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Effect of Different Sowing Dates and Row Spacing on Growth and Yield of Faba Bean under Khumaltar Environment

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ABSTRACT

Faba bean (*Vicia faba* L.) is an annual minor grain legume locally known as *Bakulla*. An experiment on sowing dates and different row spacing was conducted at the National Agronomy Research Centre (NARC) Khumaltar from 2019/20 to 2021/22 to identify suitable sowing dates and row spacing. Three sowing dates (October 24, November 7, and November 21), row spacings (30 cm, 45 cm, and 60 cm), and plant-to-plant spacing of 10 cm were evaluated in a split plot with four replications. Plot size was maintained at 7.2 m^2 (2 m x 3.6 m), the variety used was local, and the fertilizer dose applied was 20:40:20 N: P_2O_5:K_2O kg ha^{-1}. At physiological maturity, five plants per plot were sampled randomly for measurements of plant height, number of pods per plant, unfilled pods/plant, and 100 seed weight. Data on 50% flowering, days to 90% maturity, plant height, number of pods per plant, green pod yield, biological yield, and hundred seed weight were recorded. Combined analysis showed that sowing dates significantly influenced days to 50% flowering, final stand/m^2, plant height, number of branches per plant, and number of pods per plant. The final stand/m^2, plant height, straw dry matter, seed yield, and hundred seed weight were affected significantly by various row spacing. There was no significant interaction effect between sowing dates x row spacing, and all three factors (sowing dates x spacing x year) also had no significant interaction. The year they have significantly influenced all the parameters except 90% maturity and number of pods per plant. Sowing dates x year and spacing x year did not significantly influence all the parameters. Crop sown on October 24 produced the highest grain yield (1571 kg ha^{-1}), followed by November 21 (1354 kg ha^{-1}). Grain yields were significantly higher in 30 cm row spacing (1825 kg ha^{-1}), mainly due to higher plant population per m^2 than in 60 cm row spacing. It was concluded that the last week of October and 30 cm row spacing is suitable for faba bean production.

Keywords: sowing date, row spacing, faba bean, grain yield

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INTRODUCTION

Faba bean (*Vicia faba* L.), an annual minor grain legume, is mainly grown for its high protein content (on average 29%). It is an important source of proteins for humans and animals. Seed is used as human food in developing countries and as animal feed in industrialized countries. It can also be used as a green or dried vegetable, fresh or canned vegetable. It is a typical breakfast food in the Middle East, Mediterranean, China, and Ethiopia (Kawochar et al 2010). It is among the oldest crops in the world; worldwide, it is the third most important feed grain legume after soybean (*Glycine max* L.) and pea (*Pisum sativum* L.) in area and production. It is one of the best crops that can be used as green manure and one of the best biofactories of nitrogen by fixing 130 to 160 kg N ha^{-1} (Hoofmann et al 2007). Grain legumes are an important component of agricultural and food systems in practically all over the world and complement the cereal crops in several aspects. The amino acid profile of legume protein tends to complement that of cereals, adding lysine to the diet, while cereals are a better source of sulfur-containing amino acids. Furthermore, legumes are a better source of minerals, presenting two or more times the levels found in most cereals (Ihsanullah et al 2010).

Early sowing date in mid-October produced higher values of seed yield, number of pods per plant, and seeds per plant compared to November 1 (Hussein et al 2002). The sowing date is an important factor that significantly affects the timing and duration of vegetative and reproductive stages, yielding its components and seed quality. Since environmental factors, i.e., temperature and light, differ due to sowing dates. Some studies indicated that sowing date had a significant yield-limiting factor on faba beans. On the other hand, crop density or seeding rate significantly influences yield and yield components due to competition for limited resources in the field, for light, water, and nutrients. In this regard, results from different areas that describe yield response to plant population alteration in different cultivation systems are highly variable (Wakweya et al 2016). Large-seeded type is commonly grown in Kathmandu Valley and adjoining districts as a kitchen garden, whereas small-seeded types are grown as a field crop or in a home garden. Large pods are consumed mostly as green vegetables, dry seed as roasted bean, and small seed is usually split and consumed as soup (Shrestha et al 2011).

Faba bean is grown in some limited locality of Nepal. However, no productivity, area, and production data is available. However, due to the ever-increasing demand and import of pulses, Nepal has to spend valuable foreign currency every year. So, evaluating the productivity and nutritional aspects of faba beans about varying sowing dates is essential. The objectives of the present study were to investigate the effect of three sowing dates, three-row spacing, and their interactions on faba bean seed yield and yield components.

MATERIALS AND METHODS

Experiments consisting of three sowing dates and three-row spacing were conducted at the National Agronomy Research Centre, Khumaltar (1360 meters above mean sea level) during 2019/20, 2020/21, and 2021/22. The soil type of the experimental plots was silty clay loam. An experiment was laid out in a split-plot design with four replications in a plot size of 2 m x 3.6 m (7.2 m^2). Sowing dates were assigned to main plots and row spacing to the sub-plots. Three sowing dates were October 24 (7 Kartik), November 7 (21 Kartik), and November 21 (Mangsir 5), with 15-day intervals among the dates. Three rows spacing (30, 45, and 60 cm) and 20 cm plant-to-plant spacing were used. The Faba bean variety used was local. Seeds were treated with Bavistin @ 2 g kg^{-1} seed before seeding. Chemical fertilizers of 20 N: 40 P_2O_5:20 K_2O kg ha^{-1} were applied during land preparation. Thinning was done to retain a single plant per hill after a month of seeding. Cultural operations such as weeding and earthing up were done when needed. Five plants were randomly selected for data collection of plant height, number of pods per plant, and number of branches per plant at physiological maturity. Two hundred seeds were counted to estimate 100 seed weight. Subsample straw was oven-dried to estimate straw dry matter yield.

Growing season rainfall and mean temperature trend

In growing season -, the highest mean temperature of 26.0 ^{0}C was recorded in October 2019, and the minimum mean temperature was 3.5 ^{0}C in December 2019. Highest total rainfall value of 94.1 mm was recorded in April 2020 (Figure 1). During 2020/21, the highest mean temperature – (28.4 ^{0}C) was recorded in October 2020 and minimum mean temperature (3.5 ^{0}C) in January 2021. Highest total rainfall value of 90.5 mm was in April 2021 (Figure 2). In the year 2021/22 the highest mean temperature of 27.7 ^{0}C was recorded in the month of April 2022 and minimum mean temperature 4.2 ^{0}C in December 2021. The highest total rainfall value of 50.0 mm was in February 2022 (Figure 3).

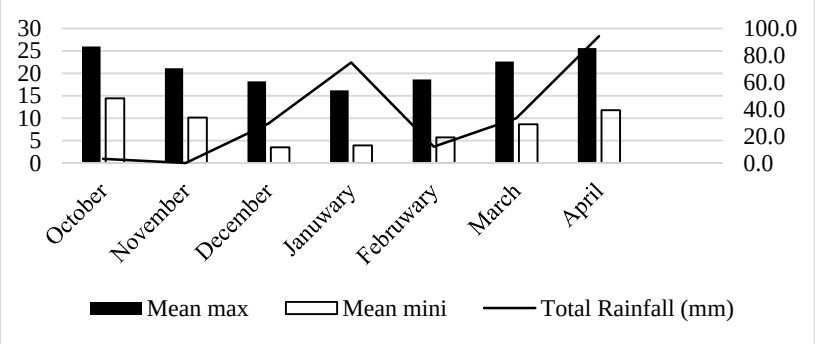

Figure 1. Growing season rainfall and mean temperature trend in Year 2019/20

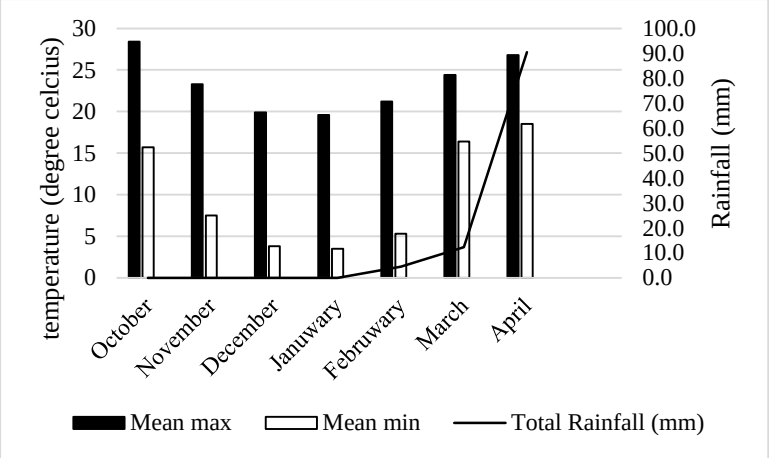

Figure 2. Growing season rainfall and mean temperature trend in Year 2020/21

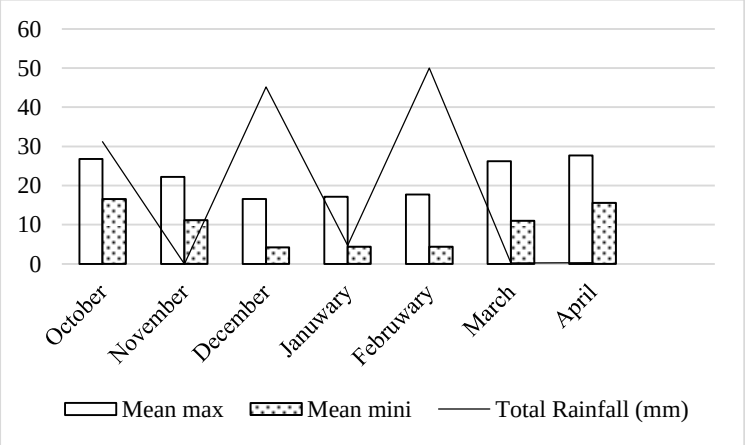

Figure 3. Growing season rainfall and mean temperature trend in Year 2021/22

RESULTS AND DISCUSSION

Phonological Parameters

All the factors did not interact significantly with physiological maturity. Sowing dates significantly influenced days to flowering, but spacing was not affected significantly. El-Masry 2010 noted that sowing in October significantly affected days to 50% flowering. There was a significant interaction effect between sowing dates and year (Table 4).

Plant stand and crop growth

1. Final plant stand

Effect of sowing date showed a highly significant difference between the first, second and third sowing dates on final plant stand in 2019. For 2020 and 2021 data showed a non-significant variation on the final stand. Effect of spacing revealed that a highly significant variation of the final plant stand was observed in 2019, 2020 and 2021. There was no significant interaction effect between the sowing date and spacing on recorded parameters (Table 1).

The combined analysis of the three years data revealed that a highly significant variation of final stand was observed between sowing dates, spacing and year (Table 4). It was observed that the highest plant stand (16 m^{-2}) was recorded on November 21. The highest plant stand (19 m^{-2}) was obtained in 30 cm spacing, while the lowest (10 m^{-2}) was observed at 60 cm spacing.The results obtained by Khalil et al 2010 and Singh et al 2013, indicated that the denser plant population increased the plant height of faba bean due to competition among plants. During the year 2021 highest plant stand (18 m^{-2}) was recorded while the lowest (8 m^{-2}) was observed in 2020. The interaction between sowing dates and year, row spacing and year of combined analysis significantly influenced. In comparison, sowing dates, spacing, and year did not show a significant interaction effect.

2. Plant height

The main effect of sowing date showed no significant difference between first, second and third sowing dates on plant height in 2019 and 2020. On the other hand, a highly significant variation was observed in 2021. The highest plant height (131, 74 and 105 cm) was observed on November 7 and October 24, sowing dates in 2019, 2020 and 2021 respectively (Table 1). During the year 2021 row spacing significantly influenced plant height. It was observed that the highest plant heights (133, 75 and 84 cm) were recorded at 30 cm row spacing while the lowest height (119, 62 and 72 cm) was observed at 60 cm respectively in 2019, 2020 and 2021. There was not any significant interaction effect between sowing date and spacing on recorded parameters

The combined analysis of data revealed that highly significant influence of plant height was observed between sowing dates, spacing and year. It was observed that the highest plant height (101 cm) was recorded on October 24 while the lowest height (82 cm) was on November 2. Uddin et al 2017 showed significant effect on plant height due to early sowing date in bean. The highest plant height was observed in 30 cm row spacing (98 cm). The highest plant height (125 cm) was recorded in 2019, while the lowest (69 cm) was observed in 2020. Sowing date and year had highly significant interaction effect. Whereas sowing dates and spacing, spacing and year and sowing date, spacing and year did not show any significant interaction effect (Table 4).

3. Number of branches per plant

The number of branches per plant was significantly influenced by the sowing date in 2020 while non-significant for 2019 and 2021. The result showed that the highest number of branches per plant (5) was observed on October 24, 2020, while the lowest score was recorded in 2021. Row spacing had no significant result in three years data. The interaction effect of sowing date and row spacing showed no significant effect for the three years (Table 1).

The data revealed that the three years of combined analysis, sowing dates were significantly influenced the number of branches per plant while it was non-significantly influenced at row spacing. The maximum score (4) was observed on October 24, while the lowest score (3) was recorded on November 7 and 21. Year significantly influenced the number of branches per plant. The highest number of branches per plant (4) was observed in 2019 and 2020. Sowing date, row spacing and year did not show any significant interaction effect (Table 4).

Table 1. Final stand and growth parameters of faba bean genotype with respect to sowing date and row spacing at Khumaltar in 2019, 2020, 2021

Treatments	Final stand/m^2			Plant height (cm)			Branches/plant		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Sowing dates (A)									
October 24	11	7	20	125	74	105	4	5	2
November 7	15	9	18	131	71	70	4	3	2
November 21	25	7	16	120	62	63	3	3	2
LSD (<0.05)	2.52	ns	ns	ns	ns	4.95	ns	1.1	ns
Spacing (B)									
30 cm	22	10	25	133	75	84	3	4	2
45 cm	16	7	17	124	70	82	4	4	2
60 cm	13	5	12	119	62	72	4	4	2
LSD (<0.05)	2.83	1.7	2.12	ns	ns	6.89	ns	ns	ns
Sowing dates x spacing (A x B)	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV%	19.7	27.4	13.8	15.0	19.5	10.1	19.2	25.7	30.5

Grain yield and yield components

1. Number of pods per plant

The number of pods per plant was significantly influenced by sowing date across the two years (2020 and 2021). While during the year 2019, data showed a non-significant variation. The result showed that the highest number of pods per plant (10, 16 and 13) was observed on October 24 followed by November 7 (10, 9 and 9) while lowest score was recorded on November 21 (8, 7, 8) respectively during the year 2019, 2020 and 2021. Row spacing did not influence the number of pods per plant. For 2019 and 2020, the highest pods per plant (11 and 12) were at 60 cm and 30 cm row spacing, respectively while for 2021 number of pods per plant was observed (10) and the lowest (8) was observed at 30 cm for 2019. Sowing date and row spacing had no significant interaction effect (Table 2).

The data revealed that three years of combined analysis and sowing dates highly influenced number of pods per plant. Wakweya et al (2016) reported a significant effect of planting date on the number of pods per plant. It was found maximum on October 24 (13). Khalil et al (2010) reported that highest number of pods per plant in low plant density. Similarly, early sowing gave the highest number of pods per plant (Moosavi et al 2014). Early-planted crop more efficiently utilized the nutrient, water and radiation for long periods, resulting in more pods than late planted crop (Tay 1992). Row spacing had not significantly influenced number of pods per plant. Whereas year also had not significantly influenced sowing dates and year had a significant interaction effect on number of pods per plant whereas sowing dates and spacing, row spacing and year and sowing dates, spacing and year did not have significant interaction effect (Table 4).

2. Number of seeds per pod

The effect of sowing date showed no significant difference between the first, second and third sowing dates in the number of seeds per pod in 2019 and 2020 while during the year 2021, there was significant influence. In the year 2019, result showed that the highest number of seeds per plant (3) was observed on November 7 and November 21 whereas in 2021, the first, second and third sowing dates recorded only 2 seeds per plant. The row spacing effect showed no significant difference in the first, second and third years. The highest number of seeds per plant (3) were recorded at 60 cm and 30 cm row spacing, respectively in 2019 and 2021. Sowing dates and spacing did not show significant interaction effect (Table 3).

The data of combined analysis of three years revealed that sowing dates and row spacing did not significantly influence the number of seeds per pod. Adisarwanto and Knight (1997) reported constant seeds per pod across the sowing date treatments. Plant population did not affect the number of seeds per pod (Refay et al 2004. Whereas the year significantly influenced the number of seeds per pod. Sowing dates and year had significant interaction effect whereas sowing dates and spacing, spacing and year and sowing dates, spacing and year did not have any significant interaction effect in number of seeds per pod (Table 4).

3. Grain yield

Sowing dates significantly influenced grain yield in the year 2019. The maximum seed yield (2788 kg ha^{-1}) was obtained on November 21, whereas the lowest value was recorded on October 4 (1128 kg ha^{-1}). During the year 2020, sowing dates did not significantly influence the yield. November 7 was the highest yielder, producing 877 kg ha^{-1}, followed by October 24 (845 kg ha^{-1}). In 2021, sowing on October 24 showed the highest grain yield than other dates and the lowest yield was on November 21. Grain yield ranged from 927-2741 kg ha^{-1}. Row spacing significantly influenced the yield in the three years. The result showed that the highest grain yield (2192, 1076 and 2207 kg ha^{-1}) was observed at 30 cm row spacing, while 60 cm row spacing resulted in the lowest grain yield (1572, 371 and 1099 kg ha^{-1}) respectively in these three years. There was no significant interaction between sowing dates and row spacing (Table 2).

The combined data analysis revealed that sowing dates showed a non-significant variation on grain yield. October 24 produced the highest grain yield (1571 kg ha^{-1}) followed by November 21 (1354 kg ha^{-1}) whereas the lowest was recorded on November 7 date of sowing (1301 kg ha^{-1}). Amer et al (2008) and Badr et al (2013), noted sowing date in the middle of October produced the highest faba bean seed yield and its components. Attia et al (2014) reported that delaying faba bean sowing beyond late October or early November reduced vegetative growth and seed yield components, resulting in a decreased seed yield.

Row spacing significantly influenced grain yield, where 30 cm (19 plants/m^2) resulted in high grain yield (1825 kg ha^{-1}) followed by 45 cm (1387 kg ha^{-1}). The narrow spacing yielded the highest seed yield, while the wide spacing obtained the lowest mean yield (Gezahegn 2017). Gezahegn et al (2016) found that the highest seed yield was obtained at 30 cm inter and 8 cm intra row spacing compared to 40 cm inter and 10 cm intra-row spacing in Vertical. Whereas Dahmardeh et al 2010 found high seed yield on faba bean in sandy loam soil at 20 plants/m^2.Turk and Tawaha (2002) also reported high yield of faba bean due to higher planting density. In three years, 2019 produced the highest grain yield (1894 kg ha^{-1}) followed by 2021 (1642 kg ha^{-1}). Sowing dates and year had significant interaction effect on grain yield whereas sowing dates and spacing, row spacing and year and sowing dates, spacing and year did not show significant interaction effect (Table 4).

Table 2. Yield and yield parameters of faba bean genotype concerning sowing date and row spacing at Khumaltar in 2019, 2020, 2021

Treatments	Pods/plant			Grain yield (kg ha^{-1})			100 seed weight (g)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Sowing dates (A)									
October 24	10	16	13	1128	845	2741	63.1	65.8	81.15
November 7	10	9	9	1767	877	1258	69.1	66.7	72.56
November 21	8	7	8	2788	346	927	76.5	54.9	72.32
LSD (<0.05)	ns	2.7	3.89	1135.0	ns	127.7	13.4	ns	4.25
Spacing (B)									
30 cm	8	12	10	2192	1076	2207	71.5	71.3	75.34
45 cm	9	11	10	1919	621	1620	67.7	60.7	77.57
60 cm	11	10	10	1572	371	1099	69.3	55.3	73.12
LSD B (<0.05)	ns	ns	ns	266.1	294.6	343.5	ns	7.4	3.54
A x B	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV%	36.4	34.6	27.6	28.3	49.84	24.4	10.64	13.85	5.5

4. Hundred seed weight

The effect of sowing date was significant on hundred seed weight throughout the three years growing seasons except for 2020 growing season in which it was non-significant (Table 2). In 2019, hundred seed weight ranged from 63.1 g on October 24 to 76.5 g on November 21. Similarly, during the year 2020, hundred seed weight ranged from 54.9 g on November 21 to 66.7 on November 7, whereas in 2021, hundred seed weight ranged from 72.3 g on November 21 to 81.15 g on October 24. Hundred seed weight were significantly influenced by the row spacing for 2020 and 2021 while non-significant for 2019. It was observed that the highest hundred seed weight obtained at 30 cm row spacing (71.5 g and 71.3 g) respectively during 2019 and 2020 while 77.5 g obtained at 45 cm during 2021. There was no significant interaction effect between sowing dates and row spacing (Table 2).

Result of combined analysis of three years revealed that sowing date had non-significantly influenced hundred seed weight. The highest hundred seed weight (70.0 g) was observed on October 24. Whereas row spacing significantly influenced hundred seed weight ranged from 65.9 g -72.8 g with highest value at 30 cm row spacing. Similarly, year also significantly influenced hundred seed weight. Highest hundred seed weight (75.3 g) was recorded in 2021. Sowing dates and year, and spacing and year had significant interaction effect on hundred seed weight. Sowing dates and spacing and sowing dates, spacing and year did not have significant interaction effect (Table 4).

5. Straw dry matter

In the year 2019, sowing dates significantly influenced straw dry matter. Among the sowing dates, November 21 resulted in straw dry matter of 7.9 ton/ha. In 2020, sowing dates did not significantly influence whereas in 2021, it significantly influenced. Sowing on October 24 showed highest straw dry matter (10.6 and 4.0 t ha^{-1}) than other dates during the year 2020 and 2021 respectively. The row spacing significantly influenced straw dry matter for three years. It was observed that the highest straw dry matter was obtained at 30 cm row spacing (7.9, 13.9 and 3.2 t ha^{-1}) while 60 cm row spacing obtained lowest straw dry matter 4.7, 3.6 and 1.7 t/ha, respectively during the year 2019, 2020 and 2021. There was no significant interaction effect between sowing dates and row spacing (Table 3).

The data of combined analysis revealed that the sowing date had non-significantly influenced straw dry matter. Straw dry matter ranged from 4.58-6.17 t ha^{-1}). Row spacing and year significantly influenced. The highest straw dry matter was observed at 30 cm row spacing (8.41 t ha^{-1}), while the lowest (3.38 t ha^{-1}) was observed at 60 cm row spacing. The dry matter yield of faba bean increased with increasing plant population due to the increase in the number of plants per unit area and the associated increase in plant height (Al-Rifaee et al 2004).

By the year 2020, the highest straw dry matter, 8.36 t ha^{-1} was recorded. Sowing dates and year and spacing and year significantly interacted with straw dry matter. Sowing dates and spacing, sowing dates, spacing, and year did not show any significant interaction effect (Table 4).

Table 3. Yield and yield parameters of faba bean genotype with respect to sowing date and row spacing at Khumaltar in 2019, 2020, 2021

Treatments	Number of seeds/pod			Straw dry matter (t ha^{-1})		
	2019	2020	2021	2019	2020	2021
Sowing dates (A)						
October 24	2	2	3	3.8	10.6	4.0
November 7	3	2	2	6.3	10.0	2.0
November 21	3	2	2	7.9	4.3	1.4
LSD (<0.05)	ns	ns	0.53	4.1	ns	0.58
Spacing (B)						
30 cm	2	2	3	7.9	13.9	3.2
45 cm	2	2	2	5.4	7.3	2.5
60 cm	3	2	2	4.7	3.6	1.7
LSD (<0.05)	ns	ns	ns	1.01	5.4	0.49
A x B	ns	ns	ns	ns	ns	ns
CV%	27.1	22.3	16.1	33.7	76.4	23.0

Table 4. Combined analysis of faba bean genotype with respect to sowing date, row spacing and year at Khumaltar in 2019, 2020, 2021

Treatments	Flr	Mat	Fs	Pth	Bran	Pod	Seed	Syld	Hswt	Sdm
Sowing dates (A)										
October 24	63	170	12	101	4	13	2	1571	70.0	6.17
November 7	68	161	14	91	3	9	2	1301	69.49	6.17
November 21	74	152	16	82	3	8	2	1354	67.93	4.58
LSD (<0.05)	2.16		1.54	7.81	0.46	1.82	ns	ns	ns	ns
Spacing (B)										
30 cm	69	161	19	98	3	10	2	1825	72.83	8.41
45 cm	68	161	13	92	3	10	2	1387	68.69	5.13
60 cm	68	161	10	84	3	10	2	1014	65.94	3.38
LSD (<0.05)	ns	ns	1.58	7.35	ns	ns	ns	209.5	3.52	2.07
Year (C)										
2019/20	67	168	17	125	4	9	3	1894	69.60	6.06
2020/21	72	164	8	69	4	11	2	689	62.51	8.36
2021/22	66	151	18	79	2	10	2	1642	75.34	2.51
LSD (<0.05)	1.51	ns	1.43	7.76	0.41	ns	ns	277.2	4.30	2.12
A x B (<0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
A x C (<0.05)	2.83		2.40	12.75		2.71	0.47	502.0	7.95	3.81
B x C (<0.05)	ns	ns	2.52	ns	ns	ns	ns	ns	6.91	3.57
A x B x C (<0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV%	2.4		13.2	9.4	14.4	18.7	12.6	17.3	5.9	42.9
Mean	**68**	**161**	**14.0**	**91**	**3.0**	**10**	**2**	**1409**	**69.15**	**5.64**

Flr = Days to 50% flowering, Mat=Days to 90% maturity, Fs = Final stand /m^2, Pth = Plant height (cm), Bran = Number of branches/plants, Pod= Number of pods/plants, Seed = Number of seeds/ pod, Syld= Seed yield (kg ha^{-1}), Hswt = 100 seed weight (g), Sdm=straw dry matter (t ha^{-1})

CONCLUSIONS

According to the findings of three growing season field studies, it is concluded that delaying planting in November caused a reduction in the seed yield. Grain yield of the faba bean crop increased with sowing on October 24 thus, it might be chosen as the optimum sowing time. Maintaining a 30 cm × 20 cm spacing was the best management practice to increase faba bean production under Khumaltar, Lalitpur conditions.

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AUTHOR'S CONTRIBUTION

Reshama Neupane conducted the experiment, generated data, analyzed them and wrote the manuscript. Other authors supervised and edited the manuscript.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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