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ORIGINAL RESEARCH ARTICLE

Growth, yield and quality of faba bean (*Vicia faba* L.) in response to sowing date and phosphorus fertilization

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ABSTRACT

An experiment was carried out to study the effect of date of sowing and level of phosphorus on the yield, yield components and seed protein content of faba bean (*Vicia faba* L.) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2018 to March 2019 to study the influence of sowing date and phosphorous fertilization on the growth, yield and quality of faba bean (*V. faba*). Three date of sowing *viz.* 25 November, 5 December, 15 December and five levels of phosphorus *viz.*, 0, 10, 20, 30, 40 kg P ha^{-1} were used in this experiment laid out in a randomized complete block design with three replications. At 60 DAS, 25 November sowing fertilized with 40 kg P ha^{-1} showed significant influence on all characters except dry matter production. Early sowing on 25 November produced the tallest plant (42.95 cm), highest number of branches $plant^{-1}$ (8.31), number of pods $plant^{-1}$ (49.87), 1000-seed weight (97.55 g), seed yield (1.21 t ha^{-1}), stover yield (1.98 t ha^{-1}) and seed protein content (31.54%) while the corresponding lowest values were recorded from late sowing on 15 December. The crop fertilized with 40 kg P ha^{-1} produced the highest number of branches $plant^{-1}$ (8.33), number of pods $plant^{-1}$ (49.05), 1000-seed weight (97.40 g), seed yield (1.33 t ha^{-1}), stover yield (2.28 t ha^{-1}) and seed protein content (38.17%) while control treatment (0 kg P ha^{-1}) produced the lowest values of all parameters. In case of interaction, the highest number of pods $plant^{-1}$ (58.42), seed yield (1.59 t ha^{-1}), stover yield (2.44 t ha^{-1}) and protein content in seeds (39.60) were recorded with 25 November sowing fertilized with 40 kg P ha^{-1} whereas the lowest seed yield (0.54 t ha^{-1}), stover yield (1.32 t ha^{-1}) and seed protein content (25.90%) were obtained from 15 December sowing along with control treatment. Therefore, early sowing (25 November) with 40 kg P ha^{-1} appears as the promising combination for higher yield and seed protein content of faba bean.

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INTRODUCTION

Faba bean (*Vicia faba* L.) is popular legume and used worldwide as an important source of protein for human and animal nutrition (Cazzato *et al*., 2012) and for nitrogen in the biosphere (Rubiales, 2010). Faba bean is grown in some limited locality of Bangladesh and it is locally known as Kalimotor, Baklakalai, Bhograkalai etc. It is commercially grown in Tangail, Gazipur, Manikgang, Faridpur, Rajbari and northern part of Bangladesh. Faba bean is grown in Bangladesh in winter after the *T. aman* harvest with minimum tillage or sometimes directly sown in low lying areas as a relay crop when *Aman* lodges in the field (Biswas, 1988). However no statistical data regarding its area and production are available. Pulse crop covered an area of 0.37 million hectares with the production of 0.39 million tons including very negligible contribution from faba bean (BBS, 2017). Most of the people of Bangladesh fulfill their protein requirement through pulses. Faba bean has been attributed with its certain medicinal

values and a drug used to treat Parkinson's disease (Brauckmann and Latte, 2010 and Ramírez-Moreno *et al*., 2015). Determination of optimum date of sowing is important because during growing period of faba bean usually fields are occupied with rice in Bangladesh. Farmers might commonly sow faba bean late because they are wait until their existing crop harvest. Early date of sowing (at the onset of November) significantly increased vegetative growth, seed yield and its quality (Attia *et al*., 2009) and the greatest values of yield and its components were resulted from the sowing date 25 November (El-Metwally *et al*., 2013). Late sowing increased field emergence and reduced the number of days to flowering, fresh harvest, reduced green pod length and number of green seeds pod^{-1} and yield. Early sowing of faba bean gave the best values for yield components and seed yield was reported elsewhere (Badr *et al*., 2013; Abido and Seadh, 2014; Kumar *at al*., 2020). Phosphorus is a major nutrient, especially for legumes (Kumar *et al*., 2019). Faba bean may require P fertilizer in the range of 20 to 30 kg P ha^{-1} (FAO, 2000). Significant increases were achieved in faba bean yield and its attributes by increasing phosphorus fertilization rate up to 45-46.5 kg P_2O_5 fed^{-1} (El-Habbasha *et al*., 2007). The present study was therefore, undertaken to generate information on the effect of sowing date and phosphorus fertilizer rate on growth, yield and quality of faba bean.

MATERIALS AND METHODS

Experimental site, soil and climatic conditions

The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from November 2018 to March 2019. The experimental site belongs to the Old Brahmaputra Floodplain agro-ecological zone (AEZ-9) and is located at 24.75°N latitude, 90.50°E longitude and an average altitude of 18 m. The experimental field was a medium high land with silt loam with pH 6.80 and low in organic matter content (1.29%). The experimental area is under the sub-tropical climate. The average monthly temperature (°C), relative humidity (%), total rainfall (mm) and suns hine (h) prevailing at the experimental site during experimentation are presented in Table 1.

Crop husbandry

The seeds of faba bean were collected from the local farmers of Gaibandha district. The experimental land was ploughed with a power tiller and kept open to sunlight. Afterwards the experimental plot was prepared by several ploughing and cross ploughing followed by laddering to break the clods and to level the soil. The weeds and stubbles were removed from the plot. Land preparation was completed on 20 November and was ready for sowing seeds. Seeds were sown in furrow as per treatments of the experiment maintaining 30 cm × 20 cm spacing with two seeds per hole. The land was fertilized with urea, muriate of potash and gypsum at the rate of 15, 60 and 45 kg ha^{-1}, respectively. The entire amount of urea, muriate of potash (MoP) and gypsum were applied at final land preparation. Phosphorus was applied as TSP as per treatments of the experiment. Weeding and thinning were done at 25 days after sowing (DAS) when the plant attained a height of 8-10 cm. Second weeding were done at 45 DAS when the plant attained about 28 -30 cm height. During experimental period, there was no irrigation required. Bean rust was successfully controlled by spraying Copper Oxy Chloride 50WP @ 0.2% fungicide on 14 February and 21 February, 2019.

Data collection at vegetative stage

At 60 DAS five plants were randomly selected excluding border rows to record the data on plant height, number of nodules plant^{-1}. Chlorophyll content of five fully expanded young leaves from each five plants was measured by using a portable SPAD meter (model SPAD-502, Minolta crop, Ramsey, NJ). To determine the dry matter production, two plants were randomly uprooted from each plot excluding border rows. The total dry weight of plant was taken by using an electric balance after proper drying in an oven at 70°C until constant weight was reached.

Data collection at harvest

Data on plant height, yield components and yield of faba bean were collected at harvest. All data including plant height at harvest, number of branches plant^{-1}, Number of pods plant^{-1}, Number of seeds pod^{-1}, 1000-seed weight except seed yield and stover yield, were collected from five randomly selected plants of each plot, while seed and stover yields data were collected from the whole plot after harvest. Protein content (%) in seeds was estimated by Micro-Kjeldahl method (AOAC, 1984) at Professor Muhammad Hossain Central Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Table 1. Monthly record of air temperature, rainfall, relative humidity and sunshine of the experimental site during the growing season.

Month	Year	Air temperature (°C)			Rainfall (mm)	Relative humidity (%)	Sunshine (hrs)
		Maximum	Minimum	Average			
November	2018	29.30	17.40	23.40	36.20	81.70	228.9
December	2018	26.00	13.50	19.80	17.70	80.20	201.3
January	2019	26.28	12.16	19.07	0.00	75.39	227.2
February	2019	27.03	15.55	21.29	30.00	75.86	164.8
March	2019	29.82	18.95	24.38	58.60	73.03	208.2

Harvesting

When 85% of the pods turned brown colour, the crop was considered to be matured. The crops were harvested plot- wise from the whole 5 m^2 (2.5 m × 2.0 m) area and then bundled separately, tagged and brought to the threshing floor of Agronomy Field Laboratory. The harvesting date for 25 November, 5 December and 15 December sowing were 14 March, 20 March and 22 March 2019, respectively. The crop bundles were sun dried for 7 days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks. The separated dried seeds and stover were cleaned and weighed. Seed and stover yields obtained from five sample plants were added with the respective whole plot harvest to get the actual seed and stover yields. Finally seed and stover yields were recorded and converted to t ha^{-1}.

Statistical analysis

Data were compiled and tabulated in proper form for statistical analysis. All the collected data were analyzed following the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Vegetative characters

Effect of sowing date had significant effect on different parameters related to growth characters of faba bean (Table 2). Early sowing on 25 November produced higher results on plant height (26.45 cm), chlorophyll content (37.06) at vegetative stage while the corresponding lowest values were recorded from late sowing on 15 December. Uddin et *al.* (2017) showed significant effect on plant height due to early sowing date in bean where as Hasanvand *et al.* (2015) stated that due to delayed sowing chlorophyll content in leaves decreased. Application of 40 kg P ha^{-1} showed higher results on plant height (24.12 cm), chlorophyll content (36.87), dry matter production $plant^{-1}$ (0.6833 g) at vegetative stage while the corresponding lowest values were recorded from control treatment (0 kg P ha^{-1}). Negasa *et al.* (2019) stated that plant height increased with increasing level of phosphorus while Mitran *et al.* (2018) observed that phosphorous plays very crucial role for increasing nodule number in leguminous plants. Root and shoot biomass increased significantly with increase in phosphorus levels, being lower and higher at low and high phosphorus levels, respectively was reported by Mourice and Tryphone (2012). On the other hand, 25 November sowing fertilized with 40 kg P ha^{-1} produced the highest result on vegetative characters of faba bean except dry matter production (Table 3). The highest plant height (28.10 cm) was obtained at 25 November sowing fertilized with 40 kg P ha^{-1} which was statistically identical at 25 November sowing fertilized with 30 kg p ha^{-1}, 25 November sowing fertilized with 20 kg P ha^{-1} and 25 November sowing fertilized with 10 kg P ha^{-1}, respectively. The highest Number of nodules $plant^{-1}$ (40.23), chlorophyll content (39.83) at vegetative stage was obtained at 25 November sowing fertilized with 40 kg P ha^{-1} while the lowest number of nodules $plant^{-1}$ (26.14) was obtained at 15 December sowing with 10 kg P which was at par with 15 December sowing fertilized with control treatment (Table 3).

Table 2. Effect of date of sowing and level of phosphorous on plant height, number of nodules $plant^{-1}$, chlorophyll content and dry matter production at 60 DAS of faba bean.

Factor and treatments	Plant height (cm)	Number of nodules $plant^{-1}$	Chlorophyll content (SPAD value)	Dry matter production (g $plant^{-1}$)
Date of sowing				
25-Nov	26.45a	33.62a	37.06a	0.586b
5-Dec	21.33b	34.21a	35.25b	0.612a
15-Dec	17.78c	31.98b	31.89c	0.550c
Level of phosphorous (kg P ha^{-1})				
0	19.67c	30.12c	32.49c	0.4933e
10	21.61b	28.23d	34.69b	0.5367d
20	21.92b	33.18b	35.10b	0.5833c
30	21.97b	37.79a	34.51b	0.6167b
40	24.12a	37.03a	36.87a	0.6833a
Level of significance	**	**	**	**
CV (%)	7.87	5.21	2.25	5.76

Figures in a column under each factor of treatment having the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** =Significant at 1% level of probability.

Table 3. Interaction effect of date of sowing and level of phosphorus on plant height, number of nodules plant^{-1}, chlorophyll content and dry matter production of faba bean at 60 DAS.

Interaction		Plant height (cm)	Number of nodules plant^{-1}	Chlorophyll content (SPAD value)	Dry matter production (g plant^{-1})
Date of sowing	Level of phosphorus (kg P ha^{-1})				
25 November	0	22.17b	32.00cd	34.83ef	0.500
	10	26.42a	26.76e	35.70cde	0.530
	20	27.75a	34.13bc	37.47b	0.550
	30	27.83a	34.99bc	37.45b	0.620
	40	28.10a	40.23a	39.83a	0.730
5 December	0	19.75bcd	30.66d	34.04fg	0.510
	10	20.92bc	31.80cd	36.40bcd	0.580
	20	20.25bcd	33.13bcd	35.07def	0.630
	30	20.33bcd	39.47a	34.04fg	0.630
	40	25.42a	36.01b	36.69bc	0.710
15 December	0	17.08d	27.71e	28.61i	0.470
	10	17.50d	26.14e	31.96h	0.500
	20	17.75cd	32.28cd	32.77gh	0.570
	30	17.75 cd	38.91a	32.03h	0.600
	40	18.83 cd	34.86bc	34.09fg	0.610
Level of significance		*	**	**	NS
CV (%)		7.87	5.21	2.25	5.76

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); * =Significant at 5% level of probability, ** =Significant at 1% level of probability, NS= Not significant.

Table 4. Effect of date of sowing and level of phosphorous on yield components, yield and seed protein content of faba bean.

Factors and treatments	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Seed protein content (%)
Date of sowing										
25 November	42.95a	8.31a	49.87a	3.45a	97.55a	1.21a	1.98a	3.19a	37.61a	31.54a
5 December	44.19a	8.17a	42.67b	3.19b	93.04a	1.07b	1.80b	2.87b	37.18a	31.48a
15 December	38.69b	7.68b	39.25c	3.07b	84.84b	0.78c	1.74c	2.52c	30.58b	30.24b
Level of phosphorous (kg P ha^{-1})										
0	37.24b	7.88c	40.29d	2.99b	84.24c	0.646e	1.38e	2.03e	31.64c	28.00c
10	41.55ab	7.88c	41.85c	3.16b	88.44bc	0.848d	1.53d	2.37d	35.20b	28.00c
20	41.99ab	8.01bc	43.48b	3.20b	93.85ab	1.09c	1.79c	2.88c	37.42a	28.67c
30	43.61a	8.14ab	44.97b	3.55a	95.11a	1.19b	2.21b	3.40b	34.81b	32.60b
40	45.31a	8.33a	49.05a	3.26b	97.40a	1.33a	2.28a	3.62a	36.56a	38.17a
Level of significance	**	**	**	**	**	**	**	**	**	**
CV (%)	11.26	2.81	3.63	8.63	6.58	6.79	1.69	2.01	3.12	2.86

Figures in a column under each factor of treatment having the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** =Significant at 1% level of probability.

Crop characters, yield components, yield and seed quality

Date of sowing significantly influenced yield components, yield and seed protein content of faba bean (Table 4). Early sowing on 25 November produced higher results on yield components and yield such as plant height (42.95 cm), number of branches plant^{-1} (8.31), number of pods plant^{-1} (49.87), number of seeds pod^{-1} (3.45), weight of 1000-seed (97.55 g), seed yield (1.21 t ha^{-1}), stover yield (1.98 t ha^{-1}), biological yield (3.19 t ha^{-1}), harvest index (37.61%) and seed protein content (31.54%) of faba bean compared to 5 December and 15 December sowing (Table 4). Early sowing gave the highest number of pods plant^{-1} was reported by Moosavi *et al.* (2014) and Mozumder *et al.* (2015). Similar result was reported by Uddin *et al.* (2017) who reported that 20 November sowing increase yield attributes including 1000-seed weight in French bean. Level of phosphorous also showed significant difference among all parameters related to yield components and yield. Application of 40 kg P ha^{-1} produced higher results on yield components and yield such as plant height (45.31 cm), number of branches plant^{-1} (8.33), number of pods plant^{-1} (49.05). Zebire and Gelgelo (2019) mentioned that effect of phosphorus significantly increase number of branches plant^{-1} of bean. Application of 39.6 kg P ha^{-1} gave the highest number of pods plant^{-1} in common bean (*Phaseolus vulgaris* L.) stated by Tesfaye and Balcha (2015). Application of 40 kg P ha^{-1} also produced higher results on weight of 1000-seed (97.40 g), seed yield (1.33 t ha^{-1}), stover yield (2.28 t ha^{-1}), biological yield (3.62 t ha^{-1}) and seed protein content (38.17%) of faba bean compared to other level of phosphorous. However, 30 kg P ha^{-1} had higher result on number of seeds pod^{-1} (3.55) of faba bean (Table 4). Interaction between 25 November sowing fertilized with 40 kg P ha^{-1} produced higher number of pods plant^{-1} (58.42), seed yield (1.59 t ha^{-1}), stover yield (2.44 t ha^{-1}), biological yield (4.03 t ha^{-1}) and seed protein content (39.60%) except plant height, number of branches plant^{-1}, 1000-seed weight of faba bean at harvest. Sowing on 25 November fertilized with 30 kg P ha^{-1} had higher result on number of seeds pod^{-1} (4.27) and 25 November sowing fertilized with 20 kg P ha^{-1} had higher result on harvest index (41.62%) of faba bean. 15 December sowing fertilized with 0 kg P ha^{-1} also produced lower results on number of pods plant^{-1} (35.74), seed yield (0.54 t ha^{-1}), stover yield (1.32 t ha^{-1}), biological yield (1.86 t ha^{-1}), and seed protein content (25.90%) of faba bean at harvest. 15 December sowing fertilized with 10 kg P ha^{-1} produced the harvest index (28.74%) of faba bean (Table 5). In case of interaction, the highest seed yield (1.59 t ha^{-1}), and protein content in seeds (39.60) were recorded at 25 November sowing fertilized with 40 kg P ha^{-1} whereas the lowest seed yield (0.54 t ha^{-1}) and seed protein content (25.90%) were obtained at 15 December sowing along with control treatment (Table 5 and Figure 1). It can be concluded that early sowing (25 November) along with higher dose of phosphorus fertilization (40 kg P ha^{-1}) appears as the promising practice for maximizing seed yield and seed protein content of faba bean.

Functional relationship between number of nodules plant^{-1} and seed yield of faba bean

Nodule numbers plant^{-1} and seed yield of faba bean had a positive linear relationship which could be adequately defined by regression equation. The regression equation specifies that increase in number of nodules plant^{-1}would lead to increase in the seed yield of faba bean (Figure 2). The functional relationship was significant at $p \leq 0.01$. The functional relationship can be determined by regression equation $y = -0.8228 + 0.0554x$ ($R^2 = 0.5422$). The functional relationship revealed that 54% of the variation in seed yield could be explained from the variation in number of nodules plant^{-1} at vegetative stage of faba bean.

Table 5. Interaction effects of date of sowing and level of phosphorous on yield components, yield and seed protein content of faba bean.

Interaction		Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Seed protein (%)
Date of sowing	Level of P										
25 November	0	35.56	8.20	45.56cd	3.13b	92.98	0.77g	1.46hi	2.23j	34.65e	28.70ef
	10	43.53	8.00	45.91cd	3.23b	98.75	0.89fg	1.65g	2.54hi	35.14e	28.70ef
	20	43.53	8.33	48.08c	3.26b	97.41	1.39b	1.95e	3.34d	41.62a	28.70ef
	30	44.74	8.40	51.36b	4.27a	98.34	1.41b	2.39a	3.80b	37.20cd	32.00d
	40	47.37	8.63	58.42a	3.33b	100.2	1.59a	2.44a	4.03a	39.45b	39.60a
5 December	0	41.52	7.96	39.57fg	3.06b	80.19	0.62h	1.38j	2.00k	31.13f	29.40e
	10	42.57	8.06	40.91efg	3.20b	86.17	1.07cde	1.50h	2.57h	41.73a	28.00ef
	20	44.63	8.16	42.41ef	3.20b	97.35	1.11cd	1.74f	2.85g	38.94bc	29.30e
	30	45.44	8.23	43.61de	3.23b	99.40	1.18c	2.14cd	3.32d	35.54de	33.60c
	40	46.77	8.40	46.84c	3.25b	102.1	1.40b	2.24b	3.64c	38.58bc	37.10b
15 December	0	34.65	7.50	35.74h	2.79b	79.56	0.54h	1.32k	1.86l	29.14g	25.90g
	10	38.56	7.60	38.73g	3.06b	80.41	0.58h	1.44i	2.02k	28.74g	27.30fg
	20	37.82	7.53	39.94fg	3.13b	86.79	0.78g	1.68g	2.46i	31.69f	28.00ef
	30	40.65	7.80	39.94fg	3.16b	87.59	0.97ef	2.10d	3.07f	31.69f	32.20cd
	40	41.79	7.96	41.91ef	3.20b	89.87	1.01def	2.18c	3.19e	31.65f	37.80b
Level of significance		NS	NS	**	*	NS	**	**	**	**	**
CV (%)		11.26	2.81	3.63	8.63	6.58	6.79	1.69	2.01	3.12	2.86

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). * =Significant at 5% level of probability, ** =Significant at 1% level of probability, NS= Not significant.

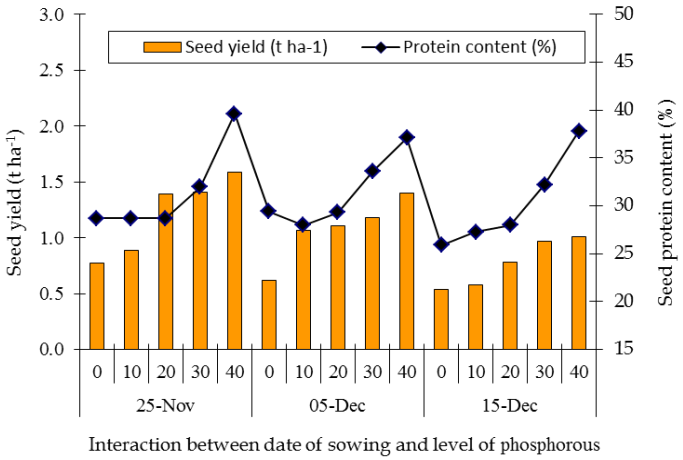

Figure 1. *Interaction effect of date of sowing and level of phosphorous on seed yield and seed protein content of faba bean.*

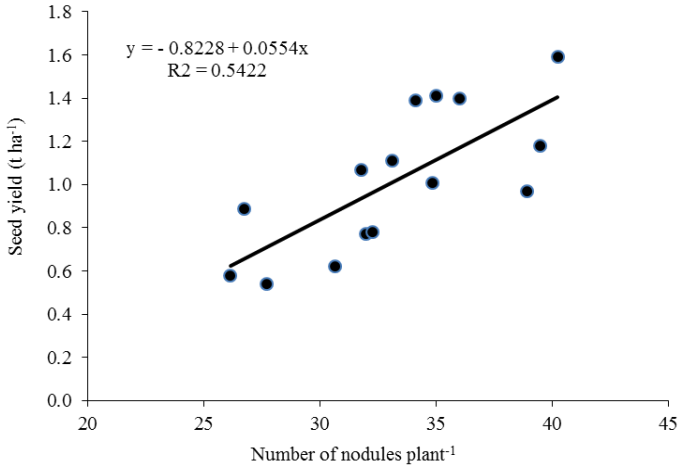

Figure 2. *Functional relationship between number of nodules plant^{-1} and seed yield of faba bean.*

Conclusion

Early sowing on 25 November produced the tallest plant, highest number of branches plant^{-1}, number of pods plant^{-1}, 1000-seed weight, seed yield, stover yield and seed protein content while the corresponding lowest values were recorded from late sowing on 15 December. The crop fertilized with 40 kg P ha^{-1} produced the highest number of branches plant^{-1}, number of pods plant^{-1}, 1000-seed weight, seed yield stover yield and seed protein content. The highest number of pods plant^{-1}, seed yield, stover yield and protein content in seeds were recorded with 25 November sowing fertilized with 40 kg P ha^{-1} whereas the lowest seed yield, stover yield and seed protein content were obtained from 15 December sowing along with control treatment. From the results of the study it can be concluded that 25 November sowing fertilized with 40 kg P ha^{-1} appears as the promising combination for higher seed yield and protein content of faba bean

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