Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
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Journal of Applied Sciences 12 (1): 96-100, 2012
ISSN 1812-5654 / DOI: 10.3923/jas.2012.96.100
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Response of French Bean (*Phaseolus vulgaris* L.) to Intra-row Spacing in Maseno Division, Kenya

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Abstract: The objective of this study was to evaluate the effect of intra-row spacing on growth of French bean (*Phaseolus vulgaris* L.) in Maseno Division, Kenya. The study was carried out at Maseno University Horticultural Farm. Intra-row spacing of 10, 15, 20 and 30 cm were evaluated in a randomized complete block design. Growth parameters of plant height, leaf number and branch number were measured on a weekly basis starting two weeks after sowing up to the sixth week. Leaf area and plant dry weight were measured once at six weeks after sowing. The data was subjected to Analysis of Variance (ANOVA) and differences declared significant at 5% level. Increasing intra-row spacing from 10 to 15 to 20 cm resulted in significant ($p<0.05$) increase in all the growth parameters that were measured except plant height. Increasing the spacing further to 30 cm between plants resulted in significant decrease in growth rate. Although intra-row spacing of 20 cm produced the highest growth rate, cost benefit analysis could be ideal to justify its recommendation over intra-row spacing of 15 cm.

Key words: French bean (*Phaseolus vulgaris* L.), Intra-row spacing, plant density

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is the most important export vegetable in Kenya accounting for over 60% of all exported vegetables and about 21% by value of the horticultural exports (Nderitu *et al*., 2007a). It ranks second after cut flowers in terms of volume and value among export crops (Nderitu *et al*., 2007b). French bean exports in Kenya have been more or less constant but the area under production has been declining (Voor den Dag, 2003) suggesting that agronomic practices have been changing. French beans are nutritionally rich in vitamin A, vitamin C, iron and calcium which can contribute significantly to mixed diets (Kelly and Scott, 1992).

Production of French beans is mainly by small to medium scale farmers and the enterprise creates on-farm employment opportunities for the rural community, especially youth and women. Inappropriate plant density has accounted for poor yields of most of the small scale farmers (Ngugi *et al*., 1982). If plants are widely spaced, not all land area is covered by leaves and much of the light available for photosynthesis is wasted. Resources of water and mineral nutrients in the soil are similarly underutilized. On the other hand, if plants are overcrowded, there is competition for water and minerals salts in the soil, as well as light because their leaves begin to shade one another (Forbes and Watson, 1992).

Among the various factors that contribute towards the attainment to potential yield of french bean, optimum plant spacing or plant population is one of the important factor (Pawar *et al*., 2007). French bean is grown as a mono crop mostly by small scale farmers on farm sizes of between 0.25 and 1 ha (Nderitu *et al*., 2007a) and therefore, plant spacing is of utmost importance. Optimization of plant density for high yielding genotypes by following suitable inter as well as intra row spacing is essential. The objective of this study was therefore to investigate the effect of intra-row spacing on growth of French bean.

MATERIALS AND METHODS

Materials: The research was conducted in Maseno University Horticultural Farm. The farm is located in Maseno division, Kenya within the upper midland Agro-ecological zone; located between latitude 5°S and 5°N and longitude 34°30' E at an altitude of 1463 M above sea level. The area receives a bimodal mean annual rainfall of 1510-1678 mm with the first rainy season falling between March and August and the second season falling

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between September and early March (Jatzold and Schmidt, 1982). The mean annual temperature is 28.7°C with the hottest season occurring between January and April (Gichimu *et al*., 2009). The soils are classified as dystric nitisols. They are well-drained, deep reddish brown, slightly friable clay with pH ranging between 4.5 and 5.4. Soil organic carbon and phosphorous content are 1.8% and 4.5 mg kg^{-1}, respectively (Gichimu *et al*., 2009). French bean variety tokai was used during the experiment.

Methods: Intra-row spacing of 10, 15, 20 and 30 cm were evaluated in a randomized complete block design with three replicates each measuring 1.5 M^2. The inter-row spacing was set at 30 cm in all the plots. Well-decomposed cattle manure was incorporated into the soil at a rate of 10 ton ha^{-1} before sowing. DAP fertilizer was applied as a basic dressing at a rate of 200 kg ha^{-1}. Two seeds per hill were planted and thinned to one plant per hill two weeks after sowing. Top dressing with CAN was applied in two splits, first at two leaf-stage and then at onset of flowering. Other cultural practices including weeding, pest and disease control and irrigation were conducted in a similar manner in all the plots during the experimental period.

Data collection and analysis: Plant height, leaf number and branch number were measured on three tagged plants per plot on a weekly basis starting two weeks after sowing upto the sixth week. Leaf area and plant dry weight were measured destructively at six weeks after sowing. The data was subjected to Analysis of Variance (ANOVA) and differences declared significant at 5% level.

RESULTS AND DISCUSSION

The effect of intra-row spacing to plant height of French beans is shown in Fig. 1. Plant height increased with time from the second to the sixth week in all the treatments. Significant results were not obtained until after the 5th week. Intra-row spacing of 10 and 15 cm recorded the highest plant height attaining 19 cm at six weeks after planting but were not significantly ($p>0.05$) different from intra-row spacing of 20 cm. The shortest plant height was observed at intra-row spacing of 30 cm.

Significant differences in branch number among treatments were observed after the 3rd week (Fig. 2). Intra-row spacing of 20 cm produced the highest number of branches which was statistically similar to that of 15 cm but significantly ($p<0.05$) different from those of 10 and 30 cm which were also statistically similar.

Leaf number increased with time in all the four treatments with significant differences being observed as

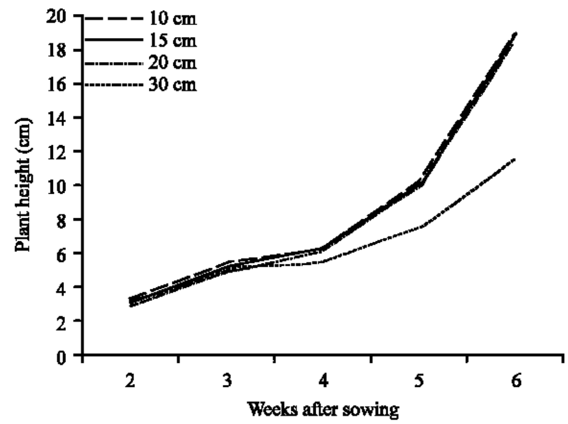

Fig. 1: Effect of intra-row spacing on plant height

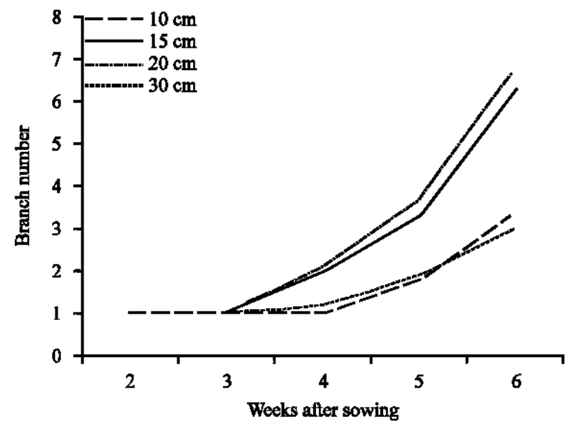

Fig. 2: Effect of intra-row spacing on branch number

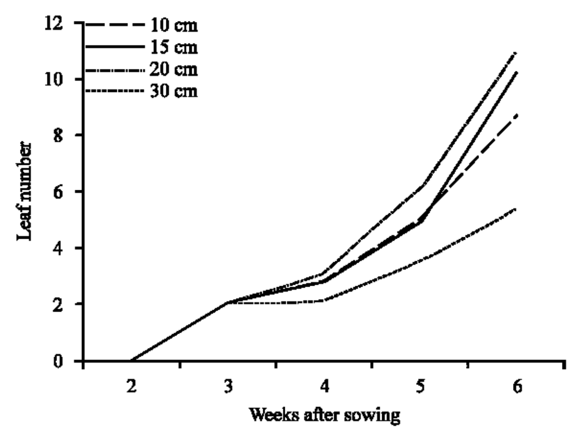

Fig. 3: Effect of intra-row spacing on leaf number

from the fourth week after sowing (Fig. 3). The closest intra-row spacing of 10 and 15 cm produced statistically equal number of leaves until after six weeks when the latter recorded significantly higher number of leaves (10.2)

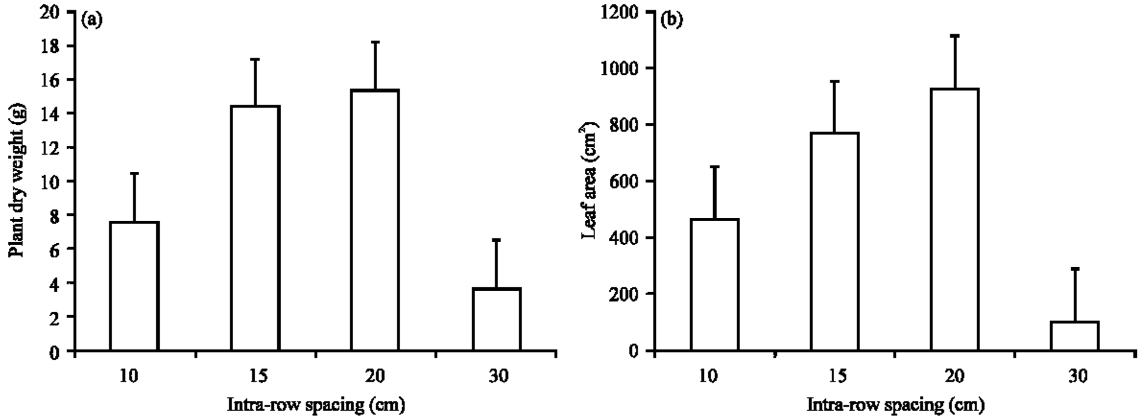

Fig. 4(a-b): Effect of intra-row spacing on (a) plant dry weight and (b) leaf area

than the former (8.7). The widest intra-row spacing of 30 cm produced the least number of leaves while the highest leaf number was observed at a spacing of 20 cm between plants.

Plant dry weight increased significantly ($p<0.05$) with increased intra-row spacing upto 20 cm beyond which it decreased (Fig. 4a). However, there were no significant differences between intra-row spacing of 15 and 20 cm. The spacing of 30 cm between plants produced the lowest dry weight followed by that of 10 cm. Leaf area also increased significantly ($p<0.01$) with an increase in intra-row spacing up to 20 cm beyond which it decreased significantly as evident in Fig. 4b. The four treatments were significantly ($p<0.05$) different from each other with the biggest leaf area being observed at a spacing of 20 cm between plants. Interestingly, the widest intra-row spacing of 30 cm produced the smallest leaf area.

The presence of a plant changes the environment of its neighbours and may alter their growth rate and form. Such changes in the environment, brought about by the proximity of individuals are termed as "interference" (Harper, 1977). The increase in plant height with decreased intra-row spacing is consistent with the studies done on legumes (*Vicia faba*) that indicate that legumes respond to shading and density stress by etiolation (Harper, 1977). This is increase in height brought about by elongation of internodes rather than increase in their number (Harper, 1977). Pawar *et al.* (2007) reported increase in plant height in densely planted French beans. Similar results were also reported by Ahlawat (1996) and Dhanjal *et al.* (2001). Etiolation is mostly caused by competition for light among plants. When the plants are sown closely together, their stems are shaded from light resulting in accumulation of auxin which is a major growth hormone that stimulates cell division and enlargement (Weaver, 1972). In sparsely spaced plants, auxin destruction by light occurs resulting in plants being shorter.

There was increase in branch number and leaf number with increased intra-row spacing (decreased plant density) up to a certain limit (20 cm between plants) beyond which reduced branch and leaf number was observed. These results are in conformity with Koli and Akashe (1995). Chatterjee and Som (1991) also reported increased branch number with increased intra-row spacing in French beans. In addition, Fawusi *et al.* (1982) indicated that increasing plant density in cowpea resulted in decreased branch and leaf number per plant. The results also concurs with Harper (1977) who indicated that legumes respond partly to density by reduction of some plant parts; leaves, branches, flowers, fruits and even root-lets. He added that such population-like structure of an individual plant enables it to respond to stresses by varying the birth rate and the death rate of its parts (Harper, 1977). Dhanjal *et al.* (2001) and Mozumder *et al.* (2003) also attributed increased growth rate in sparsely populated plants to less competition for space, nutrients, moisture and light.

Plant leaf area was also found to increase with decreased plant density up to intra-row spacing of 20 cm. Previous studies done on maize (Harper, 1977) indicated that plants respond to density stress by a reduction in leaf area per plant as was the case with this French bean experiment. However, reduced leaf area observed at the widest intra-row spacing of 30 cm could not be explained. Since plant leaf area was measured destructively, it was not possible to measure the actual pod yield as the experiment was terminated six weeks after planting. Plant dry weight was therefore used as an indicator of yields. The increase in mean dry weight of French beans with increase in intra-row spacing concurs with Harper (1977) who reported that plants respond to density stress by a reduction in biomass of the plant. Koli and Akashe (1995) reported increased dry weight in French beans with increase in row spacing. The mass per plant is affected according to the intensity and duration of the interference and biomass accumulation varies as a reciprocal of density (Loomis and Connor, 1996).

Competition for light, CO_2, moisture and nutrients among closely spaced plants could have lead to reduction in branch number, leaf number, leaf area and plant dry weight as higher plants react to stresses of density by plastic responses as well as altered risk of death (Harper, 1977). The low dry weight observed at the widest intra-row spacing of 30 cm was in conformity with Kwapata *et al.* (1990) who observed greater dry-matter production in cowpea at higher plant density. This was attributed to differences in amounts of Photosynthetically Active Radiation (PAR) intercepted by crop canopies and in the efficiency of light conversion into biomass. The same could have caused the low branch and leaf number observed at widest intra-row spacing of 30 cm. Reduced leaf area observed at this particular treatment could also have played a role in reduction of branch number, leaf number and plant dry weight.

CONCLUSION

It was evident from this study that plant density plays a major role in growth and yield regulation. Although intra-row spacing of 20 cm produced the highest growth rate, cost benefit analysis could be ideal to justify its recommendation over intra-row spacing of 15 cm. This study used plant dry weight as an indicator of yield but further research to investigate the effect of intra-row spacing on actual yields of French beans could be ideal.

ACKNOWLEDGMENTS

We thank Maseno University for providing the land, French Bean seeds, fertilizers and laboratory equipments and/or machines used in growth measurements.

REFERENCES

Ahlawat, I.P.S., 1996. Response of French bean (*Phaseolus vulgaris* L.) varieties of plant density and phosphorus level. Indian J. Agric. Sci., 58: 263-267.

Chatterjee, R. and M.G. Som, 1991. Response of French bean to different rates of P, K and plant spacing. Crop Res., 4: 214-217.

Dhanjal, R., O. Prakash and I.P.S. Ahlawat, 2001. Response of French bean (*Phaseolus vulgaris* L.) varieties to plant density and nitrogen application. Indian J. Agron., 46: 277-281.

Fawusi, M.O.A., S.B.C. Wanki and D. Nangju, 1982. Plant density effects on growth, yield, leaf area index and light transmission on intercropped maize and *Vigna unguiculata* (L.) Walp. in Nigeria. J. Agric. Sci., 99: 19-23.

Forbes, J.C. and R.D. Watson, 1992. Plants in Agriculture. 1st Edn., Press Syndicate of the University of Cambridge, Cambridge, New York, ISBN: 9780521427913, Pages: 355.

Gichimu, B.M., B.O. Owuor and M.M. Dida, 2009. Comparing the yield components of three most popular commercial watermelon cultivars in Kenya with one newly introduced cultivar and one landrace. J. Plant Breed. Crop Sci., 1: 65-71.

Harper, J.L., 1977. Population Biology of Plants. 1st Edn., Academy Press, London, ISBN-13: 978-0123258502.

Jatzold, R. and H. Schmidt, 1982. Farm Management Handbook of Kenya: Natural Conditions and Farm Management Information. Vol. 2, Ministry of Agriculture, New Delhi, India, Pages: 397.

Kelly, J.F. and M.K. Scott, 1992. The nutritional value of snap beans versus other vegetables. Proceedings of the International Conference, October 16-20, 1989, Cali, Colombia..

Koli, B.D. and V.B. Akashe, 1995. Dry matter production of French bean variety Waghya as influenced by row spacing, plant densities and nitrogen levels. Curr. Res., 24: 209-211.

Kwapata, M.B., A.E. Hall and M.A. Madore, 1990. Response of contrasting vegetable-cowpea cultivars to plant density and harvesting of young green pods II. Dry-matter production and photosynthesis. Field Crops Res., 24: 11-21.

Loomis, R.S. and D.J. Connor, 1996. Crop Ecology: Productivity and Management in Agricultural Systems. Cambridge University Press, Cambridge, UK., pp: 32-59.

Mozumder, S.N., M. Moniruzzaman, M.R. Islam and S.N. Alam, 2003. Effect of planting time and spacing on the yield performance of bush bean (*Phaseolus vulgaris* L.) in eastern hilly area of Bangladesh. Legume Res., 26: 242-247.

Nderitu, J.H., E. Wambua, F. Olubayo, J. Kasina and C. Waturu, 2007a. Evaluation of pesticide/variety combinations for thrips (Thysanoptera: Thripidae) management on French beans (*P. vulgaris* L.) in Kenya. Afr. Crop Sci. Conf. Proc., 8: 987-992.

Nderitu, J.H., E.M. Wambua, F. Olubayo, J.M. Kasina and C.N. Waturu, 2007b. Evaluation of French bean (*Phaseolus vulgaris* L.) cultivars and breeding lines for resistance to thrips (Thysanoptera: Thripidae) pests in Kenya. J. Entomol., 4: 202-209.

Ngugi, D., P.K. Karau and W. Nguyo, 1982. East African Agriculture: A Textbook for Secondary Schools. Macmillan Education, New Jersey, ISBN: 9780333341544, Pages: 282.

Pawar, S.U., M.L. Kharwade and H.W. Awari, 2007. Effect of plant density on vegetative growth and yield performance of different varieties of French bean under irrigated condition. Karnataka J. Agric. Sci., 20: 684-685.

Voor den Dag, T., 2003. Export chain of french beans from kenya. Ph.D. Thesis, Development Economics Group, Marketing and Consumer Behaviour Group, Wageningen University.

Weaver, R.J., 1972. Plant Growth Substances in Agriculture. W.H. Freeman, New York, ISBN: 9780716708247, Pages: 594.