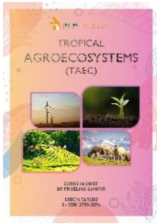
ZIBELINE INTERNATIONAL PUBLISHING

Tropical Agroecosystems (TAEC)

DOI: http://doi.org/10.26480/taec.02.2024.64.70

ISSN: 2735-0274 (Online)
CODEN: TARGDB



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RESEARCH ARTICLE

EFFECT OF DATE OF SOWING ON GROWTH AND YIELD OF BUSH BEAN IN MUSIKOT, WEST RUKUM, NEPAL

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ARTICLE DETAILS

Article History:

Received 8 April 2024
Revised 15 May 2024
Accepted 27 June 2024
Available online 30 June 2024

ABSTRACT

Sowing date and time are important agronomic practices determining the growth and yield of any crop. To improve the growth and yield of bush beans through the proper date of sowing, a field experiment was conducted from March 2022 to July 2022 at the Vegetable Seed Production Centre, Chapa, Musikot-04, West Rukum. The experiment was laid out in a randomized complete block design with the 5 different sowing dates, viz., (17th February), (4th March), (19th March), (4th April), and (19th April), and replicated four times. The observations on parameters such as plant height, number of leaves, number of branches, number of pods per plant, pod length, pod diameter, number of seeds per pod, and yield were recorded. The results obtained were in favor of the planting made on March 4, which was significantly different from the plant sown on February 17, March 19, March 3, and April 18. The result shows that the best sowing date for bush beans was found in the first week of March.

KEYWORDS

Bush bean, Climate, Rukum, Sowing date.

1. INTRODUCTION

Bush bean (Phaseolus vulgaris L.) belongs to the Leguminosae family and is a significant legume crop. It is also referred to by the names French bean, kidney bean, haricot bean, snap bean, navy bean, and common bean and can be a determinate type (bush type) and indeterminate type (Pole type) (Paudel et al., 2004). One of the popular varieties of bush bean is contender beans (Phaseolus vulgaris L.cv, Contender), a native of South Carolina. Generally, bush beans prefer warm, sunny weather with temperatures between 60 and 85° Fahrenheit (15 to 29° Celsius). It is grown throughout the year in a variety of agroclimatic conditions, from plains at 300 masl to high hills at 2,500 masl (Neupane et al., 2008). Beans have a high vitamin and protein content (Valdez-Perez et al., 2011). People who reside in the hills depend on beans, the "meat of the poor," to provide them with vital protein, preventing them from malnourishment (Pandey et al., 2011). It is drought-tolerant, can grow in poor soil conditions and with inadequate management techniques, and improves soil fertility by fixing atmospheric nitrogen, and all of which fits well with the upland area's rice and maize cropping patterns (Paudel et al., 2004). It is extensively cultivated in the mid and high hills of Nepal (Schoon and Te Grotenhuis, 2000). The plants are compact and do not require staking or trellising, making them ideal for growing in small spaces. Bush bean pods are usually harvested when they are still young and tender before the seeds inside have fully developed (Sanyal et al., 2020).

Beans grown in the hills have a better flavor and fetch higher prices than those grown in the plains so hilly region has enormous export potential (Neupane et al., 2008). Farmers in the hills grow various landraces of beans with different morphologies as a cash crop (Neupane and Vaidya, 2002). However, there are some limiting factors to cultivate and produce bush beans in the hilly region of Nepal. In Nepal, the area of production of dry beans is 22271 ha, production is 19157.76 tons, and productivity is 860.21 kg/ha which is low compared to the average of land-locked countries, having productivity of 1058.33 kg/ha (FAOSTAT, 2021). The main challenges are a lack of suitable varieties for wider adaptation and large-scale production of bush beans, a lack of appropriate practices, disease, and pest control, and adverse effects of climate throughout the crop production season (Bhattarai et al., 1997). Nepalese farmers are leaving land fallow between crops due to a lack of knowledge about catch crops and short-duration crops like bush beans (Sapkota et al., 2015). Bush bean is a newly introduced crop, and farmers in Nepal are cultivating it without any information on accurate time of sowing and plant management practices (Basnet et al., 2022). In the hills, beans sown in late April might be more affected by rainfall during harvesting. Such unreliable and heavy rains make harvesting challenging, as they can result in flooding, harm plants, and lower bean yields. Similarly, it can be difficult to move around the farm and harvest the beans without damaging them during the rainy season because of the muddy and slippery conditions.

The crops sown at the proper time are exposed to favorable weather conditions, which help them to grow and develop to a sufficient degree, and produce a satisfactory yield. (Basnet et al., 2022). French bean yields are lowered by unfavorable weather conditions for crops that are sown early or late (Basnet et al., 2022). In all 2 years of research, the yield of beans was significantly lower with later sowing date (Yoldas and Esiyok, 2007). The study on the effect of sowing date on Anthracnose of Rajma bean showed a significant but negative correlation between the maximum and minimum temperatures and the incidence of anthracnose (Padul et al., 2018). The growth and development of bean plants are greatly affected by air temperature and rainfall (Kakon et al., 2017). Sowing at the optimal time (2nd fortnight of October) resulted in a significant increase in grain yield of rajma bean (up to 300%) compared to early (1st October) and late (15th November) crops in Chitwan, Nepal (Dutta et al., 2003). There have been very few research studies conducted on bush beans, especially in the Hilly regions of Nepal. Furthermore, because Nepal has such a wide range of climates, research in one agro-climatic region cannot be generalized to

Quick Response Code	Access this article online	
	Website: www.taec.com.my	**DOI:** 10.26480/taec.02.2024.64.70

Cite The Article: Pratikshya Subedi, Prajjwal Koirala, Rijwan Sai (2024). Effect Of Date Of Sowing On Growth And Yield Of Bush Bean In Musikot, West Rukum, Nepal. *Tropical Agroecosystems, 5(2): 64-70.*

other regions. Therefore, this research will assess the effect of different sowing dates on the growth and yield of bush beans in the west hilly region of Nepal.

2. Materials And Methods

2.1 Experimental location

The field experiment was conducted at the Vegetable and Seed Production Centre (VSPC) located at Chapa-4, Musikot municipality, West Rukum. The experimental site is illustrated in Figure 1. This location is situated at 28° 44.6065' N latitude and 82° 28.5166' E longitude with a subtropical and sub-temperate climate suitable for vegetable farming. The elevation of the experimental site is 1440 masl. The experimental site is in a subtropical climate region with dry sunny summer and cold winter. The climate during the experiment of the site is illustrated in Figure 2. The topography was south-facing which is most suited for the production of vegetables and their seeds. The research is characterized by three distinct seasons namely, Cool winter (November-February), mild spring (February - March), and hot and dry summer (April - May). The highest maximum temperature was recorded in April (30.9 ^{0}C) whereas the lowest minimum temperature was 7 ^{0}C in January. According to the soil report from the field study, the soil of this area was found deficient in micronutrients like Zn, Fe, B, Cu, and Mo. The soil type of the experimental site was quartzite with 2.52% organic matter content. The following are the results between 28.619 N and 82.461 E coordinates.

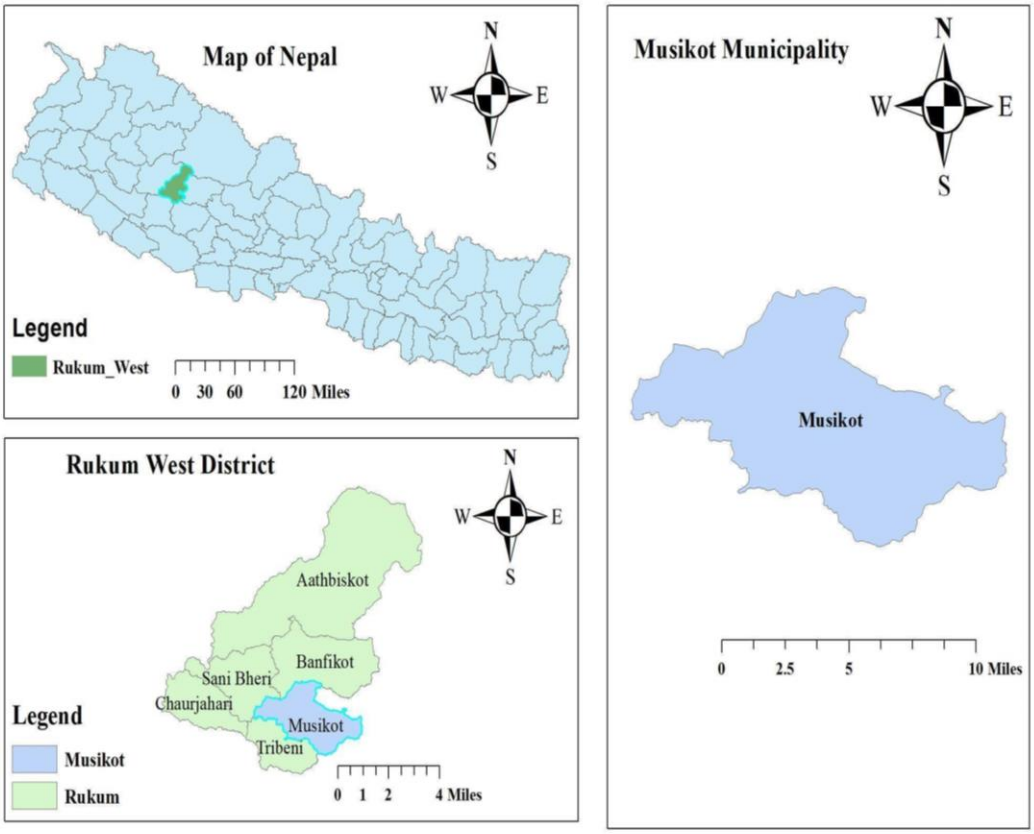

Figure 1: Map showing the research site.

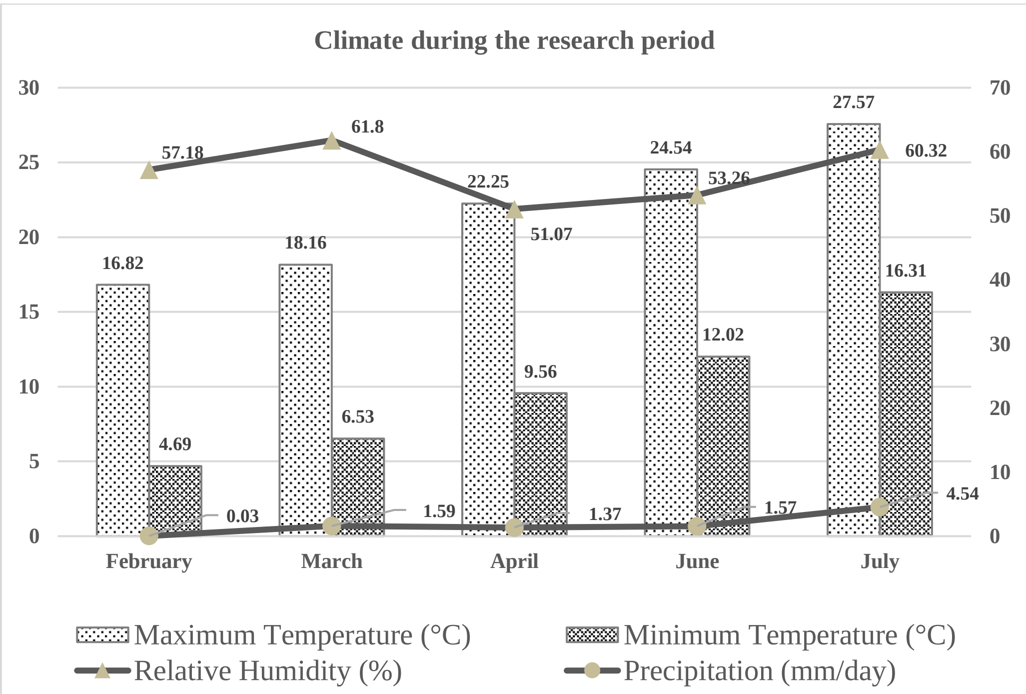

Figure 2: Temperature, rainfall, and relative humidity data records during the research period

2.2 Experimental setup

The experiment was laid out in simple RCBD (Completely Randomized Block Design) with 4 replications. There were five treatments on the date of sowing i.e., 17th February, 4th March, 19th March, 3rd April, and 18th April. A contender variety of bush beans was selected for the experiment. The plot size used was 1.7m * 1m. The row-to-row distance of 65 cm and a plant-to-plant distance of 30 cm were maintained. Each plot had twenty plants maintained and 20 plots in the study. From each plot, five plants were sampled. Land preparation was done using power tillage, and a raised bed was prepared using helping hands. The detail of treatment is shown in Table 1.

Table 1: Five treatments with four replications applied in the field

SN	Treatments	Treatment symbol
1	17th February	T^1
2	4th March	T^2
3	19th March	T^3
4	3rd April	T^4
5	18th April	T^5

2.3 Data collection and measurement

The Data were collected from five plants that were chosen at random from each plot. Various sample techniques were used. The Vegetative parameters and reproductive parameters of plants were collected and recorded every 30, 45, 60, 75, and 90 days after sowing (DAS). Plant height (cm), number of leaves per plant, and number of branches per plant were recorded under vegetative parameters. Pod length (cm), pod diameter (mm), pod weight (gm), number of pods per plant, number of seeds per pod, and pod yield per pod were recorded under reproductive parameters.

2.4 Statistical analysis

Data collected from the sample plant was entered systemically in MS Excel (Office package 2016). The statistical test such as Analysis of Variance (ANOVA) was carried out using R-studio (version 4.3.2). The mean comparison was conducted using Duncan's Multiple Range Test (DMRT) and significant differences between the mean values at a 5% level of significance were found.

3. Result And Discussion

The results obtained during the experiment are analyzed and presented in this section with the help of the table wherever necessary.

3.1 Growth parameters

3.1.1 Plant height

The effect of different dates of sowing of bush bean on plant height is shown in Table 2. The plant height showed a significant difference for the various dates of sowing at 30 DAS ($p<0.05$), 45 DAS ($p<0.05$), 60 DAS ($p<0.10$), and 75 DAS ($p<0.05$). At 30 DAS, the maximum height was obtained on 4th March (23.05cm) which was statistically at par with the plant height (19.9cm) obtained on the plant sown on 19th March followed by the plant height (21.07cm) on plant sown in 17th February. The minimum plant height (19.11cm) was obtained from the plant on 18th April. At 45 DAS, the significant maximum height was obtained on 4th March (26.42cm) which was statistically at par with the plant height on 17th February (25.32cm). In contrast, the minimum plant height (21.22cm) was obtained on 18th April. At 60 DAS the maximum height was obtained in the plant sown on 4th March (32.92cm) which was statistically par with the plant height (31.145cm) obtained on 17th February. Similarly, plants sown on 19th March, 3rd April, and 18th April showed statistically similar height. Finally, at 75 DAS the maximum height was obtained on 4th March (36.83cm) at par with the plant height obtained on 17th February i.e. (35.04cm). Similarly, the plant height sown on 19th March, 3rd April, and 18th April was statistically similar to others. Plant height decreased linearly with delayed sowing. A similar result was reported by İPEKEŞEN in dry beans. The early planting of the crop promoted proper light utilization, vegetative growth, nutrient absorption, and improved plant height (Khalil et al., 2010). The higher plant height of dry beans on the early sowing date is due to the certain extent of sunlight that stimulates growth compared to the late sowing date (İPEKEŞEN et al., 2022).

Table 2: Height of bush bean as influenced by the date of sowing in Musikot, West Rukum, Nepal, 2023

Treatments	Plant height(cm)			
	30 DAS	45 DAS	60 DAS	75 DAS
17th February	21.07^{b}	25.325^{ab}	31.14^{ab}	35.04^{ab}
4th March	23.05^{a}	26.425^{a}	32.92^{a}	36.83^{a}
19th March	19.99^{ab}	24.300^{b}	29.62^{b}	33.80^{b}
3rd April	19.87^{bc}	22.0^{bc}	29.88^{b}	33.67^{b}
18th April	19.11^{c}	21.22^{c}	29.47^{b}	33.42^{b}
SEM (±)	1.01	2.66	1.60	1.41
F-test	**	**	*	**
LSD 0.05	1.54	2.51	1.95	1.83
CV (%)	4.88	6.83	4.138	3.44

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 10% ($p<0.10$), **Significant at 5% ($p<0.05$), ***Significant at 1% ($p<0.01$)

3.1.2 Number of leaves per plant

The result shows that the number of leaves per plant was significantly affected by sowing dates except at 60 DAS (Table 3). The highest number of leaves (17.0) was obtained in the plant sown on 4th March at 75 DAS at ($p<0.10$) level of significance. At 45 DAS, the highest number of leaves (7.55) was obtained on the plant sown on 17th February which was statistically similar to the plant sown on 4th March (7.40) at ($p<0.10$) level of significance. At 30 DAS, the highest number of leaves per plant was also observed on 4th March. The result showed that the plant sown early gives higher leaves in bush beans. Early planting of faba bean results in more leaves per plant because of longer vegetative growth than late planting, which forces the crop to finish its life cycle faster due to high temperatures (Singh et al., 1992). The highest leaves were obtained in early March, followed by late March and mid-April (Palsaniya et al., 2016). The potential cause of this decline in height in subsequent sowing could be attributed to a decrease in temperature and sunlight intensity, which may have contributed to a plant's decreased photosynthetic efficiency compared to earlier sowing dates (Kaul et al., 2018). The highest number of leaves per plant may be obtained in early March due to the availability of higher nutrient content. Sowing in early to mid-March resulted in the highest total nutrient (NPK) content, followed by those sown in mid-February and mid-April (Mohamed, 2016).

Table 3: Number of leaves of the bush bean as influenced by the date of sowing in Musikot, West Rukum, Nepal, 2023				
Treatments	**Number of leaves per plant**			
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**
17th February	5.55ab	7.55a	13.15	14.0ab
4th March	6.05a	7.40a	14.15	17.0a
19th March	4.65b	6.70ab	12.87	12.75b
3rd April	4.40b	6.50ab	13.00	11.0b
18th April	4.62b	5.87b	12.02	11.0b
SEM (±)	0.60	0.42	0.70	5.61
F-test	*	*	ns	*
LSD (0.05)	1.20	0.99	ns	3.65
CV(%)	15.42	9.53	6.44	18.02

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 10% ($p<0.10$), **Significant at 5% ($p<0.05$)

3.1.3 Number of branches

The number of branches as influenced by the different dates of sowing was significant at 60 DAS and 90 DAS and non-significant at 45 DAS and 75 DAS (Table 4). At 60 DAS, the maximum number of branches (7.2) was obtained on the plant sown on 4th March which was at par with the plant sown on 17th February (6.75) at ($p<0.10$) level of significance. The number of branches obtained on 19th March, 3rd April, and 18th April was statistically similar to each other. At 90 DAS, the maximum number of branches was obtained on 17th February (7.35) and 4th March (7.65) which were statistically similar with each other at par with 19th March (6.95) and 4th April (6.95) with the minimum number of branches obtained on plant sown in 18th April (6.50) at ($p<0.10$) level of significance. Delaying the sowing dates resulted in decrease in the number of branches per plant which was also seen in a report by İPEKEŞEN in dry beans (İPEKEŞEN et al., 2022). The longer vegetation period for crops and the ideal soil moisture helped in the better performance of crops in the early to mid-March sowing dates (İPEKEŞEN et al., 2022). Due to improved environmental conditions, early sowings produced a high number of primary branches per plant reported by (Shukla and Singh, 2021; Mozumder et al., 2003) . The decrease in several branches per plant may be due to a low amount of nutrient (NPK), sowing in early to mid- March highest value of total nutrient (NPK) content was gained followed by descending order by those sown in mid-February and mid-April (Mohamed, 2016).

Table 4: Number of branches of bush bean as influenced by the date of sowing in Musikot, West Rukum, Nepal, 2023				
Treatment	Number of branches per plant			
	45 DAS	60 DAS	75 DAS	90 DAS
17th February	3.0	6.75ab	7.07	7.35a
4th March	3.25	7.25a	7.35	7.65a
19th March	2.95	6.25b	6.70	6.95ab
3rd April	2.90	6.25b	6.62	6.95ab
18th April	2.75	6.17b	6.32	6.50b
SEM (±)	0.04	0.23	0.27	0.21
F-test	ns	*	ns	*
LSD (0.05)	0.33	0.74	0.81	0.72
CV(%)	7.19	7.36	7.74	6.60

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 10% ($p<0.10$), **Significant at 5% ($p<0.05$)

3.2 Reproductive parameters

3.2.1 Number of pods per plant

The number of pods per plant as influenced by the date of sowing was found significant in all the days of observations made at 60 DAS, 75 DAS, and 90 DAS (Table 5). The highest number of pods per plant (12.5) was obtained on plant sown on 4th March which was statically at par with plant sown on 17th February at ($p<0.01$) level of significance. At 60 DAS and 75 DAS observation, the maximum number of pods per plant was obtained on the plant sown on 4th March which was statistically similar to that of the plant sown on 17th February and other treatments were statistically different. The number of pods per plant was significantly affected by the sowing date with early sowing resulting in a higher pod number which was also reported by (Zhang et al., 2010; Mozumder et al., 2003; İPEKEŞEN et al., 2022). March is considered an early spring and optimum growing conditions such as moderate temperature, sufficient moisture, longer photoperiod may trigger robust pod setting and better pod development in early March than late April (Nosser and Behnan, 2011).

Table 5: Number of pods per plant as influenced by the date of sowing in Musikot, West Rukum, Nepal, 2023			
Treatment	**Number of pods per plant**		
	60 DAS	**75 DAS**	**90 DAS**
17th February	4.05a	8.50a	9.8ab
4th March	4.15a	9.0a	12.5a
19th March	3.20b	6.50b	8.0b
3rd April	3.0b	7.0b	8.1b
18th April	3.0b	7.05b	8.1b
SEM (±)	0.05	0.15	3.76
F-test	***	***	*
LSD (0.05)	0.36	0.59	2.9
CV(%)	6.78	5.08	20.8

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 10% (p<0.10), **Significant at 5% (p<0.05), ***Significant at 5% (p<0.01)

3.2.2 Pod length

The pod length was significantly influenced by the different dates of sowing on 75 DAS at (p<0.10) level of significance (Table 6). At 75 DAS, the maximum pod length (16.50 cm) was obtained on 4th March and 17th February which was statically at par with the plant sown on 19th March (15.65 cm). The finding suggested a gradual decrease in pod length with each delay in the sowing of plants which was also reported by Mozumder et al. (2003) and Datta et al. (2023). T Elagöz & Manning's (2005) study suggests that the time of flowering, pollination, and length of daylight affect the reproductive process, potentially contributing to longer pod development in the early-sown crop. However, the study suggests late-sown crops may experience terminal stress, which affects the development of pods and results in a shorter pod length.

Table 6: Pod length as influenced by the date of sowing in Musikot, West Rukum, Nepal, 2023

Treatments	Pod length(cm)	
	75 DAS	90 DAS
17th February	16.50a	16.07
4th March	16.50a	16.40
19th March	15.65ab	15.62
3rd April	15.24b	15.17
18th April	14.90b	15.37
SEM (±)	0.55	0.32
F-test	*	ns
LSD (0.05)	1.14	0.87
CV(%)	4.72	3.61

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 10% (p<0.10), **Significant at 5% (p<0.05)

3.2.3 Pod diameter

The Pod diameter as influenced by different dates of sowing was found to be significant at 75 DAS at (p<0.01) level of significance (Table 7). At 75 DAS, the maximum pod diameter (7.10 mm) was obtained on the plant sown on 4th March which was statistically similar to the pod diameter obtained on the plant sown on 17th February (7.07 mm). The study shows a positive effect on pod diameter due to early sowing of beans which was also observed by Elhag & Hussein (2014). The temperature during the growing season significantly impacts plant growth and development, including the diameter of the beans, as documented by (Vaz et al., 2017).

Table 7: Pod diameter as influenced by the date of sowing in Musikot, West Rukum, Nepal, 2023

Treatments	Pod Diameter(mm)	
	75 DAS	90 DAS
17th February	7.07a	8.20
4th March	7.10a	8.50
19th March	6.95ab	8.15
3rd April	6.85ab	7.90
18th April	6.70b	7.75
SEM (±)	0.03	0.13
F-test	*	ns
LSD (0.05)	0.27	0.55
CV(%)	2.59	4.45

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 10% (p<0.10), **Significant at 5% (p<0.05)

3.2.4 Number of seeds per pod

The seed per pod was significantly influenced by the different dates of sowing on 75 DAS (Table 8). At 75 DAS the maximum number of seeds per pod (4.1) was obtained on plant sown on 4th March which was statistically at par with the seed per pod (3.99) obtained on plant sown on 17th February. The results suggest that different seeding dates significantly influenced the number of seeds per pod in bush beans and 4th March gave higher seeds per pod. A similar result was obtained in mung bean by (Palsaniya et al., 2016). This suggests that the early march provides more favorable conditions for seed development such as temperature, humidity, and moisture availability that are more conducive to the seed development given by (Moghazy, 2014).

Table 8: Seed per pod as influenced by the date of sowing in Musikot, West Rukum, Nepal, 2023

Treatments	Seed per pod	
	75 DAS	90 DAS
17th February	3.99a	3.65
4th March	4.12a	3.77
19th March	3.20b	3.20
3rd April	3.22b	3.15
18th April	3.13b	2.97
SEM (±)	0.11	0.15
F-test	**	ns
LSD (0.05)	0.52	0.60
CV(%)	9.55	11.70

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 10% (p<0.10), **Significant at 5% (p<0.05)

3.2.5 Seed yield

The average seed yield was significantly influenced by the date of sowing at (p<0.10) level of significance (

). The highest seed yield (1.225 t/ha) was found on plant sown on 4th March. Similarly, other treatments except 4th March showed statistically similar seed yield. The results suggest early sowing leads to higher seed yield. The plants sown in March produced higher yields, which were also obtained by Moghazy in common beans and Palsaniya et al., in mung beans (Moghazy (2014; Palsaniya et al., 2016). Furthermore, the lower yield on plants sown later may be due to a lower vegetative growth period, and a decrease in the vegetative growth of the branches may decrease the source-sink relationship between the leaves and the pod (Nuñez Barrios et al., 2005). The study conducted in 2006 observed consistent rainfall in early March is particularly beneficial as it allows for a steady supply of water and nutrient uptake to plants which helps in yield maximization (Zehtab-Salmasi et al., 2006). The time of sowing plays a significant role in the development and severity of disease, where beans sown in early to mid-March showed low incidence and severity of anthracnose disease and increased slowly throughout the growing season. Furthermore, when sowing was delayed to mid to last April incidence and severity of the disease increased significantly (Silva et al., 2013).

Table 9: Seed yield of the bush bean as influenced by the date of sowing in Musikot, West Rukum, Nepal, 2023.

Treatments	Seed yield (t/ha)
17th February	1.04b
4th March	1.22a
19th March	0.94b
3rd April	0.92b
18th April	0.88b
SEM (±)	0.01
F-test	*
LSD (0.05)	0.16
CV(%)	10.54

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 10% (p<0.10), **Significant at 5% (p<0.05)

4. Conclusion

In conclusion, vegetative characters and yield parameters of bush beans were significantly affected by different dates of sowing. Early planting, notably on the 4th of March, emerges as a key factor contributing to heightened plant height, increased leaf and branch development, and ultimately, enhanced pod production and seed yield. The result disclosed that the best sowing date for bush beans was found in the first week of March, which was favored by optimum climatic conditions and consistent rainfall.

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