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Studies on faba bean growth, yield attributes and yield in response to varying planting pattern, geometry and seeding depth

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ABSTRACT

To know the extent and pattern of response by faba bean (*Vicia faba* L.) to alterations, a two year field experimentation was carried out with two crop establishment methods (i) flatbed planting, and (ii) raised bed planting; four planting geometries (i) 30 x 20 cm (ii) 30 x 30 cm (iii) 30 x 45 cm, and (iv) 45 x 45 cm; and three seeding depths in factorial experiment in complete randomized block design with three replications. Germination was significantly higher under raised bed planting (85.7 per cent) over flatbed planting. Early onset of flowering (58.3 days) and early maturity (97.5 days) was noticed in shallow depth (5.0 cm) of sowing. Maximum plant height (86.8 cm) was noted under raised bed planting. Maximum leaf area index (LAI) was recorded (4.15) with planting geometry (30 x 30 cm) at 90 DAS. Leaf weight ratio (LWR) and RGR were influenced with all the treatments. Pods per plant, seed yield (g/plant and kg ha^{-1}) were influenced significantly with all the treatments. Raised bed planting proves superior over flatbed in case of seed yield. Square planting with 30 cm planting distance proved better (3,690.9 kg ha^{-1}) than other planting geometries. Seeding at 10 cm depth showed significant improvement in seed yield over other two tested seeding depths.

Key words: *Vicia faba* L., planting geometry, seeding depth, growth and development, seed yield.

INTRODUCTION

Globally, faba bean (*Vicia faba* L.), is third most important feed grain legume after soybean and pea a total production of 4.87 MT and harvested area of 2.63 m ha (Mihailovic *et al.*, 8). It is one of the oldest crops having long tradition of cultivation in old world agriculture (Anon, 9). Faba bean is cultivated in different states in considerable area particularly in the states of Uttar Pradesh, Bihar, Punjab, Haryana, Jammu & Kashmir, Rajasthan, Karnataka and Madhya Pradesh. It is a wonderful legume which can grow well in wide range of pH (5.5 to 9.0). Faba bean seeds can be used in variety of ways; right from human consumption (green pod as vegetable, grain as sprout, roasted) to animal feed; leaves are good source for delicious fodder enriched with protein equally good for green manure. Constraints that contribute to low productivity of faba bean include improper cultural practices and lack of good quality seeds, leading to sub optimum plant stand resulting poor yield.

MATERIALS AND METHODS

The field experiment was conducted at Crop Research Programme, Pusa (25.98° N Lat., 85.67° E Long.), Bihar during *rabi* seasons of 2006-07 and 2007-08. 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 consists of two crop establishment methods (i) flatbed planting (ii) raised bed planting, four planting geometries (i) 30 cm x 20, (ii) 30 cm x 30, (iii) 30 cm x 45 cm and (iv) 45 cm x 45 cm and three seeding depths. All the treatments (two crop establishment methods, four planting geometries and three seeding depths) were combined together consisting 24 treatments, were organized in factorial experiment in complete randomized block design (CRBD) with three replications. Sowing operation was carried out during first week of November during both the years. Seeds were sown on well prepared flat and raised bed as per spacing, respectively. Three seeds were sown in each hole. Planting of seeds was done at desired depths (5.0, 7.5 or 10 cm). After fortnight of sowing operation plant were thin out keeping two healthy plants per hole to maintain optimum plant population. Standard package of practices were adopted. Crop was fertilized with NPK @ 20:50:40 kg/ha, respectively. Three irrigations were given at grand growth, pre-flowering and pod filling stages during both the seasons. Observations were recorded before harvest to know the effects of planting modification and environmental condition on germination (%), days to first flowering, leaf areas were measured for each plant by leaf area meter.

Five plants were selected at random from the inner rows of each sub-plot at 60 and 90 days after

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sowing to determine the relative growth rate and its components. Plant growth and development were evaluated based on the estimated relative growth rate (RGR), and its components, net assimilation rate (NAR), specific leaf area (SLA) and leaf weight ratio (LWR) by the interval method from 60 to 90 days after sowing. RGR, NAR, LWR, and SLA were calculated in the two harvests according to Hunt (6). At harvest, plant height (cm), productive branch/ plant, days to maturity, first podding height (cm), pod/ plant, pod length (cm), grains /pod, root dry weight (g) seed yield (g/plant), seed yield, seed yield 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 (4), using the MSTATC version 2.1 (Michigan State University, USA) statistical package.

RESULTS AND DISCUSSION

Data presented in Table 1, show that seed establishment method (planting method) had significant effect on seed germination. Raised bed planting (85.7%) out performed flatbed method significantly. However, planting geometry (spacing) failed to influence germination significantly. Moreover, seeding / planting depth had variable influence, seeding at 7.5 cm depth has significantly more germination than shallow and deep placement of seed. The seed requirement was significant 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 (2), and Graf and Rowlanda (5).

Maximum plan height (cm) was recorded in case of raised bed planting which might be due to efficient resource utilization, be it added or natural. Planting geometry played no significant role in plant height however it was noticed that slightly more taller plants were produced in case of dense planting 81.3 cm (30 cm x 20 cm) than spars planting 78.6 cm (45 cm x 45 cm). Similar results were reported by Graf and Rowlanda (5), Alghamdi (2), and Abdel Latif and Idris (1).

Maximum productive branch per plant (12.3) was recorded with square planting (30 cm x 30 cm), whereas corresponding minimum was 10.4 with 30 cm x 20 cm spacing. Except plant spacing other treatments fail to influence productive branches might be due to the nature of this traits which is largely govern by its genetic makeup. Similar conclusion was reached by Stutzel and Aufhammer (9); and Abdel Latif and Idris (1).

Planting geometry and seeding depth had considerable influence on days to flowering, whereas crop establishment method did not influence it significantly (Table 1). Days taken to complete its lifecycle (maturity) provide an idea about its suitability

Table 1. Effects of planting depth, pattern and geometry on growth and phenology of faba bean.

Treatment	Germination (%)	Plant height (cm)	Productive branch/plant	Days to first flowering	Days to maturity	Root dry wt. (g)
Planting method						
Flatbed planting	74.5	81.2	11.2	61.0	107	4.01
Raised bed planting	85.7	86.8	11.6	59.6	110	4.15
LSD (P = 0.05)	14.5	3.1	NS	NS	NS	0.13
Planting geometry (cm × cm)						
30 × 20	81.3	86.5	10.4	61.1	106.5	3.85
30 × 30	80.2	84.7	12.3	59.6	107.1	4.05
30 × 45	79.5	83.5	11.7	59.1	109.0	4.14
45 × 45	78.6	81.3	11.2	61.4	111.4	4.28
LSD (P = 0.05)	NS	2.8	0.6	1.3	2.5	0.12
Planting depth (cm)						
5.0 Shallow (D1)	80.2	85.5	12.0	58.3	97.5	4.10
7.5 Medium (D2)	86.8	84.2	11.2	60.4	107	4.25
10 Deep (D3)	72.7	82.3	11.0	62.2	112	3.89
LSD (P = 0.05)	11.3	2.5	0.5	1.1	2.3	0.11

under cropping system, sequential cropping. Days taken to maturity also followed similar trends, as case of days to maturity. In case of plant spacing maximum days taken to maturity was recorded in case of lax planting (45 cm x 45 cm), whereas shortest time taken by dense planting (30 cm x 20 cm), the possible reason behind force maturity under comparable overcrowded situation might be due lesser and lesser availability of energy to maintain momentum for longer time, than in case of availability of abundant energy. These results closely follow the findings of Alghamdi (2), and Graf and Rowlanda (6).

It was found that all the treatments had significant effect on root dry weight. Raised bed planting (4.15 g) produced significantly over flatbed planting. Similarly in case of planting geometry spars planting at 45 cm x 45 cm produced significantly higher root dry weight (4.28 g) than other test plan spacing, this might be wider planting provided more root zone space, which helps in production of significant more root dry matter harvest. In case seeding depth, seeding at 7.5 cm depth produced significantly higher dry root weight (4.28 g) than other tested depth, similar results was also reported by Abdel Latif and Idris (1).

Higher LAI was recorded in case of planting geometry maintained with 30 cm x 30 cm during both the growth stages, which was significantly higher than 45 cm x 45 cm spacing and at par with other spacing 60 days after planting, similar pattern was also noticed at 90 DAS. Similar results were also reported by Tawaha and Turk (10). Leaf weight ratio (LWR) is the ratio of leaf dry weight to plant dry weight, which is significantly influenced by all the treatments. This might be due to the effects of each factor on this trait. Raised bed planting (0.008) prove superior over flat bed. Plant geometry with 45 cm x 45 cm produced maximum LWR (0.355). Closer spacing produces lower LWR (Table 2). Specific leaf area ($cm^2\ g^{-1}$) is leaf area per unit leaf weight. It is not influenced by any of the treatment tested in this study. Net assimilation rate ($mg\ cm^{-2}\ w^{-1}$) is the net dry matter productivity per unit leaf area per unit time. This trait is only influenced by planting geometry. Maximum NAR was recorded ($4.115\ mg\ cm^{-2}w^{-1}$) with 30 cm x 30 cm planting, which was significantly higher than other planting distance. Relative growth rate ($mg\ mg^{-1}\ w^{-1}$) is one of the most important growth parameter get influenced with all the tested factors. Flatbed planted faba bean crop recorded significantly lower (0.475) relative growth rate than raised bed planted (Table 2). Spacing at 30 x 30 cm recorded significantly higher RGR (0.496) than 30 cm x 20 cm and 45 cm x 45 cm planting and at par with 30 cm x 45 cm. These results are in close conformity with Tawaha and Turk (10), Alghamdi (2), and Metwally and Abdelhamid (7).

None of factors other than planting geometry had influence on first podding height (Abdel Latif and Idris, 1). Spacing at 45 cm x 45 cm distance provided

Table 2. Effects of planting depth, pattern and geometry on phenology development of faba bean.

Treatment	LAI (60 DAS)	LAI (90 DAS)	LWR	SLA ($cm^2\ g^{-1}$)	NAR ($mg\ cm^{-2}\ w^{-1}$)	RGR ($mg\ mg^{-1}\ w^{-1}$)
Planting method						
Flatbed planting	2.13	3.82	0.341	0.355	3.976	0.475
Raised bed planting	2.21	3.94	0.361	0.361	4.052	0.499
LSD (P = 0.05)	NS	NS	0.008	NS	NS	0.014
Planting geometry (cm × cm)						
30 × 20	2.20	3.76	0.344	0.362	3.984	0.472
30 × 30	2.32	4.15	0.351	0.358	4.115	0.496
30 × 45	2.22	4.01	0.354	0.357	4.074	0.498
45 × 45	1.94	3.61	0.355	0.355	3.887	0.482
LSD (P = 0.05)	0.11	0.16	0.007	NS	0.025	0.013
Planting depth						
Shallow (D1)	2.14	3.84	0.351	0.361	3.924	0.492
Medium (D2)	2.29	4.01	0.359	0.355	3.941	0.483
Deep (D3)	2.08	3.79	0.343	0.358	4.177	0.486
LSD (P = 0.05)	0.10	NS	0.006	NS	NS	0.012

ample amount of space to complete all phenological 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 were close conformity with Stutzel and Aufhammer (9), and Abdel Latif and Idris (1). Raised bed planting produced significantly more pods (43.1) than flatbed bed. This might be due to more efficient and effectively management and resource utilization under raised bed planting compare to flatbed. Similar result was also obtained in case of planting pattern (plant spacing), maximum pods per plant was recorded in case of 45 cm x 45 cm spacing and with further reduction pod bearing ability reduced considerably. It is worth to mention here that square planting at 30 cm x 30 cm distance, produced significantly higher pods per plant (41.6) than 30 cm x 20 cm spacing and at par with 30 cm x 45 cm. These findings are similar to those of Abdel Latif and Idris (1), Alghamdi (2), and Graf and Rowlanda (6). Grains per pod (Table 2) was considerably influenced by the entire factor significantly except establishment method, which has no significant role, though raised bed has produced numerically more seeds per pod (Table 2). In case of planting geometry crop grown with spacing of 30 cm x 30 cm produced maximum and significantly higher grain per pod (3.44) than grains produced in case 30 cm x 20 planting and at par with other planting geometry. In case of seeding /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 (5.0 cm deep planting) which was significantly superior to deep placement of seed and at with medium depth of seed placement. Similar findings were also reported Graf and Rowlanda (6), and Abdel Latif and Idris (1).

Results revealed that seed producing ability of individual plant significantly influenced by all the tested three factors (Table 2). This might be due yield is polygenic character and governed as well as influenced by several factor directly or indirectly. In case of plant establishment method, raised bed planting prove superior over flatbed planting produces significantly higher seeds per plant (38.7 g). 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). Seeding at medium depth (7.5 cm) produced significantly highest seeds (38.4 g/ 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 (9), and Abdel Latif and Idris (1).

Table 3. Effects of planting depth, pattern and geometry on phenology growth and development and yield of faba bean.

Treatment	First podding height (cm)	Pods/plant	Pod length (cm)	Grains/pod	Seed yield (g/ plant)	Seed yield (kg ha^{-1})
Planting method						
Flatbed planting	6.8	40.5	4.15	3.49	36.5	3447.3
Raised bed planting	6.4	43.1	4.29	3.23	38.7	3524.1
LSD (P = 0.05)	NS	2.1	NS	NS	1.5	91.5
Planting geometry (cm × cm)						
30 × 20	7.1	39.4	4.18	3.22	33.7	3536.2
30 × 30	6.9	41.6	4.22	3.44	35.4	3690.9
30 × 45	6.5	42.5	4.23	3.35	39.7	3469.7
45 × 45	5.9	43.7	4.25	3.43	41.6	3246.3
LSD (P = 0.05)	1.1	1.5	NS	0.15	1.4	71.8
Planting depth (cm)						
5.0	6.5	43.2	4.26	3.43	37.9	3493.6
7.5	6.3	41.8	4.21	3.35	38.4	3543.3
10.0	6.8	40.4	4.19	3.30	36.4	3420.3
LSD (P = 0.05)	NS	1.3	0.07	0.12	1.20	63.5

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 cm 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, whereas under mixed population, better performance was recorded under optimum plant population with square planting with 30 cm apart. Results indicate that depth of sowing has considerable influence on growth, yield attributes and finally yield. Abdel Latif and Idris (1), Alghamdi (2); and Graf and Rowlanda (6) also reported parallel to these findings.

Faba bean seed yield has been improved significantly under raised bed with square planting (30 cm x 30 cm) and with medium depth of seeding (10 cm).

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