Webo was sown in autumn or spring in 1981 - 82 and 1982 - 83. In 1983 - 84 and 1985 - 86, 6 winter and 3 spring cultivars were sown on 3 dates in Sep.-Oct. and 2 dates in Mar.-Apr. The phases of maximum increase in number of newly formed leaves, mature flowers and growing pods and maximum Pod set were 21.5, 19.8, 17.8 and 15 d earlier in autumn-sown crops than there of in spring-sown crops. The developmental stages were longer in autumn-sown crops. Shoot density was much greater in autumn-sown crops, except in 1981- 82. Early rather than late autumn sowing increased

numbers of leaves, flowers and pods shoot^{-1}. Enhancement of tillering by early sowing diminished after spring.

Labuda (1989) carried out field trials at Lublin-Felin in 1977-80 seven *V. faba* cultivars were sown in late Apr. or mid - or late May at 40 X 20 cm spacing. Plant height and number of inflorescences, flowers and pods/plant were greatest at the intermediate sowing date. Climatic factors had the greatest effect on the duration of particular growth stages. It was concluded that the seed yield/plant depended on the number of mature pods/plants, which decreased markedly with delay in sowing.

Pilbeam *et al.* (1989) conducted field trials at Sutton Bonington to evaluate growth and development of *Vicia faba* cv. Alfred and Ticol which were sown on 11 Mar., 3 Apr. or 29 Apr. 1986 and on 24 Feb., 26 Mar. or 22 Apr. 1987. Seed yields were highest with sowing on 3 Apr. 1986 and 24 Feb. 1987. Earlier sown crops had larger canopies especially at pod filling. This probably reflected the influence of temperature on the expansion and senescence of leaves during development. The semi-determinate cv. Alfred yielded 31% more than the determinate cv. Ticol.

Haddad and Thalji (1988) studied a field trial in 1984-86 at Maru and M'shagar. A local faba bean cultivar was sown in late Nov., Dec or Jan. at row spacings of 20, 30, 40, 50 or 60 cm. Yields after sowing in Nov. were more than double than those after sowing in January. The highest yields were produced with Nov. sowing at densities of

17, 20 or 25 plants/m^2. Yield increased as a result of early sowing which was due to increased pod number, plant height, root DW, nodule number and nodule DW.

Gorashi (1987) conducted field trials on three faba bean cultivars which were sown on 4 dates in the 1981 - 82 and 1982 - 83 winter seasons in the field of New Haifa. Mean seed yield was 0.76, 1.48, 1.43 and 1.14 ton ha^{-1} when sown on 1 Oct., 15 Oct., 1 Nov. and 15 Nov., respectively. Plant height and seed wt/plant were highest with 15 Oct. sowing in 1982.

McEwen *et al.* (1988) conducted experiments on sowing dates (late Sep. and approx. 28 and 56 days later) on *V. faba* grown on clay with flints soil at Rothamsted. Seed yield was always highest with the earliest sowing and least with the latest. The earliest sowing advanced flowering date by 2 weeks compared with the latest but did not affect harvest date. Early sowing did not increase susceptibility to winter kill.

Murabaa *et al.* (1987a) conducted an experiment on faba beans which were sown on 25 Oct. or 25 Nov. in 1982 - 83, and on these dates and 25 Sep. in 1983 - 84 and 1984 - 85 at Assiut, Egypt. Late sowing increased field emergence and reduced the number of days to flowering, fresh harvest and maturity, but suppressed vegetative growth as measured by plant height and number of primary branches and reduced green pod length and number of green seeds/pod. Sowing on 25 Oct. gave the highest FW and dry seed yields (7.5-9.7 and 1.57-1.79 ton $fedd^{-1}$, respectively). Late sowing reduced

yields from 5.45 - 6.73 t on fresh weight and 0.83 - 1.58 t dry seeds $fedd^{-1}$. Dry seed protein content was lowest with the earliest sowing date in 1984. [1 feddan = 0.42 ha]

Murabaa *et al.* (1987b) conducted an experiment on seven large flat seeded *Vicia faba* var. major and 5 medium seeded *V. faba* var. equina cultivars which were sown on 25 Sep., 25 Oct. or 25 Nov. in 1982 - 83, 1983 - 84 and 1984 - 85 at Assiut, Egypt. They reported that there was significant effect of sowing date 25 Oct. showing the heist yield.

2.2. Effects of different fertilizers

Rizk *et al.* (2006) carried out two field experiments at the Agricultural Research Station of Giza, Agricultural Research Center, Egypt, during the winter seasons of 2000 - 2001 and 2003 - 2004. The study was conducted to investigate the effect of organic manure, bio- and mineral fertilizers as a total or partial replacement of mineral fertilizers on yield and yield components of faba bean (*Vicia faba*). Three levels of organic manure (garbage compost) and six treatments of bio- and mineral fertilizer i.e., zero nitrogen + 15.5 P_2O_5 + 12 K_2O, 15 N + 15.5 P_2O_5+12 K_2O, zero nitrogen + 7.75 P_2O_5+6 K_2O, 15 N + 7.75 P_2O_5+6 K_2O, phosphorin (biofertilizer) and phosphorin + 12 K_2O, were used. A strip plot design with four replications was used. The results indicated that 40 m^3/fad of organic manure increased all studied traits. Similar results were obtained by using biofertilizer (phosphorin) as well as the combination of 15 N + 15.5 P_2O_5+12 K_2O fad^{-1}. The promising interaction treatment

that gave the highest yield and yield components was $40m^3$/fad of organic manure + 15 N + 15.5 P_2O_5+12 K_2O.

Abagy (2003) conducted a field experiment in Kalubia Governorate, Egypt, during 1994 - 95 and 1995 - 96 winter seasons to study the effect of broad bean plants with foliar fertilizers, i.e. Greenzit, Vitaforte, Folifertile and Wxal at 0.0, 0.75 and 1.50% level. There were significant differences among the foliar fertilizer levels in all the studied growth characters. In addition, spraying the plants with Greenzit at 1.5% concentration gave the best results. Using foliar fertilizers at different concentrations (0.75 and 1.50%) increased the percentage of total N, P and K content which in tern produced green seeds.

Ahmed *et al.* (2003) conducted field experiments at El-Nagah village, south Tahrir Region, Behira Governorate, Egypt, in a reclaimed sandy soil during the winter seasons of 2001- 02 and 2002 - 03 to study the effect of some fertilizers (biofertilizer (phosphorine), chemical fertilizer (nitrogen, phosphorus and potassium) and organic fertilizer) on the growth and yield of faba bean cv. Giza 614. Significant differences were obtained for all the characters between control and all treatments at the vegetative stage except the treatment of chemical fertilizer.

Abdalla (2002) conducted field experiments in Egypt, during 2000 and 2001 to study the effects of mineral and/or biofertilizer treatments of P on the growth and productivity of faba beans (cv. El-Kobrsy). The treatments comprised: no application,

application at sowing + application at sowing and one month after sowing of biofertilizer (phosphorin; 2 packages each of 1 kg fed^{-1}); and 100, 150 and 200 kg superphosphate fed^{-1}. Biofertilizer treatments improved plant height, number of leaves and shoots, and dry matter content compared to the control. Superphosphate at 150-200 kg fed^{-1} improved plant growth. The contents of N, P, K, protein, total soluble sugars and ascorbic acid increased with biofertilizer treatments and with increasing rates of P from 100-200 kg super phosphate/fed. (1fed = 0.42 ha)

Adam (2002) conducted field experiments in Egypt, during 1999 - 2000 and 2000 - 01 to study the effects of bionitrogen (Nitrobein) and chemical nitrogen fertilizers on the growth and productivity of *Vicia faba* cv. El-Kobrsy. The treatments comprised combinations of bionitrogen (no application, single and double doses) and chemical nitrogen fertilizer (100, 150 and 200 kg ammonium sulfate fed^{-1}). Plant height, number of leaves and branches, and whole plant dry weight improved with 2 doses of Nitrobein. Ammonium sulfate at 100-200 kg fed^{-1} slowly increased the vegetative growth parameters. The interaction between the bio- and chemical nitrogen fertilizers significantly improved growth, which was highest in plants treated with 2 doses of Nitrobein combined with 150 kg ammonium sulfate/fed.

Kurdali *et al.* (2002) evaluated the impact of three rates of potassium (K) fertilizer (0, 75 and 150 kg K2O/ha) on nodulation, dry matter production and nitrogen (N_2) fixation by faba bean (*Vicia faba)* cv. Baladi in a pot experiment. Plant species

differed in their response to K fertilizer as a means of enhancing growth and overcoming the stress conditions. The higher level of K fertilizer increased both dry matter production and total N_2 fixed in faba bean as well as the percentage of N_2 fixed. However, in well-watered plants, a high requirement of the symbiotic system for potassium was needed to ensure an optimum growth and N_2 fixation.

Labuda (2002) conducted field experiments in 1999-2001 in Poland to evaluate pod setting in 5 faba bean cultivars (Windsor Bialy, Bartom, Neptun, samson and Lider) under different N fertilizer treatments. N showed a weaker effect on the number of pods per plant compared to weather conditions. The highest number of pods per plant (16.6) was observed at an N rate of 68 kg ha^{-1}, and the lowest was in the control treatment. Faba bean flowering was not related to pods per plant.

Ulukan *et al.* (2002) studied the response of faba bean cultivar (Filiz 99) and inbred lines (PN 55 K.No. 584-066 Reine Blance and PN 54 K.No. 7954x964-12B) to zinc fertilizer rates (0.0, 2.5, 5.0 and 7.5 kg ha^{-1}) in Ankara, Turkey, during 1999/2000 and 2000/2001. The increase in zinc rate enhanced plant height, biological yield and grain yield, but reduced first pod height, number of pods per plant and number of seeds per pod. The effects of zinc fertilizer on pod length, 100-seed weight and seed protein content were not significant. The performance of the cultivars varied with year and fertilizer rate; however, Filiz 99 showed greater stability in yield and yield components than the inbred lines.

Hernandez *et al.* (2001) conducted an experiment in Mexico from June to December 1995 to evaluate the effects of 17 fertilizer rates of nitrogen (0-76 kg ha^{-1}), phosphorus (0-76 kg ha^{-1}) and potassium (0-57 kg ha^{-1}) on the growth and yield components of faba bean. Treatment with nitrogen, phosphorus and potassium increased the plant height but not the number of branches. The cultivar had a positive response only for the 100-seed weight and yield per hectare. The optimum fertilization rate was 00 – 76 - 57 kg NPK ha^{-1}.

Soheir (2001) carried out Two field experiments in Ain Shams University of Agriculture Experimental Farm, at Shalakan, Egypt during 1998 - 99 and 1999 - 2000 seasons to investigate the effect of N (30, 45 or 60 kg fed^{-1}) and P (15.5, 23.25 or 31 kg fed^{-1}) fertilization. Increasing nitrogen from 30 to 60 kg fed^{-1} increased yield and yield attributes. N at 45 kg fed^{-1} increased seed yield by 550 and 200 kg fed^{-1} over those receiving 30 or 60 kg N fed^{-1}, respectively. The response of seed yield and yield attributes of faba bean plants to P fertilization followed the same trend as that of N fertilization. However, 31 kg P_2O_5 fed^{-1} increased seed yield by 550 and 340 kg fed^{-1} compared to those receiving 15.5 and 23.25 kg P_2O_5 fed^{-1}, respectively. Straw yield followed a similar trend. The highest seed yield was obtained at 45 kg N fed-1 and 31 kg P_2O_5 fed^{-1}, while the highest straw yield was obtained from 60 kg N fed^{-1} and 31 kg P_2O_5 fed^{-1}.

Yakout and Greish (2001) conducted a two-year (1998 - 2000) field study on sandy soils in Egypt and showed that soil application of phosphorus with or without biofertilizer (microbein) along with foliar fertilization (stimphol) significantly increased the yield, yield components and quality of faba bean. Results also indicated that incorporating biofertilizers with soil application of fertilizer improved utilization efficiency thereby resulted in saving of significant amount of P fertilizer use. This effect was more pronounced by including foliar nutrition.

Bolland *et al.* (2000) reported on seed (grain) yield responses of faba bean (*Vicia faba* L. cv. Fiord) to applications of fertilizer phosphorus (0, 5, 10, 20 and 40 kg P ha^{-1} as triple superphosphate) and zinc (0, 0.5, 1 and 2 kg Zn ha^{-1} as zinc oxide). Additions of fertilizer phosphorus significantly ($P < 0.001$) increased grain yields by about 50 and 100% in 2 experiments, but in the third experiment differences in grain yield due to applications of fertilizer phosphorus were not significant ($P > 0.05$). Increases in grain yields due to zinc fertilizer were small (< 10%) and were only significant ($P < 0.05$) in one experiment.

Srivastava and Srivastava (2000) conducted a field experiment at Ranchi, Bihar during the winter seasons of 1991 - 94 to study the effect of nitrogen and phosphorus on seed yield of faba bean (*Vicia faba*) cv. J5. Yield averaged 0.53, 0.76, 1.03 and 0.89 t/ha with 0, 20, 40 and 60 kg N/ha, and 0.55, 0.77, 1.00 and 0.90 t with 0, 20, 40 and 60 kg P_2O_5 ha^{-1}.

Dwivedi and Nayak (1998) carried out a field trial to evaluate the effect of sulfur (0, 20, 40 kg S/ha) and nitrogen (0, 20, 40 kg N/ha) application on yield and nutrient composition of faba bean (*Vicia faba*) grown on vertisol. Application of sulfur fertilizer at the rate of 40 kg/ha and nitrogen at the rate of 20 kg/ha significantly increased grain yield along with the composition of S and P. The interaction of S x N was synergistic and significant in faba bean.

Filek *et al.* (1997) conducted an experiment on *V. faba* cv. Nadwislanski (indeterminate) and cv. Tibo (determinate) which were grown on field plots in 1995 at a density of 20, 40 and 80 plants m^{-2} with 20 kg N ha^{-1} (low) or 150 kg N ha^{-1} (very high). Increased density of sowing as well as the high level of nitrogen fertilizer application inhibited the growth and development of root nodules and limited their nitrogenase activity in both cultivars. Plants of both cultivars were characterized by a similar potential of forming the root nodules. However, in plants of the cv. Tibo, the nitrogenase activity of nodules was much lower than in the cv. Nadwislanski. The depression of nitrogen fixation was under high N fertilizer application.

Nayak *et al.* (1997) observed in a field trial at Jabalpur, Madhya Pradesh whith *V. faba* cv. JV-2 where 0, 20 or 40 kg S and 0, 20 or 40 kg N/ha was given. Seed yield was highest (2.76 ton ha^{-1}) with 20 kg N + 40 kg S.

Salama and Dawood (1994) conducted field trials in 1992 - 94 at Assiut *V. faba* cv. Giza 402 was sown at 74 000, 111 100 or 222 400 plants/feddan and was given 22.5,

30, 37.5 or 45 kg P_2O_5 fed^{-1}. Seed yield was increased with up to 37.5 kg P fed^{-1}. The interaction between plant density and P application was significant; the highest seed yield was obtained with 37.5 kg P. (1fed = 0.42 ha)

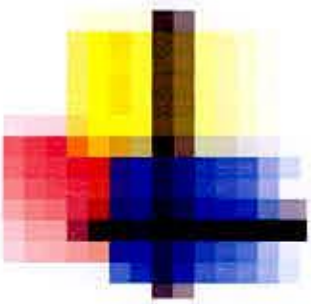
2.3. Interaction effect of sowing date and fertilizers

Kumar *et al.* (2005) determined the effects of different sowing dates (10 and 25 October; 5, 15 and 25 November) and levels of potash application (20, 40, 60 and 80 kg/ha) on yield of *Vicia faba* during 2000 - 01 in Bihar, India. Early-sown crop (15 October) recorded minimum disease intensity resulting in maximum grain yield followed by 25 October-sown crop. Grain yield recorded in 15 and 25 October-sown crop did not significantly differ. A delay in sowing increased disease intensity. The highest seed yield was obtained in 5 November-sown crops. An increase in potash level decreased disease intensity where minimum disease intensity was recorded in crops supplemented with 80 kg potash/ha. Maximum disease intensity (66.3%) was recorded in plots with no potash supplement. There was no significant difference in grain yield for the different levels of potash.

Turk and Tawaha (2002b) conducted field experiments during the winter seasons of 1998 - 99, 1999 - 2000 and 2000 - 01 at the semi-arid region of north Jordan to study the effects of sowing dates (14 January, 28 January and 12 February) and phosphorus levels (0, 17.5, 35.0 and 52.5 kg P ha^{-1}) on the growth and yield of faba beans cv. Minor. Sowing date and rate of phosphorus had significant effects on most of the

measured traits and yield components. In general, high yields were obtained by early sowing (14 January) and P application (52.5 kg P ha^{-1}).

Zeidan (2002) conducted two field experiments in Egypt during 1999 - 2000 and 2000 - 2001 to investigate the effect of sowing date (15 October, 1 November and 15 November) and urea fertilizer rate (0, 1, 2 and 3%) on the growth and yield of determinate faba bean cv. FLIP-87-117. Early sowing resulted in higher growth and yield than late sowing in 2 growing seasons. But this result was higher during 1999 - 2000 than in 2000 - 01. The growth, yield and protein content of faba bean were higher with 2% urea than the other rates. Spraying urea at 2% and were sowing at the earliest date resulted in the highest 100-seed weight, seed yield and harvest index.



CHAPTER 3

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

In this chapter, the details of different materials used and methodology followed during the experimental period are described.

3.1 Experimental site

The research work was carried out at the experiment field of Sher-e-Bangla Agricultural University, Dhaka, during the period from October, 2006 to March, 2007. Field view of the experimental field is shown in Plate I.

3.2 Soil

The soil of the experimental plots belonged to the agro-ecological zone of Madhupur Tract (AEZ-28) as shown in Appendix I. Initial soil samples from 0-15 cm depth were collected from experimental field. The collected samples were analyzed at Soil Resources Development Institute (SRDI), Dhaka, Bangladesh. The physio-chemical properties of the soil are presented in Appendix II.

3.3 Climate

The experimental area is under the subtropical climate. Usually the rainfall was heavy during Kharif season and scanty in Rabi season. The atmospheric temperatures were

higher in Kharif season. The weather conditions during experimentation such as monthly mean rainfall (mm), mean temperature (^{0}C), sunshine hours and humidity (%) are presented in Appendix III.

3.4 Planting material

This cultivar is grown in some areas of Manikgonj district. This is a popular crop to some farmers as these crops locally known to be diseases and drought resistant to some extent. More over, local farmers also grow this crop on marginal lands where no other crops or pulses are not seemed to be profitable to grow. The cultivar of faba bean used in the present study was a local one named Kalimotor. The seeds of this cultivar were collected from the local farmers of Harirampur Thaana in Manikgonj district. Before sowing, the seeds were tested for germination in the laboratory and the percentage of germination was found to be over 90%. The important characteristic of this variety is mentioned below:

3.4.1 Faba bean (Kalimotor)

Plants are of average 60 - 100 cm height. Leaves are darker green. The variety gave higher yield. Maximum seed yield is 3 - 4 t/ha. Seeds contain 22 - 43% protein and 45 - 59% Carbohydrate (Bond *et al.*, 1985)

3.5 Land preparation

The land was irrigated before ploughing. After having Joe condition the land was first opened with a tractor drawn disc plough. The ploughed soil was then brought into desirable fine tilth by 4 operations of harrowing and cross harrowing followed by laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 10 and 18 October, 2006, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers was incorporated thoroughly.

3.6 Fertilizer application

Fertilizer was applied in the experiment as per treatment. The doses of nutrients were determined following the various findings on pulses. N, P_2O_5, K_2O and S were applied as basal dose in the form of urea, TSP, MOP and gypsum.

3.7 Experimental design and lay out

The experiment was laid out in a randomized complete block design (RCBD). Each treatment was replicated three times. The size of each plot was 4m×3m. The distance between two adjacent replications (block) was 1.0 meter and plot-to-plot distance was 0.75 meter. The intra block and intra plot spaces were used as irrigation and drainage channels. A layout of the experiment has been shown in Appendix IV.

3.8 Treatments of the experiment

Sowing date:

S_1=20 October, 2006

S_2=15 November, 2006

S_3=10 December, 2006

Fertilizer combinations:

F_1= Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}

F_2= Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}

F_3= Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}

F_4= Nitrogen 24kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

The following treatments combinations were tested in this study:

S_1F_1 = 20 Oct., 2006 + (Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}),

S_1F_2 = 20 Oct., 2006 + (Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}),

S_1F_3 = 20 Oct., 2006 + (Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}),

S_1F_4 = 20 Oct., 2006 + (Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}),

S_2F_1 =15 Nov., 2006 + (Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15kg ha^{-1}),

S_2F_2 = 15 Nov., 2006 + (Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}),

S_2F_3 = 15 Nov., 2006 + (Nitrogen 18 kg+ P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}),

S_2F_4 = 15 Nov., 2006 + (Nitrogen 24 kg+ P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}),

S_3F_1 = 10 Dec., 2006 + (Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15kg ha^{-1}),

S_3F_2 = 10 Dec., 2006 + (Nitrogen 12 kg+ P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1})

S_3F_3 = 10 Dec., 2006 + (Nitrogen 18 kg+ P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}),

S_3F_4 = 10 Dec., 2006 + (Nitrogen 24 kg+ P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1})

3.9 Germination test

Germination test was performed before sowing seeds in the field. Three layers of filter papers were placed on petri dishes and seeds were placed on filter paper. Each petridis contained 100 seeds. By adding drops of water, the filter paper was kept moist from setting to the final count of the germination test. The ruptured seeds having plumule and radical were considered to be germinated. Germination percentage was calculated by using the following formula.

$$\% \text{ Germination} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds set for germination}} \times 100$$

3.10 Sowing of seeds in the field

The seeds of kali motor were sown as per treatment. Seeds were treated with Bavistin before sowing to control the seed borne diseases. The seeds were sown in solid rows in the furrows having a depth of 3-4 cm. Row to row distance was 40 cm and plant to plant distance 20 cm.

3.11 Intercultural operations

3.11.1 Thinning

Seeds were germinated four days after sowing (DAS). Thinning was done two times; first thinning was done at 12 days after sowing and second was done at 20 days after sowing maintaining plant population density of 1,25,000 plants ha^{-1}.

3.11.2 Irrigation and weeding

Irrigation was done as per treatments. The crop field was weeded thrice; first weeding was done at 12 DAS and second and third weeding was done 20 and 40 DAS respectively.

3.11.3 Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors (jassid) attacked the young plants and at latter stage of growth pod borer (*Maruca testulalis*) attacked the plant. Cymbuse 50 EC was sprayed at the rate of 1litre/ha.

3.12 Sampling and data collection

Ten plants from each treatment were randomly sampled and marked with sample card. The data on plant height, number of branches, number of flowers, and leaves per plant were recorded from sampled plants at harvest.

3.13 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color. The matured pods were collected by hand picking from a pre demarcated area of linear meter at the center of each plot.

3.14 Data collection

The following data were recorded

i. Plant height (cm.)
ii. Number of primary branches per plant
iii. Number of secondary branches per plant
iv. Number of filled pods per plant
v. Per cent of filled pods per plant
vi. Number of unfilled pods per plant
vii. Per cent of unfilled pods per plant
viii. Number of pods per plant
ix. Number of seeds per pod
x. 1000- seed weight (g)
xi. Grain weight per plant (g)
xii. Grain weight per hectare (ton)
xiii. Straw dry weight per plant (g)
xiv. Per cent straw dry weight per plant
xv. Grain dry weight per plant (g)
xvi. Per cent Grain dry weight per plant
xvii. Total above ground dry weight per plant (g)
xviii. Total above ground dry weight per hectare (ton)
xix. Grain nutrient analysis (Carbohydrate, Protein, Fats &Oils and Ash) (%)
xx. Harvest index (%)

3.15 Procedure of data collection

3.15.1 Plant height (cm)

The heights of ten plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

3.15.2 Number of primary branches plant^{-1}

All the primary branches present on ten sample plants were counted and were averaged.

3.15.3 Number of secondary branches plant^{-1}

All the secondary branches present on ten sample plants were counted and were averaged.

3.15.4 Number of filled pods plant^{-1}

Presence of only food material (grain) in the pod was considered as filled pod. Number of filled pods of ten plants from each plot was counted and the mean number was expressed in per plant basis.

3.15.5 Per cent of filled pods plant^{-1}

Per cent of filled pods per plant denotes the ratio of filled pods to total pods and was calculated with following formula.

$$\text{Filled pods per plant (\%)} = \frac{\text{Number of filled pods per plant}}{\text{Number of total pods per plant}} \times 100$$

3.15.6 Number of unfilled pods plant^{-1}

Pods' containing no food material (grain) in the pod was considered as unfilled pod. Number of unfilled pods of ten plants from each plot was counted and the mean number was expressed on per plant basis.

3.15.7 Per cent of unfilled pods plant^{-1}

Per cent of unfilled pods per plant denotes the ratio of filled pods to total pods and was calculated with following formula.

$$\text{Filled pods per plant (\%)} = \frac{\text{Number of unfilled pods per plant}}{\text{Number of total pods per plant}} \times 100$$

3.15.8 Number of pods plant^{-1}

Number of total pods of ten plants from each plot was counted and the mean number was expressed on per plant basis.

3.15.9 Number of seeds pod^{-1}

The number of seeds in each pod was also recorded from ten randomly selected pods.

3.15.10 Weight of 1000-seed (g)

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram.

3.15.11 Grain weight plant^{-1} (g)

Grain weight in each plot was also recorded from ten randomly selected plants.

3.15.12 Grain yield (t ha^{-1})

The seeds collected from 1 m^2 of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.15.13 Straw dry weight plant^{-1} (g)

The sum of the ten plants' parts (leaves dry weight stem dry weight and pod shell) constituted the straw dry weight.

3.15.14 Per cent of straw dry weight plant^{-1}

Percent of straw dry weight per plant denotes the ratio of straw dry weight to total dry weight and was calculated with following formula.

$$\text{Straw dry weight per plant (\%)} = \frac{\text{Straw dry weight per plant}}{\text{Total dry weight per plant}} \times 100$$

3.15. 15 Grain dry weight plant^{-1} (g)

Grain dry weight of ten plants of the each treatment was measured at harvest.

3.15.16 Per cent of grain dry weight plant^{-1}

Per cent of grain dry weight per plant denotes the ratio of grain dry weight to total dry weight and was calculated with following formula.

$$\text{Grain dry weight per plant (\%)} = \frac{\text{Grain dry weight per plant}}{\text{Total dry weight per plant}} \times 100$$

3.15.17 Total above ground dry weight plant^{-1} (g)

The sum of the plant parts (leaves dry weight, stem dry weight and reproductive dry weight) constituted the total above ground dry weight.

3.15.18 Total above ground dry weight ha^{-1} (ton)

The plants collected from 1 m^2 of each plot were oven dried properly. The dry weight of plants was taken and converted the total above ground dry weight in t ha^{-1}.

3.15.19 Grain nutrition level analysis (Carbohydrate, Protein, Fats and Oils and ash)

The grain was analysed from Animal Resources Department, Farmgate, Dhaka.

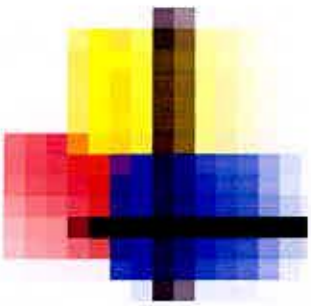
3.15.20 Harvest index (%)

The harvest index was calculated by using the following formula

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.15.25 Analysis of data

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT-computer package program developed by Russel (1986). The means were compared by DMRT test.



CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISSCUSSION

The present study was carried out to determine the effect of sowing date and NPKS level and their interaction on growth, dry matter, yield and yield attributes and grain nutrition level of faba bean cv. Kalimotor. The parameters studied in the experiment were statistically analyzed and results obtained were presented to arrive at logical conclusion as per objectives of the study.

4.1 Plant height (cm)

4.1.1 Effect of sowing date

Plant height varied significantly due to the sowing dates (Fig.1). The plant height was the highest (46.37cm) with crop sown on S_2 which was however, similar with S_1. The shortest plants (34.19cm) were observed with the crop sown on S_3. Hatam *et al.* (1999) observed on faba bean that the plant height was varied due to different sowing dates and the highest plant height (81.6cm) was obtained with the early sowing of 20 October to 7 January under Peshawar Valley environment of Pakistan.

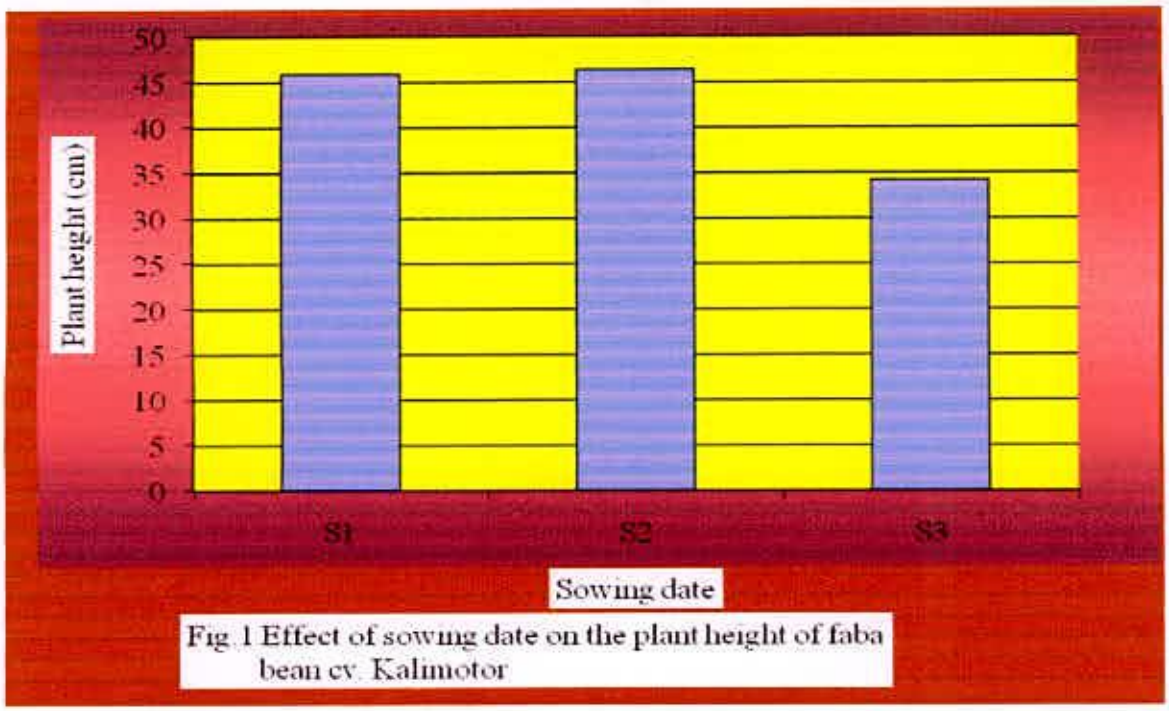


Fig. 1 Effect of sowing date on the plant height of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3

4.1.2 Effect of fertilizers

The plant height varied significantly among fertilizer doses (Fig. 2). The treatment F_3 produced the tallest plant (45.9cm). But F_2 and F_4 were statistically similar. The plot applied F_1 produced significantly shortest plants (38.44 cm) which were inferior to all other treatments.

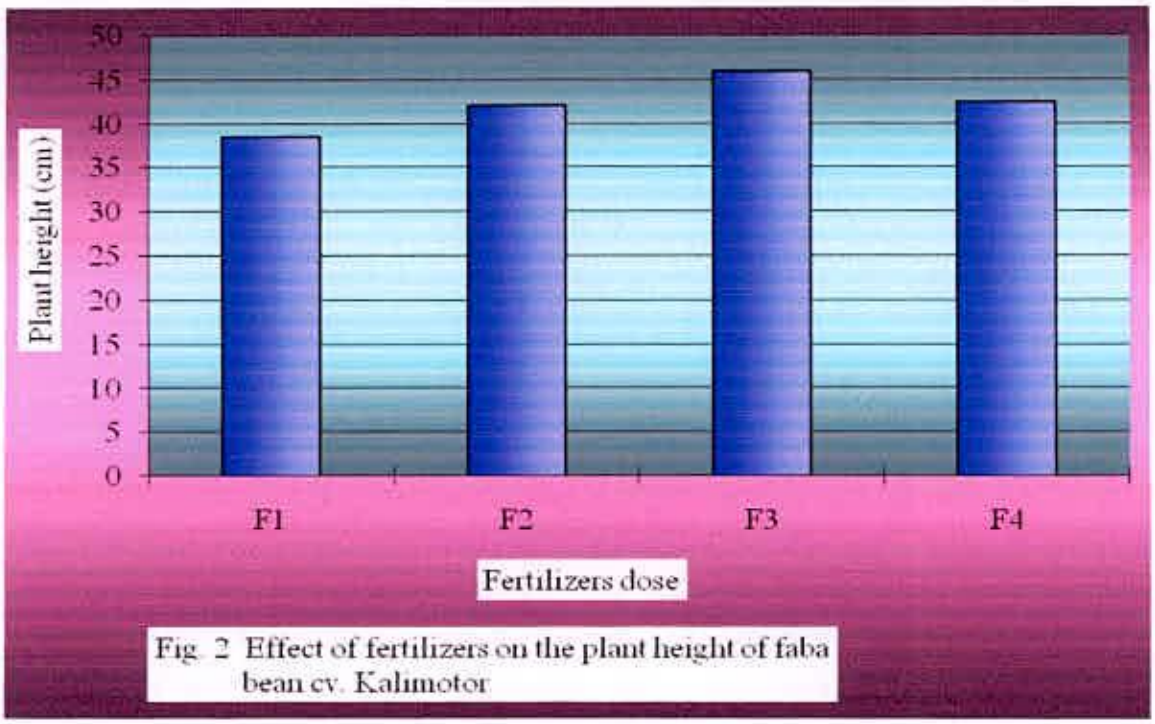


Fig. 2 Effect of fertilizers on the plant height of faba bean cv. Kalimotor

F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.1.3 Interaction effect of sowing date and fertilizers

There was a significant effect between sowing dates and fertilizers on plant height (Fig. 3). Significantly the tallest plants (50.91cm) was found with S_1F_3 which was statistically similar with S_2F_2, S_2F_3 and S_2F_4 while the shortest plant (31.89cm) was found with S_3F_4 which was also statistically similar to S_3F_1 and S_3F_2. Both optimum sowing date and fertilizers probably increased the cell division or cell elongation of faba bean leads to the increased plant height.

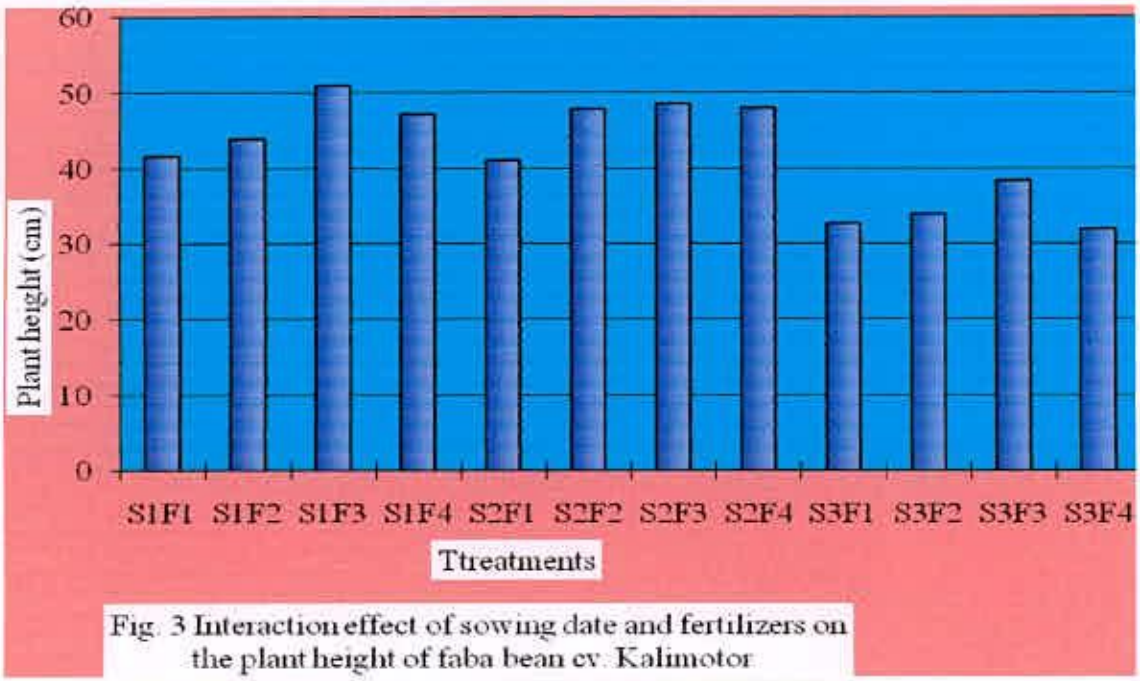


Fig. 3 Interaction effect of sowing date and fertilizers on the plant height of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3
F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.2 Number of primary branches plant^{-1}

4.2.1 Effect of sowing date

Variation in the number of primary branches was highly significant due to the sowing dates (Fig.4). Number of primary branches was the highest (5.79) with crop sown on F_2 which was however, similar with F_1. On the contrary the lowest (3.56) were observed for the crop sown on F_3. Mekky *et al.* (2003) observed on faba bean that the number of primary branches plant^{-1} was varied due to different sowing dates and the highest number of primary branches plant^{-1} was obtained when the crop was on 1 November. Murabaa *et al.* (1987) investigated on faba

bean that delayed sowing gave minimum number of primary branches plant^{-1} under Egyptian condition. Madonald (1994) also observed on faba bean that delayed sowing increased the time for establishment.

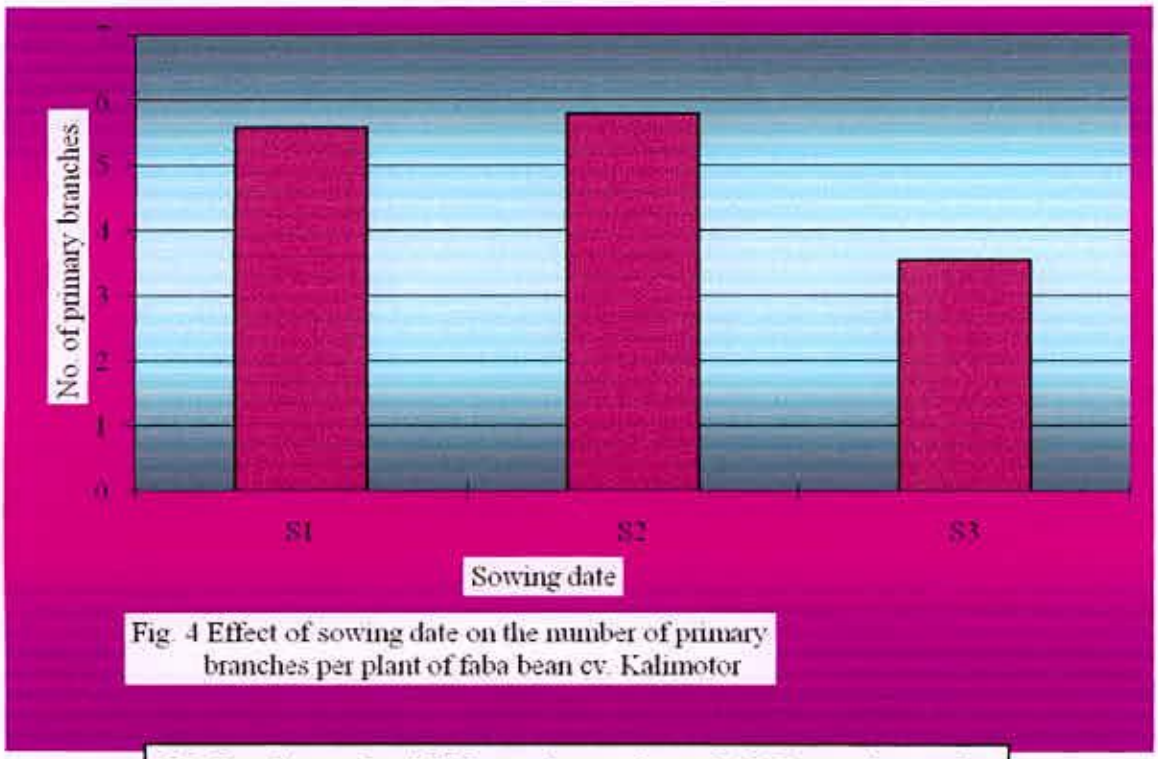


Fig. 4 Effect of sowing date on the number of primary branches per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3

4.2.2 Effect of fertilizers

The number of primary branches plant^{-1} varied significantly due to for fertilizer dose (Fig. 5). The treatment F_3 produced the highest number of primary branches plant^{-1} (5.69) which was however identical with F_2. The treatment F_1 produced significantly lowest number of primary branches plant^{-1} (3.98). Rizk *et al.* (2006) observed on faba bean that using 15kg N + 15.5kg P_2O_5+12kg K_2O fad^{-1} gave the highest number of primary branches plant^{-1} under Egyptian condition.

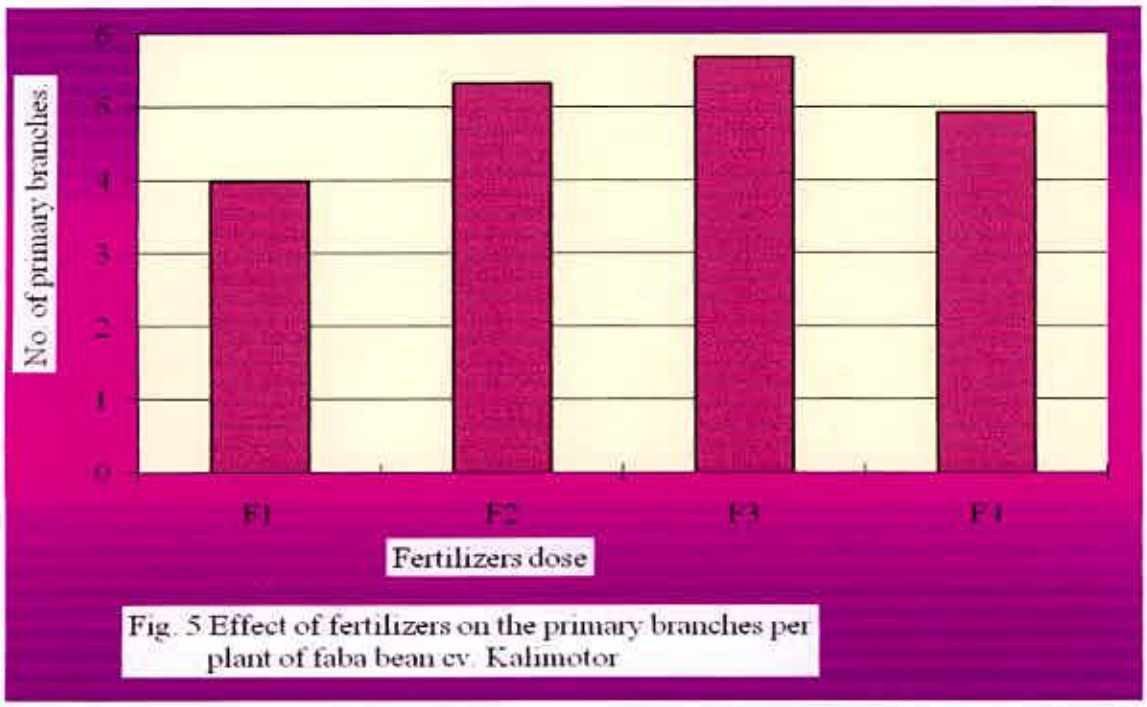


Fig. 5 Effect of fertilizers on the primary branches per plant of faba bean cv. Kalimotor

F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.2.3 Interaction effect of sowing date and fertilizers

There was a significantly effect of interaction between sowing dates and fertilizers on the number of primary branches $plant^{-1}$ (Fig. 6). The highest number of primary branches $plant^{-1}$ (6.547) was found with S_1F_3 which was similar to S_2F_2, S_2F_3 and S_2F_4 while the lowest number of primary branches $plant^{-1}$ (2.857) was obtained with S_3F_4. This was statistically similar to S_3F_1.

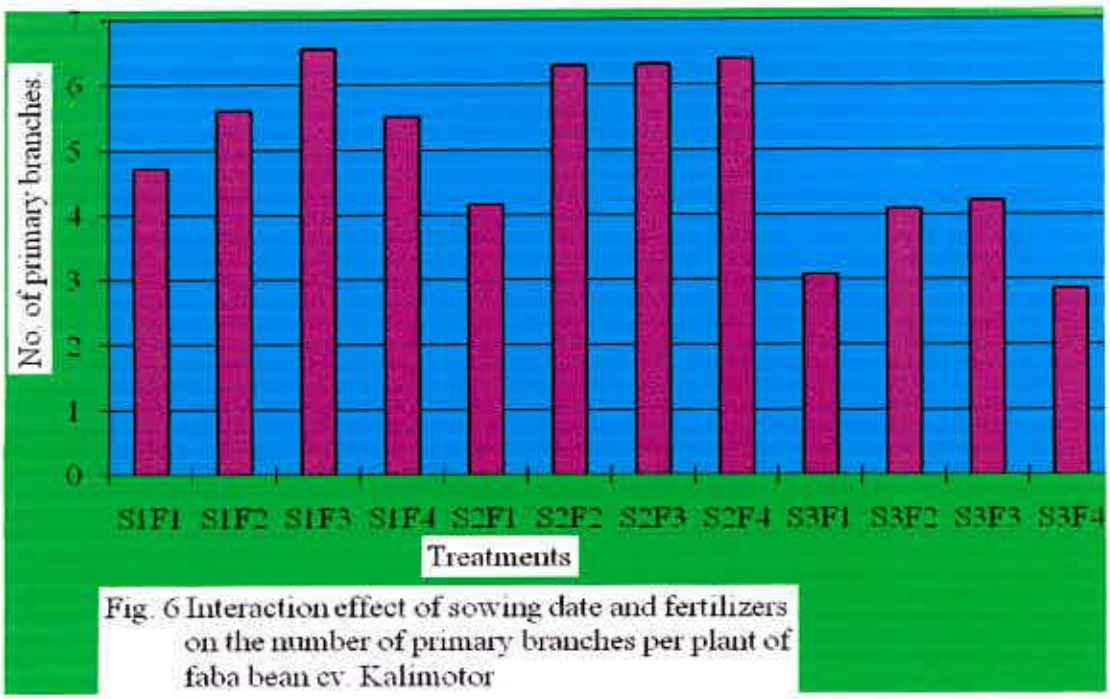


Fig. 6 Interaction effect of sowing date and fertilizers on the number of primary branches per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3
F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.3 Number of secondary branches plant^{-1}

4.3.1 Effect of sowing date

Number of secondary branches was found to be significant due to the sowing dates (Fig.7). Number of secondary branches was the highest (5.798) with crop sown on F_2. The lowest (2.829) was observed for the crop sown on S_3. Mekky *et al.* (2003) observed on faba bean that the number of branches plant^{-1} was varied during different sowing dates and the highest number of branches plant^{-1} was obtained on 1 November.

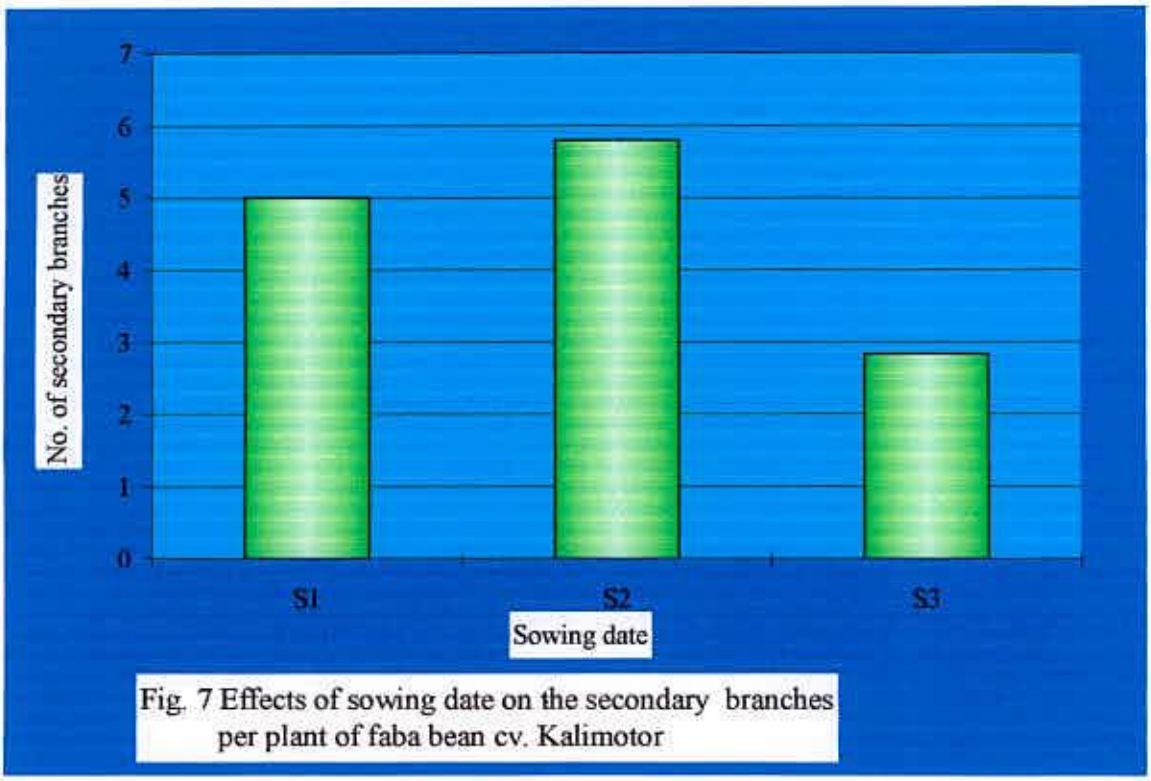


Fig. 7 Effects of sowing date on the secondary branches per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3

4.3.2 Effect of fertilizers

The number of secondary branches plant^{-1} varied significantly for fertilizer doses (Fig. 8). The treatment F_3 produced the highest number of secondary branches plant^{-1} (5.707) but it significantly differed with the rest. The plot treated with F_1 produced significantly lowest number of secondary branches plant^{-1} (3.203) which was also inferior to all other treatments. Dwivedi and Nayak (1998) observed on faba bean that the fertilizer combination of 20kg N + 40kg S ha^{-1} gave the highest number of secondary branches plant^{-1} of faba bean.

Fig. 8 Effect of fertilizers on the secondary branches per plant of faba bean cv. Kalimotor

F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.3.3 Interaction effect of sowing date and fertilizers

There was a highly significant effect of interaction between sowing dates and fertilizers on the number of secondary branches $plant^{-1}$ (Fig. 9). The highest number of secondary branches $plant^{-1}$ (6.67) was found with S_1F_3 but this was similar to S_2F_2, S_2F_3 and S_2F_4 while the lowest number of secondary branches $plant^{-1}$ (2.097) was with S_3F_1 which was however, statistically similar to S_3F_4.

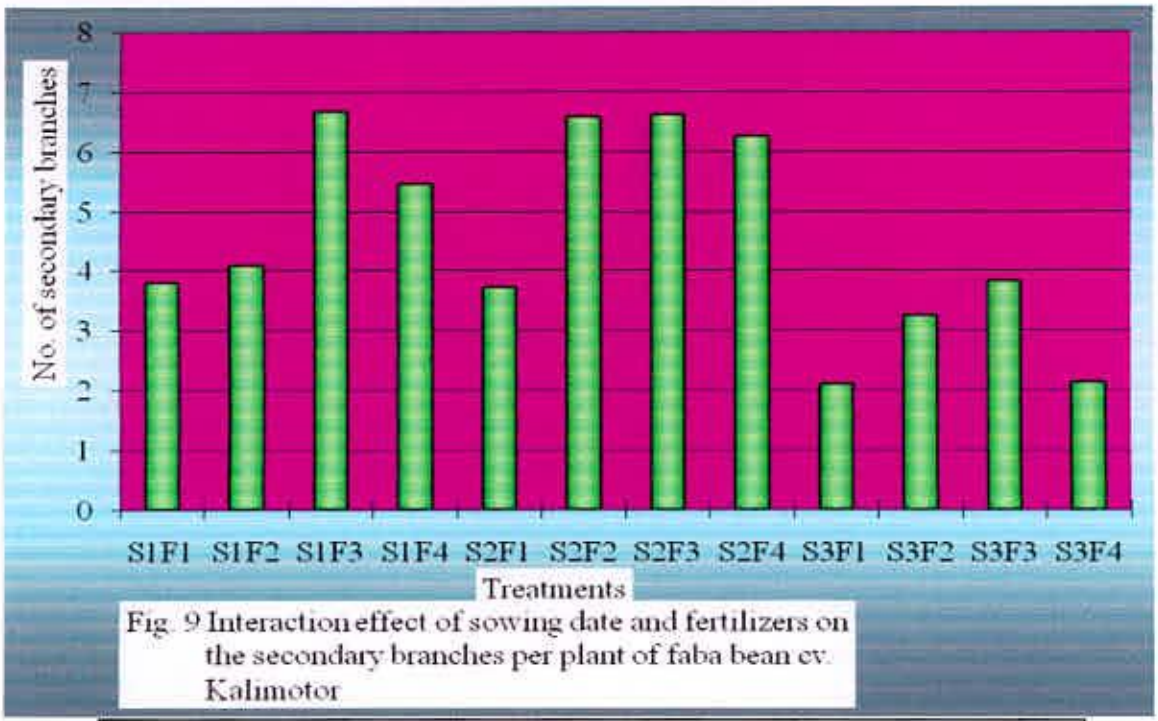


Fig. 9 Interaction effect of sowing date and fertilizers on the secondary branches per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3
F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.4 Yield and yield attributes

4.4.1 Number of pods plant^{-1}

4.4.1.1 Effect of sowing date

Number of pods plant^{-1} varied significantly due to the sowing dates (Fig. 10). Number of pods plant^{-1} was found to be the highest (57.58) with crop sown on S_2. Probably optimum environment at condition on this time confirmed better growth

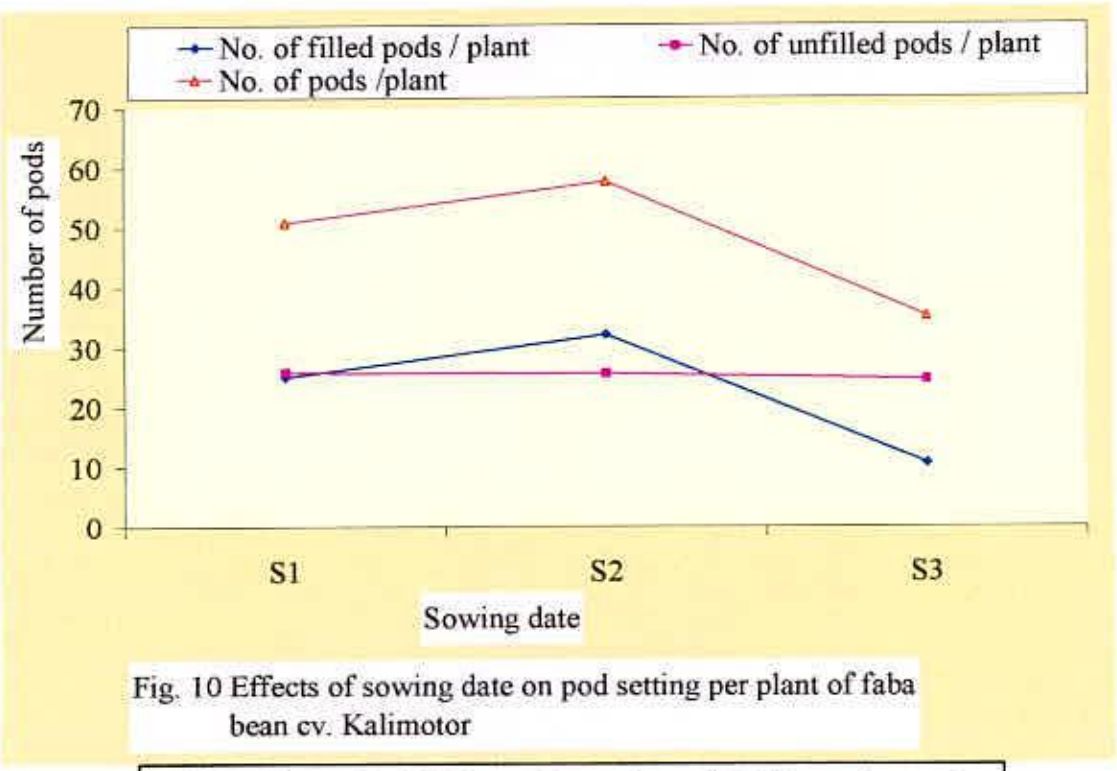


Fig. 10 Effects of sowing date on pod setting per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3

of plant and created minimum stress for plants. The lowest number (35.05) was observed in the crop sown on S_3 which was inferior to all other treatments. Hatam *et al.* (1999) observed on faba bean that when sowing was delayed from 22 October to 7 January then it decreased the number of pods plant^{-1} from 26 to 14 in Peshawar Valley of Pakistan. Bakheit *et al.* (2001) observed on faba bean that early planting date (1 October) produced highest pods per plant compared to other planting dates under Egyptian condition.

4.4.1.2 Effect of fertilizers

The number of pods plant^{-1} showed significant variation due to fertilizer differential dose (Fig. 11). The treatment F_3 showed the highest number of pods

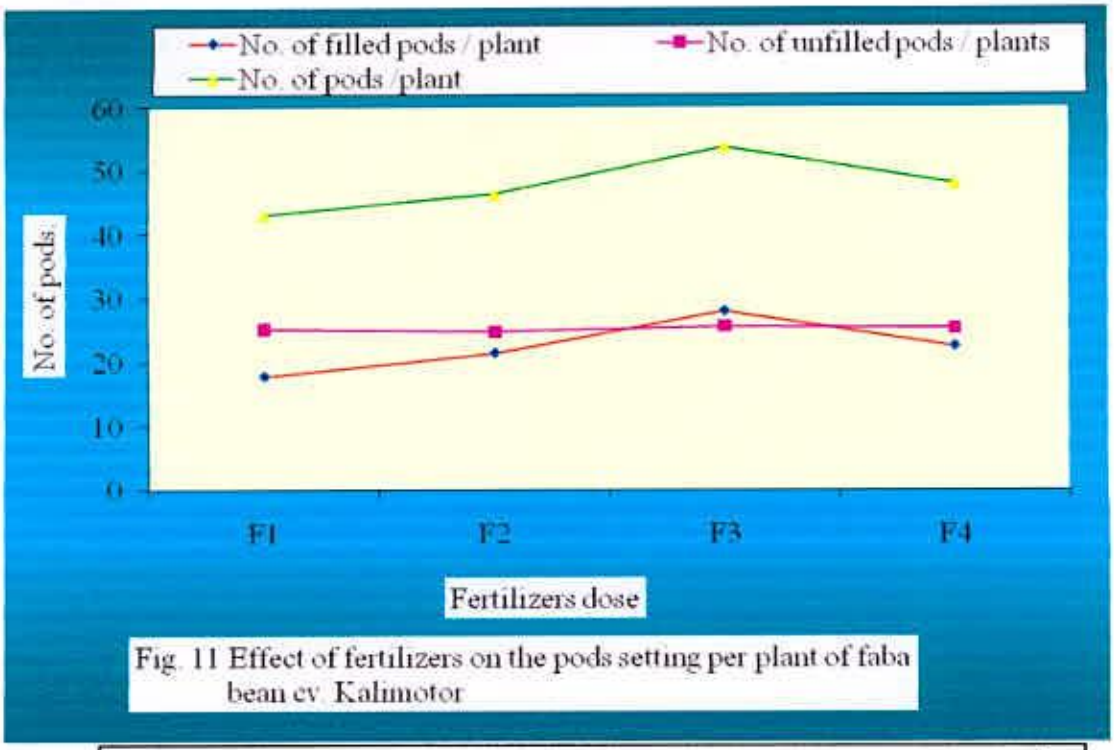


Fig. 11 Effect of fertilizers on the pods setting per plant of faba bean cv. Kalimotor

F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

$plant^{-1}$ (53.80) and that was significantly different from the rest. The plot treated with F_1 produced significantly lowest number of pods $plant^{-1}$ (43.11) which was however identical to F_2. Abdalla (2002) observed on faba bean that fertilizer improved the plant height; number of leaves and number of branches $plant^{-1}$ compared to control and also observed that two dose of biofertilizer with 200 g supper phosphate fed^{-1} gave highest pods plant-1 under Egyptian condition. Rizk *et al.* (2006) also observed on faba bean that 15kgN+ 15.5kg P_2O_5 +12kg fed^{-1} gave highest yield under Egyptian condition.

4.4.1.3 Interaction effect of sowing date and fertilizers

Significant interaction effect of sowing dates and fertilizers on the number of pods plant^{-1} was noticed in this respect (Fig. 12). The highest number of pods plant^{-1} (61.09) was found with S_1F_3 which was statistically similar to S_1F_4, S_2F_1, S_2F_2, S_2F_3 and S_2F_4. While the lowest number of pods plant^{-1} (30.08) was found with S_3F_1 which was statistically similar to S_3F_2 and S_3F_4.

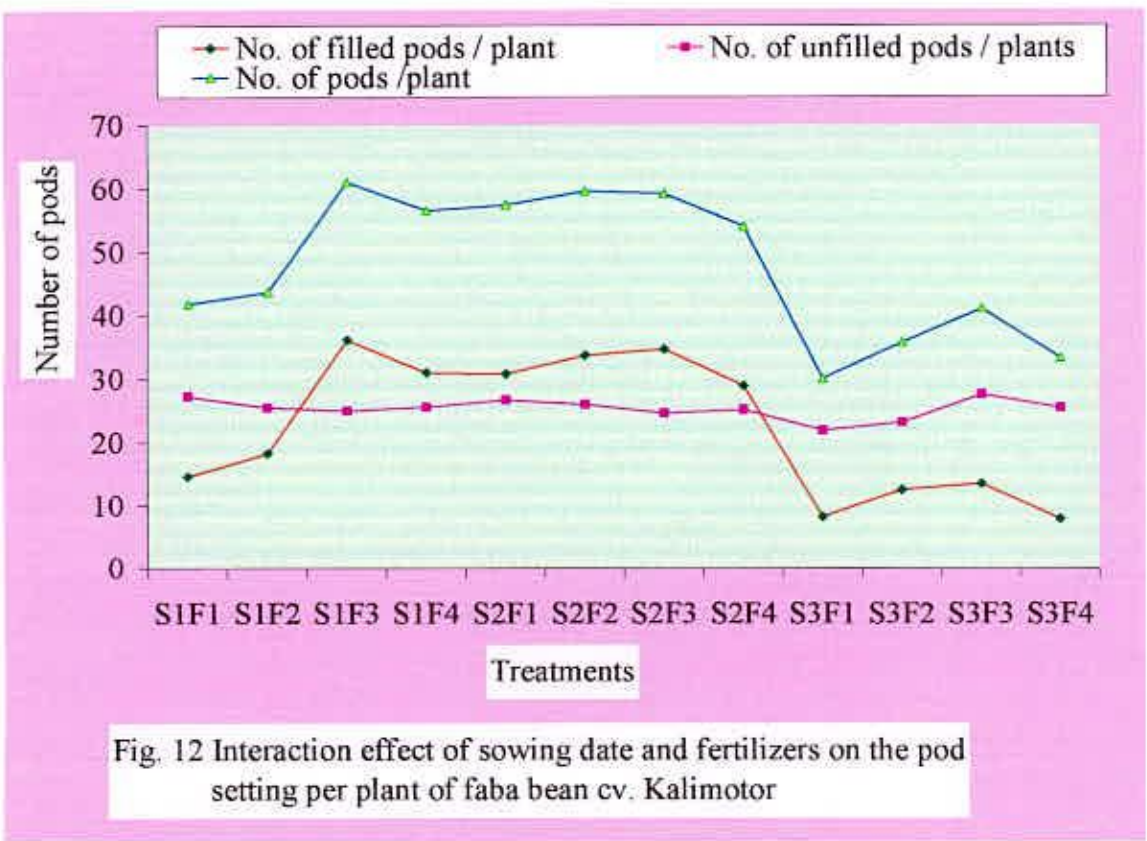


Fig. 12 Interaction effect of sowing date and fertilizers on the pod setting per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3
F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.4.2 Number of filled pods plant^{-1}

4.4.2.1 Effect of sowing date

Number of filled pods plant^{-1} varied significantly due to the sowing dates (Fig. 10). Number of filled pods plant^{-1} was the highest (32.01) with crop sown on S_2. The lowest (10.54) was observed for the crop sown on 10 December which was inferior to all other treatments. Labuda (1989) observed that climatic factor had the greatest effect on the duration of particular growth stage. Optimum sowing date gave more favorable environment to development. Tay (1992) observed that highest filled pods plant^{-1} (21.4) was produced from 26 June sowing under central valley region of Chile.

4.4.2.2 Effect of fertilizers

The number of filled pods plant^{-1} was highly significant due to various fertilizer dose (Fig. 11). The treatment F_3 produced the highest number of filled pods plant^{-1} (28.12) which was also significantly different than the rest. The treatment F_1 showed significantly the lowest number of filled pods plant^{-1} (17.85). Probably Number of pods plant^{-1} was influenced by the number of flowering, nodes plant^{-1}, branches plant^{-1}. Greater photosynthesis was occurred due to enhanced by more nutrient uptake which ultimately helped to develop more filled pods.

4.4.2.3 Interaction effect of sowing date and fertilizers

There was a highly significant effect of interaction between sowing dates and fertilizers on the number of filled pods plant^{-1} (Fig. 12). The highest number of filled pods plant^{-1} (36.14) was found with S_1F_3. But this was statistically similar to S_2F_2, S_2F_3 and S_2F_4. The lowest number of filled pods plant^{-1} (7.847) was obtained with S_3F_4 which was however statistically similar to S_3F_1 and inferior to all other treatments.

4.4.3 Number of unfilled pods plant^{-1}

4.4.3.1 Effect of sowing date

There was no significant influence of sowing date on number of unfilled pods plant^{-1} (Fig 10). Numerically, the highest number of unfilled pods plant^{-1} (25.79) was found with 20 October sowing and the lowest (24.51) for 10 December. Labuda (1989) observed on faba bean that climatic factor had the greatest effect on the duration of particular growth stage. Optimum sowing date gave more favourable environment to pod development. Sekar *et al.* (2001) also observed on faba bean that delayed sowing date increased the number of flower bud but decreased the level of pods in Poland.

4.4.3.2 Effect of fertilizers

In this study, not significant influence of fertilizers on number of unfilled pods plant^{-1} was found (Fig 11). Numerically, the highest number of unfilled pods plant^{-1} (25.68) was found with F_3 and the lowest (24.51) from F_2.

4.4.3.3 Interaction effect of sowing date and fertilizers

The interaction effect between sowing dates and fertilizers on the number of unfilled pods plant^{-1} was found to be significant (Fig. 12). The highest number of unfilled pods plant^{-1} (27.55) was found with F_3F_4 which was similar to all the comprised treatments except S_3F_1. While the lowest number of unfilled pods plant^{-1} (21.89) was found with S_3F_1.

4.4.4 Percentage of filled and unfilled pods plant^{-1}

4.4.4.1 Effect of sowing date

Percentage of filled and unfilled pods plant^{-1} varied significantly due to the sowing dates (Fig. 13). Percentage of filled and unfilled pods plant^{-1} increased and decreased respectively with delay sowing. Percentage of filled pods plant^{-1} was the highest (55.57%) with crop sown on 15 November. Which was also showed lowest (44.26%) of unfilled pods plant^{-1}. The lowest percentage (29.93%) of filled pods plant^{-1} was observed for the crop sown on S_3.

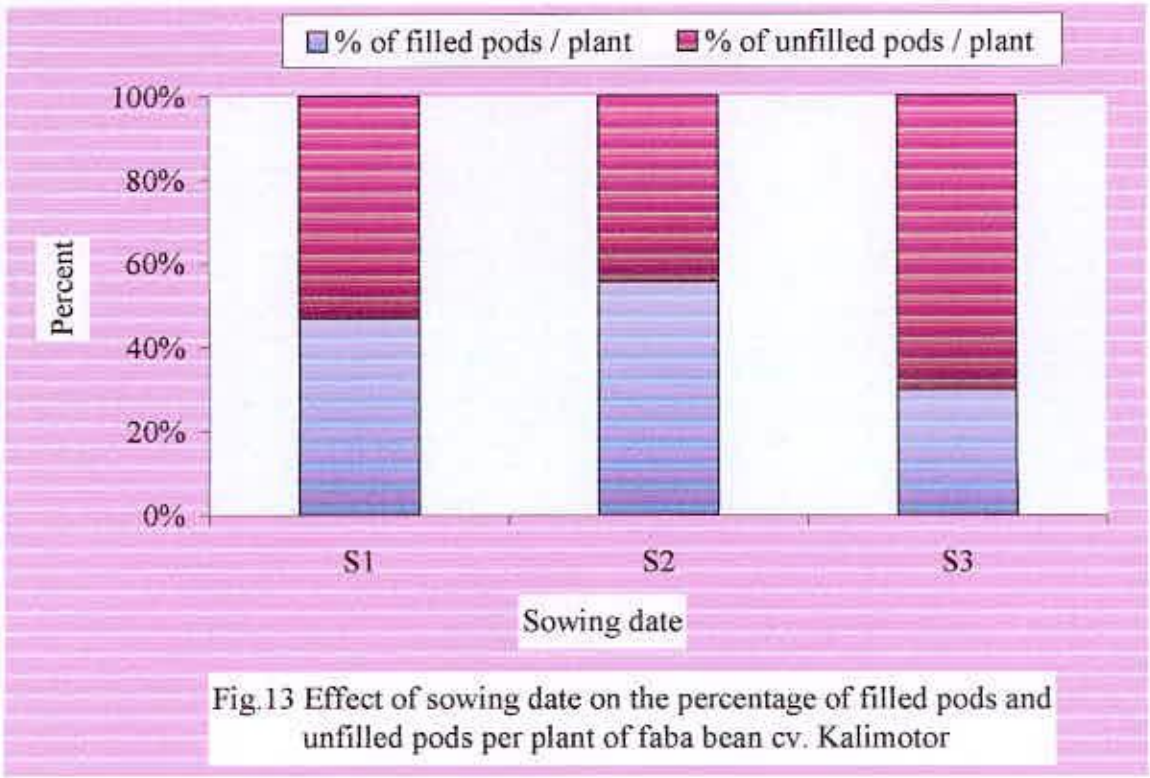


Fig.13 Effect of sowing date on the percentage of filled pods and unfilled pods per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3

4.4.4.2 Effect of fertilizers

Percentage of filled and unfilled pods plant^{-1} varied significantly due to fertilizer dose (Fig. 14). Percentage of filled and unfilled pods plant^{-1} increased and decreased respectively with increased fertilizers rate. The treatment F_3 produced the highest percentage of filled pods plant^{-1} (50.30%) which was also gave the lowest percentage (49.70%) of unfilled pods plant^{-1}. The plot applied with F_1 showed significantly the lowest percentage (38.77%) of filled pods plant^{-1}. This treatment also gave the highest percentage (61.33%) of unfilled pods plant^{-1}.

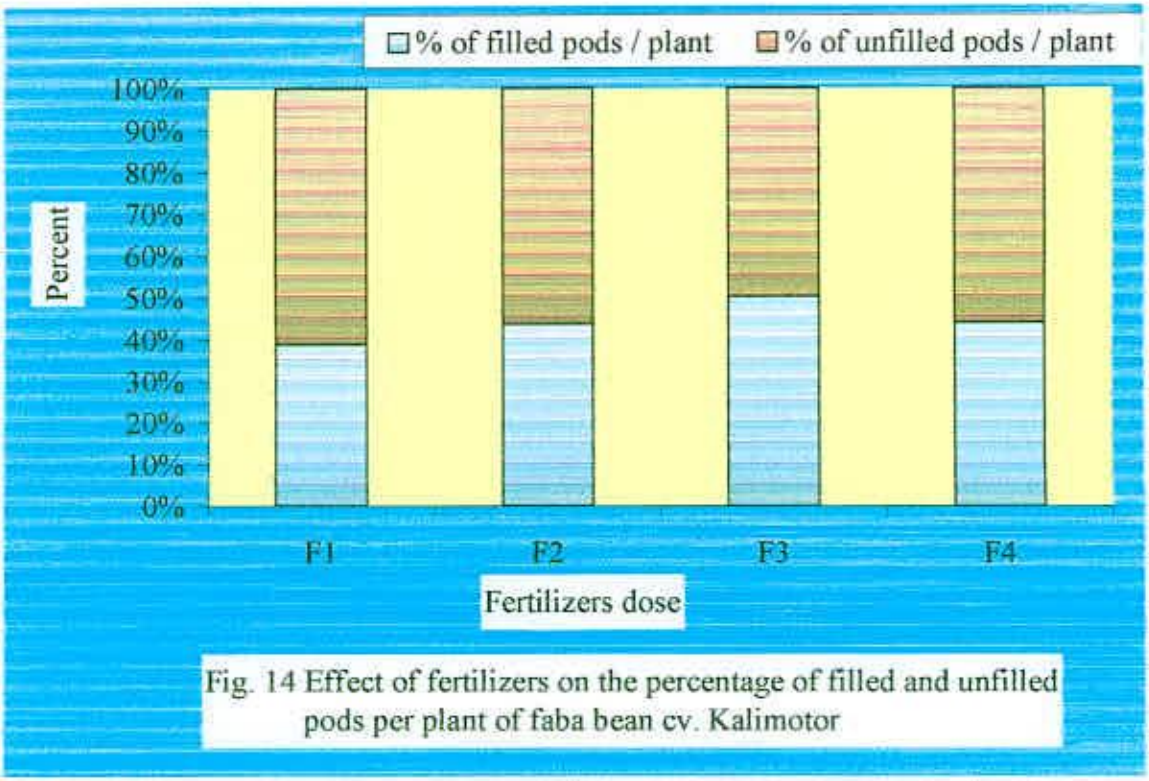


Fig. 14 Effect of fertilizers on the percentage of filled and unfilled pods per plant of faba bean cv. Kalimotor

F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.4.4.3 Interaction effect of sowing date and fertilizers

There was a highly significant effect of interaction between sowing dates and fertilizers on the number of filled and unfilled pod percentage $plant^{-1}$ (Fig. 15). The percentage of filled pods $plant^{-1}$ increased with delay sowing and late sowing showed lower percentage of filled pods $plant^{-1}$. The highest percentage of filled pods $plant^{-1}$ (59.19%) was found with S_1F_3 which was however, similar to S_1F_4, S_2F_1, S_2F_2, S_2F_3 and S_2F_4. While the lowest percentage of filled pods $plant^{-1}$ (23.63%) was found with S_3F_4 which was however, statistically similar to S_3F_1.

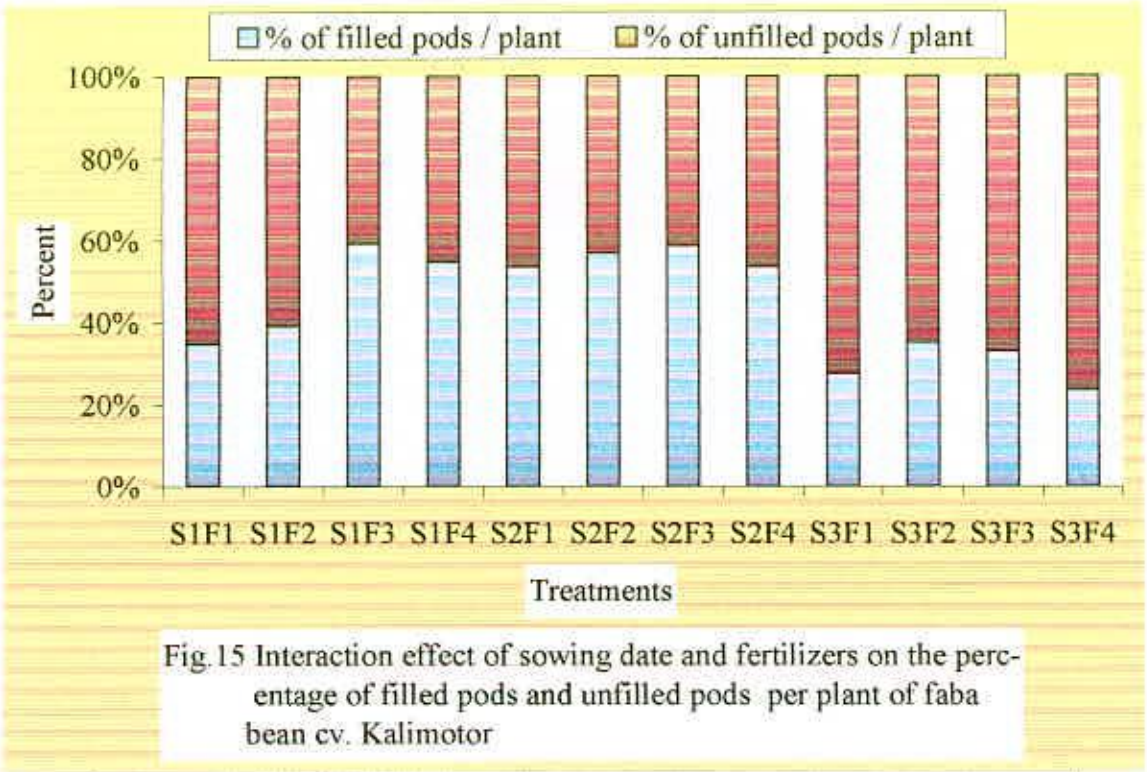


Fig.15 Interaction effect of sowing date and fertilizers on the percentage of filled pods and unfilled pods per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3
F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.4.5 Number of seeds filled pod^{-1}

4.4.5.1 Effect of sowing date

Significantly influence of sowing date on number of seeds pod^{-1} was observed (Table 1). The highest number of seeds pod^{-1} (3.325) was found with S_2 sowing and the lowest (3.224) with S_1. This finding agrees with Hatam *et al.* (1999) who observed that delayed sowing from 22 October to 7 January decreased the number of seeds pod^{-1} (3 to 2.6) in Peshawar valley of Pakistan. However, Adisarwanto and Knight (1997) observed on faba bean that seeds pod^{-1} remained constant across the sowing treatments.

4.4.5.2 Effect of fertilizers

There was no significant influence of fertilizers on number of seeds filled pod^{-1} (Table 1). Numerically, the highest number of seeds filled pod^{-1} (3.344) was found with F_3 and the lowest (3.209) with F_1.

4.4.5.3 Interaction effect of sowing date and fertilizers

Interaction effect between sowing dates and fertilizers on the number of seeds filled pod^{-1} was found insignificant (table 1). Numerically, the highest number of seeds filled pod^{-1} (3.383) was found with S_2F_3 while the lowest number of seeds filled pod^{-1} (3.183) was found with S_3F_1.

4.4.6 1000-Seeds weight (g)

4.4.6.1 Effect of sowing date

1000-seeds weight varied significantly due to the sowing dates (Table 1). It was the highest (91.10g) with crop sown on S_2 while the lowest (73.68g) with that sown on S_3.

4.4.6.2 Effect of fertilizers

1000-seeds weight also varied significantly due to fertilizer dose (Table 1). The treatment F_3 produced the highest 1000-seeds weight (92.13g) which was significantly highest with the rest. The plot fertilized with F_1 showed significantly lowest 1000-seeds weight (74.80g).

Table 1 Effect of sowing date and fertilizers and their interaction on the yield components of faba bean cv. Kalimotor

Treatments	No. of filled pods / plant	No. of average seeds/filled pod	1000-Seeds wt. (g)	Grain wt. /plant (g)
Sowing date = S				
S_1	24.99b	3.224	87.99b	7.253b
S_2	32.01a	3.325	91.16a	9.689a
S_3	10.54c	3.313	73.68c	2.590c
Level of significance	**	NS	**	**
$S_{\bar{x}}$	2.136	0.083	3.133	0.733
Fertilizers dose = F				
F_1	17.85c	3.209	74.80c	4.436d
F_2	21.51b	3.289	85.67b	6.203c
F_3	28.12a	3.344	92.13a	8.946a
F_4	22.57b	3.300	84.51b	6.459b
Level of Significance	**	NS	**	**
$S_{\bar{x}}$	7.235	0.095	3.617	0.847
Interaction = SF				
S_1F_1	14.60c	3.200	68.55g	3.203gh
S_1F_2	18.28d	3.233	94.85bc	5.600f
S_1F_3	36.14a	3.200	97.92ab	11.30b
S_1F_4	30.95bc	3.193	90.62cd	8.910d
S_2F_1	30.76bc	3.233	82.68e	8.223e
S_2F_2	33.69ab	3.350	88.74d	9.990c
S_2F_3	34.66a	3.383	102.3a	11.98a
S_2F_4	28.93c	3.333	90.93cd	8.560de
S_3F_1	8.187f	3.183	73.15fg	1.880i
S_3F_2	12.57e	3.283	73.41fg	3.020h
S_3F_3	13.55e	3.450	76.17f	3.553g
S_3F_4	7.847f	3.383	71.97fg	1.907i
Level of significance	**	NS	**	**
$S_{\bar{x}}$	4.273	0.165	6.266	1.467
CV (%)	5..93	3. 92	2.70	2.68

In a column, figures having similar letter (s) do not differ significantly at 5% level of probability,

NS= Non significant,

* = Indicates significant at 5% level of probability,

** = Indicates significant at 1% level of probability.

4.4.6.3 Interaction effect of sowing date and fertilizers

There was significant effect of interaction between sowing dates and fertilizers on the 1000-seeds weight (Table 1). The highest 1000-seeds weight (102.30g) was obtained with S_2F_3 which was however similar with S_1F_3. While the lowest value (68.55) was found with S_1F_1.

4.4.7 Grain weight plant^{-1}(g)

4.4.7.1 Effect of sowing date

Grain weight plant^{-1} was found to be significant due to the sowing dates (Table 1). It was the highest (9.689g) with crop sown on S_2. The lowest value (2.590g) observed for the crop sown on S_3. Cercitari (1998) observed in Romania that crop sown in the first 2 weeks of spring was superior and sowing after that time leaded to a significant decrease in yield and yield component.

4.4.7.2 Effect of fertilizers

There was a significant difference in grain weight plant^{-1} due to fertilizer dose (Table 1). The treatment F_3 had the highest grain weight plant^{-1} (8.94g) which significantly differed to the rest. The plot applied with F_1 showed significantly lowest value (4.436g).

4.4.7.3 Interaction effect of sowing date and fertilizers

A highly significant effect of interaction between sowing dates and fertilizers on the grain weight plant^{-1} was noticed (Table 1). The highest grain weight plant^{-1} (11.98g) was found with S_2F_3. While the lowest grain weight plant^{-1} (1.88g) was obtained with S_3F_1 which was statistically identical to S_3F_4.

4.5 Grain weight ha^{-1} (ton)

4.5.1 Effect of sowing date

Grain weight varied significantly due to the sowing dates (Fig. 16). It was the highest (1.454 t/ha) with crop sown on S_2. The lowest (0.372 t /ha) was observed from the crop sown on S_3. Sekara and Podniedzialek (2001) observed on faba bean

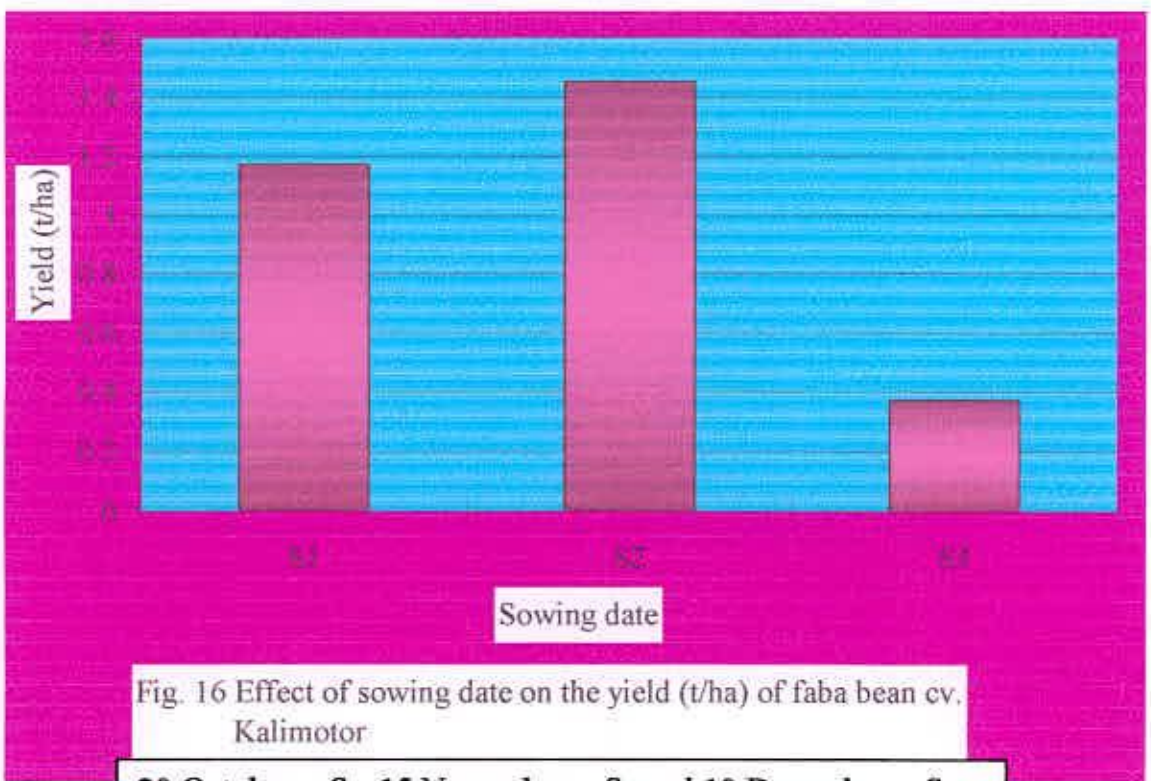


Fig. 16 Effect of sowing date on the yield (t/ha) of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3

while carrying out a study under Poland condition found that sowing on the first two week of April led to the achievement of 3.5-7.1 t/ha yield and due to the increase of delay sowing, the yield was considerably lower which was attributed to high temperature in the seeds germination phase. It was also concluded that emergence were the main factors determining the yield.

4.5.2 Effect of fertilizers

Grain weight per ha differed significantly among the fertilizer doses (Fig. 17). The treatment F_3 resulted the highest grain weight (1.342 t/ha). On the contrary the plot applied with F_1 showed significantly the lowest grain weight (0.665 t/ha). Rizk *et al.* (2006) observed on faba bean that application of 15kg N + 15.5kg P_2O_5+12kg K_2O fad^{-1} gave the highest yield.

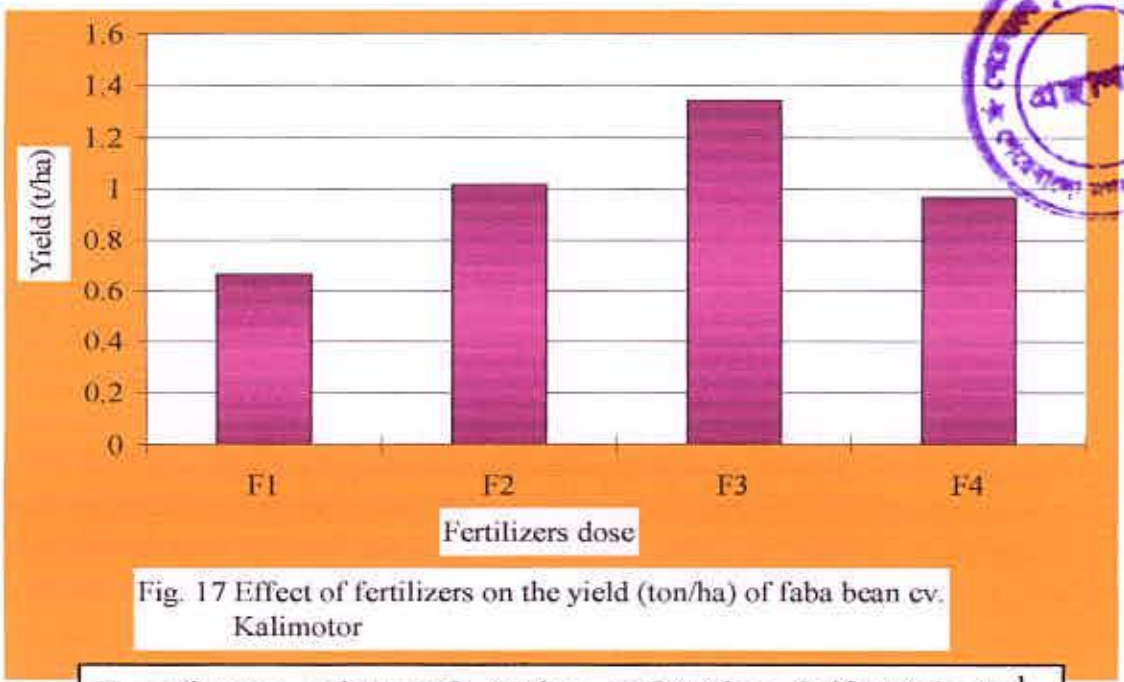


Fig. 17 Effect of fertilizers on the yield (ton/ha) of faba bean cv. Kalimotor

F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.5.3 Interaction effect of sowing date and fertilizers

There was a significantly effect of interaction between sowing dates and fertilizers on the grain weight per hectare (Fig. 18). The highest grain weight (1.798 t/ha) was obtained with S_2F_3 which was however, identical to S_1F_3 and S_2F_2 while the lowest grain weight (0.2823 t/ha) was found with S_3F_1 which was however, statistically similar to S_3F_2, S_3F_3 and S_3F_4.

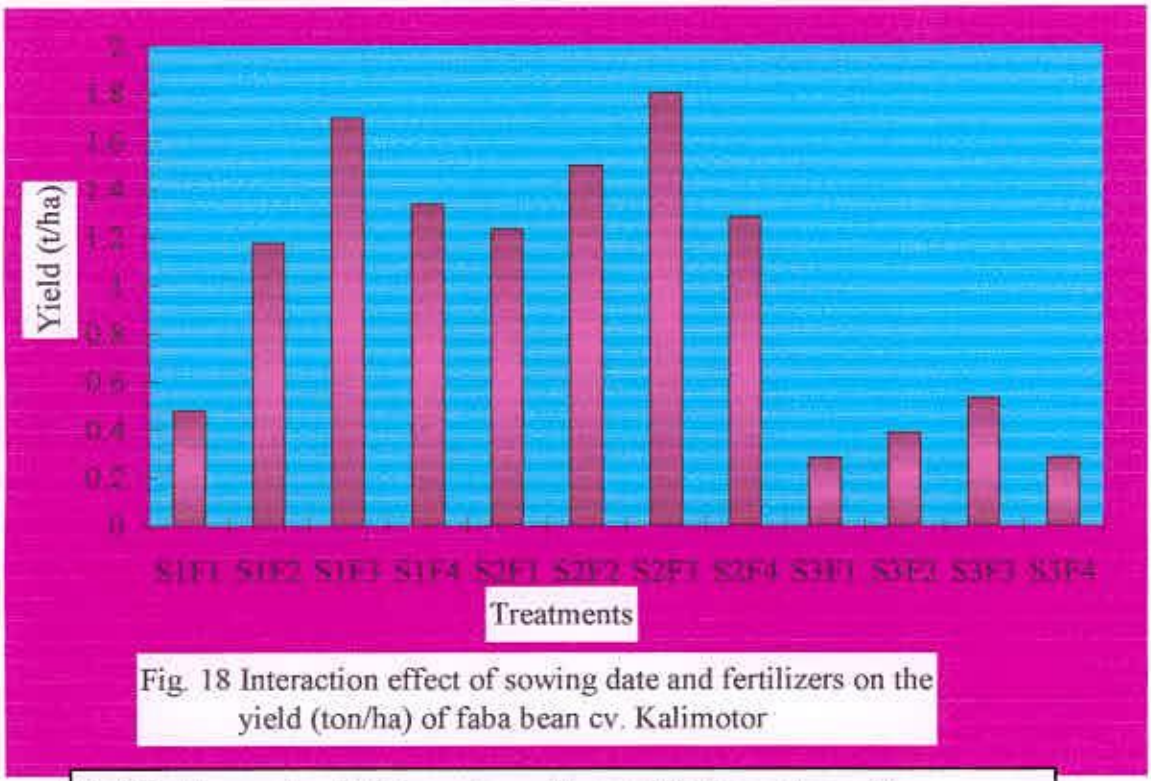


Fig. 18 Interaction effect of sowing date and fertilizers on the yield (ton/ha) of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3
F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.6 Dry matter weight

4.6.1 Straw dry matter weight $plant^{-1}$(g)

4.6.1.1 Effect of sowing date

Straw dry matter weight plant^{-1} varied significantly due to the sowing dates (Fig. 19). It was the highest (15.34g) with crop sown on S_2. The lowest (10.18g) was observed with S_3.

4.6.1.2 Effect of fertilizers

Straw dry matter weight plant^{-1} was significant at varying fertilizer doses (Fig. 20). The treatment F_3 produced the highest straw dry matter (15.46g). The plot applied with F_1 showed significantly lowest straw dry matter (10.66g).

4.6.1.3 Interaction effect of sowing date and fertilizers

Highly significant effect of interaction among sowing dates and fertilizer doses on the straw dry matter was observed (Fig. 21). The highest straw weight (17.50g) was found with S_1F_3 which was similar to S_2F_4. While the lowest (8.50g) was obtained from S_3F_4.

4.6.2 Grain dry weight plant^{-1}(g)

4.6.2.1 Effect of sowing date

Grain dry weight plant^{-1} varied significantly due to the sowing dates (Fig. 19). It was the highest (8.53g) with crop sown on S_2. The lowest (2.28g) was observed with S_3. Mekky *et al.* (2003) observed on faba bean that the grain dry weight plant^{-1} was varied during different sowing dates and the highest grain dry weight plant^{-1} was obtained on 1 November.

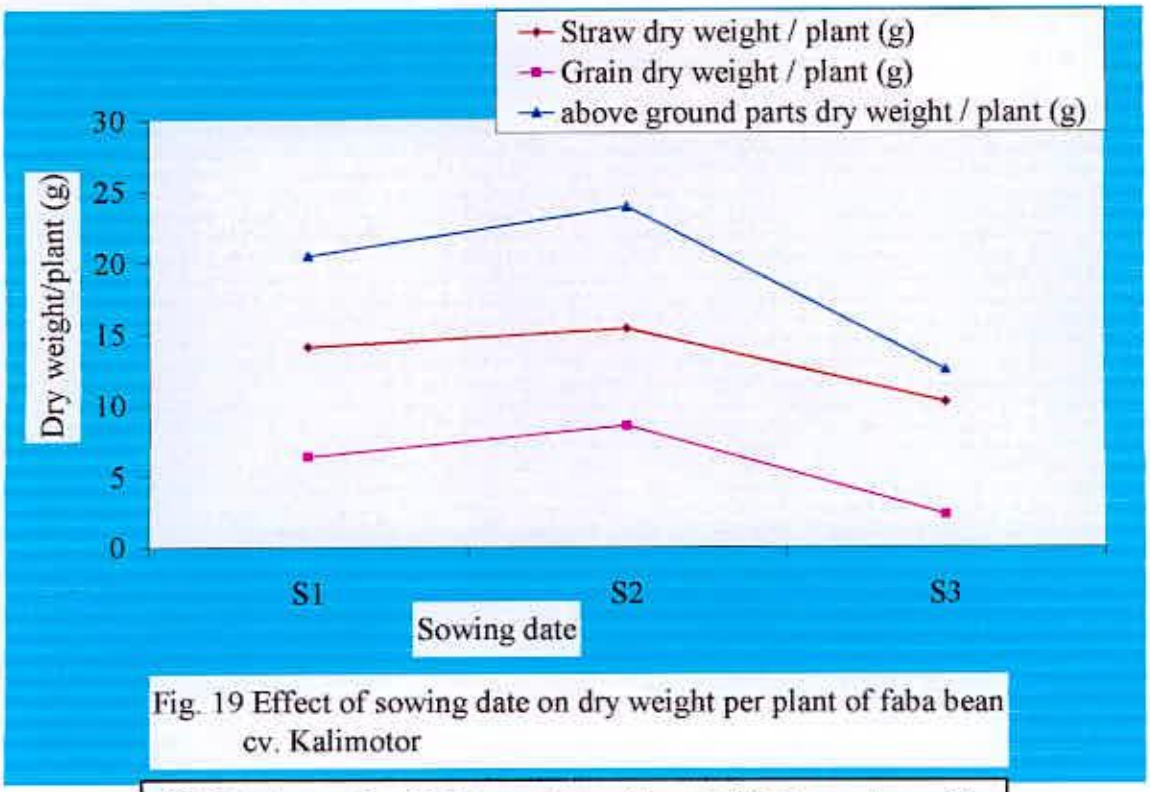


Fig. 19 Effect of sowing date on dry weight per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3

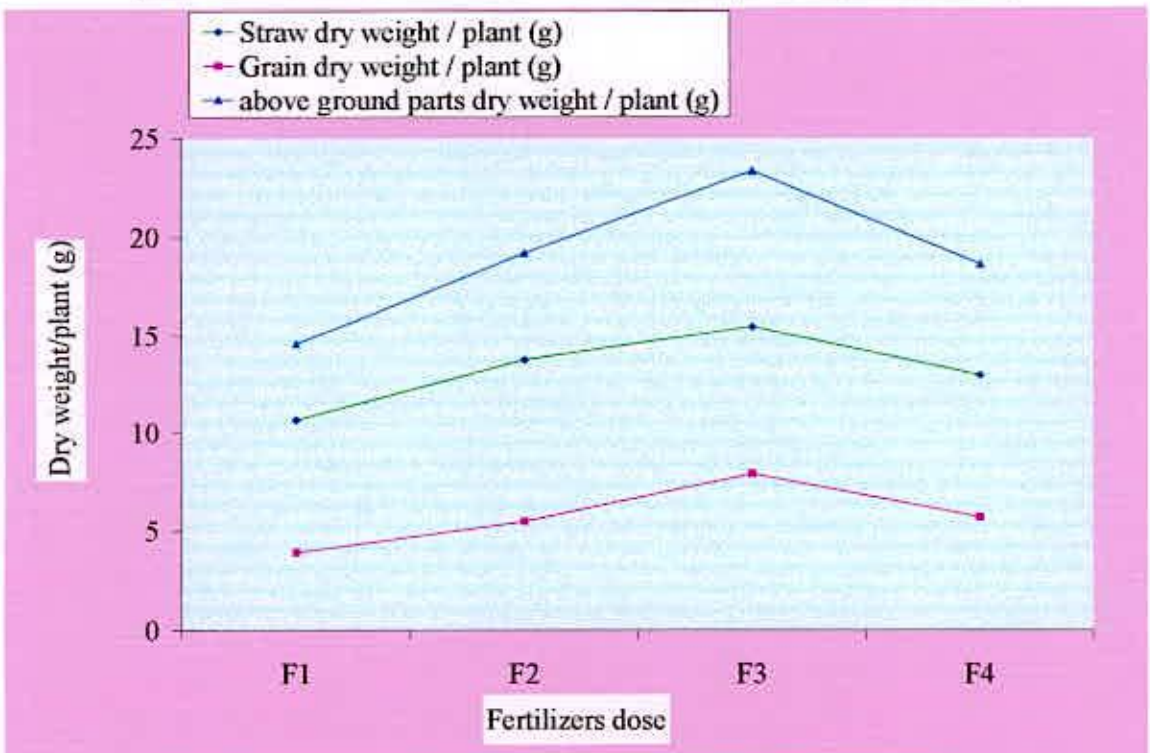


Fig.20 Effect of fertilizers on the dry weight per plant of faba bean cv. Kalimotor

F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

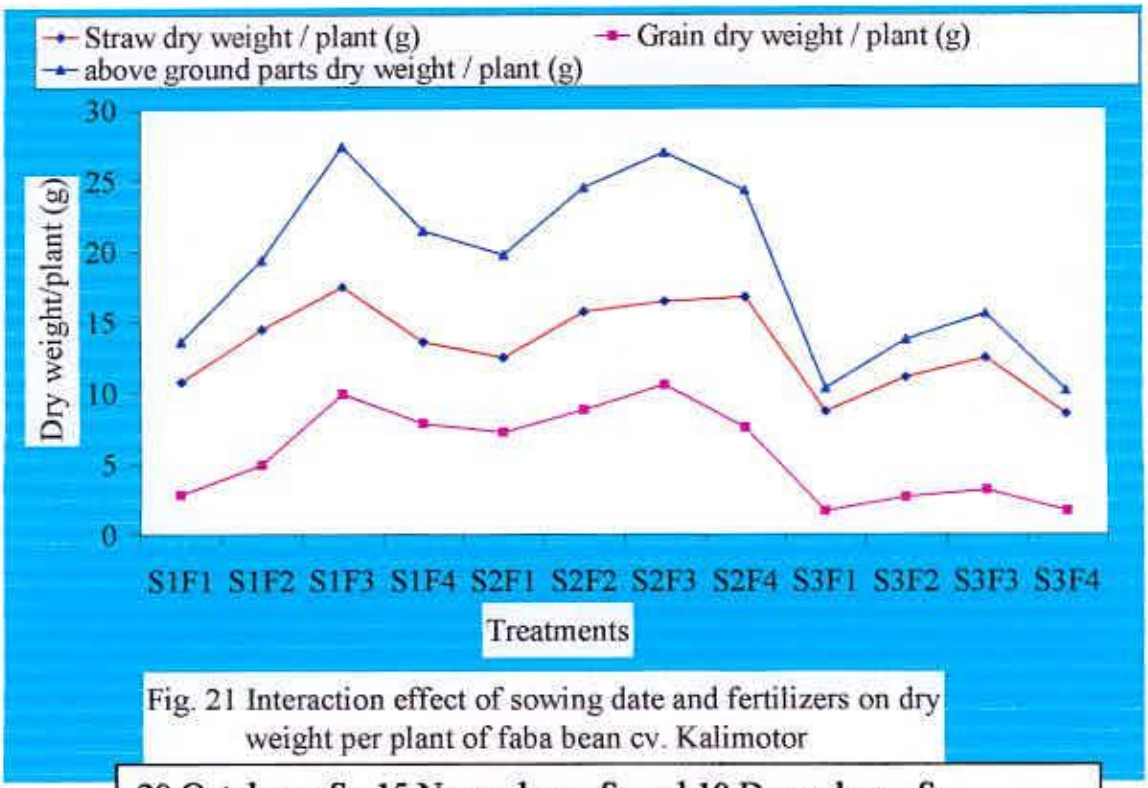


Fig. 21 Interaction effect of sowing date and fertilizers on dry weight per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3
F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.6.2.2 Effect of fertilizers

Grain dry weight $plant^{-1}$ varied significantly due to fertilizer doses (Fig. 20). The treatment F_3 showed the highest grain dry weight (7.877g). The plot applied with F_1 produced significantly lowest grain dry weight (3.903g).

4.6.2.3 Interaction effect of sowing date and fertilizers

There was a significant effect of interaction between sowing dates and fertilizer doses on the grain dry weight $plant^{-1}$ (Fig. 21). The highest Grain dry weight (10.56g) was obtained with S_2F_3 while the lowest grain dry weight (1.657g) was obtained with S_3F_1 which was however, statistically similar to F_4S_3.

4.6.3 Total above ground dry weight plant^{-1}(g)

4.6.3.1 Effect of sowing date

Total above ground dry weight plant^{-1} varied significantly due to the sowing dates (Fig. 19). It was the highest (23.88g) with crop sown on S_2. The lowest (12.45g) was observed when sown on S_3 which was inferior to all other treatments. Tay (1992) observed on faba bean that highest total above ground dry matter plant^{-1} (8.3t/ha) was obtained when sown on 26 June under the climatic condition of central valley region of Chile.

4.6.3.2 Effect of fertilizers

Total above ground dry weight plant^{-1} also varied significantly for fertilizer doses (Fig. 20). The treatment F_3 produced the highest total above ground dry weight (23.33g) which was significantly higher the rest. The plot applied with F_1 showed significantly lowest total above ground dry weight plant^{-1} (14.56g).

4.6.3.3 Interaction effect of sowing date and fertilizers

A highly significant effect of interaction between sowing dates and fertilizers on the total above ground dry weight plant^{-1} was observed (Fig. 21). The highest total above ground dry weight plant^{-1} (27.44g) was found from F_3S_1 which was however, similar to F_3S_2. While the lowest value (10.18g) was found F_4S_3 which was also statistically similar to F_1S_3.

4.6.4 Percentage of partitioning dry matter plant^{-1}

4.6.4.1 Effect of sowing date

Straw dry weight plant^{-1} was subtracted from the total dry weight per plant and the grain dry weight plant^{-1} was obtained. Contribution of straw and grain dry weight plant^{-1} to total dry weight varied significantly due to the sowing dates (Fig. 22). Percentage of straw dry weight decreased with delay sowing up to 15 November. On the contrary percentage of grain dry weight plant^{-1} was the highest (35.68%) with crop sown on 15 November due to further delay the straw weight increased but grain weight decreased. The lowest contribution (17.98%) of grain weight was observed for the crop sown on S_3 which was however, also highest percentage (82.02%) of straw dry weight plant^{-1}.

Fig. 22 Effect of sowing date on dry matter partitioning percentage per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3

4.6.4.2 Effect of fertilizers

Contribution of straw and grain dry weight plant^{-1} varied significantly due to varying fertilizer doses (Fig. 23). The contribution of straw and grain respectively decreased and increased with increased fertilizers rate up to F_3. At F_3 the highest contribution of grain (31.82%) was observed conversely at this dose which lowest contribution (68.18%) of straw was noticed.

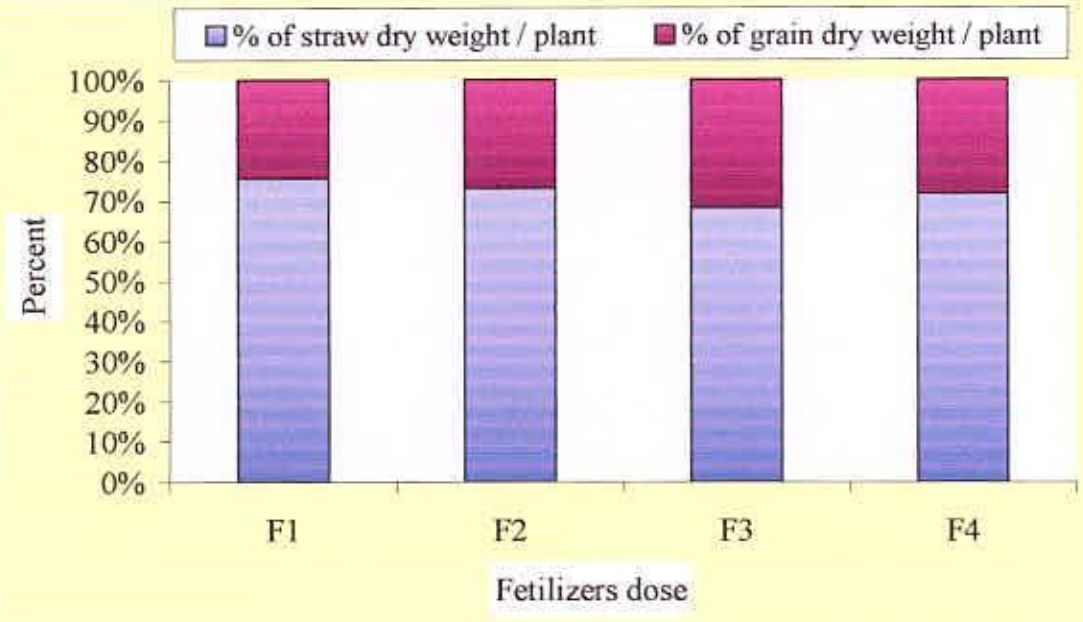


Fig. 23 Effect of fertilizers on dry matter partitioning percentage per plant of faba bean cv. Kalimotor

F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.6.4.3 Interaction effect of sowing date and fertilizers

There was a highly significant effect of interaction between sowing dates and fertilizers on the contribution of straw and grain to total dry weight plant^{-1} (Fig. 24). Fig. 24 shows that the contribution of grain increased with sowing of S_1 with the fertilizer treatment F_3. This trend continued up to the delay sowing of S_2 under increased application of fertilizer up to F_4. Further delay caused the grain contribution to be decreased significantly. The highest (39.14%) was found with S_2F_3. While the lowest (16.02%) with S_3F_1 which was statistically similar to S_3F_4.

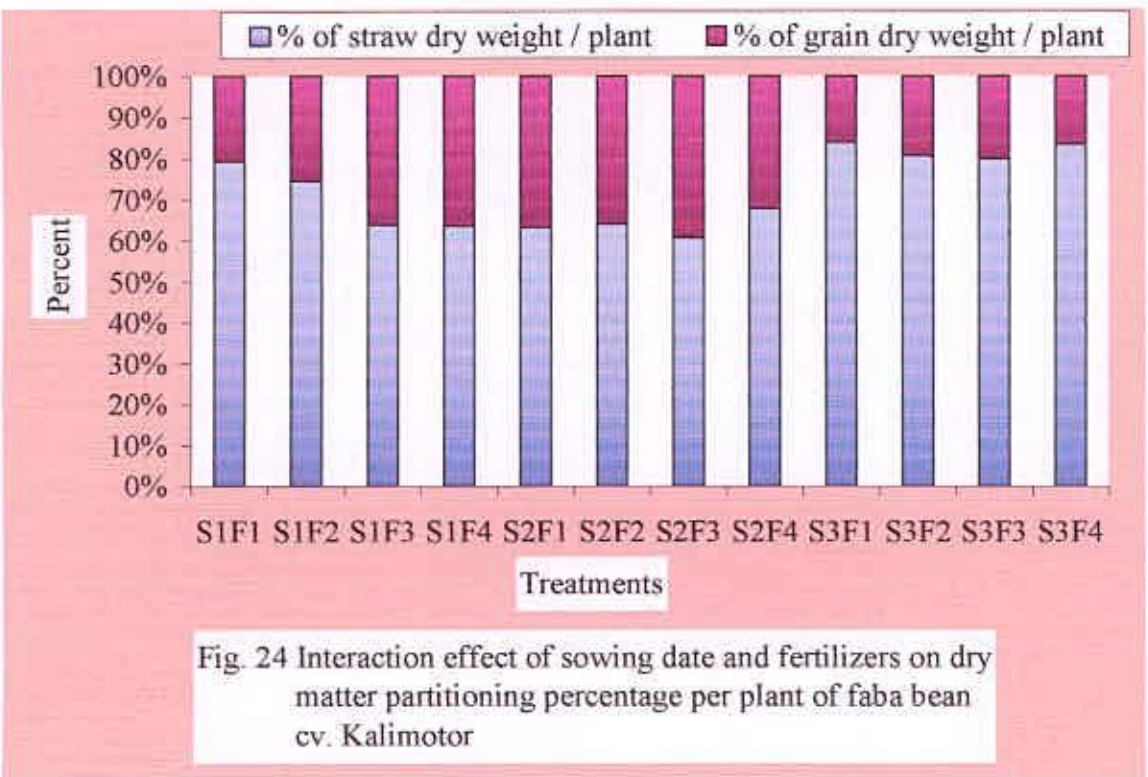


Fig. 24 Interaction effect of sowing date and fertilizers on dry matter partitioning percentage per plant of faba bean cv. Kalimotor

20 October = S_1, 15 November = S_2 and 10 December = S_3
F_1 = Nitrogen 6 kg + P_2O_5 20 kg + K_2O 20 kg + Sulfur 15 kg ha^{-1}
F_2 = Nitrogen 12 kg + P_2O_5 40 kg + K_2O 40 kg + Sulfur 30 kg ha^{-1}
F_3 = Nitrogen 18 kg + P_2O_5 60 kg + K_2O 60 kg + Sulfur 45 kg ha^{-1}
F_4 = Nitrogen 24 kg + P_2O_5 80 kg + K_2O 80 kg + Sulfur 60 kg ha^{-1}

4.6.5 Total above ground dry weight ha^{-1} (ton)

4.6.5.1 Effect of sowing date

Total above ground dry weight varied significant due to the sowing dates (Table 2). It was the highest (3.58 t/ha) with S_2. The lowest (1.868 t/ha) was observed in S_3. Oweiset *et al.* (2005) observed on faba bean that early sowing date of faba bean increased biomass (early 5.13 t/ha and late 3.48t/ha) steadily. Hatam *et al.* (1994) also observed on faba bean that sowing was delayed from 22 October to 7 January with delayed biomass weight from 3246 kg to 596 kg/ha.

4.6.5.2 Effect of fertilizers

Total above ground dry weight ha^{-1} deferred significantly due to fertilizer doses (Table 2). The treatment F_3 showed the highest (3.50 t/ha) total above ground dry weight ha^{-1}. The plot applied with F_1 showed significantly lowest (2.18 t/ha) total above ground dry weight ha^{-1}.

4.6.5.3 Interaction effect of sowing date and fertilizers

A significant effect showed between sowing dates and fertilizer doses on the total above ground dry weight ha^{-1} (Table 3). The highest value (4.12 t/ha) was found with S_1F_3 which was however, similar to S_2F_3 while the lowest value (1.527 t/h) was found with S_3F_4 which was however, also statistically similar to S_3F_1.

Table 2 Effect of sowing date and fertilizers and their interaction on the total above ground dry matter ha^{-1} of faba bean cv. Kalimotor

Treatments	Dry wt. of total above ground part / ha (ton)
Sowing time = S	
S_1	3.072b
S_2	3.582a
S_3	1.868c
Level of significance	**
$S_{\bar{x}}$	0.222
Fertilizers dose = F	
F_1	2.183d
F_2	2.882b
F_3	3.502a
F_4	2.797c
Level of significance	**
$S_{\bar{x}}$	0.257
Interaction = SF	
S_1F_1	2.043f
S_1F_2	2.910d
S_1F_3	4.120a
S_1F_4	3.217c
S_2F_1	2.960d
S_2F_2	3.677b
S_2F_3	4.047a
S_2F_4	3.647b
S_3F_1	1.547g
S_3F_2	2.060f
S_3F_3	2.340e
S_3F_4	1.527g
Level of significance	**
$S_{\bar{x}}$	0.444
CV (%)	2. 21

In a column, figures having similar letter (s) do not differ significantly at 5% level of probability,
NS= Non significant,
* = Indicates significant at 5% level of probability,
** = Indicates significant at 1% level of probability.

4.7 Harvest Index (%)

4.7.1 Effect of sowing date

Sowing dates showed significantly effect on harvest index (Table 3). The highest harvest index (35.67%) was obtained with S_2. The lowest harvest index (17.98%) was observed with S_3 which was however, inferior to all other treatments.

4.7.2 Effect of fertilizers

Harvest index varied significantly due to fertilizer doses (Table 3). The treatment F_3 showed the highest value (31.81%). The plot applied with F_1 showed significantly lowest value (24.47%).

4.8.3 Interaction effect of sowing date and fertilizers

Harvest index (HI) indicates the partitioning of dry matter between economic yield and biological yield. The ratio of economic yield to biological yield is termed as harvest index (Table 3). Higher HI might be beneficial in obtaining higher economic yield. A significant increase in HI was found due to application of appropriate dose of fertilizer with proper sowing date. The highest HI (39.14%) was observed with S_2F_3. It was better due to increased dry matter accumulation, better root development resulting from higher partitioning of dry matter towards the production of economic yield. The lowest HI was observed with S_3F_1

Table 3 Effect of sowing date and fertilizer level and their interaction on the harvest index of faba bean cv. Kalimotor

Treatments	Harvest index
Sowing date = S	
S_1	29.73b
S_2	35.67a
S_3	17.98c
Level of significance	**
$S_{\bar{x}}$	1.45
Fertilizers dose = F	
F_1	24.47c
F_2	26.87b
F_3	31.81a
F_4	28.02b
Level of Significance	**
$S_{\bar{x}}$	1.085
Interaction = SF	
S_1F_1	20.72e
S_1F_2	25.41d
S_1F_3	36.24b
S_1F_4	36.55b
S_2F_1	36.67b
S_2F_2	35.87b
S_2F_3	39.14a
S_2F_4	31.02c
S_3F_1	16.01f
S_3F_2	19.33e
S_3F_3	20.06e
S_3F_4	16.50f
Level of significance	**
$S_{\bar{x}}$	2.130
CV (%)	3.18

In a column, figures having similar letter (s) do not differ significantly at 5% level of probability

NS= Non significant,

*= Indicates significant at 5% level of probability,

** = Indicates significant at 1% level of probability.

4.8 Grain nutrition level (%)

4.8.1 Carbohydrate (%)

4.8.1.1 Effect of sowing date

Carbohydrate in grain varied significantly due to sowing dates (Table 4). The highest value (59.44%) gave with S_1 however, statistically similar to S_2. The lowest (54.62%) was observed with S_3.

4.8.1.2 Effect of fertilizers

There was no significant influence of fertilizers on grain carbohydrate (Table 4). Numerically, the highest Carbohydrate (58.42%) was showed with F_3 and the lowest (56.44%) with F_3.

4.8.1.3 Interaction effect of sowing date and fertilizers

A significant interaction had among sowing dates and fertilizer doses on the carbohydrate (Table 4). The highest carbohydrate (61.27%) was showed with S_1F_2. The lowest value (52.08%) was found with S_3F_4.

4.8.2 Protein (%)

4.8.2.1 Effect of sowing date

Protein in grain deferred significantly due to the sowing dates (Table 4). It was the highest (29.24%) with S_3. The lowest (22.9%) was observed with S_2. Murabaa (1987) observed on faba bean in Egypt that seed protein content was lowest with the earliest sowing date (25 October- 25 November).

4.8.2.2 Effect of fertilizers

Protein in grain varied significantly due to fertilizer doses (Table 4). The treatment F_3 showed the highest protein (26.33%) which was however, significantly higher with the rest. The plot applied with F_1 showed significantly lowest (24.89%).

4.8.2.3 Interaction effect of sowing date and fertilizers

There was a significant effect of interaction between sowing dates and fertilizers on grain protein (Table 4). The highest (30.8%) showed with F_1 on S_3. While the lowest value (21.49%) was found with S_1F_2.

4.8.3 Fat and oils (%)

4.8.3.1 Effect of sowing date

Fat and oils in grain varied due to sowing dates (Table 4). It was the highest (0.664%) with crop sown on S_1. The lowest value (0.584%) was observed with S_2 which was however, inferior to all other treatments.

Table 4 Effect of sowing date and fertilizer and their interaction on the grain nutrient level of kalimotor.

Treatments	Carbohydrate (%)	Protein (%)	Fats & Oils (%)	Ash (%)
Sowing date = S				
S_1	59.44a	24.66b	0.6642a	4.332c
S_2	59.09a	22.96c	0.5842b	4.431b
S_3	54. 62b	29.24a	0. 6483a	5.210a
Level of significance	**	**	**	**
$S_{\bar{x}}$	1.262	1.077	0.063	0.029
Fertilizers dose = F				
F_1	58.42	25.35bc	0.6389	3.853b
F_2	58.32	25.92ab	0.6300	4.930a
F_3	56.44	26.33a	0.6267	4.873a
F_4	57.68	24.89c	0.6333	4.973a
Level of Significance	NS	* *	NS	* *
$S_{\bar{x}}$	1.458	1.243	0.057	0.073
Interaction = SF				
S_1F_1	58.29abc	21.49e	0.6367abcd	4.110g
S_1F_2	61.27a	26.62bc	0.6767a	4.540e
S_1F_3	57.81abc	24.18d	0.6833a	3.957g
S_1F_4	58.99abc	26.34c	0.6600ab	4.720e
S_2F_1	57.66abc	23.70d	0.6033abcd	3.750h
S_2F_2	60.00ab	23.07de	0.5633d	4.990d
S_2F_3	59.42abc	23.58d	0.5767cd	4.633e
S_2F_4	60.67ab	21.50e	0.5933bcd	4.350f
S_3F_1	59.32abc	30.86a	0.6767a	3.700h
S_3F_2	53.68abc	28.07b	0.6500abc	5.260c
S_3F_3	52.08c	31.23a	0.6200abcd	6.030a
S_3F_4	53.38bc	26.82bc	0.6467abc	5.850b
Level of significance	**	**	**	**
$S_{\bar{x}}$	2.525	2.153	0.135	0.127
CV (%)	5.03	2.59	4.45	1.61

In a column, figures having similar letter (s) do not differ significantly at 5% level of probability

NS= Non significant,

* = Indicates significant at 5% level of probability,

** = Indicates significant at 1% level of probability.

4.8.3.2 Effect of fertilizers

Not significant influence was observed on fat and oils due to fertilizer doses (Table 4). Numerically, the highest value (0.639%) was found with F_1. The lowest value showed with F_3.

4.8.3.3 Interaction effect of sowing date and fertilizers

There was a significant effect of interaction between sowing dates and fertilizer doses on the contribution of fates and oils (Table 4). The highest value (0.683%) was found S_1F_3. The lowest (0.563%) was found with S_2F_2.

4.8.4 Ash (%)

4.8.4.1 Effect of sowing date

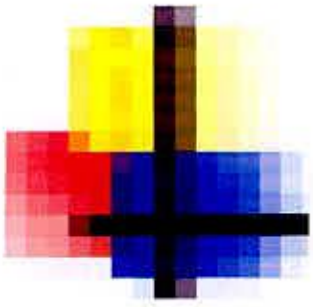
Ash in grain differed significantly due to the sowing dates (Table 4). It was the highest (5.21%) with crop sown on S_3. The lowest (4.33%) was observed with S_1.

4.8.4.2 Effect of fertilizers

Ash in grain varied significantly due to fertilizer doses (Table 4). The treatment F_4 showed the highest value (4.973%) which was however significantly differed with the rest. The plot applied with F_1 had significantly lowest (3.85%).

4.8.4.3 Interaction effect of sowing date and fertilizers

A significant effect showed between sowing dates and fertilizers interaction on the ash in grain (Table 4). The highest value (6.03%) was found with S_3F_1. The lowest (3.7%) was found with S_3F_2.



CHAPTER 5

SUMMARY

CHAPTER V

SUMMARY

An experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of sowing date and fertilizer on the dry matter, grain nutrition level and yields of faba bean (*Vicia faba* L.) cv. Kalimotor during the period from October 2006 to March 2007. The trial comprised three sowing dates (20 October = S_1, 15 November = S_2 and 10 December = S_3) and four fertilizer treatments (F_1 = 6 kg N + 20 kg P_2O_5 + 20 kg K_2O + 15 kg S ha^{-1}, F_2 = 12 kg N + 40 kg P_2O_5 + 40 kg K_2O + 30 kg S ha^{-1}, F_3 = 18 kg N + 60 kg P_2O_5 + 60 kg K_2O + 45 kg S ha^{-1} and F_4 = 24 kg N + 80 kg P_2O_5 + 80 kg K_2O + 60 kg S ha^{-1}).

The experiment was set up in randomized complete block design (RCBD) with three replications. The plot was fertilized as per following treatments. Faba bean seeds of cv. local race named Kalimotor were sown on 20 October, 15 November and 10 December and harvested on 3, 10 and 15 March respectively. Data on different growth, dry matter, yield attributes and grain nutrition level were recorded and analyzed statistically following the DMRT test.

Results showed that plant height varied significantly and the plant height was the highest (46.37cm) with crop sown on S_2. While the shortest plants (34.19cm) was observed from S_3 sowing. F_3 produced the tallest plant (45.9cm) while F_1 produced significantly shortest plant (38.44cm). The tallest plants (50.91cm) were found with S_1F_3. While the shortest plants (31.89cm) was found with S_3F_4.

In respect of primary and secondary branches plant^{-1} significantly both the highest number of primary branches (5.792) and secondary branches (5.798) were found with crop sowing on S_2 while the lowest on S_3. The treatment F_3 produced the highest number of primary branches plant^{-1} (5.686) and secondary branches plant^{-1} (5.707) while F_1 produced significantly the lowest number of primary (3.984) and secondary branches (3.203) plant^{-1}.

The highest number of pods plant^{-1} (57.58) and filled pods plant^{-1} (32.01) were observed with crop sown on S_2. This sowing time also gave highest percentage of filled pods plant^{-1} (55.57) and lowest percentage of unfilled pods plant^{-1} (44.26). The lowest number of pods plant^{-1} (35.05) and filled pods plant^{-1} (10.54) were observed with crop sown on S_3. The treatment F_3 produced the highest number of pods plant^{-1} (53.80) and filled pods plant^{-1} (50.30) which also gave highest percentage of filled pods plant^{-1} (59.19) and lowest percentage of unfilled pods plant^{-1} (40.81).

Number of seeds pods^{-1} was insignificant due to sowing date, fertilizers. 1000-seeds weight varied significantly due to the sowing dates, fertilizers and interaction. 1000-seeds weight was the highest (91.10g) with crop sown on S_2 while the lowest (73.68g) sown on S_3. The treatment F_3 produced the highest 1000-seeds weight (92.13g) while F_1 the lowest 1000-seeds weight (74.80g). The highest 1000-seeds weight (102.30g) was found with S_2F_3, which was similar to S_1F_3 while the lowest 1000-seeds weight (68.55) was found with S_1F_1, which was statistically identical to S_3F_1, S_3F_2 and S_3F_4.

Grain weight plant^{-1} varied significantly due to the sowing dates. Grain weight plant^{-1} was the highest (9.689g) with crop sown on S_2. The lowest (2.590g) was observed for the crop sown on S_3. Grain weight plant^{-1} also varied significantly among the fertilizer doses. The treatment F_3 produced the highest grain weight plant^{-1} (8.94g) which significantly differed with the rest. The plot applied F_1 produced significantly lowest grain weight plant^{-1} (4.436g). There was a highly significant effect of their interaction. The highest grain weight plant^{-1} (11.98g) was found with S_2F_3 while the lowest (1.88g) was found with S_3F_1, which was similar at S_3F_2.

Grain weight per hectare was the highest (1.454 ton/ha) with crop sown on S_2. While the lowest (0.372 t /ha) was observed for the crop sown on S_3. The treatment F_3 produced the highest grain weight (1.342 t/ha). The plot treated with F_1 produced significantly the lowest grain weight (0.665t/ha). There was a highly significant effect of their interaction. The highest grain weight (1.798t/ha) was found with S_2F_3 which was identical to S_1F_3 and S_2F_2 while the lowest (0.2823 t/ha) with S_3F_1 which was identical at S_3F_2, S_3F_3 and S_3F_4

Straw dry matter weight plant^{-1} varied significantly due to the sowing dates. It was the highest (15.34g) with crop sown on S_2. The lowest (10.18g) was observed for the crop sown on S_3. It varied significantly for varying fertilizer doses. The treatment F_3 produced the highest (15.46g). The plot applied with F_1 produced significantly the lowest (10.66g). There was a highly significantly effect due to

interaction. The highest (17.50g) was found with S_1F_3, which was identical to S_2F_4 while the lowest (8.50g) with S_3F_4, which was also statistically identical to S_3F_1.

Grain dry weight plant^{-1} varied significantly due to the sowing dates. It was the highest (8.53g) with crop sown on S_2. The lowest (2.28g) was observed on S_3. It was significant due to fertilizer doses. The F_3 produced the highest (7.877g). The plot treated with F_1 produced significantly lowest (3.903g). There was a significant effect even due to interaction. The highest value (10.56g) was found with S_2F_3 while the lowest (1.657g) was found with S_3F_1, which was identical to S_3F_4.

Total above ground dry weight plant^{-1} varied significantly due to the sowing dates, fertilizer doses and interaction. It was the highest (23.88g) with crop sown on S_2. The lowest (12.45g) was observed on S_3. The treatment F_3 showed the highest (23.33g). While the plot applied with F_1 produced lowest (14.56g). The highest (27.44g) was found with S_1F_3, which was identical to S_2F_3 while the lowest (10.18g) was found with S_3F_4, which was identical to S_3F_1.

Percentage of straw dry weight and grain dry weight plant^{-1} varied significantly due to the sowing dates and fertilizer doses. It was the highest (35.68%) with crop sown on S_2, which had also lowest percentage (63.48%). The lowest percentage (17.98%) of grain dry weight plant^{-1} was observed for the crop sown on S_3, which also had the highest percentage (82.02%) of straw dry weight plant^{-1}. The treatment F_3 showed the highest percentage of grain (31.82%) which was gave the lowest percentage (68.18%) of straw dry weight plant^{-1}. The plot applied with F_1 produced lowest percentage (24.47%) of grain dry weight plant^{-1} as well as gave

the highest percentage (75.53%) of straw dry weight plant^{-1}. The highest percentage of grain (39.14%) was found with S_2F_3 while the lowest (16.02%) with S_3F_1.

Total above ground dry weight per hectare varied significantly due to the sowing dates, fertilizers and interaction. It was the highest (3.58 t/ha) with crop sown on S_2. The lowest (1.868 t/ha) was observed on S_3 sowing. The treatment F_3 showed the highest value (3.50 t/ha). The plot applied with F_1 produced lowest (2.18 t/ha). The highest (4.12 t/ha) was found with S_1F_3 which was identical to S_2F_3 while the lowest (1.527 t/h) was found with S_3F_4 which was identical to S_3F_1.

Carbohydrate percentage in grain varied significantly due to the sowing dates and interaction but insignificant due to fertilizers. It was the highest (59.44%) with crop sown on S_1, which was statistically identical with that of S_2 sowing. The lowest (54.62%) was observed in the crop sown on S_3. The highest Carbohydrate percentage in grain (58.42%) was found with F_3 and the lowest (56.44%) with F_3. The highest carbohydrate percentage in grain (61.27%) was found with S_1F_2 while the lowest (52.08%) with S_3F_4.

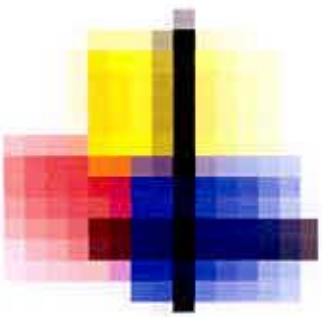
Protein percentage in grain also varied significantly due to the sowing dates, fertilizers and their interaction. Protein percentage was the highest (29.24%) with crop sown on S_3. While the lowest (22.9%) was observed with the crop sown on S_2. The treatment F_3 produced the highest protein percentage in grain (26.33%). The plot applied with F_1 produced lowest percentage in grain (24.89%). The

highest percentage of protein (30.8%) was found with T_9, while the lowest (21.49%) with S_1F_2.

Fat and oils percentage in grain also varied significantly due to the sowing dates and interaction of sowing dates and fertilizers but it was insignificant due to fertilizers. Fat and oils percentage was the highest (0.664%) with crop sown on S_1, which was however, statistically identical with sowing on S_3. The lowest (0.584%) was observed for the crop sown on S_2. The highest fat and oils in grain percentage (0.683%) was found with S_1F_3 while the lowest (0.563%) with S_2F_2.

Ash percentage in grain varied significantly due to the sowing dates, fertilizers and their interaction. Ash percentage was the highest (5.21%) with crop sown on S_3. The lowest (4.33%) was observed for the crop sown on S_1. The treatment F_4 produced the highest ash percentage in grain (4.973%). The plot applied with F_1 produced significantly the lowest ash percentage in grain (3.85%). The highest ash percentage in grain (6.03%) was found with S_3F_1 while the lowest (3.7%) with S_3F_2.

Sowing dates had also a highly significant effect on harvest index. The highest harvest index (35.67%) was obtained with crop sown on S_2. The lowest (17.98%) was observed in the crop sown on S_3. Harvest index also varied significantly among fertilizer doses. The treatment F_3 produced the highest harvest index (31.81%). The plot applied with F_1 produced significantly the lowest harvest index (24.47%). The highest HI (39.14%) was observed at with S_2F_3. The lowest HI was observed with S_3F_1.



CONCLUTION

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CONCLUSION

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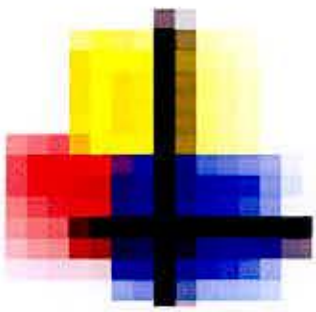
RECOMENDATION

Faba bean seed when sowing on 15 November and the resultant crop fertilized with 18 kg N + 60 kg P_2O5 + 60 kg K_2O +45 kg S fertilizers per hectare (during final land preparation) could be optimum for better performance in respect of growth characters, dry matter, yield attributes, yield and grain nutritional level.

However, this was a one-year experiment and some combined treatments of several plant nutrients were tried. So, the trial could be repeated for couple of years in different agro ecological zone to evaluate the individual effect of N, P_2O_5, K_2O and S.



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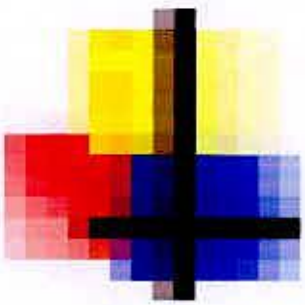
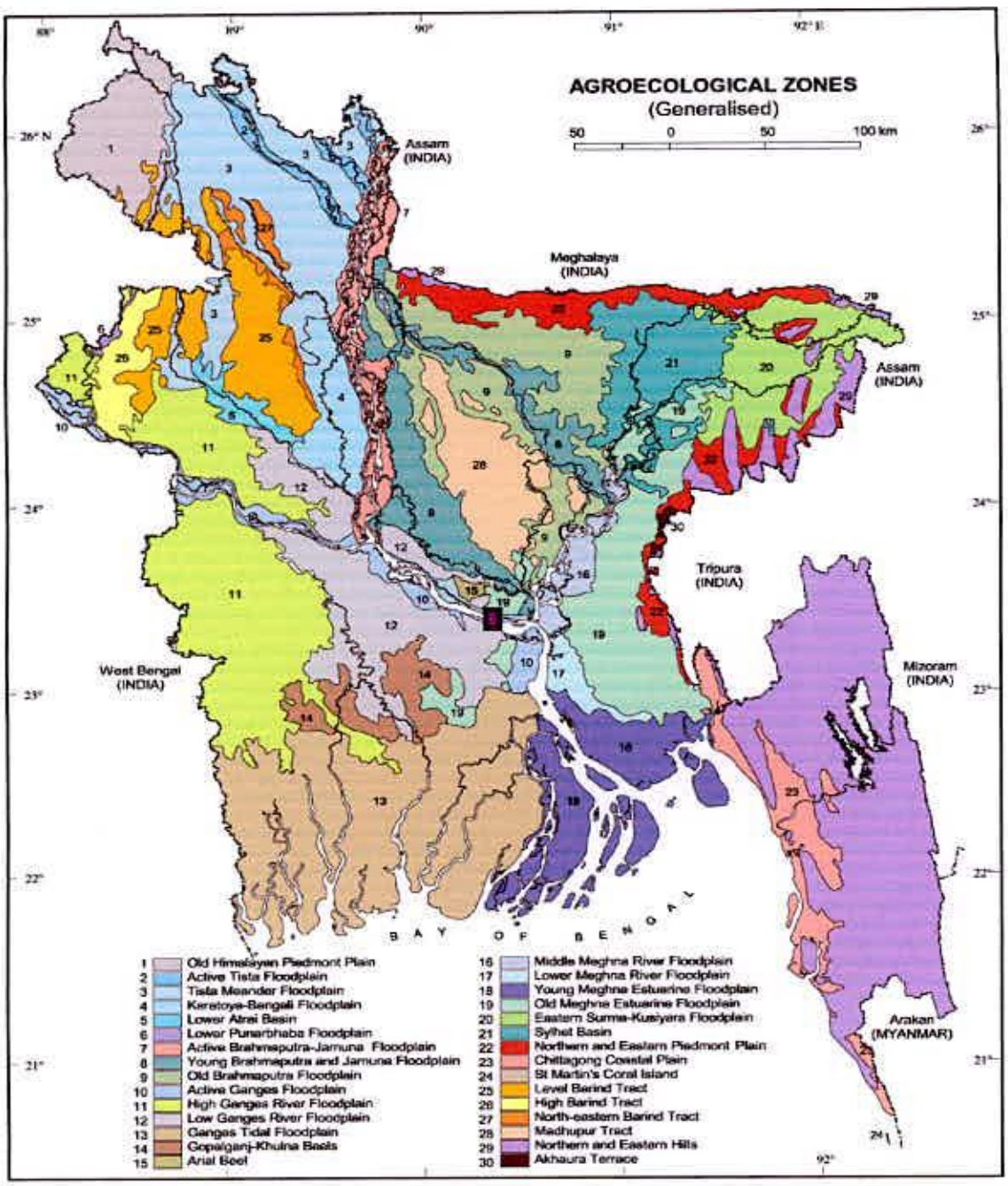


APPENDICES

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0 - 15 cm depth).

Mechanical composition:

Particle size constitution

Sand	:	26%
Silt	:	45%
Clay	:	29%
Texture	:	Silty clay
P^H	:	5.6

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Magnesium	1.00 meq/100 g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Zinc	3.32 µg/g soil

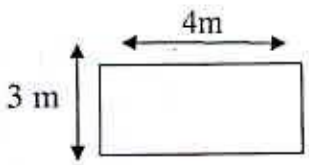
Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix III. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from October 2006 to March 2007.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)	Sunshine (h)
		Maximum	Minimum	Mean			
2006	October	30.5	24.3	27.4	80.00	41.7	238.6
	November	29.70	20.10	24.90	65.00	5.0	230.7
	December	27.90	15.80	21.35	68.14	0.0	213.5
2007	January	24.60	12.50	18.55	66.01	0.0	192.5
	February	27.10	16.80	21.95	64.21	2.0	220.3
	March	36.20	22.10	29.10	46.13	0.0	235.2

Source: Bangladesh Meteorological Department (Climate division), Dhaka-1212.

Appendix IV. Experimental layout



Plot size: 4 m×3 m
Between Plot: 0.5m
Between replication: 0.75 m

Replication I	Replication II	Replication III
T_3	T_4	T_2
T_6	T_8	T_{10}
T_9	T_{12}	T_5
T_{12}	T_3	T_3
T_5	T_6	T_9
T_{10}	T_9	T_1
T_2	T_2	T_4
T_4	T_1	T_6
T_8	T_{10}	T_7
T_7	T_7	T_{11}
T_{11}	T_5	T_{12}
T_1	T_{11}	T_8

Appendix V. Summary of analysis of variance and co-variance on growth, yield attributes, yield and harvest index of faba bean cv. Kalimotor

Source of variance	Degrees of freedom	Mean square						
		Plant height (cm)	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Number of filled pods plant^{-1}	Number of unfilled pods plant^{-1}	Number of pods plant^{-1}	% of filled pods plant^{-1}
Replication	2	0.952	0.148	0.080	4.745	11.701	5.700	22.137
Sowing date	2	571.798**	18.333**	28.340**	1438.476**	5.601^{NS}	1603.195**	2770.120**
Fertilizers	3	83.660**	4.842**	9.495**	162.419**	1.069^{NS}	180.260**	200.051**
Sowing date X Fertilizers	6	13.781**	0.909**	1.912**	98.627**	11.633^{NS}	87.188**	139.197**
Error	22	1.805	0.135**	0.097	1.782	5.936	9.063	5.533
CV (%)		3.19	7.38	6.86	5.93	9.63	6.30	5.30

CV= coefficient of variance
NS= non significant
*= 1% level of probability
**= 5% level of probability

Appendix V. Contd.

Source of variance	Degrees of freedom	Mean square					
		% of unfilled pods plant^{-1}	Number of seeds pod^{-1}	1000 seeds weight (g)	Grain weight plant^{-1}(g)	Grain weight per hectare (ton)	Harvest index (%)
Replication	2	12.619	0.002	1.885	0.065	0.043	0.496
Sowing date	2	2052.759**	0.053^{NS}	1041.095**	156.156**	3.778**	973.567**
Fertilizers	3	211.061**	0.039^{NS}	460.591**	30.996**	0.690**	84.338**
Sowing date X Fertilizers	6	190.820**	0.016^{NS}	140.521**	9.061**	0.164**	75.633**
Error	22	15.953	0.017	5.163	0.031	0.027	0.783
CV (%)		7.12	3.92	2.70	2.68	16.47	3.18

CV = coefficient of variance
NS = non significant
* = 1% level of probability
** = 5% level of probability

Appendix VI. Summary of analysis of variance and co-variance on dry matter of faba bean cv. Kalimotor

Source of variance	Degrees of freedom	Mean square				
		Straw dry wt. plant^{-1} (g)	Grain dry wt. plant^{-1} (g)	Total dry wt. plant^{-1} (g)	% of straw dry wt. plant^{-1}	% of grain dry wt. plant^{-1}
Replication	2	0.098	0.050	0.208	4.473	0.440
Sowing date	2	87.371**	121.038**	412.646**	1055.187**	973.587**
Fertilizers	3	35.755**	24.060**	115.990**	88.583**	84.351**
Sowing date X Fertilizers	6	4.723**	7.014**	15.086**	62.121**	75.607**
Error	22	0.146	0.023	0.171	2.757	0.778
CV (%)		2.90	2.65	2.18	2.31	3.17

CV = coefficient of variance
NS = non significant
* = 1% level of probability
** = 5% level of probability

Appendix VI. Cont.

Source of variance	Degrees of freedom	Mean square			
		Straw dry wt. m^{-2} (g)	Grain dry wt. m^{-2} (g)	Total dry wt. m^{-2} (g)	Total dry wt. ha (ton)
Replication	2	820.640	13.885	45.981	0.005
Sowing date	2	18079.610**	27289.657**	92837.108**	9.297**
Fertilizers	3	5614.223**	5515.903**	26098.744**	2.620**
Sowing date X Fertilizers	6	940.321**	1612.939**	3392.085**	0.339**
Error	22	465.047	6.342	38.511	0.004
CV (%)		11.20	2.92	2.19	2.21

CV = coefficient of variance
NS = non significant
* = 1% level of probability
** = 5% level of probability

Appendix VII. Summary of analysis of variance, co-variance and LSD- value on grain nutrition level of faba bean cv. Kalimotor

Source of variance	Degrees of freedom	Mean square			
		Carbohydrate (%)	Protein (%)	Fates and oils (%)	Ash (%)
Replication	2	0.582	1.347	0.001	0.003
Sowing date	2	86.809**	126.776**	0.011**	2.777**
Fertilizers	3	7.501^{NS}	3.614**	0.000^{NS}	2.602**
Sowing date X Fertilizers	6	17.757**	15.107**	0.002**	0.985**
Error	22	8.422	0.440	0.001	0.006
CV (%)		5.03	2.59	4.45	1.61

CV = coefficient of variance
NS = non significant
* = 1% level of probability
** = 5% level of probabili

PLATES

PLATES

Plate I. Showing total field view of the experiment of faba bean cv. Kalimotor

Plate II. Field view showing differences in plants due to different sowing dates of faba bean cv. Kalimotor

Plate III. The picture showing flowering stage of faba bean cv. Kalimotor

Plate IV. Showing cluster of flower in plant of faba bean cv. Kalimotor

Plate V. Showing cluster of flower of faba bean cv. Kalimotor

Plate VI. Showing indivisual flower of faba bean cv. Kalimotor

Plate VII. Showing pods of faba bean cv. Kalimotor in grain filling stage

Plate VIII. Showing pods of faba bean cv. Kalimotor in pod maturing stage

Plate IX. Showing ripen pods of faba bean cv. Kalimotor

Plate X. Showing seeds of faba bean cv. Kalimotor

Plate XI. Showing dehusked seeds of faba bean cv. Kalimotor