Journal Home page : www.jeb.co.in ★ E-mail : editor@jeb.co.in

JEB
Journal of Environmental Biology

ISSN: 0254-8704
CODEN: JEBIDP

Planting geometry to optimize growth and productivity in faba bean (*Vicia faba* L.) and soil fertility

A.K. Singh[1]*, B.P. Bhatt[1], P.K. Sundaram[1], A.K. Gupta[2] and Deepak Singh[3]
[1]ICAR Research Complex for Eastern Region, Patna-800 014, India
[2]Krishi Vigyan Kendra, Saharanpur- 247 007, India
[3]Krishi Vigyan Kendra, Sitamarhi- 843 320, India
*Corresponding Author email : aksingh_14k@yahoo.co.in

Publication Info

Paper received:
26 August 2011

Revised received:
08 February 2012

Accepted:
22 March 2012

Abstract

Faba bean (*Vicia faba* L.) responses to alteration of its ambient environment leads to certain modification in the crop phenology, yield attributes and economic yield. To know the extent and pattern of response by faba bean to alterations, a two year field experimentation was carried out with two crop establishment methods (i) flatbed planting (ii) raised bed planting, four planting geometry (i) 30X20 cm(ii) 30X30 cm (iii) 30X45 cm and (iv) 45X45cm and three seeding depth. All the treatment (two crop establishment methods, four planting geometry and three seeding depth) were combined together consisting twenty four treatments, were organized in factorial experiment in complete randomized block design (CRBD) with three replications. Data were recorded on growth and development; yield attributes and yield. Soil analysis was done and finally statistical tool were applied to come in to valid conclusion. Raised bed planting proves superior over flatbed in case of seed yield. Square planting architect with 30 cm apart prove better (3690.9 kg ha^{-1}) than other tested planting geometry. Seeding at 10 cm depth showed, significant improvement in seed yield per plant and per ha over other two tested seeding depth. Phosphorus availability was significantly higher in raised bed planting (36.9 kg ha^{-1}). However, available K (kg ha^{-1}) was significantly influenced by planting geometry and seeding depth. It was maximum (155.2 kg ha^{-1}) with 30X 45 cm plant geometry, proved significantly higher than 30X20 cm and 30X30 cm and at par with 45X45 cm planting.

Key words

Vicia faba, Planting geometry, Seeding depth, Crop phenology

Introduction

Globally, faba bean (*Vicia faba* L.), is third most important feed grain legume after soybean (*Glycine max*) and pea (*Pisum sativum* L.) with a total production of 4.87 MT and harvested area of 2.63 Mha, as reported by Mihailovic *et al.* (2005). Razia Akbar (2000) reported the practice of cultivation and soil enhancing properties of faba bean in India. Being one of the most potential crops to serve humanity at global level, unfortunately in India it is still treated as a minor legume / unutilized / underutilized crop (Singh *et al.,* 2009; Singh *et al.,* 2010). China is currently the world leading producer with 60% of the total yield followed by Northern Europe, Mediterranean, Ethiopia, Central and East Asia and Latin America (FAOSTAT, 2009).

Faba bean is cultivated in different North Indian states. It is cultivated during winter (states of seasons) in plains and during rainy season (Kharif) in hilly and mountainous region. It is as an agronomically viable alternative to cereal grains (Singh *et al.,* 2010). It is being taken as sole crop and as intercropped/mixed crops with variety of combination even as border / guard crop in eastern India (Singh *et al.,* 2009 and Singh *et al.,* 2012).

Despite good coverage of the crop, very limited work has been done on its agronomic management and varietals improvement. Constraints that contribute to low productivity of faba bean include improper cultural practices and lack of good quality seeds (Singh *et al.,* 2009) leading to sub optimum plant stand resulting in poor yield. In order to improve the production and productivity of faba bean crop in traditional areas of Bihar, participatory research appraisal (PRA) has been conduced to workout researchable issue related to this crop. On the basis of participatory research appraisal (PRA) conducted for acceleration of productivity of this orphan but economically important crop of this region revealed that researchable agronomical constraints are establishment methods, planting geometry and seeding depths which needs to be undertaken on priority basis (Singh *et al.,* 2012).

In order to optimize the production potential of this crop, an experimental trail was conducted to ascertain the role of establishment methods, planting geometry and seeding depths to optimize faba bean (*Vicia faba* L.) productivity.

Materials and Methods

The field experiment was conducted at ICAR Research Complex for Eastern Region Patna **(**25°35'N latitude and 85° 05'E longitude) Bihar during 2008-09 and 2009-10 periods. The soil of experimental site was sandy-loam in texture, calcareous in nature and slightly alkaline in reaction. The inherent nutrient supplying capacity of the soil was in the medium range in respect of available nitrogen, phosphorus and potassium as well. The experiment consisted of two crop establishment methods i.e. flatbed planting and raised bed planting, four planting geometry i.e. 30X20, 30X30, 30X45 and 45X45 cm and three seeding depth, consisting of 24 treatments. The experiment was conducted in complete randomized block design in factorial experiment with three replications. Sowing operation was carried out during first week of November during both the period. Three seeds were sown in each hole at desired depth of 5.0, 7.5 or 10 cm. After fortnight of sowing, plants were thinned out keeping two healthy plants per hole to maintain optimum plant population.

Faba bean crop was fertilized with NPK at the rate of 20:50:40 kg ha^{-1} respectively. Three irrigations were given at grand growth, pre-flowering and pod filling stages during both the Rabi seasons. Two hand weeding was carried out one at initial stages of crop growth and second between grand growth and flowering. No major incidence of pests and disease were noticed during the course of experimentation. Germination of seeds were satisfactory during the both the *rabi* season hence crop stand was normal. Weather condition viz., rainfall, temperature (minimum and maximum), relative humidity (%) of Patna, Bihar, was within the range during the experimentation period of both the Rabi.

Physical and chemical parameters of soils such as pH, EC (d sm M^{-1}), water holding capacity (%), OC(%), available P and K (kg ha^{-1}) before sowing and after harvest crop were analysed following the procedure described by AOAC (1980).

Biometrical data viz., germination (%), days to first flowering were recorded before harvest. At harvest, plant height (cm), productive branch per plant, days to maturity, first podding height (cm), pod per plant, pod length (cm), grains per pod, seed yield (g per plant), seed yield (kg ha^{-1}), 100 seed weight (g) Seed yield (kg ha^{-1}) were estimated based on seed weight per plot adjusted to 15% moisture. Regular analysis of variance was performed for each trait in both seasons and the combined (Pooled) analysis over seasons after testing error variance homogeneity was carried out according to the procedure outlined by Gomez and Gomez (1984), using the MSTATC version 2.1 (Michigan State University, USA) statistical package design. Significant differences between the treatments were compared with the critical difference at (± 5%) probability by LSD.

Results and Discussion

Seed germination is basic prerequisite for uniform and optimum plant stand per unit area. This is much more of significant, particularly for slow starter, faba bean is one of the slowest germinator, taking time 7-15 days depending upon depth of sowing and prevailing agroclimatic condition. Data presented in Table1, showed seed establishment method (planting method) has significant contribution on seed germination (Singh *et al.,* 2012). Raised bed planting (85.7%) out performed over flatbed significantly, however planting geometry (spacing) failed to influenced germination significantly. Moreover, seeding per planting depth had variable influence, seeding at 7.5 cm depth had significantly more germination than shallow and deep placement of seed. Faba bean needs heavy amount of seed (based on its test weight ranged 300-1100 g) which can be reduced by adopting raised bed planting and 10 cm deep placement. Improved impact of seeding depth and planting method on faba bean germination were also reported by Alghamdi (2002) and Singh *et al.* (2010). Height of plant is one of the important parameter upon which other growth, development and afterward on yield attributes and yield based. Taller plants may produced more yield attributes (pods per plant, seed per pod etc.) and finally yield. Interestingly all the treatments have influenced on this trait. Maximum plant height was recorded in case of raised bed planting might be due to efficient resource utilization, be it added or natural. Perusal of data revealed that planting geometry plays no significant role in plant height however, it was noticed that slightly more taller plant was produced in case of dense planting 81.3 cm (30X20 cm) than spars planting 78.6cm (45X45 cm) suggest that plant attains more height might be due more competition for resources especially for sunlight. Similar results were reported by Alghamdi (2002), Abdel

Latif (2008) and Singh *et al.* (2010). Productive branch is that branch which produces flowers and afterward seeds containing pods. It is the first and foremost crucial trait in vegetative phase (growth and develepement stage) sets for perfect reproductive stage. This trait gives glimpse of the potentiality of particular genotype under given agroclimatic situation. This trait is only influenced by planting geometry. Maximum productive branch per plant (12.3) was recorded with square planting (30X30 cm), whereas corresponding minimum was 10.4 with 30X20 cm planting. Except plant spacing other treatments failed to influence productive branches which might be due to the nature of this traits which is largely govern by its genetic makeup. The same conclusion was reached by Stutzel and Aufhammer (1992), Abdel Latif (2008). Days taken to come in to reproductive phase (flowering per anthesis), is one of the traits that can provide fair idea about crop duration and or longevity of reproductive period. Early onset of reproductive phase may be one of the good indicators to produce more seed by directing photosynthesis to the sink part. It is very common phenomena in case of all legumes, after certain period of time. Planting geometry and seeding depth has considerable influence on days to flowering, whereas crop establishment method did not influence it significantly (Table1). Days taken to complete its lifecycle (maturity) provide an idea about its suitability under cropping system, sequential cropping. Days taken to maturity also followed similar trend, as case of days to maturity. In case of plant spacing, maximum days taken to maturity was recorded in case of lax planting (45X45 cm), where as shortest time taken by dense planting (30X20 cm), the possible reason behind forced maturity under comparable overcrowded situation might be due to lesser and lesser availability of energy to maintain momentum for longer time, than in case of availability of abundant energy. These results closely followed the findings of Alghamdi (2002) and Singh *et al.* (2009). Perusal of data presented in Table 1 accord that podding initiation height (first podding height) is much of economic importance in case of faba bean. None other than planting geometry has influence on first podding height (Abdel Latif, 2008). Spacing at 45 X45 cm distance provided ample amount of space to complete all phonological event comparatively with no or minimum competition, consequently first pod was borne at minimum (5.9 cm) plant height ,whereas maximum podding height was recorded with highly dense populated planting geometry. These results are in close conformity with Stutzel and Aufhammer (1992), Abdel Latif (2008) and Singh *et al.* (2010), respectively.

Results indicated that there was a significant influence of all the tested treatments on the numbers of pods per plant. In case of establishment method, crop grown under raised bed planting produced significantly more pods (43.1) than flatbed bed (Singh *et al.,* 2012). This might be due to more efficient and effectively management and resource utilization under raised bed planting compared to flatbed. Similar result was also obtained in case of planting pattern (plant spacing), maximum pods per plant was recorded in case of 45X 45 cm spacing and with further reduction pod bearing ability reduced considerably. It is worth to mention here that square planting at 30 X30 cm distance, produced significantly higher pods per plant (41.6) than 30X20 cm spacing and at par with 30X 45 cm. These findings are similar to the findings of Singh *et al.* (2010), Abdel Latif (2008) and Alghamdi (2002). Pod length is one of important but secondary yield attributing trait. Perusal of data presented in Table 2 revealed that pod length was not influenced by any of the factor tested, but surprisingly it

Table 1 : Effect of establishment method, planting geometry and seeding depth on growth and development of faba bean

Treatment	Germination (%)	Plant height (cm)	Productive branch per plant	Days to first flowering	Days to maturity	First podding height (cm)
Establishment method						
Flatbed planting	74.5	81.2	11.2	61.0	107	6.8
Raised bed planting	85.7	86.8	11.6	59.6	110	6.4
CD at (± 5%)	14.5	3.1	NS	NS	NS	NS
Planting geometry						
30X20	81.3	86.5	10.4	61.1	106.5	7.1
30X30	80.2	84.7	12.3	59.6	107.1	6.9
30X45	79.5	83.5	11.7	59.1	109.0	6.5
45X45	78.6	81.3	11.2	61.4	111.4	5.9
CD at (± 5%)	NS	2.8	0.6	1.3	2.5	1.1
Seeding depth						
5.0 cm	80.2	85.5	12.0	58.3	97.5	6.5
7.5 cm	86.8	84.2	11.2	60.4	107	6.3
10 cm	72.7	82.3	11.0	62.2	112	6.8
CD at (± 5%)	11.3	2.5	0.5	1.1	2.3	NS

Table 2 : Effect of establishment method, planting geometry and seeding depth on yield attributes and seed yield of faba bean

Treatment	Pod/Plant	Pod length (cm)	Grains / Pod	Seed yield (g per plant)	Seed yield (kg ha^{-1})	100 seed weight (g)
Establishment method						
Flatbed planting	40.5	4.15	3.49	36.5	3447.3	29.3
Raised bed planting	43.1	4.29	3.23	38.7	3524.1	29.1
CD at (± 5%)	2.1	NS	NS	1.5	91.5	NS
Planting geometry						
30X20	39.4	4.18	3.22	33.7	3536.2	28.6
30X30	41.6	4.22	3.44	35.4	3690.9	29.4
30X45	42.5	4.23	3.35	39.7	3469.7	29.6
45X45	43.7	4.25	3.43	41.6	3246.3	29.2
CD at (± 5%)	1.5	NS	0.15	1.4	71.8	NS
Seeding depth						
5.0 cm	43.2	4.26	3.43	37.9	3493.6	29.4
7.5 cm	41.8	4.21	3.35	38.4	3543.3	29.2
10 cm	40.4	4.19	3.30	36.4	3420.3	29.0
CD at (± 5%)	1.3	0.07	0.12	1.20	63.5	NS

was significantly influenced by seeding depth, this indicated that there might be some kind of relation with its initial vigour and coleoptiles length etc. Since, it is trait of genetic nature, so input management practice has least role to play in this trait. Grain per pod (Table 2) is considerably influenced by the entire factor significantly except establishment method, which has no significant role, though raised bed had produced numerically more seeds per pod (Table 2). In case of planting geometry crop grown with spacing of 30 X 30 cm produced maximum and significantly higher grain per pod (3.44) than grains produced in case 30 X 20 planting and at par with other planting geometry. In case of seeding per planting depth, number of grains per pod decreased with the every increase in depth of planting. Significantly maximum grains per pod were recorded (3.43) with shallow depth of planting (5.0cm deep planting) which was significantly superior to deep placement of seed and at with medium depth of seed placement. Similar findings were also reported by Singh *et al.* (2012); Singh *et al.* (2009) and Abdel Latif (2008). Seed yield per plant is an indication of ability of a particular plant to produce under prevailing environmental situation. In the present study, faba bean was tested under three different but interlinked factors which may or may not influence performance of individual plant in isolation and in a population under stress and normal condition. Results revealed that seed producing ability of individual plant was significantly influenced by all the tested three factors (Table 2). This might be due yield which is polygenic character and governed as well as influenced by several factor directly or indirectly. In case of plant establishment method, raised bed planting proved superior over flatbed planting that produced significantly higher seeds per plant (38.7 g). This may be due to more facilitation for effective cultural practices and efficient utilization of natural and added inputs over flat bed method of planting. Plant geometry play crucial role in producing seeds per plant. It was noticed that with increase in plant density faba bean produced significantly more seed per plant with each increase in plant spacing (33.7 g) up to the last tested spacing (41.6 g). Perhaps, this is unique and ideal example of plasticity of plant, a natural gift to accommodate more plants in less area and vice versa. Seeding depth influenced seed producing ability of individual plant significantly. Seeding at medium depth (7.5 cm) produced significantly highest seeds (38.4g per plant) than other tested depth of sowing. This might be due to more appropriate utilization of all the available resources in comparison to shallow and deep placement of seed. (Stutzel and Aufhammer, 1992; Abdel Latif, 2008 and Singh *et al.,* 2012). Seed yield is economic produce and the final output of all the yield attributes, derived from growth and development. Seed yielding ability in isolation i.e. per plant may or may not be equally applicable under optimum population. Seed yield has been positively influenced by all the tested factors (2). Raised bed method of seed establishment produced significantly more seed yield (3524.1 kg ha^{-1}) over flat sowing. In case of planting geometry, square planting (30 X 30 cm) produced significantly higher seed yield (3690.9 kg ha^{-1}) over other tested planting pattern. It is worth mentioning that individually, sparse planting has produced maximum seed (g) per plant, where as under mixed population, better performance was recorded under optimum plant population with square planting with 30 cm apart. This might be due the plasticity of faba bean which provide ample opportunity to adjust under favourable and adverse condition. Similarly in case of seeding depth data revealed that moderate depth of seed sowing produced significantly higher yield (3543.3 kg ha^{-1}) over other tested

Table 3 : Effect of establishment method, planting geometry and seeding depth on faba bean soil properties

Treatment	pH	EC (dSm M^{-1})	Water holding capacity (%)	OC (%)	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Establishment method						
Flatbed planting	8.5	0.24	39.1	0.54	34.3	150.6
Raised bed planting	8.4	0.23	39.5	0.55	36.9	153.8
CD at (± 5%)	NS	NS	NS	NS	1.6	NS
Planting geometry						
30X20	8.5	0.24	40.5	0.55	35.4	151.7
30X30	8.5	0.23	39.4	0.54	36.1	148.6
30X45	8.4	0.23	39.1	0.54	35.1	155.2
45X45	8.4	0.24	38.2	0.55	35.8	153.3
CD at (± 5%)	NS	NS	NS	NS	NS	3.3
Seeding depth						
5.0 cm	8.5	0.24	39.4	0.54	35.7	152.6
7.5 cm	8.5	0.23	39.2	0.55	36.8	154.3
10 cm	8.4	0.24	39.3	0.54	34.3	149.7
CD at (± 5%)	NS	NS	NS	NS	NS	3.6

depth of sowing. Results indicate that depth of sowing has considerable influence on growth, yield attributes and finally on seed yield. Abdel Latif (2008), Alghamdi (2002) and Singh *et al.* (2009) also reported parallel to these findings. To know the effects of different factor tested in this experiment data were also recorded on seed index. None of the treatments had significantly influenced this trait. It is established fact that seed index is a highly genetically associated traits least influenced by other factors/inputs (Singh *et al.*, 2010; Abdel Latif, 2008).

Data presented in Table 3, exhibit the effects of faba bean crop on soil physico-chemical properties. pH of the soil was not influenced by any of the factors during individual season and under pooled condition also, though it ranged narrowly between 8.4 to 8.5. Electrical conductivity was also not influenced by any of the factor/ treatments and it ranged in between 0.23 to 0.24. Similar trend was also observed in case of water holding capacity (38.2 to 40.5 %) and organic carbon content (0.54 to 0.5%). These results might be an indication towards its nature, which is an inherent kind of properties and hardly get influenced immediately in season or two, changes in these characters takes place after a long period of time. Similar impact of seed bed, plant geometry and seeding depth on soil physico-chemical was also reported by Alghamdi (2002) and Turk and Tawaha (2002). Available P (kg ha^{-1}) was not influenced by planting geometry and seeding depth, though methods of plant establishment had significant influence on it. Raised bed planting (36.9 kg ha^{-1}) proved superior over flatbed; this might be due to better nodulation and efficient mobilization of immobile /fixed native phosphorus. Improved impact of planting geometry and seeding depth on available P was also reported by Alghamdi (2002), Turk and Tawaha (2002) and El-Gizawy *et al.* (2009). Potassium availability was significantly influenced by alteration in planting geometry and seeding depth, though planting method failed to register any influence. Maximum available K (155.2 kg ha^{-1}) was recorded with 30X 45cm planting, which was significantly higher than 30X20 and 30X30 cm planting but at par with 45X45cm planting. This trend suggests that K availability is progressed positively with sparse planting. Alghamdi (2002), Singh *et al.* (2009) and Turk and Tawaha (2002) also reported similar results. Interestingly the availability of K showed just revers trend than in case of, this might be due to the nature of each nutrient on soil clay complex and interaction with faba bean roots in *rhizospher*.

Faba bean responses to modification of its environment leads to certain modification in the crop phenology, yield attributes and economic yield. Productivity of faba bean can be improved through appropriate plant architect modification with the help of seeding adjustment, population management and by seedbed configuration. This not only enhances productivity and soil fertility in long run but also improves the resistance power of the crop to cope up with biotic and abiotic stress in better way. Seed yield in faba bean was improved significantly under raised bed with square planting (30X30cm) and with medium depth of seeding (10cm). Sparse planting and dese planting has its own advantage over resources utilization and biotic and abiotic stress management. This study highlighted that the response of faba bean may be unique in isolation and or under wider spacing, which may not fit equally good for mass production. Similarly yield attributes (on unit plant basis) in general did not respond in similar fashion under maximum or optimum plant population.

Acknowledgments

Senior author sincerely acknowledge his gratitude to Dr. M. A. Khan, Ex Director ICAR, Research complex for Eastern Region Patna 800 014, for providing necessary facilities to conduct field experiment. Acknowledgement is also due to Dr. L. K. Prasad and Dr. K. Rajan, Incharge, Hi-tech lab of this institute for analysing experimental soils.

References

Abdel Latif and Y. Idris: Effect of seed size and plant spacing on yield and yield components of faba bean (*Vicia faba* L.). *Res. J. Agric. Biol.,* **4,** 146-148(2008).

Alghamdi, S.S.: Effect of salinity on germination and seedling growth of selected genotypes of faba bean (*Vicia faba* L.). *Alex. Sci. Exch.,* **23**, 409-420 (2002).

AOAC: Official methods of analysis of the association official analytical chemist. 13th Edn., AOAC ,Washington DC, USA (1980).

FAOSTAT: Production Stat: Crops. FAO statistical databases (FAO stat), food and agriculture organization of the United Nations (FAO), http://faostat.fao.org. (2009).

Gomez, K.A. and A.A. Gomez: Statistical procedures for agricultural research. 2nd Edn., John Wiley & Sons Inc., Singapore (1984).

El-Gizawy, N. K. B.and S. A. S Mehasen.:Response of faba bean to bio, mineral phosphorus fertilizers and foliar application with zinc.*World Appl. Sci. J.*, **6,** 1359-1365 (2009)

Mihailoviæ, V., A. Mikiae, B. Aeupina and P. Eriae: Field pea and vetches in Serbia and Montenegro. *Grain Legumes*, **44**, 25-26. (2005).

Razia Akbar (Tr.): Nuskha Dar Fanni-Falahat: (The Art of Agriculture); (Persion Manuscript Compiled In The 17Th Century by the Mughal Prince DaraShikoh) (Agri-History Bulletin No. 3)MunshiramManoharlal Publishers Pvt. Ltd., p. 98 (2000).

Singh, A.K., N. Chandra, R.C. Bharati and S.K. Dimree: Effect of seed size and seeding depth on faba bean (*Vicia faba* L.) productivity. *Envi. Ecol*., 2**8**, 1522-1527(2010).

Singh, A.K., S.K. Dimree, M.A. Khan and A. Upadhyaya: Agronomic Evaluation of faba bean (*Vicia faba* L.) performance under impending climate change situation. National Symposium on Recent Global Developments in the Management of Plant Genetic Resources. Indian Society of Plant Genetic Resources, New Delhi, pp. 171-179 (2009).

Singh, A.K., B.P. Bhat, P.K. Sundaram, N. Chandra, R.C. Bharati and S.K. Patel: Faba bean (*Vicia faba* L.) phenology and performance in response to its seed size class and planting depth. *Int. J. Agril. Stat. Sci*., **8**, 97-109. (2012).

Stutzel, H. and W. Aufhammer: Grain yield in determinate and indeterminate cultivars of *Vicia faba* L. with different plant distribution patterns and population density. *J. Agric. Sci. Camb.,* **118**, 343-352 (1992).

Turk, M. and A. Tawaha: Impact of seeding rates, seeding dates, rate and methods of phosphorus application in faba bean (*Vicia fava* L.). in the absence of moisture stress. *Biotechnol. Agron. Soc. Environ.*, **6**, 171-178 (2002).