International Journal of Environment, Agriculture and Biotechnology
Vol-7, Issue-1; Jan-Feb, 2022

Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Peer Reviewed

Effect of date of sowing of French bean (*Phaseolus vulgaris* L) in minimizing climatechange impact and in its performance in inner Terai region of Nepal

Dinesh Bahadur Basnet[*1], Prof. Komal Bahadur Basnet[2],PhD, Prakash Acharya,PhD[3]

[1]Agronomist, Programme Manager, Sarbodaya Nepal,
[2]Professor, Agronomy Department, Agriculture and Forestry University, Nepal,
[3]Senior Crop Development Officer, Ministry of Agriculture and Livestock Development, Nepal
Corresponding author: dineshbamti@gmail.com

Received: 16 Dec 2021; Received in revised form: 06 Feb 2022; Accepted: 16 Feb 2022; Available online: 26 Feb 2022

***Abstract*— *Research was conducted during 2008/09 at Institute of Agriculture and Animal Sciences (IAAS), Rampur, Chitwan to assess the influence of date of sowing in minimizing climate change impact and performance of French bean (Phaseolus vulgaris L.) The experiment was laid out in split- plot design comprising 3 dates of sowing (October 21st, November 5th and November 20th) as main plot factor with fivelevels of nitrogen in three replications. The soil of the experimental plots was sandy loam with acidic (pH 6.33) in nature and PDR 14 (or Uday) variety was planted. The important crop growth stages like reproductive period of the French bean sown on November 5th (mid-sown crop) was exposed to the optimum temperature, reflected to higher grain yield production, as compared to the early and late sown crops. The French bean sown on October 21st (early sown crops) was exposed to lower temperature in its critical reproductive stages like flower bud formation, flowering, pod formation and pod development while the November 20th sown (late sown) crop was exposed to higher temperature in pod setting to maturity stages. The crop sown on November 5th produced significantly higher grain yield (2.16 t/ha) than October 21st (2.0 t/ha) and November 20th (1.75 t/ha) sowings. So, in order to minimize the impact of climate change and achieve higher productivity of french bean, November 5th can be considered as an optimum time of sowing in the humid sub-tropical condition of Chitwan.*

***Keywords*— French bean, Sowing time, Climate Change, Yield.**

I. INTRODUCTION

Grain legumes are the important crops in Nepal both in terms of their contribution to human nutrition and as the component of the indigenous cropping systems for improving the soil fertility (Neupane, 2003; Singh, 1995). In Nepal, it is an important grain legume crop which is used as vegetable and pulse crop (Begum et al., 2003). In terms of production and productivity Nepal ranks at 36th and 81st position in the world. In Nepal pulses are grown in around 311,000 hectares which is computed as only 10.22 % of the total agricultural land cultivated during 2018 and production was confined to only 368,000 tonnes with the productivity of 1184 kg/ha (Acharyaet al., 2019). Per capita consumption of grain legumes in Nepal is around 10 kg/annum or 27g/capita/day (Hunsigi & Krishna, 1998) which is 3 times less than minimum requirement (80 g/capita/day) prescribed by WHO (Yadav, 2000).

French bean (*Phaseolus vulgaris* L.) is the second ranking legume after soybean in the world. It is believed to have originated in Southern Mexico and Central America (Bhurer et al., 2003) which is known by the various names viz. Kidney bean, Phaseolus bean, Rajmas or Rajma bean and others depending on the types of bean and its uses in particular locality (Ahlawat, 2009). It is an important nutritive legume having 22.25% protein in grain and 1-2.4% in green pods (Singh & Singh, 1987). French bean supplies 1.7 g protein, 50 mg calcium, 28 mg phosphorus, 1.7 mg iron, 132 mg carotene, 0.08 mg thiamine, 0.06 mg riboflavin, 24 mg vitamin C per 100 g. of edible pods. French bean is used in soups, chili dishes, refried bean paste and fresh salads (Gopalan et al., 1982; Hardman et al., 1990).

French bean is recently introduced as a winter crop in rice or maize based cropping system (Vaidya, 2004) and gaining popularity with its short durability and high nutritive value (Kakon etal., 2017). It is cultivated extensively throughout the mid and high hill (Dutta et al., 2003) in the rainfed condition. In the terai region, French bean for the dry grain purpose, is generally cultivated after harvesting of rainy season crops, usually from the beginning of October to whole November to utilize the land. However, appropriate time of sowing of french bean for higher yield is not established for specific agro-climatic region. Time of planting is the priceless resource in agricultural sector which plays a vital role in the successful production of the crop (Ali and Mishra, 2004).

Nepalese agriculture sector has been experiencing the higher negative impacts of climate change in recent years. Climate change and variability has affected the agricultural systems substantially, requiring farmers to adapt at the same time at the farm level (Rosenzweig & Tubiello, 2007).

Sowing the crop at appropriate time allows crops to expose in favorable weather condition that contributes towards sufficient growth and development of a crop to obtain a satisfactory yield. A remarkable increase in grain yield (up to 300%) was obtained by Ahlawat (1995) at New Delhi, India and Dutta et. al. (2003) at Chitwan, Nepal by sowing at the optimum time (2nd fortnight of October) than early (1st October) and late (15th November) sown crop.

In contrary, early or late sown crop faces unfavorable weather conditions causes of low yield of French bean (Basnet, 2012). Among the weather factors, mainly air temperature and rainfall greatly affect the growth and development of bean plants (Kakon et al., 2017). The optimum temperature range for optimum bean growth is 16-30^{0}C (Nonneck, 1989). The life cycle of french bean includes a series of phenological stages and each stage represents an important change in morphology as well as function of the different plant organs which is directly influenced by the ambient temperature. High temperature is one of the major environmental stresses that affect plant growth and development (Boyer, 1982) and causes substantial loss in crop yield due to damage of reproductive organs (Savin & Nicolas, 1996) whereas the lower temperature has a negative effect on the metabolism with a corresponding reduction in crop quality and quantity (Kumar etal., 2017). Basnet (2009) found that weather fluctuation or temperature outside the optimum growth range affects for variation in phonological stages, plant growth pattern, and crop duration that eventually impacts on grain yield. Thus, optimum sowing time is one of the important adaptive farming practices for successful crop production which not only makes correct choice of planting but also allows crops to escape from adverse weather condition to prevent crop failure or loss.

Since french bean is a newly introduced crop, technology for its cultivation is not well developed in Nepal. Due to these reasons, the average yield (1.9 t/ha) of french bean obtained in the farmers field of Chitwan (DADO, 2007) is low as compared to its potential (3.0 t/ha) yield (Yadav, 2000). In the context of Nepal, research information regarding the appropriate time of sowing french bean (*Phaseolus vulgaris* L.) is not sufficient. Moreover, the changing climatic conditions has always threatened the production system of many crops including French bean. Therefore, the present investigation was carried out as an attempt to determine the optimum time of sowing to address the impact of climate change for higher productivity to fulfill the increasing demand of vegetable protein for growing population.

II. MATERIALS AND METHODS

The field research experiment was conducted at Horticulture farm of Rampur Campus, Tribhuvan University, Nepal during winter season of 2008/2009 to determine the appropriate sowing date for the yield performance of French bean in inner terai region. The experimental site was located in a plain area under sub-tropical climate of inner terai region (27° 37' N and 84° 25' E, 256 m above mean sea level). Before the tillage, the soil sample was taken from experimental land and tested in Regional Soil and Fertilizer Testing Laboratory, Pokhara. The soil was sandy loam in texture with slightly acidic in nature (pH 6.33), low in organic matter (2.03 %), total nitrogen (0.1%) and available potassium (108.33 kg/ha), but medium in available phosphorus (51.33 kg/ha).

The field experiment was laid out in split-plot design with three dates of sowing (October 21st, November 5th and November 20th) as main-plot withfive levels of nitrogen(0, 40, 80, 120 and 160 kg/ha) as sub-plot with 3 replications. The unit plot size was 4.5 m length and 3.6 m breadth (16.2 m^2 area) with 0.5 m space between two plots and 1 m space between the replications. There were 10 rows in each plot and 24 plants in each row. The crop geometry of french bean was 45 cm X 15 cm (row to row and plant to plant spacing, respectively) with one plant per hill. The central 5 rows were treated as the net plot rows for harvesting and phenological observation, and there were two destructive rows for taking plant samples for growth analysis. Further, outermost plant of each plot and one row between net plot and destructive rows from both sides was kept as a guard row.

The growth and development parameter of French bean sown in different dates has been presented as a correlation for yield performance with the association of meteorological data like temperature, sunshine hour, relative humidity and rainfall of the experimental site during the cultivation period. Similarly, extensive information has been collected with respect to climate change and weather fluctuation that has been affecting for French bean and how the appropriate sowing time can be used as an adaptive measure to minimize the impact of climate change for the sake of successful production of French bean.

The field was ploughed twice on first week of October 2008. The crop was fertilized with the application of 50% of the total recommended dose of nitrogen (as per treatment plot) and full dose of FYM (@ 10 tonne/ha), phosphorus (@60 kg/ha), potassium (@40 kg/ha) at the time of final land preparation and the rest amount of nitrogen was top dressed into two equal splits at flower bud initiation stage before 1st irrigation and at pod filling stage before 2nd irrigation. The source of chemical fertilizer was urea, single super phosphate and muriate of potash. PDR-14 variety of the french bean, which is popularly known as Uday in India, was sown manually with narrow spade as per assigned treatment dates using 3 grains per hill to confirm germination because gap filling could not be done as one of the factors of research was sowing date. Seed was treated with Bevistin (carbendazim 50% WP) @ 2 g/kg grain before sowing. Thinning was done at 15 DAS to maintain single plant per hill. Two weeding were done: 1st weeding at flower bud initiation stage (28 DAS) and 2nd at pod formation stage (56 DAS). Hoeing followed by earthing up was done at flower bud initiation stage (31-43 DAS) after weeding and first nitrogen side dressing. Similarly, the field was irrigated two times after hand weeding during the crop growing period in the furrow made by earthing up. Plant protection measures were carried out to control fungal diseases with Bevistin (Carbendazim 50% WP), SAAF (carbendazim 12% + Mancozeb 63% WP), Blue copper ($CuOCl_2$ 50% W/W), and insects with Cypermethrin (25% EC) in the standing French bean. Postharvest activities were done manually and the seed was dried to reduce the moisture content up to 10 to 12% for its measurement. At each harvesting time, ten plants were harvested randomly from each net plot to record the data on yield components. The data of different parameters was analyzed by using M-STAT, analysis of variance and compared by Least Significant Difference (LSD) test.

III. Weather condition during experimental period

The experimental site lies in the subtropical humid climatic zone of Nepal, characterized by three distinct seasons: rainy monsoon (June to October), cool winter

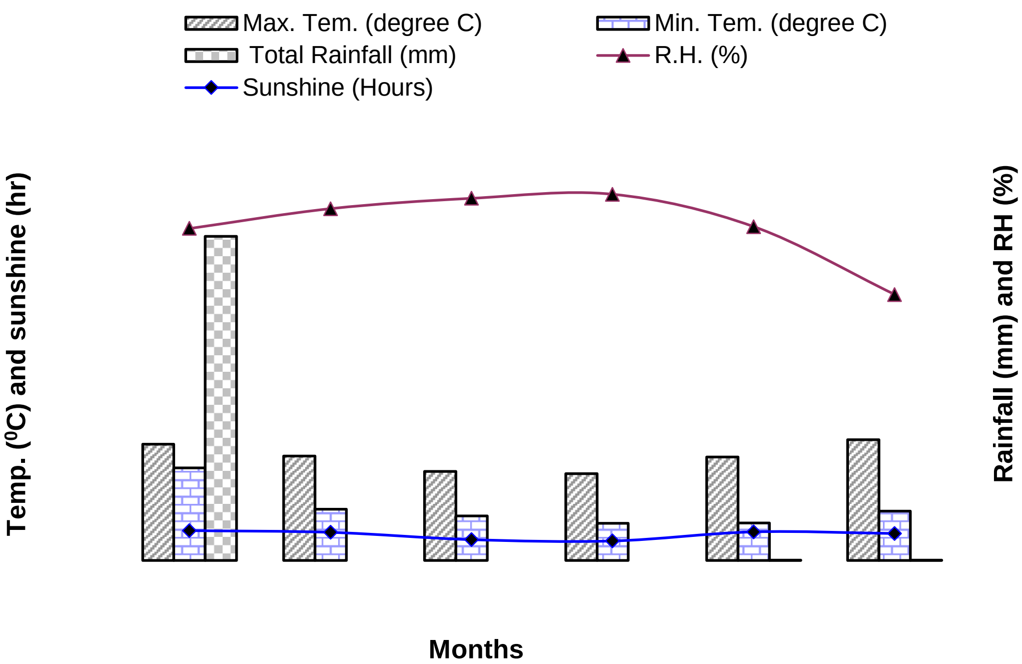

Fig.1. Weather condition during the course of experimentation at Rampur, Chitwan, 2008/09 (Source: NRMP, 2009).

(November to February) and hot spring (March to May). The maximum temperature during winter season rises up to 27 ^{0}C (end of the February) whereas during the hottest months (April–June) it reaches up to 42 ^{0}C. Rainy season starts from June and lasts up to October. July-August receives the highest amount of rainfall (up to 150 mm/day). Winter season is generally dry with occasional rainfall and generally remains foggy with minimum sunshine hours. The relative humidity (RH) commences rising up from May (average 50%) and reaches to maximum (100%) in December and January (Thapa and Dangol, 1988).

Monthly average data related to different weather parameters i.e. maximum and minimum temperatures, total rainfall, sunshine (hrs.) and relative humidity were recorded at National Maize Research Program (NRMP), Rampur, Chitwan are depicted in Figure 1.

Among the weather factors, mainly air temperature and rainfall greatly affect the growth and development of bean plants. (Kakon et al., 2017). The optimum temperature range for optimum bean growth is 16-30^{0}C (Nonneck, 1989).The total rainfall of 87.43 mm was received during the entire period of experimentation i.e. from October to March. There was a rainfall of about 87.3 mm in October month only. Well distributed rainfall of about 350–400 mm is needed during the entire crop season of French bean (Sharma et al., 1991). Therefore, irrigation was provided twice at flower budding and pod filling stages.Further, mean temperature in fifteen days interval up to 120 days of all the sowing dates of French bean also presented in Table 1.

Table 1. Average temperature data (^{0}C) of experimental location during crop growing period at 15 days interval, 2008/09

Treatments-Sowing dates	Temp (^{0}C)	Intervals (DAS) 1-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120
October 21st	Max	30.26	28.41	26.52	24.25	22.4	23.97	23.49	27.75
	Min	16.98	14.51	10.97	12.89	10.2	8.67	11.91	10.05
	Ave	23.62	21.46	18.75	18.57	16.3	16.32	17.70	18.9
November 5th	Max	28.41	26.52	24.25	22.4	23.97	23.49	27.75	29.29
	Min	14.51	10.97	12.89	10.2	8.67	11.91	10.05	10.55
	Ave	21.46	18.75	18.57	16.3	16.32	17.70	18.9	19.75
November 20th	Max	26.52	24.25	22.4	23.97	23.49	27.75	29.29	32.67
	Min	10.97	12.89	10.2	8.67	11.91	10.05	10.55	12.29
	Ave	18.75	18.57	16.3	16.32	17.70	18.9	19.75	22.48

DAS: Days after sowing, D1: Early sowing i.e. Oct 21st, D2: Mid sowing i.e. Nov 5th and D3: Late sowing i.e. Nov 20th

The mean maximum and minimum temperatures were 27.87 ^{0}C and 14.02 ^{0}C, respectively during the growing season (from October 2008 to March 2009) of French bean. Further, the average temperature was declining with delay in sowing from October 21st to November 20th at different growth stages. Such trend was observed from emergence to the flower budding stage. Thereafter, at flowering and pod formation stages it began to increase in late sown condition (November 20th) than November 5th but was still lesser than that of October 21st sowing date.

Table 2. Average temperature data recorded during phonological stages of french bean sown at different dates

Phenological stages	Sowing dates October 21st (^{0}C)	November 5th (^{0}C)	November 20th (^{0}C)
Emergence	23.66	20.03	18.9
First pair leaves	23.53	20.15	19.27
First trifoliate leaf	22.56	18.78	18.78
Second trifoliate leaf	22	18.19	18.55

Flower budding	19.38	18.93	15.45
Flowering	18.53	16.78	17.92
Pod setting	18.53	15.13	17.96
Pod maturity	17.1	19.66	22.1

DAS: Days after sowing, D1: Early sowing i.e. Oct 21st, D2: Mid sowing i.e. Nov 5th and D3: Late sowing i.e. Nov 20th

Finally, at physiological maturity stage it was increasing as the date of sowing was scheduled from October 21st to November 20th. Thus, the average temperature recorded during emergence was 23.6, 20.03 and 18.9 ^{0}C for October 21st, November 5th and November 20th dates of sowing, respectively. Similarly, they were 19.38, 18.9 and 15.25 ^{0}C at flower budding; 18.83, 15.13 and 17.96 ^{0}C at pod formation and 17.1, 19.66 and 22.1 ^{0}C at physiological maturity stages for early (October 21st), mid (November 5th) and late (November 20th) sown crops, respectively. So, prevailing of lower temperature at the early vegetative growth stages and its gradual increase from flowering to maturity in late sown crop of November 20th compared with other dates of sowing (Table 2) caused a reduction in crop growth characters and consequently in grain yield.

Climate change and weather fluctuation affects the crops to various magnitude. Rosenzweig and Tubiello, 2007 mentioned that agricultural production may already have been affected by rising temperatures in recent decades, which may also be affecting yields in tropical regions. French bean is equally grown in upland areas without having source of irrigation. High temperature increases evaporative demands may increase the need for irrigation in specific regions, further straining competition for water with other sectors (Rosenzweig et al., 2004) and lacking additional water resources, increases cost of production, labor and sometimes entire cropping systems may go out of production.

IV. RESULTS AND DISCUSSION

Crop developmental events and growth duration of French bean were influenced by prevailing temperature variations (Table 1, 2 and 3). Crop growth duration was recorded maximum (108.3 days) in mid sown crop followed by late-sown (106.6 days) and early sown crop (99.87 days) (Table 3). The reasons for short duration of early sown crop might be due to higher temperature (23.53 ^{0}C to 18.53 ^{0}C from emergence to pod setting stages) in all the phenological stages up to pod development associated with early development of the respective stages as compared to mid sown and late sown crops. Similarly, medium crop duration of late sown crop might be due to prevailing high temperature from flowering up to pod maturity (average temperature 17.92 ^{0}C to 22.1 ^{0}C) than mid sown crop (average temperature 16.78 ^{0}C to 19.66 ^{0}C) (Table 2). The higher temperature (33.7 ^{0}C daily max temp) at reproductive stages shortened between the pod formations to pod maturity period of late sown crop (40.80 days) than early sown crop (48.74 days) and mid sown crop (50.57 days) (Table 2). Similar results for variation in growth duration were observed by Kakon et. al. (2017).

Table 3. Crop development events and duration of French bean as affected by sowing dateat Rampur, Chitwan

Treatments-Sowing dates	Emergence	Flower budding	Flowering	Pod formation	Maturity
October 21st	9.46^c	32.13^c	45.87^c	51.13^c	99.87^c
November 5th	12.40^b	36.67^b	52.40^b	57.73^b	108.30^a
November 20th	14.26^a	41.60^a	61.20^a	65.80^a	106.60^b
LSD (P= 0.05)	0.23	0.74	4.40	3.42	1.30
CV%	3.50	2.20	3.83	3.71	1.45

DAS = Days after sowing. Treatments means followed by the common letter(s) within a column are non-significantly different based on DMRT at 5% level of significance.

French bean can be grown successfully having a temperature of 20 to 25 ^{0}C during the crop growth period (Singh, 2005). The optimum temperature for growth and yield ranges from 22 to 28 ^{0}C (Ustimenko–Bakumovsky, 1983). At high or low temperature, the balance of growth substances affects growth (Reddy & Reddi, 2005). Thus, availability of low temperature during early growth period and relatively high temperature at maturity should be the main reason of poor growth and yield of French bean in late sown condition (November 20th) than that of early sowing dates i.e. October 21st and November 5th. Temperature above 30^0 C may cause the bean flower buds to fall and in temperature above 35^0 C bean seeds might not form (www.agrifarming.in/beans-farming-information).

The more sunshine that the French bean plants got for their growth was recorded in the month of October 2008 (8.03 hours) and it was minimum in January 2009 (5.25 hours) with the average of 6.90 hours during the cropping period. This may be the reason for obtaining better growth characters in October 21st sown crop as bright sunlight favors the crop growth (Singh, 2005). The relative humidity ranged from 71.65% (March 2008) to 98.65% (January 2009). Low night temperature (10.02 ^{0}C) accompanied with high relative humidity (98.65%) and less sunshine hours (5.25 hours) in January favored fungal diseases after pod setting which was controlled using fungicide.

4.1 Plant height and growth rate for French bean:

The plant height of french bean was recorded significantly lower in crop sown on November 20th (25.67 cm) than October 21st (43.31 cm) and November 5th (40.50 cm) sowings. The better soil moisture condition (figure 1) prevailed at the initial growth stage of the early sown crop (October 21st) might have enhanced the crop growth in height (Rutkowski & Fordonski, 1987; Sreelatha et al., 1997).

Similarly, the higher temperature from sowing time to early vegetative phase was also higher in earlier sown crops. The maximum and minimum temperatures for October 21st, November 5th and November 20th sowing dates were 29.37 and 15.78; 27.48 and 12.89; and, 25.50 and 12.00 ^{0}C, respectively for the first 30 days after sowing (Table 4). In this way, the decrease in temperature during the intensive growth period with the delay in sowing from October 21st to November 20th for the first 30 days after sowing affected plants growth in height.

Table 4. Average temperature data of experimental location for the first 30 days after sowing (DAS)

Average temperature (^{0}C)	Dates of sowing		
	October 21st	November 5th	November 20th
Maximum	29.37	27.48	25.50
Minimum	15.78	12.89	12.00
Average	22.57	20.19	18.75

Thus, at the optimum temperature, high growth rate of the plant is accompanied by the high activity of auxins, gibberellins and cytokinins and lower activity of abscisic acid but reverse occurs at low temperature (Reddy & Reddi, 2005). A significant decrease in plant height with delay in sowing was also mentioned by Ahlawat (1995) in his experiment.

4.2 Leaf Area Index (LAI)

On average, the LAI was increasing up to 60 DAS and in late sown crop up to 75 DAS and then declined gradually up to 90 DAS (Table 5). The effect of sowing dates was observed in LAI which was closely associated with plant height at early vegetative stages and with the crop duration at 90 DAS (Table 5).

Thus, at the early stages (30 and 45 DAS) the LAI decreased significantly with delay in sowing from October 21st to November 20th. On the other hand, at 60 and 75 DAS, the early sowing dates i.e. October 21st and November 5th were at par with each other but significantly superior to late one (November 20th). Finally at 90 DAS, the LAI (1.83) recorded in November 5th sowing was significantly greater than October 21st (0.84) and November 20th (1.05). This might be one of the reasons for getting significantly higher yield attributes (Table 7) and consequently grain yield (Table 8) in the crop sown on November 5th as compared to October 21st and November 5th.

Table 5. Effect of sowing dates on leaf area index (LAI) of French bean at Rampur, Chitwan

Treatments-Sowing dates	Leaf Area Index (LAI)				
	Days after sowing				
	30	45	60	75	90
October 21st	0.70a	1.57a	2.09a	1.96a	0.84b
November 5th	0.40b	1.35b	2.05a	2.03a	1.83a
November 20th	0.23c	0.56c	0.91b	1.56b	1.05b
LSD (P= 0.05)	0.09	0.18	0.13	0.19	0.36
CV%	10.18	12.57	12.18	12.53	17.29

Treatments means followed by the common letter(s) within a column are non-significantly different based on DMRT at 5% level of significance.

The insignificant difference between October 21st and November 5th sowing dates in respect of LAI at 60 and 75 DAS might be related to the size of the leaves as well as shedding of older leaves in October 21st sowing. Because of this fact, significantly higher LAI was retained at 90 DAS in November 5th sowing which assisted to improve all yield attributing characters and finally the grain yield.

Leaves are the primary sites for carbon fixation (photosynthesis) and synthesis of nitrogenous compounds (Krishnan et al., 1998). As leaves grow, their ability to photosynthesize increases for a time and then, often even before maturity, begins slowly to decrease (Salisbury & Ross, 2001). The leaves of a plant are normally its main organs of photosynthesis, and the total area of leaves per unit area of land surface, called leaf area index (LAI), as the best measure of the capacity of crop producing dry matter and called it as productive capital (Arnon, 1972). For dry matter accumulation, LAI differs with the crop and their leaf orientation. Optimum LAI is between 3 to 4 for crops with horizontally oriented leaves and 6 to 9 for crops with upright leaves (Reddy & Reddi, 2005).

4.3 Total dry matter production

The first prerequisite for high yield is a high production of total dry matter per unit area. The amount of dry matter production depends on the effectiveness of photosynthesis of the crop and furthermore, on plants which vital activities are functioning efficiently (Arnon, 1972). The total yield of dry matter is the total amount of dry matter produced, less the photosynthates used for respiration. Finally, the manner in which the net dry matter produced is distributed among the different parts of the plant will determine the magnitude of the economic yield (Arnon, 1972).

Table 6. Dry matter production of French bean as influenced by sowing dates at Rampur, Chitwan

Treatments-Sowing dates	Dry matter (g/plant)				
	Days after sowing				
	30	45	60	75	90
October 21st	3.00a	8.27a	12.46a	22.37a	17.18b
November 5th	1.60b	7.13b	12.42a	14.54b	21.64a
November 20th	1.27b	3.21c	5.07b	10.48c	14.20c
LSD (P= 0.05)	0.63	0.81	1.12	2.97	2.74
CV%	16.93	12.92	13.35	10.20	11.45

Treatments means followed by the common letter(s) within a column are non-significantly different based on DMRT at 5% level of significance.

Total dry matter production of french bean plants was affected by sowing dates at all growth stages (Table 6). The total dry matter production was decreasing with delay in sowing from October 21st to November 20th irrespective of growth stages up to 75 DAS. At these stages, the total dry matter production per plant was significantly higher in October 21st date of sowing than that of November 5th and 20th, but at grain development stage (90 DAS), it was significantly greater in November 5th (21.64 g/plant) than October 21st (17.18 g/plant) and November 20th (14.20

g/plant). This was due to retention of significantly higher dry matter in leaves (7.21 g/plant) and stem (5.96 g/plant) than October 21st (3.15 and 3.86 g/plant, respectively) at 90 DAS. It was one of the reasons for achieving higher grain yield in November 5th than October 21st and November 20th sowing dates.

Significant decrease in total dry matter production of October 21st sowing date at the end of crop period (90 DAS) was related to remarkably declination in leaves and stem dry matter accumulation as compared to November 5th sowing. The accumulation of higher quantity of dry matter in leaves at the pod and grain development stages (60 and 90 DAS) enabled to give significantly higher yield attributing characters (Table 7) consequently yield (Table 8) in crop sown on November 5th than October 21st sowing. The correlation between total dry matter per plant and yield was positive ($r = 0.778^{**}$). In the young plants most of the assimilates are used for the production of stem and leaves. As the plants enter reproductive stage, assimilates are partitioned to stem, leaf and inflorescence. Once the grains are set, most of the assimilates move to the grain (Reddy & Reddi, 2005).

The response of dry matter production to temperature depends on the stage of the crop. Higher temperature at maturity of the crop decreases dry matter production while at early vegetative growth stage it assists to increase (Reddy & Reddi, 2005). Thus, the effect of sowing dates on the growth of the plant in height, formation of leaves per plant and assimilating surface (LAI) was also reflected on total dry matter accumulation by plants. As in other characters, the total dry matter production per plant was significantly higher in October 21st than November 20th due to higher temperature in the vegetative growth stages. However, due to early shedding of old leaves in October 21st date of sowing it was significantly greater in crop sown on November 5th at 90 DAS owing to significantly higher accumulation of dry matter in leaves per plant. This was reflected on yield attributes and grain yield positively. Moreover, the amount of economic yield depends on the manner in which the net dry matter produced is distributed among the different parts of the plant (Arnon, 1972). Although, the dry matter accumulation in leaves was insignificant between November 5th and 20th dates of sowing at 90 DAS, it was poorly distributed to pods in November 20th sown crop than November 5th sowing. Therefore, all yield attributes as well as yield were significantly lower in November 20th than that of November 5th sowing date.

4.4 Yield attributes of French bean:

All yield attributing characters were significantly higher in crop sown on November 5th than early (October 21st) and late (November 20th) sown crops (Table 7). This was due to retention of higher LAI and total dry matter per plant at the end of crop duration (90 DAS) (Basnet, 2009). The differences between early and late sown crops in respect of all yield attributing characters, except thousand grain weight were non-significant. The thousand grain weight was significantly higher in November 5th (488.9 g) sown crop than October 21st (460.3 g) and November 20th (439.4 g) sowings. In the case of shelling percentage, November 5th sowing date was significantly superior to November 20th but at par with October 21st. Significantly lower values of yield attributes obtained in early sown crop of October 21st compared with that of November 5th sowing was related to early (from 75 DAS) and remarkable shedding of leaves (Basnet, 2012). This fact caused a reduction in the supply of assimilates to growing pods and grains in early sown crop (October 21st) than in November 5th sowing.

On the other hand, significantly lower yield attributes recorded in late sown crop of November 20th in comparison to November 5th sowing was associated with prevailing lower temperatures at the early growth stages (Table 2) which retarded crop growth characters. Moreover, higher temperatures at later stages caused a reduction in the supply of assimilates to the growing pods and grains due to higher rate of respiration. Thus, poor growth of the plants and availability of assimilates to growing pods and grains resulted in significantly lower values of yield attributes in November 20th than November 5th sowing. Besides, High temperature stress causes substantial loss in crop yield due to damage of reproductive organs (Savin & Nicolas, 1996) and reduced length of reproductive period.

There was a stiff fall in thousand grain weight with delayed sowing in November 20th compared to both early sown crops because of inadequate vegetative growth due to prevailing of lower average temperatures at the early stages of growth and higher at maturity. This was reflected on grain yield. Sahuet. al. (1995) also observed a sharp decrease in yield of french bean with delayed sowing because of stiff fall in number of pods per plant and thousand grain weight.

Table 7. Yield attributing characters of french bean as influenced by sowing datesat Rampur, Chitwan

Treatments-Sowing dates	Yield attributing characters						
	Branches per plant	Pods per plant	Pod length (cm)	Grains per pod	Grain weight per pod (g)	Thousand grain weight (g)	Shelling percentage
October 21st	4.39^{b}	8.35^{b}	8.82^{b}	2.47^{b}	1.17^{b}	460.30^{b}	76.53^{ab}
November 5th	5.70^{a}	14.37^{a}	9.62^{a}	3.41^{a}	1.67^{a}	488.90^{a}	79.28^{a}
November 20th	4.16^{b}	7.21^{b}	8.57^{b}	2.37^{b}	1.06^{b}	439.40^{c}	74.45^{b}
LSD (P= 0.05)	1.19	5.06	0.75	0.84	0.39	18.27	3.34
Grand mean	4.75	9.97	9.00	2.75	1.30	462.89	76.75
CV%	9.11	12.91	3.06	9.44	9.59	2.19	3.09

Treatments means followed by the common letter(s) within a column are non-significantly different based on DMRT at 5% level of significance. In all treatments, uniform plant population (148.15 thousand/ha) was maintained.

Ahlawat (1995) reported that branches per plant, pods per plant and grains per pod were significantly lower in late sown crop of 15 November as compared to both (15 and 30) October sowings. Moreover, grain per pod decreased significantly with delay in sowing from 15 October to 15 November. The branches per plant recorded in 30 October (4.0) sowing was significantly greater than that of 15 October (3.57) and 15 November (3.31). Further, the pods per plant (5.26) and grains per pod (2.52) obtained in 15 November sown crop was significantly lower with that of 15 October (6.42 and 3.37) and 30 October (6.52 and 3.43, respectively) which were at par with each other.

4.5 Grain yield

Significantly higher grain yield (2.16 t/ha) was obtained in November 5th sowing than early (2.00 t/ha) and late (1.76 t/ha) sown crops (Table 8). Moreover, early sown crop of October 21st was also significantly superior to late (November 20th) sowing. The increments in yield of November 5th sowing date were 8% and 23.42% as compared to October 21st and November 20th, respectively. Further, the yield increased by 14.29% in early sowing (October 21st) than the late one (November 20th).

Variation in temperature at the early stages of growth and development due to different sowing dates affected all growth parameters like plant height, leaf per plant, LAI and total dry matter production per plant significantly (Basnet, 2012). Significantly higher grain yield obtained in November 5th than October 21st and November 20th sowing dates was due to better yield attributing characters which was related to the greater LAI and total dry matter per plant retained at the end of crop duration (90 DAS) (Basnet, 2009). A significant decrease in yield (0.71 t/ha) was obtained by Ahlawat (1995) in late sown crop of 15 November compared with 15 and 30 October (0.97 and 0.99 t/ha) which were at par with each other.

Table 8. Effect of sowing dates on grain yield of french bean at Rampur, Chitwan

Treatments-Sowing dates	Grain yield (t/ha)
October 21st	2.00^{b}
November 5th	2.16^{a}
November 20th	1.75^{c}
LSD (P= 0.05)	0.10
Grand mean	1.97
CV%	8.01

Treatments means followed by the common letter(s) within a column are non-significantly different based on DMRT at 5% level of significance. In all treatments, uniform plant population (148.15 thousand/ha) was maintained.

Similarly, Dutta et. al. (2003) reported a significant decrease in yield with delay in sowing from 16 October (1.31 t/ha) to 15 November (0.45 t/ha). Kakon et.al. (2017) also found in similar field research of French bean in Bangladesh that late sowing crop faces unfavorable weather conditions at its reproductive phase and gave low yield. So, in order to get higher productivity it is essential to select ideal time of planting of French bean because early as well as delay planting causes a substantial reduction in yield (Yadav, 2000). Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield because high temperature is one of the major environmental stresses that affect plant growth and development (Boyer, 1982). Rosenzweig and

Tubiello, 2007 also mentioned that climate variability may heighten the risks of crop failures, often connected to specific extreme events during critical crop phases like flowering.

V. SOWING TIME- AN ADAPTATION PRACTICE TO ADDRESS EFFECT OF CLIMATE CHANGE

Analyses of temperature records from around the world show that many regions are experiencing a warming trend, especially from the 1970s to the present (Cayan et al., 2001). Climate change and variability will affect agricultural systems substantially, requiring farmers to adapt at the same time at the farm level (Rosenzweig & Tubiello, 2007). Nepal has been facing an unpredictable effect of climate change in the form of flood, landslide, drought, untimely onset and exhaust of monsoon almost every year in the recent past however, there is very little to do with mitigation and the adaptation is only way to cope up with effect of climate change (Paudel, 2016). The responses of agricultural systems to such changes is important in regard to impacts and adaptation: for instances, switching to planting dates, changing the cultivars, etc. Optimum sowing date is also most important factor for successful production of any seed crops (Vishwanath et al., 2004). The common Indian beans grow within a range of temperatures of 17.5 to 27^0 C requires a cold climatic condition. Temperature above 30^0 C may cause the bean flower buds to fall and in temperature above 35^0 C bean seeds might not form (www.agrifarming.in/beans-farming-information) whereas low temperature and frost have a negative effect on the metabolism with a corresponding reduction in crop quality and quantity (Kumar etal., 2017). Basnet (2012) mentioned that daily minimum, maximum and high variation of daily maximum and minimum temperature affect the yield attributes and yield of French bean. High temperature stress causes substantial loss in crop yield due to damage of reproductive organs (Savin & Nicolas, 1996). As per the field research of Basnet (2009), the French bean sown on October 21st (early sown crops) was exposed to lower temperature in its critical reproductive stages like flower bud formation, flowering, pod formation and pod development while the November 20th sown (late sown) crop was exposed to higher temperature in pod setting to maturity stages. The November 5th sown French bean (mid-sown crop) was exposed to its reproductive phases to optimum temperature, reflected to higher grain yield production, as compared to the early and late sown crop (Table 2 and Table 3).

VI. CONCLUSION

Agriculture sector has been highly affecting from the climate change impact. For the least developed and developing countries like Nepal, applying the adaptation practices to minimize the climate change impact are the sustainable solutions for successful crop production which is also a low external input approach. Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield because high temperature is one of the major environmental stresses that affect plant growth and development as the early or late sown crop faces unfavorable weather conditions. Thus, in order to achieve higher productivity of French bean (*Phaseolus vulgaris* L.) November 5th can be considered as an optimum time of sowing in the humid sub-tropical condition of Chitwan, Nepal.

AUTHORS' CONTRIBUTIONS

D.B. Banset conducted research and wrote paper. K.B. Basnet and P. Acharya reviewed and provided the suggestions to finalize the paper.

REFERENCES

[1] Acharya, P., Basnet, D. B., & Sanjel, P. K. (2019). Pulses Value Chain Development Activities for Achieving Food and Nutrition Security and Contributing to SDGs: Present Status, Challenges and Way Forward in Nepal. Pulses Value Chain Development for Achieving Food and Nutrition Security in South Asia, Current Status and Future Prospects, SAARC Agriculture Centre and ICRISAT, 94- 114.

[2] Agri-farming. (2021). A step by step guide- Beans farming techniques, tips and ideas (online). www.agrifarming.in/beans-farming-information.

[3] Ahlawat, I. P. S. (1995). Response of french bean (*Phaseolus vulgaris*) genotypes to date of sowing. Indian Journal of Agronomy, 40(1): 117-119.

[4] Ahlawat, I. P. S. (2009). French bean. Indian Agricultural Research Institute, http:// www.irri/org.

[5] Ali, M., & Mishra, J. P. (2004). Rabi pulses. *In*: R. Prasad (ed.) Textbook of Field Crops Production, ICAR, Krishi Anusandhan Bhavan, Pusa, New Delhi, 317-372.

[6] Arnon, I. (1972). Crop production in dry region. Leonard Hill, London, Vol. 1, 650.

[7] Basnet, D.B. (2009). Performance of french bean (*phaseolus vulgaris* l.) as influenced by sowing dates and nitrogen levels in inner Terai, Chitwan. Thesis, M. Sc. Ag. Tribhuvan University, Nepal.

[8] Basnet, D.B. (2012). French Bean Performance with Dates and N2 Management in Chitwan, Nepal: A coping strategy for climate change with different sowing dates and nutrients management system, LAP LAMBERT Academic Publishing.

[9] Begum, A., Ahad, A., Kaisar, M. O., Islam, M. M., & Anam, M. K. (2003). Effect of sowing dates and fertilizer treatments on the reproductive variability of french bean (*Phaseolus vulgaris* L.). Pakistan Journal of Biological Science, 6(22), pp 1897-1901.

[10] Bhurer, K. P., Sah, M. P., Regmi A. P., & Gharti, D. B. (2003). Response of french bean to nitrogen levels. *In*: R. K. Neupane and N. P. Khanal (eds.) Proceedings of National Winter Workshop (Grain Legume), National Grain Legume Research Program, Rampur, Chitwan, Nepal, pp 76-79.

[11] Boyer, J.S. (1982). Plant Productivity and Environmental Science, 218, 443-448.

[12] Cayan, D. R., Kammerdiener, S. A., Dettinger, & M. D. et al. (2001). Changes in the onset of spring in the western United States. B Am Meteorol Soc, 8(3), 399–415.

[13] DADO (2007). Annual report. District Agricultural Development Office, Chitwan, Nepal, p. 49.

[14] Dutta, V. K., Pokhrel, D. N., & Maharjan, R. (2003). Response of rajma bean (*Phaseolus vulgaris*) to different dates of sowing and spacing. *In*: Proceeding of 25th National Winter Crops Legumes, held at NARC, Khumaltar, National Grain Legumes Research Program (NGLRP), Rampur, Nepal, pp. 73-75.

[15] Gopalan, C., Ramasastri, B. V., & Balasubranian, S. C. (1982). Nutritive value of Indian food. ICMR, National Institute of Nutrition, Hyderabad, India, p. 286.

[16] Hardman, L. L., Oplinger, E. S., Schulte, E. E., Doll, J. D., & Worf, G. L. (1990). Dry bean production handbook: Revised (A-602). Cooperation Extension Service, North Dacota, State University, USA, p. 256.

[17] Hunsigi, G., & Krishna, K. R. (1998). Science of field crop production. Oxford and IBM Publishing Co. Ltd., pp. 152-188.

[18] Kakon, S.S., Khan, M.S.A., Choudhury, J.A., Ali, M.Z., & Aziz, M.A. (2017). Influence of sowing time based temperature on flowering and seed yield of french bean (*Phaseolus vulgaris* L.). Agronomy Division, Bangladesh Agricultural Research Institute, SAARC J. Agri., 15(1), 77-84.

[19] Krishnan, P., Swain, S., & Nayak, S. K. (1998). Effect of nitrogen levels on pattern of incremental biomass partitioning in rice (Oryza sativa) at different growth stages. Indian Journal of Agricultural Sciences, 68(4), 189 – 193.

[20] Kumar, R., Chaurasiya, P. C., Singh, R. N., & Singh, S. (2018). Low Temperature Stress for Crop Production: A Review Report. Indira Gandhi Krishi Viswavidyalaya, Raipur, International Journal of Pure and Applied BioScience, 6(2), 575-598.

[21] Neupane, R. K. (2003). Present scenario of winter grain legumes research in Nepal. *In*: Proceedings of National Winter Crop Research Workshop Grain Legumes, NGLRP, NARC, Rampur, Chitwan, pp. 1-9.

[22] Nonnecke, R. (1989). Vegetables Production. Van Notrand Reinhold, New York, USA.

[23] Paudel, M. N. (2016). Consequences of climate change in agriculture and ways to cope up its effect in Nepal. National Agriculture Genetic Resource Center, Khumaltar, Agronomy Journal of Nepal (Agron JN) vol. 4.

[24] Reddy, T. Y., & Reddi, G. H. (2005). Principles of Agronomy (2nd ed.). Kalayani Publisher, New Delhi, India, p. 552.

[25] Rosenzweig, C., & Tubiello, F. N. (2007). Adaptation and mitigation strategies in agriculture: An analysis of potential synergies. NASA Publications, vol. 25.

[26] Rosenzweig, C., Strzepek, K.M., Major, D.C., Iglesias, A., Yates, D.N., McCluskey, A., & Hillel, D. (2004). Water resources for agriculture in a changing climate: International case studies. Global Environ Change, 14:345–360.

[27] Rutkowski, M., & Fordonski, G. (1987). Effect of sowing and harvesting date on field bean yields. Biuletyn-Instytutu-Hodowli-i-Aklimatyzacji-Roslin, 163, 165-174.

[28] Sahu, J. P, Singh, N. P., & Sharma, B. B. (1995). Performance of rajmash genotypes at different dates at different dates of planting. Indian Journal of Pulses Research, 8(1), 25-28.

[29] Salisbury, F. B., & Ross, C. W. (2001). Plant physiology. New Delhi, CBS Publishers, p. 20.

[30] Savin, R., & Nicolas, M. E. (1996). Effect of short periods of drought and high temperature on grain growth and starch accumulation of two malting barley cultivars. Australian Journal of Plant Physiology, 23: 201-210.

[31] Sharma, K. P., Dahal, K. R.,&Neupane, K. R. (1991). An introduction to agronomy. Tribhuvan University Press, Kirtipur,p. 297.

[32] Singh, D. P. (1995). Country report on pulses in India. *In*: Proceeding of FAO Regional Workshop on Pulses in South Asia, New Delhi, India.

[33] Singh, R. C., & Singh, N. (1987). Response of french bean varieties to sowing time. Haryana Agriculture University, Indian Journal of Agronomy, 17 (3), 66-68.

[34] Singh, S. S. (2005). Crop management. Kalyani Publishers, New Delhi, India, p. 538.

[35] Sreelatha, D., Rao, K. Veeraghavaiah, L., R., & Padmaja, M. (1997). Physiological variations in french bean (*Phaseolus vulgaris*) cultivars as affected by sowing dates. Annals of Agricultural Research, 18, 111- 114.

[36] Ustimenko–Bakumovsky, G. V. (1983). Plant growing in tropics and subtropics. Mir Publisher, Moscow. p. 385.

[37] Vaidya, M. L. (2004). Integrated disease management on Phaseolus bean. In: Proceedings of National Winter Crop Research Workshop Grain Legumes, NARI, NARC, Khumaltar, Lalitpur, Nepal, pp. 85-88.

[38] Vishwanath, K., Kalappa, V. P., & Lokesh, K. (2004). Influence of sowing dates on seed yield and quality of French bean (*Phaseolus vulgaris* L.) varieties. Department of Seed Science and Technology, UAS, GKVK, Banglore, Mysore J. Agric. Sci. 38(1), 56-59.

[39] Yadav, C. R. (2000). Production technology of rajmash. Nepal Agriculture Research Council, National Grain Legume Research Program, Rampur, Chitwan, p. 4.