**Advances in Bioresearch**
Adv. Biores., Vol 12 (4) July 2021: 185-191

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.12.4.185191

Advances in Bioresearch

## ORIGINAL ARTICLE

# Effect of plant spacing on the growth and yield attribute of French beans *(Phaseolus vulgaris L.)* under Agri-silvicultural practices in central India

**Wadahunlang Kharsahnoh*, Hemant Kumar, Neeta S. Kerketta, Haurudeiwa Lakiang and Shikha Murmu**
College of Forestry, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj
Email: wada.kharsahnoh@gmail.com

**ABSTRACT**
*A field experiment was conducted to study the effect of plant spacing on the yield improvement and attribute of French beans (Phaseolus vulgaris L.) under Poplar based agroforestry system in the rabi season of year 2019-20 under 9 treatments in a Randomized Block Design with three replications. The seeds were sown with the maintaining plant-plant spacing of 10cm, 15cm and 20cm while the row-row spacing was 20cm, 30cm and 45cm respectively. The method of sowing done for this specific experiment was line sowing method in each plot. On the basis of the results attempted from present investigation it is concluded that significant differences exhibited on growth and yield attribute of French bean with different plant density and spacing under agri-silviculture system. Treatment* $T_5$ *i.e. plant spacing of 15cm x30cm was found to be the best treatment for growth, yield (93.65). This treatment also showed maximum gross return, net return and benefit-cost ratio under poplar based agroforestry system. The implications of the results are discussed in the context of the suitability of the above species in this region and their usefulness in agroforestry systems.*
*Keywords: Agroforestry, French beans, Plant spacing, Yield, Poplar and growth etc.*

Received 01.04.2021 Revised 20.06.2021 Accepted 20.07.2021

**How to cite this article:**
W Kharsahnoh, H Kumar, N S. Kerketta, H Lakiang and S Murmu. Effect of plant spacing on the growth and yield attribute of French beans *(Phaseolus vulgaris L.)* under Agrisilvicultural practices in central India. Adv. Biores. Vol 12 [4] July 2021. 185-191

## INTRODUCTION

Agroforestry is a sustainable management system for land that increases overall production, combines agricultural crops and animals simultaneously. It integrates trees, crops and animals in a way that is scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farmers where woody perennials are deliberately grown on the same land management unit as agricultural crops or animals in some form of spatial arrangement or temporal sequence [1, 23-26]. Agroforestry has a long tradition in the Indian subcontinent. The socio-religious fabric of the people of the subcontinent is interwoven to a very great extent with caring for and respecting trees. Trees are integrated extensively in the crop- and livestock-production systems of the region according to the agro-climatic and other local conditions. Agroforestry practices in the humid tropics are part of a continuum of landscapes ranging from primary forests and managed forests to row crops or grasslands[2]. Agroforestry systems contain 50 to 75 Mg of carbon per hectare compared to row crops that contain less than 10 Mg of carbon per hectare. The difference in carbon content between both systems indicates the mentioned potential for agroforestry systems to store additional carbon, however, possible tradeoffs between carbon storage and profitability in agroforestry systems have to be taken into account [3, 4, 29-31]. The effects of different agroforestry techniques in enhancing the resilience of agricultural systems against adverse impacts of rainfall variability, shifting weather patterns, reduced water availability, soil erosion as well as pests, diseases and weeds is been well tested [20, 21,22]. To cope with some of these challenges and tackle these problems of food and environmental security, the potentials of agroforestry need to be fully exploited. Presently some initiatives are being undertaken by the governments, farmers, non-government organizations and industries in the subcontinent to develop appropriate agroforestry systems and popularize them. According to Kyoto protocol, agroforestry is recognized as an afforestation activity that, in addition to sequestering carbon dioxide ($CO_2$) to soil, conserves biodiversity, protects cropland, works as a windbreak, and provides food and feed to human and livestock, pollen for honey bees, wood for fuel, and timber for shelters construction. Similarly development and enhancement of tree plantation can promotes economic and environmental growth, mitigates deforestation and illegal logging, prevent soil degradation and restores degraded lands in both village as well as urban area of India [5-9]. Agroforestry is more attractive as a land use practice for the farming community worldwide instead of cropland and forestland management systems. This practice is a win–win situation for the farming community and for the environmental sustainability. The implications of the results are discussed in the context of the suitability of the French bean under poplar in this region and their usefulness in agroforestry systems [15, 19].

French bean (*Phaseolus vulgaris L.*) is a member of the Fabaceae family, highly used as vegetables is of American origin but has become quite popular in India. It has also high export potentiality as a food, may be consumed as dried beans or in the fresh state as green beans. They are also widely used as a vegetable when harvested while the young tender pods are still immature. In different locations, these immature pods are referred to as string beans, snap beans, French beans or green beans. They are rich in protein and iron and contain essential nutrients such as ascorbic acid, vitamin A, vitamin B and calcium [10-14]. Green beans are a very valuable crop when cultivated for the fresh market and are a means by which local farmers can diversify their agricultural production. Green beans grown for their tender pods require between 50-75 days, depending upon variety and planting season. It supplies easily digestible protein for the human diet and also rich source of minerals and vitamins [16-18, 30, 31].

*Populus deltoides* belong to the family Salicaceae is an exotic species introduced to India during 1950s is prominently adopted under agroforestry practices in many parts of the country due to its fast growing nature and industrial utility. The most important use of poplar wood is pulp and paper. Poplar wood substitutes well for aspen for pulp and paper products, and is being grown for pulpwood extensively in all parts of the world [28, 29, 5]. Poplar wood has been used locally for construction lumber. It possesses most of the characters suitable for agroforestry systems like property of tolerance to pruning, constricted crown, light branching, tolerance to side shade, efficiency in pumping nutrient materials and leafs flushing or leaf fall that do not affect the ground flora [32-34]].

Plant spacing is another factor that affects the yield contributing characters and yield which can be manipulated to maximize yield. With higher spacing vegetative growth enhances because of less competition of nutrients, light, moisture and space but yield potential decreases. The role of adequate plant spacing regarded as major factor in determining the production of French bean. The plants grown in the wider spacing exhibit more horizontal and continuous vegetative growth due to less population pressure but they also give less yield. However, plants grown under normal spacing will have an optimum population density which provides optimum conditions for luxuriant crop growth and better plant canopy due to maximum light interception, photosynthetic activity, assimilation and accumulation of more photosynthates into the plant system and hence plants can produce more fresh pods with quality seeds [27, 35]. Optimization of plant density for high yielding genotypes by following suitable inter as well as intra row spacing is essential.

## METHODS AND MATERIALS

The present study was carried out during the Rabi season 2019-20 and comprised a field experiment which was laid out at the Nursery of College of Forestry, Sam Higginbottom University of Agriculture, Technology and Sciences Prayagraj, U.P, India. French bean seeds were sown with maintaining the plant-plant spacing of 10cm, 15cm and 20cm while the row-row spacing was 20cm, 30cm and 45cm respectively in a randomized block design (RBD) under total 9 treatment combinations replicated thrice. Seed of French bean cultivars (SPL-BINS) were sown on a ploughed field with a plant to plant spacing of 10cm, 15cm and 20cm, and row-row spacing of 20cm, 30cm and 45cm respectively. At the time of sowing experimental plot was ploughed, well prepared and levelled. Phosphorus and potassium were applied in single dose at the rate of 50 and 40 kg $ha^{-1}$, respectively, while, nitrogen was applied at the rate of 40 kg $ha^{-1}$ in two split doses. All other recommended practices and inputs including hoeing and irrigation were kept uniform for all the treatments from sowing till harvesting.

### Study Area

The experimental site is located in the sub-tropical region with $25^0$ 57′ N latitude, $81^0$ 57′ E longitude and 98 meter above the mean sea level. The climate has been classified as semi-arid with both the extent of temperature during winter and summer. During December to January, the temperature may drop down to as low as 2˚C, while it may exceed to 47˚C during May- June. Frost during winter and hot air during summer are common occurrences. The average annual rainfall is about 1100 mm with maximum concentration during July to September and with occasional showers during winter season. It comes under subtropical climate receiving the mean annual rainfall of about 1100mm, major rainfall from July to end of September. However, occasional precipitation was also not uncommon during winter. The winter months were cold while summer months were very hot and dry. The minimum temperature during the crop season was to be 5.9 $^0$C and the maximum is to be 29.04 $^0$C. The minimum humidity was to be 42.72.0% and maximum was to be 93.28%.

**Statistical analysis:** The data recorded during the course of investigation were subjected to statistical analysis of variance, (ANOVA) as suggested by Fisher, 1950. The significance of the treatment effect was judged with the help of "F" variance ratio test. Calculated "F" value (Variance ratio) was compared with the tabulated value of "F" at 5 % level of significant, otherwise the effect is considered non- significant. The significant difference between the mean was tested against the critical difference at 5% level of significance.

## RESULTS AND DISCUSSION

The purpose of present study is to analyze result of the French bean under agroforestry systems, in order to try and identify the growth and yield considerations that have caused farmers to adopt those [2]. Plant interaction is common in agroforestry system that has direct or indirect detrimental or advantageous effects of one plant to another. Their effects through the release of the secondary metabolites or waste products of plants into the environment through leaching root exudation, volatilization and decomposition of plant residues. The results of the experiment have been presented in tables wherever required, and discussed in the light of the findings reported by earlier researchers. The observations were recorded under the following parameters.

### Plant height (cm)

The effect of plant spacing to plant height of French beans is presented in table 1shows significance differences in all treatments. The plant height as influenced by spacing and their interaction. Plant height increased with time from 20DAS to 90DAS in all the treatments. Plant spacing of 15 cm x 30 cm recorded the highest plant height attaining 32.063cm at 90 DAS. The shortest plant height was observed at plant spacing of 20cm x 45cm as increase in the plant spacing results in decrease in growth of French beans.

**Table 1: Effect of plant spacing on plant height of French Beans (*Phaseolus vulgaris*) under Poplar based Agroforestry System.**

| Treatment | Plant height at 30days | Plant height at 60days | Plant height at 90days |
|---|---|---|---|
| $T_1$ [10cm x 20 cm] | 12.7 | 20.6 | 29.7 |
| $T_2$ [15cm x 20 cm] | 14.0 | 24.6 | 30.6 |
| $T_3$ [20cm x 20 cm] | 11.6 | 21.1 | 28.4 |
| $T_4$ [10cm x 30 cm] | 10.6 | 17.3 | 28.5 |
| $T_5$ [15cm x 30 cm] | 14.8 | 26.6 | 32.0 |
| $T_6$ [20cm x 30 cm] | 11.4 | 20.4 | 28.5 |
| $T_7$ [10cm x 45 cm] | 10.5 | 17.4 | 26.8 |
| $T_8$ [15cm x 45 cm] | 10.5 | 18.0 | 28.4 |
| $T_9$ [20cm x 45 cm] | 11.2 | 19.6 | 28.3 |
| C.D. | 1.408 | 0.553 | 2.558 |
| SE(m) | 0.466 | 0.183 | 0.846 |

### No. of leaves per plant

Significant differences in leave number among treatments were observed after 30DAS and 60DAS as well as in 90DAS (Table2). Plant spacing of 15cm x 30cm expressed the highest number (26.3) of leaves at 90DAS whereas the minimum (23) was recorded at plant spacing of 10 cm x 20 cm as closer spacing results in minimum number of leaves per plant due to competition for sunlight and nutrients [7].

 

**Table2. Effect of plant spacing on number of leaves per plant of French Beans (*Phaseolus vulgaris. L*) under Poplar based Agroforestry System.**

| Treatment | No. of leaves per plant at 30days | No. of leaves per plant at 60days | No. of leaves per plant at 90days |
|---|---|---|---|
| $T_1$ [10cm x 20 cm] | 2.2 | 11.0 | 23.0 |
| $T_2$ [15cm x 20 cm] | 1.9 | 10.7 | 24.1 |
| $T_3$ [20cm x 20 cm] | 2.1 | 11.0 | 24.7 |
| $T_4$ [10cm x 30 cm] | 1.9 | 10.1 | 24.2 |
| $T_5$ [15cm x 30 cm] | 2.4 | 12.4 | 26.3 |
| $T_6$ [20cm x 30 cm] | 2.0 | 10.9 | 24.7 |
| $T_7$ [10cm x 45 cm] | 1.8 | 9.8 | 24.0 |
| $T_8$ [15cm x 45 cm] | 1.8 | 9.2 | 23.5 |
| $T_9$ [20cm x 45 cm] | 1.8 | 9.6 | 23.8 |
| C.D. | 0.275 | 0.927 | N/A |
| SE(m) | 0.091 | 0.306 | 0.847 |

**No of branches**

The effect of plant spacing to number of branches of French beans is presented in table 1shows significance differences in all treatments. The numbers of branches are influenced by spacing and their interaction. Significant differences in branch number among treatments were observed after all interval of time (Table3). Plant spacing of 15 cm x30 cm produced the highest number (11.6) of branches at 90DAS whereas it was found that the minimum branch number(6.4) was recorded at plant spacing of 10 cm x 20 cm as wider spacing results in the increase of number of branches per plant than closely sowed plants [7].

**Table3: Effect of plant spacing on number of branches per plant of French Beans (*Phaseolus vulgaris .L* ) under Poplar based Agroforestry System.**

| Treatment | No. of branches at 30 days | No. of branches at 60 days | No. of branches at 90 days |
|---|---|---|---|
| $T_1$ [10cm x 20 cm] | 2.9 | 5.6 | 6.4 |
| $T_2$ [15cm x 20 cm] | 3.3 | 7.1 | 8.8 |
| $T_3$ [20cm x 20 cm] | 3.5 | 7.4 | 9.0 |
| $T_4$ [10cm x 30 cm] | 3.0 | 6.9 | 8.8 |
| $T_5$ [15cm x 30 cm] | 4.8 | 8.1 | 11.6 |
| $T_6$ [20cm x 30 cm] | 2.6 | 6.4 | 9.1 |
| $T_7$ [10cm x 45 cm] | 3.1 | 7.0 | 8.8 |
| $T_8$ [15cm x 45 cm] | 2.7 | 6.3 | 9.8 |
| $T_9$ [20cm x 45 cm] | 2.4 | 6.4 | 10.0 |
| C.D. | 0.297 | 0.733 | 0.541 |
| SE(m) | 0.098 | 0.242 | 0.179 |

**Yield attributes**:

Green French bean were plucked regularly on their maturity and cumulative data for experimental plot were recorded at the end on yield attributes. Yield attributes differ significantly in almost all treatment with spacing combinations.

**No. of Pods per plant**

The no. of pods per plant was recorded at harvest, is presented in Table 4 shows that there is a significant effect of different treatments on the number of pods per plant. There was a marked influence due to the different plant spacing on the number of pods per plant. A perusal of data indicated that the treatment $T_5$ [with Plant Spacing of 15x30cm] was recorded maximum pods per plant(30.25), followed by $T_8$ (25.41) [with Plant Spacing of 15x45cm], while minimum (17.03) in treatment $T_2$ [with Plant Spacing of 15x20cm] .

 

**Table4: Effect of plant spacing on number of pods per plant of French Beans (*Phaseolus vulgaris*) under Poplar based Agroforestry System.**

| Treatment | Pods per plant (no.) | Length of pod (cm) | Width of pod (cm) | Seeds per pod (no.) | Pod yield (kg) | Pod Yield (t/ha) |
|---|---|---|---|---|---|---|
| $T_1$ [10cm x 20 cm] | 20.76 | 10.34 | 0.42 | 5.35 | 2.36 | 35.39 |
| $T_2$ [15cm x 20 cm] | 17.03 | 10.05 | 0.44 | 5.85 | 2.66 | 51.09 |
| $T_3$ [20cm x 20 cm] | 23.20 | 12.04 | 0.45 | 6.42 | 2.47 | 44.10 |
| $T_4$ [10cm x 30 cm] | 18.29 | 12.04 | 0.40 | 6.40 | 2.45 | 40.72 |
| $T_5$ [15cm x 30 cm] | 30.27 | 15.72 | 0.55 | 8.12 | 3.19 | 93.65 |
| $T_6$ [20cm x 30 cm] | 21.14 | 12.79 | 0.43 | 5.66 | 3.11 | 53.11 |
| $T_7$ [10cm x 45 cm] | 17.80 | 12.49 | 0.45 | 5.98 | 2.68 | 53.43 |
| $T_8$ [15cm x 45 cm] | 25.42 | 13.25 | 0.47 | 5.37 | 2.64 | 49.74 |
| $T_9$ [20cm x 45 cm] | 17.18 | 14.96 | 0.47 | 6.21 | 2.68 | 53.43 |
| C.D. | 4.203 | 2.73 | N/A | 1.216 | 0.321 | 2.36 |
| SE(m) | 1.39 | 0.903 | 0.037 | 0.402 | 0.106 | 7.08 |

**Pod length (cm)**

The pod length was recorded at harvest, is presented in Table 4 shows that there is a significant effect of different treatments on the pod length. A perusal of data indicated that the treatment $T_5$ with Plant Spacing of 15x30cm recorded maximum pod length (15.72cm), followed by $T_8$ (13.25cm) with plant spacing of 15x45cm while the minimum (10.05cm) in treatment $T_2$ with Plant Spacing of 15x20cm.

**Pod width (cm)**

The data on pod width was recorded at harvest, is presented in Table4 shows that there is a non-significant effect of different treatments on the pod width. A perusal of data indicated that the treatment $T_5$ with Plant Spacing of 15x30cm was recorded maximum pod width (0.55cm), followed by treatment $T_8$ (0.47cm) with spacing of 15x45cm, while minimum (0.40cm) in treatment $T_4$ with Plant Spacing of 10x30cm.

**Number of seeds per pod**

The number of seeds per pod was recorded at harvest, is presented in Table 4. The data shows that there is a significant effect of different treatments on the number of seeds per pod. A perusal of data indicated that the treatment $T_5$ with Plant Spacing of 15x30cm was recorded maximum number of seeds per pod (8.12), followed by $T_3$ (6.42) with with Plant Spacing of 20x20cm, while minimum (5.21) in $T_9$ with plant spacing of 20x45cm.

**Pod yield (kg)**

The Pod yield/plant (kg) recorded at harvest is presented in Table4. The data shows that there was a significant effect of different treatments on the Pod yield/plant (kg).A perusal of data indicated that the treatment $T_5$ with Plant Spacing of 15x30cm was recorded maximum pod yield (3.18) followed by $T_6$ (3.11) with Plant Spacing of 20x30cm while treatment $T_1$ recorded the minimum (2.363).

**Pod yield (t ha$^{-1}$)**

The Pod yield/plant (t ha$^{-1}$) recorded at harvest is presented in Table 4. The data shows that there was a significant effect of different treatments on the Pod yield/plant (t ha$^{-1}$).A perusal of data indicated that the treatment $T_5$ with plant spacing of 15x30cm was recorded maximum pod yield (93.61) followed by treatment $T_7$ (53.43) with plant spacing of 10x45cm while minimum recorded in $T_6$ with plant spacing of 20x30cm.

The presence of a plant changes the environment of its neighbors and may alter their growth rate and form. Such changes in the environment, brought about by the proximity of individuals are termed as "interference" [16]. The plants grown in the wider spacing exhibit more horizontal and continuous vegetative growth due to less population pressure but they also give less yield. However, plants grown under normal spacing will have an optimum population density which provides optimum conditions for luxuriant crop growth and better plant canopy due to maximum light interception, photosynthetic activity, assimilation and accumulation of more photosynthates into the plant system and hence plants can produce more fresh pods with quality seeds [26]. The increase in plant height, number of leaves and number of branches as well as the increase in the yield attributes of the crop with the decrease in plant spacing as closer plant spacing increases the number of plants in a unit area and crowded plants struggle among themselves for sufficient sunlight and spacing that resulted in increase of growth and yield of French bean plants. Decrease in plant spacing also results in higher density of French beans. The individual plants might contribute cumulatively towards more yield than more spaced plants. Hence, the decrease in the value of growth and yield attributes in the various treatments with wider spacing [24].

 

Sparse plant population with wider spacing results in higher yield per plant but lower yield per unit area. This was also in agreement with the study of Ball RA *et al*., [5] who reported that increasing plant population reduced yield of individual plants but increased yield per unit area of common beans. Similarly Abubaker reported superior yield from the high plant populations over that of low plant population of haricot beans

## CONCLUSION

On the basis of the results attempted from present investigation conducted, it is concluded that significant differences exhibited on growth and yield attribute of French bean with different plant density and spacing under agri-silviculture system. Treatment $T_5$ i.e. plant spacing of 15cm x 30cm found to be the best treatment for growth, yield (93.65) over others. This treatment also showed maximum gross return, net return and benefit: cost ratio. Hence spacing 15cm x 30cm is recommended to farmers for higher yield and profit.

## ACKNOWLEDGMENT

The authors are grateful to the College of Forestry, Sam Higginbottom University of Agriculture Technology and Sciences, (Formerly Allahabad Agriculture Institute), Prayagraj, India for providing all necessary helps and facilities during the course of experiment and valuable comments of anonymous reviewers helped us a lot to improve this manuscript.

## REFERENCES

1. Adigun, J., Osipitan, A.O., Lagoke, S.T, Adeyemi, R.O. and Folami S.O. (2014). Growth and Yield Performance of Cowpea [*Vignaunguiculata.(L)Walp*] as Influenced by Row-Spacing and Period of Weed Interference in South-West Nigeria*. J Agri Sci*.6 (4): 188-198.
2. Agarwal, Yogesh Kumar, Ramchandra, Hemant Kumar and Anil Kumar (2020). Performance analysis and economics of coriander (*coriandrum sativum* l.) cultivation under subabul (*leucaena leucocephala*) based alley cropping system, *Plant Archives,* 20(1)1970-1974.
3. Ahlawat, I.P.S., (1996), Response of French beans ( *Phaseoulus vulgaris. L*) varieties to plant density and phosphorus level*. Indian J. Agric. Science*., 66 (6) : 338 – 42
4. Ahmed Naveed, Razaq Muhammad, AlamHasnain, and Salahuddin, (2016). Response of French Bean Cultivars to Plant Spacing Under Agroclimatic Condition of Baffa, *Journal of Northeast Agricultural University (English Edition)*, Vol. 23 No. 1 16-19.
5. Ball, J., Carle, J., Del,Lungo.A. (2005).Contribution of poplars and willows to sustainable forestry and rural development.Unasylva; 56(221):8-9.
6. Bokade, (2008).Effect of spacing and fertilizer von growth, yield and quality of yard long bean (*Vignaunguiculata sub spsesquipedalis*) var. 'KonkanWali'. M.Sc. (Horti) thesis submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.
7. Chakravorty, S.,Ghosh, C., MandalJoydip,(2009).Effect of Spacing on Growth and Yield of French Bean (*Phaseolus vulgaris L.)* " in Red and Lateritic Belt of West Bengal, Department of Crop Improvement, Horticulture & Agricultural Botany Institute of Agriculture. Vlsva-Bharati Sriniketan 731236.*India, Environment & Ecology* 27 (2): 493-495.
8. ChaudarySanjai, (2009), Growth and yield of French bean (*Phaseolus vulgaris L*.) as influenced by different levels of row spacing, seed rate and nitrogen, *International Journal of Agricultural Sciences, June to December*, 2009, Vol. 5 Issue 2 : 549-551.
9. Dev, H. (2010). Standardization of planting time and spacing in French bean cv. Lakshmi as autumn crop for lower hills of Northern India. *Asian J. Horti.*5(2): 318-320
10. Dhanjal,R., Prakash Om, Ahlawat, I.P.S, (2001). Response of french bean (*Phaseolus vulgaris*) varieties to plant density and nitrogen application, *Indian Journal of Agronomy*,Volume:46,Issue: 2.
11. Dhillon, T.S., Dhall. R.K. (2016), Seed Production of French Bean,Training Programme on seed Production and certification, Punjab Agricultural University, Ludhiana, Punjab.
12. Dusabumuremyi, P., Niyibigira, C., Mashingaidze, A.B. (2014). Narrow row planting increases yield and suppresses weeds in common bean (*Phaseolus vulgaris* L.) in a semi-arid agro-ecology of Nyagatare, Rwanda, *Crop Protection*, Volume 64.
13. Gebremariam Gebrelibanos, BarakiFiseha, (2018). Effect of Inter Row and Intra Row Spacing on Yield and Yield Components of Mung Bean (*Vignaradiata L*.) in Northern Ethiopia,*IJEDR* | Volume 6, Issue 1 | ISSN: 2321-9939, 2018.
14. GetachewEssubalew, Mohammed Ali, TesfayeAbush, (2015). Impact of sowing date and plant spacing on yield, quality and disease incidence of Snap bean (*Phaseolus vulgaris l.*) varieties at Jimma Southwestern, Ethiopia, *Global Advanced Research Journal of Educational Research and Review* (ISSN: 2315-5132) Vol. 4(5) pp. 081-089, May, 2015.
15. Ghosh, D.K and Bandhopadhyay, A. (2008). Effect of different spacing of French bean (*Phaseolusvulgaris.L*) on its growth and yield grown as inter crop with coconut. *Indian Coconut J*.38(12): 19-22

 

16. Hasani, Ali.andHasani, Maryam. (2017). Effect of planting on the yield of mung bean ( Vigna radiate to L.) at Sardasht of Khuzestan. *Journal of Research in Ecology, An International Scientific Research Journal*.(ISSN: Print: 2319-1546; Online: 2319-1554).
17. India State of Forest Report (ISFR) (2019), PO- Kaulagarh, Dehradun, U.K
18. Jain, K. S., Singh Parmatma, 1999. Performance of Intercrops in Agroforestry System : the Case of Poplar (*Populusdeltoides*) in Uttar Pradesh (India)Volume 125, Issue 2, Febraury 1999.
19. Kabir, M.H., Sarkar, M.A.R. 2008. Seed yield of mungbean as affected by variety and plant spacing in Kharif-I season, *J. Bangladesh Agril. Univ*. 6(2): 239-244,2008.
20. Kamarr, S.M. A. H. M, IsramrM. K, KawocharsM. A, MahfuzM.S, Savem M.A,2015, Effect of mulching on growth and yield of French Bean, *Bangladesh J. Environ. Sci*., Vol. 19,63-66,2010.
21. Koli, B. D., Shaikh, A.A. and Akashe, V.B. (1996).Uptake pattern of N, P and K of French bean as influenced by row spacings, plant densities and nitrogen levels*. PKV Res. J*. 20(1): 80-81
22. Kumar Tiwari, Ashwini, ChaubeyTribhuvan , (2017). Quality seed production of French bean, Assistant Professor (Horticulture), Fiji National University, Fiji Principal Scientist, ICAR-IIVR, Varanasi.
23. Manna Dulal Chandra, Ray Prabuddh, 2015, Assessment of Ideal Crop Geometry for Yield Improvement of French Bean during Rabi Season under Irrigated Medium Land Situation of Birbhum District.
24. MasaMaguje, TanaTamado, Ahmed Abdulatif, 2017. Effect of Plant Spacing on Yield and Yield Related Traits of Common Bean (*Phaseolus vulgaris L*.) Varieties at Areka, Southern Ethiopia*, Journal of Plant Biology & Soil Health*, December 2017 Vol.:4, Issue:2
25. Moniruzzaman, M.,Halim, G. M. A., Firoz, Z. A., 2009, Performances of French Bean as influenced by plant density and nitrogen application, *Bangladesh J. Agril. Res.* 34(1) : 105-111
26. Mozumder, S.N., Moniruzzaman, M., Islam, M.R., Alam, S.N. 2003.Effect Of Planting Time And Spacing On The Yield Performance Of Bushbean (*Phaseolus vulgaris L*.) in the Eastern Hilly Area of Bangladesh*, Legume Research*, 26(4):242-247.
27. Muchira Bernard, Kamau Peter, Mushimiyimana David, 2018.Effects Of Spacing And Fertilization On Growth And Grain Yields Of Mung Beans [*Vignaradiata (L) wilckzeck*] In Dry Areas Of Subukia, Kenya, *International Journal of Advanced Research and Publications* ISSN: 2456-9992,Volume 2 Issue 7, July 2018.
28. Mureithi, D. M., Onyango, M. O., Jeruto, A. P. and Gichimu, B. M. (2012).Response of French bean (*Phaseolusvulgaris.L*) to intra-row spacing in Maseno Division, Kenya.*J. of Applied Sci*. 12(1): 96-100.
29. Parvez, M.N., Islam, M. S., Islam, M.R., Islam, A.K.M., Mondal, M.F. 2006. Effects of plant spacing and mulching on growth and yield of French Bean, *J. Bangladesh Soc. Agric. Sci. Technol*., 3 [3 and 4]; 161- 164, 2006.
30. Pathak, P., Hemant Kumar, G., Kumari and Halliru Bilyaminu 2016. Biomass production potential in different species of bamboo in central Uttar Pradesh, *The Ecoscan*. 10(1and2): 41-43.
31. Sahariar, M.S.,Karim, M .R.,Nahar, MA., Rahman, M., Islam, M.U. 2015. Influence of mulching and plant spacing on growth and yield of French bean (*Phaseolus vulgaris L*.), *Progressive Agriculture* 26: 129-135, 2015.
32. Saresh, N. V., Verma, Archana, Rana, D. S., Bhardwaj, Ravi, Mahantesh, B., Hulikatti, Raghavendra, S. M., and Sankanur, M. S. (2018). Poplar (*Populusdeltoides*) based Agroforestry Systems: an economically viable livelihood option for the farmers of North India. In book: Climate Change and Agroforestry Adaptation, Mitigation and Livelihood Security, Publisher: New India Publishing Agency.pp579.
33. Sharma, V. K., Pathania, P. and Sharma, G. D. (2008).Response of French bean (*Phaseolus vulgaris.L*) varieties to sowing dates and plant density in cold desert region.*Legume Res*. 31(3): 230-231.
34. Singh Guriqbal, Bains, T.S., (2011). Effect of Plant Density on the Growth and Yield of Mungbean [*Vignaradiata (L.)Wilczek*] Genotypes under Different Environments in India and Taiwan, International *Journal of Agricultural Research*6(7):573-583.
35. Singh, D.P., Rajput, A.L., Singh, S.K. (1996). Response of French bean (*Phaseolus vulgaris*) to spacing and nitrogen levels.