MERIT RESEARCH JOURNALS
www.meritresearchjournals.org

Merit Research Journal of Agricultural Science and Soil Sciences (ISSN: 2350-2274) Vol. 2(7) pp. 086-095, July, 2014
Available online http://www.meritresearchjournals.org/er/index.htm

Original Research Article

Influence of plant spacing and date of sowing on yield and yield components of two snap bean (*Phaseolus vulgaris* L.) varieties in Jimma, Southwestern Ethiopia

Essubalew Getachew Seyum

Department of Horticulture, Wolkite University College of Agriculture P.O.Box 07, Wolkite, Ethiopia

Email: essubalewgetachew@yahoo.com

Abstract

Apposite plant spacing and date of sowing alongside with variety has paramount significance in improving the pod yield and yield components of green bean. The aspire of the experiment was to determine the proper sowing date, varieties, and optimum plant spacing, and their combinations for better yield of green beans under Jimma condition. The treatments were five levels of spacing; four level of sowing dates and two varieties laid out in Randomized Complete Block Design with three replications. The analysis of variance revealed that variety significant differences for total pod yield, while spacing illustrated a significant difference for total pod yield, leaf area and number of primary branches. Date of sowing also showed significant differences in total pod yield and tap root length. Variety X date of sowing revealed a significant interactions for days to 50% flowering, leaf area, plant height, root fresh weight, root volume and number of primary branches. Variety X spacing showed significant interactions for days to 50% flowering and tap root length. The spacing X date of sowing interaction was significant only for root fresh weight. The highest total pod yield was produced by green bean sowed on July 3, green bean spaced at 40cmx7cm and Melka-5 variety. The study results suggested that early July appears the most appropriate date of sowing and a spacing at 40 cm x 7 cm with a variety of Melak-5 recommended for optimum yield of green been production at Jimma conditions.

Keywords: Green bean, plant spacing, sowing date, varieties, total pod yield.

INTRODUCTION

Snap bean *(Phaseolus vulgaris L.)* is widely used as protein source with highly nutritive value in human nutrition in the world (El-Noemani *et al.,* 2010). Currently, the total area coverage of green bean in Ethiopia is more than 15,379ha with an average total production of 6,803tonnes (FAO, 2009). It has been among the most important and highly prioritized crops as a means of foreign currency earning in Ethiopia (Gezahegn and Dawit, 2006 and Kay, 1979). Recently, it has become one of the most important vegetables in local market, commonly used in standard hotels and for festivities, to create variety of dishes. It has been considered as an important protein supplement in cereals and root crops based diet of in the low income community of the country. It serves as green vegetables and provides protein, calories, vitamins and minerals, such as calcium, phosphorus, and iron (Lemma, 2003).

Sam and Yosef (1985) reported the major production constraints in Ethiopia includes given the minimum genotype screening undertaken across different climatic zones, the genotype entries had not been consistent, diseases and pests were higher with rain-fed varietals screening than with those under irrigated conditions, when no crop protection measures were taken and high

post-harvest losses (Lemma, 2003). Site-specific factors, such as cultural practices and sowing date influence yield and yield characteristics of green bean. Selection of the most suitable variety, determining suitable sowing date and applying appropriate cultural practices are very important for increasing quality and yield of green bean. Among various factors, optimum sowing date and best variety are of primary importance to obtain potential yield (Amanullah *et al*., 2002). Various variety trials and agronomic experiments of the country used planting density of 50cmx25cm and 40cmx20cm for rain-fed and irrigated conditions, respectively. Later, a standard spacing of 40cmx10cm has been adopted; irrespective of rain-fed or irrigated conditions (Godfery *et al*., 1985), which was not clear how this standard planting was determined without having planting density study including number of plants per hill. In Ethiopia, particularly in Jimma zone there are several production constraints that include: absence of systematic and continuous research on the adaptability and productivity potential of the cultivars, lack of awareness, serious diseases and pest prevalence and lack of appropriate agronomical and cultural practices for the crop and there was no green bean production around Jimma both at small scale and commercial farmer's field, and hence the appropriate variety and planting date and the optimum plant population was not known for green bean under Jimma condition. Therefore, this study was conducted with the objectives of determining appropriate sowing date, optimum plant spacing, varieties and their combination for better pod yield and related agronomic traits of green beans under Jimma condition.

MATERIALS AND METHODS

Description of the Experimental Site

The experiment was conducted in Jimma University College of Agriculture and Veterinary Medicine Experimental Station at Eladalle during the main cropping season under rain-fed condition. The site was situated at latitude of 7^0 S 42' 9''N and longitude 36^0 47' 6'' E and an elevation of 1753m above sea level**.** The experimental site receives an average annual rainfall of 1559 mm with maximum and minimum temperatures of 26.8 and 13.6^0C, respectively; and the average maximum and minimum relative humidity of the area are 67.5 and 37.9%, respectively. The soil of the experimental site is reddish brown clay, classified as Nitisol with pH range of 5.0 to 6.0 (BPEDORS, 2000).

Experimental Design and Treatments

Two candidate green bean varieties (Melka-1 and Melka-5) were obtained from Melkassa Agricultural Research Center (MARC). The experiment consisted of three factors namely, five levels of inter-row and intra-row spacing (50 x 7 cm, 40 x 15 cm, 40 x 10 cm, 40 x 7 cm, 30 x 15 cm), with four levels of time of sowing (July 3rd, July 18th, August 2nd, and August 17th, 2010) and two candidate green bean varieties (Melka-1 and Melka-5) arranged in 5 x 4 x 2 factorial arrangement in randomized complete block design with three replications.

Experimental Management

The total experimental area for a single replication was 35 X 8 m^2=1925 m^2 and there were four rows in each plot with two harvestable middle two rows. Spacing between plots, replication and intra-blocks were 0.5 m, 1 m and 0.5 m, respectively. Then seeds were sown as per the treatment with a seed rate ranging from 98 to 218 per plots, depending on the spacing treatment. The first sowing was done on July 3, 2010 and subsequent sowings for the other treatments were made at 15 days interval. All management practices were performed as per the general recommendations for green bean (Lemma, 2003).

Data Collection

Data on the pod yield and yield related agronomic traits of green bean were recorded from each plot by taking ten random plants. These quantitative traits includes: total pod yield (kg ha^{-1}), days to 50% flowering, plant height (cm), leaf area (cm^2), root fresh weight (gm), root volume (cm^3), tap root length (cm) and number of primary branches.

Data Analysis

Analysis of Variance (ANOVA) and correlation was performed using Genstat version 11 (VSN International, 2008) with the REML variance components analysis. Mean separation was carried out using LSD (Least Significant Difference) test at 5% level of significance for traits that showed significant mean squares (Gomez and Gomez, 1984). All the graphs and tables were generated using excel computer program.

RESULTS AND DISCUSSION

There was a significant ($P<0.05$) interaction effect between variety and sowing date, varieties and spacing on days to 50% flowering, plant height, leaf area, root fresh weight, root volume, tap root length, number of primary branches and days to 50% flowering and tap root length, respectively. The interaction effect between date

Table 1. Mean square error for the parameters

Parameters	Variety	Spacing	Sowing date	Variety* Spacing	Variety* Sowing date	Spacing* Sowing date	Variety* Spacing* Sowing date
TPY	4.51*	6.86*	146.76**	3.49^{ns}	0.56^{ns}	20.93^{ns}	15.00^{ns}
DF	8.05**	7.35^{ns}	2686.38**	11.08*	19.70**	10.11^{ns}	11.91^{ns}
TRL	10.38**	11.20*	216.19**	11.32*	5.60^{ns}	16.31^{ns}	16.21^{ns}
RV	0.032*	6.31^{ns}	136.10**	4.28^{ns}	19.26**	16.76^{ns}	12.71^{ns}
NPB	19.26**	17.84**	371.33**	8.12^{ns}	15.40**	14.26^{ns}	13.25^{ns}
RFW	5.54*	7.34^{ns}	164.83**	3.71^{ns}	11.89*	23.87*	8.64^{ns}
LA	2.50^{ns}	9.98*	79.98**	1.30^{ns}	41.23**	16.75^{ns}	14.21^{ns}
PH	0.97^{ns}	3.40^{ns}	86.87**	2.66^{ns}	10.36*	5.33^{ns}	5.45^{ns}

***=Significant, **= Highly Significant and NS= Non- Significant**
TPY= Total pod yield, DF= Days to 50% flowering, TRL=Tap root length, RV= Root volume, NPB= Number of primary branches, RFW= Root fresh weight, PH= Plant height, LA= Leaf area

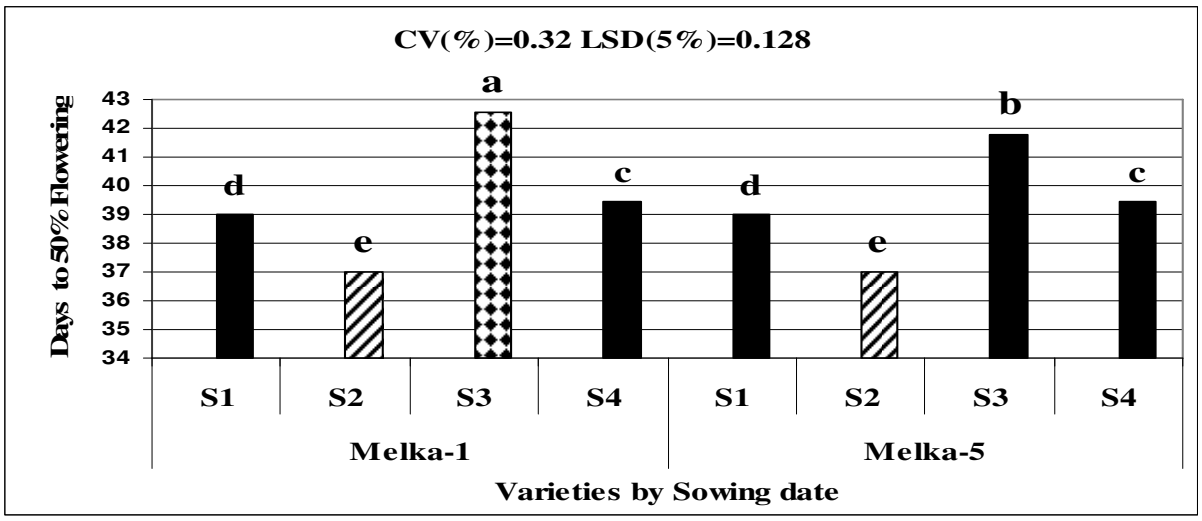

Figure 1. **Interaction effect of varieties and sowing date on days to 50% flowering of green bean.**

sowing and plant spacing also resulted in significant on root fresh weight. Spacing imparted significant differences with regard to the tap root length, leaf area and number of primary branches and total pod yield. Sowing date and variety independently significantly affected the total pod yield of green bean (Table 1).

Days to 50% Flowering

Maximum numbers of days to 50% of flowering was recorded for Melka-1 sown on 2nd August whereas, the minimum number of days to 50% flowering was recorded for Melka-1 sown on 18th July and for Melka-5 sown on 18th July, respectively (Figure 1). The observed difference could be due to high rainfall (water) and less sunlight period that might have lead to production of more vegetative parts rather than reproductive parts as a result of sowing on 18th July. Ndegwa *et al*. (2001) showed that snap bean varieties flowered in the range of 41 to 43 days in the long rainy season whereas, in the late season the snap bean varieties flowered within 39 to 41 days. Snap bean with an early planting took more number of days to flower and mature than in the other planting seasons and earliest flowering snap bean was observed when it was planted in the late planting season (23rd July) while delayed flowering was observed in snap beans planted in the normal or summer planting season (13rd June), hastening its development (Marlene *et al*., 2008).

Longest number of days to 50% flowering was recorded for Melka-1 sown at the spacing of 40cm x 10cm. The least number of days to 50% flowering was recorded on variety Melka-5 sown at the spacing of 40cmx7cm (Table 2). This could be probably be due to the fact that at lower density there is a less competition between plants for water, nutrients, and minerals that led to the development of vegetative parts rather than forming reproductive parts. Samih (2008), reported that when beans are planted at the lower planting densities required more number of days for blooming (flowering). The difference in the days to flowering between the two

Table 2. Interaction effect of plant spacing and varieties on days to 50% flowering of green bean

Variety	Plant Spacing					Mean	CV (%)	LSD (5%)
	50cmx7cm	40cmx15cm	40cmx10cm	40cmx7cm	30cmx15cm			
Melka-1	39.50^{bc}	39.59^{ab}	39.67^{a}	39.50^{bc}	39.25^{d}	39.5	0.41	0.160
Melka-5	39.25^{d}	39.58^{ac}	39.25^{d}	39.08^{e}	39.43^{c}	39.3		
Mean	39.36	39.56	39.46	39.29	39.34	39.4		

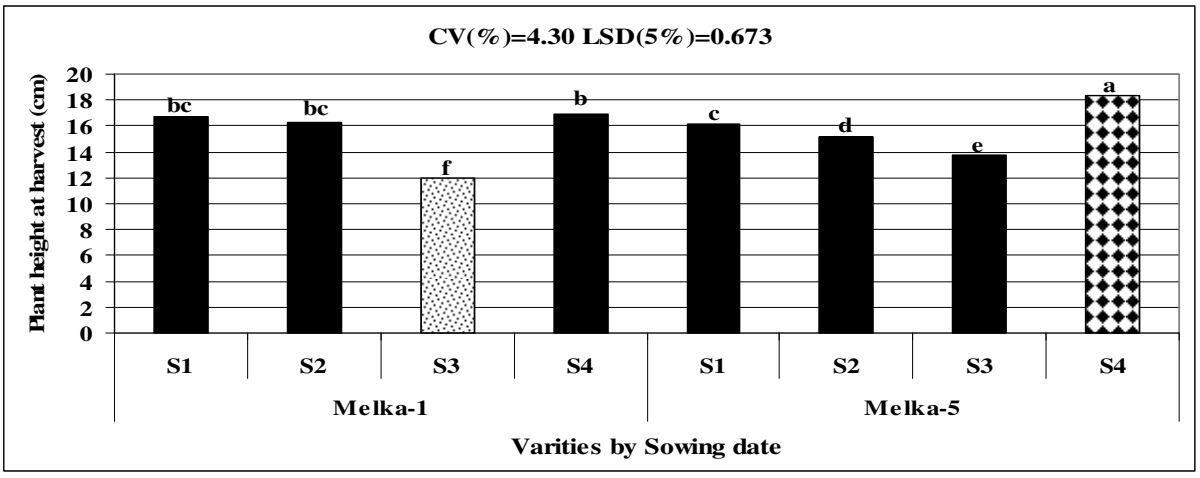

Figure 2. Interaction effect of varieties by sowing date on plant height of green bean

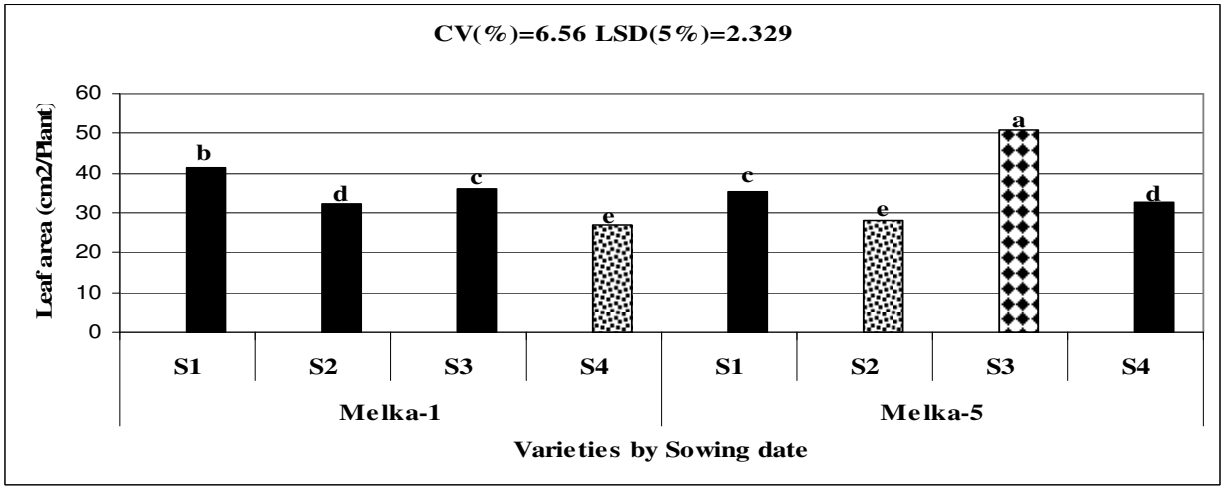

Figure 3. Interaction effect of varieties with sowing date on leaf area of green bean

varieties could be probably due to the genetic make-up of the two varieties (El-Noemani et al., 2010) .

Plant Height

Maximum plant height was recorded from Melka-5 sown on 17th August followed by Melka-1 sown on same date. In contrast, the least plant height was scored from Melka-1 sown on 2nd August (Figure 2). This could be due to the extended prevalence of sunlight during the growth period which might have stimulated more growth Melka-5 compared to other sowing dates. Singer *et al.* (1996) reported maximum plant height at the warmest than the coolest environmental condition. Vieira *et al.* (1990) also reported that the depression of plant height could result from reduction of photosynthetic efficiency of a plant. Melka-5 sowed on the appropriate sowing date resulted in superior plant height as compared to Melka-1, implying that genotypically Melka-5 is superior than Melka-1.

Table 3. Effect of plant spacing on leaf area of green bean

Spacing	Leaf Area (cm^2/plant)
50cmx7cm	36.89[b]
40cmx15cm	34.25[c]
40cmx10cm	33.18[c]
40cmx7cm	38.44[a]
30cmx15cm	34.63[c]
Mean	35.478
CV (%)	4.13
LSD (5%)	1.465

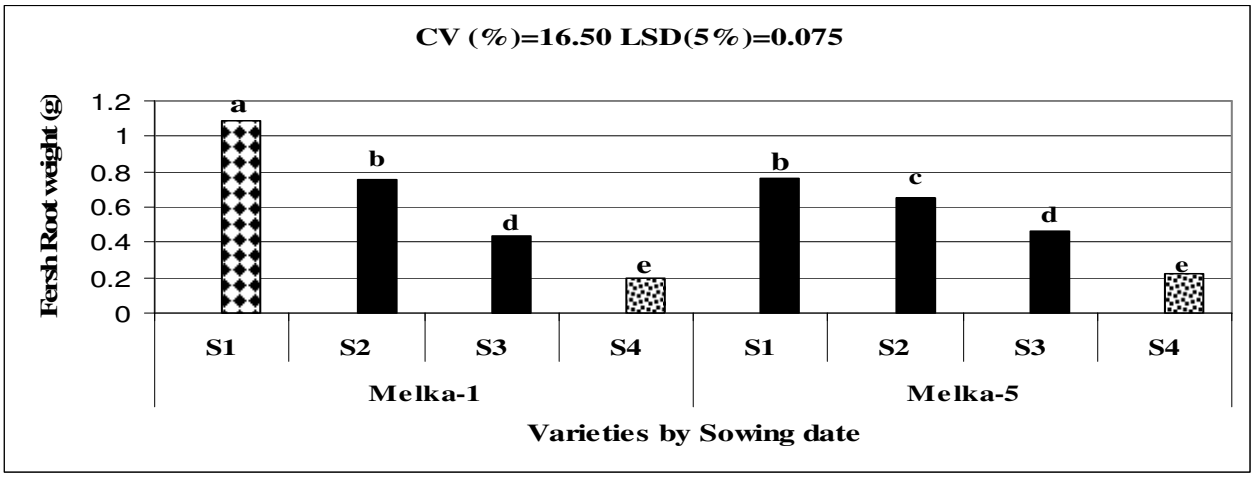

Figure 4. Interaction effect of varieties with sowing date on fresh root weight of green bean

Lemma *et al.* (2006) showed Melka-5 is superior in plant height than Melka-1. Uddin *et al.* (2007) also reported that interaction between planting time and genotypes on soybean varieties resulted in increased plant height in December planting as compared to November planting. The author's associated this with the increased temperature intercepted by the genotypes sowed in December planting during its life time.

Leaf Area

The maximum leaf area was observed from Melka-5 sowed on 2nd August whereas the lowest leaf area was observed from Melka-1 sowed on 17th August (Figure 3). This result is in-agreement with the work of Singer *et al.* (1996) reported that higher leaf area was recorded for late sowing than early sowing of green bean.

The highest leaf area was observed from plants spaced at 40cmx7cm. In contrast, the lowest leaf area was scored on plants spaced at 40cmx15cm (Table 3). Jadoski *et al.* (2000) increased leaf area of individual plants as plant population decreased. Zhou *et al.* (2011) also reported that competition between plants varied from spacing to spacing; wherein soybean plants planted in narrow rows spacing attained high light capture than in wider rows spacing. Gardineri *et al.* (1978) reported that higher percentage of PAR (Pohtosentitically Active Radiation) interception of bush cultivar was higher when bush cultivars were planted at 45.5cm row spacing than that of 91 cm row spacing irrespective of sowing dates.

Root Fresh Weight

The highest root fresh weight was observed from Melka-1 sown on the 3rd July, which was 89.59 percent more than the lowest fresh root weight that was observed from Melka-1 sown on 17th August and Melka-5 on 17th August (Figure 4). The observed difference in terms of root fresh weight could be probably due to the at this sowing there is less rainfall received after planting on 17th August and exposure of the plants to more sunlight as compared to the other sowing dates which all together resulted in plants that produced less vegetative parts; less fibrous root with less fresh root weight. The difference between the two varieties could be attributed to their genetic makeup. Even though, literatures that support this finding were not found on snap bean and other related *phaseolus* species, Alem *et al.* (2010) reported similar result in radish that fresh root weight was significantly higher in early sowing than late sowing in Bangladesh.

Table 4. Interaction effect of plant spacing and sowing date on root fresh weight of green bean plants

Spacing	Sowing date	Root Fresh Weight (gm)
50cmx7cm	3rd July	0.608bcd
	18th July	0.690b
	2nd August	0.496cde
	17th August	0.200f
40cmx15cm	3rd July	1.186a
	18th July	0.732b
	2nd August	0.345ef
	17th August	0.211f
40cmx10cm	3rd July	0.721b
	18th July	0.708b
	2nd August	0.433de
	17th August	0.179f
40cmx7cm	3rd July	1.004a
	18th July	0.707b
	2nd August	0.478de
	17th August	0.208f
30cmx15cm	3rd July	1.108a
	18th July	0.679bc
	2nd August	0.492cde
	17th August	0.241f
Mean		0.57
CV (%)		28.51
LSD (5%)		0.163

Table 5. Interaction effect of sowing date and varieties on root volume of green bean plants

Variety	Sowing Date				Mean	CV (%)	LSD (5%)
	3rd July	18th July	2nd August	17th August			
Melka-1	1.3680a	0.9814b	0.8980c	0.4727d	0.93	8.61	0.076
Melka-5	0.9585bc	0.9847b	0.9279bc	0.4983d	0.84		
Mean	1.16	0.98	0.91	0.48	0.88		

The highest root fresh weight was found on a plot of beans sown on the 3rd of July at a spacing of 40cmx15cm. On the contrary, the lowest root fresh weight was recorded from plots sown with beans on the 17th of August at spacing of 40 cm x 10cm (Table 4). The availability of sufficient moisture in the soil following the sowing of beans earlier (3rd July) and at the optimum spacing (40cmx15cm, 40cmx7cm and 30cmx15cm) might have favored maximum vegetative growth including root development. The condition gets so sever when planting is too late or too early. Under low density, plants could get the essential resources easily thus resulting in the development of high root fresh weight.

Root Volume

The maximum root volume was recorded from variety Melka-1 sown on the 3rd of July. In contrast, the minimum root volume was scored from Melka-1 sown on the 17th of August, (Table 5). Plants established earlier (3rd July) received more rainfall as compared to late sown ones (17th August) and hence the later might have suffered from shortage of moisture and extended sunlight period which altogether might have induced the production short and few number of fibrous roots by the crops.

Tap Root Length

The longest tap root was observed from plants of the variety Melka-1 sown at 40cmx7cm. In contrast, the shortest tap root was noted from plants of the variety Melka-5 established at a spacing of 40cmx10cm (Table 6). The observed increase in tap root length in Melka-1 that was planted at different spacing combinations could probably be a response of the variety. Moreover, the maximum tap root length achieved at 40cmx7cm might have created high competition between plants for water, minerals and other resources and the growth and developments of plants at this situation makes the plants to produce longer tap roots running in search of water and other resources.

The maximum mean tap root length was found from

Table 6. Interaction effect of plant spacing and varieties on tap root length of green bean plants

Variety	Plant Spacing					Mean	CV (%)	LSD (5%)
	50cmx7cm	40cmx15cm	40cmx10cm	40cmx7cm	30cmx15cm			
Melka-1	13.62^{bc}	12.63^{de}	13.88^{ab}	14.34^{a}	14.01^{ab}	13.69	4.75	0.631
Melka-5	12.41^{e}	13.39^{bc}	11.69^{f}	13.59^{bc}	13.21^{cd}	12.86		
Mean	13.01	13.01	12.79	13.97	13.61	13.28		

Table 7. Effect of sowing date on tap root length of green bean plants

Sowing date	Tap Root Length (cm)
3rd July	13.85^{b}
18th July	16.22^{a}
2nd August	12.62^{c}
17th August	10.42^{d}
Mean	13.29
CV (%)	1.91
LSD (5%)	0.254

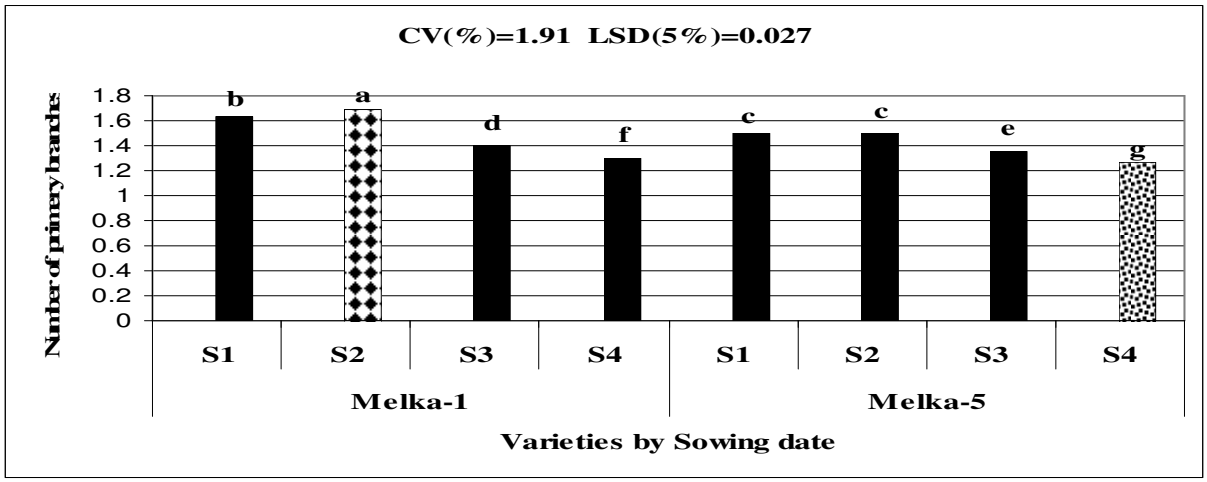

Figure 5. Interaction effect of sowing date and varieties on number of primary branches of green bean

plants sown on the 18th of July whereas, the shortest was registered from sowing on the 17th of August (Table 7). The highest intensity of rainfall at the study site was observed to be during the month of July and decreased in August. Consequently, the roots of plants from June sowing could get sufficient moisture within their reach and hence did not develop long tap root to search for moisture. Notably, the shortest tap root length was recorded for late sowing (17th August) which vividly experienced a limited amount of rainfall.

Number of Primary Branches

More number of primary branches was observed from Melka-1 sown on the 18th of July whilst, the least number of primary branches was registered from Melka-5 sown on 17th August (Figure 5). The apparent discrepancy in the number of primary branches between early and late sowing dates could be attributed to the difference in moisture content of the soil; early sowing leading to more moisture availability than late sowing and thus affecting vegetative growth including primary branch development. On the other hand, the difference between the two varieties in terms of primary branch production is probably due to their genetic makeup. Yusufali *et al.* (2006) reported more number of primary branches with an early sowing than late sowing of field beans in Karnataka (India). Uddin *et al.* (2007) observed that the number of branches per plant in soybean varieties increased in November planting as compared to December planting.

Table 8. Effect of plant spacing on number of primary branches of green bean plants

Spacing	Number of primary branches
50cmx7cm	1.43[c]
40cmx15cm	1.44[c]
40cmx10cm	1.46[b]
40cmx7cm	1.46[b]
30cmx15cm	1.49[a]
Mean	1.46
CV (%)	1.22
LSD (5%)	0.018

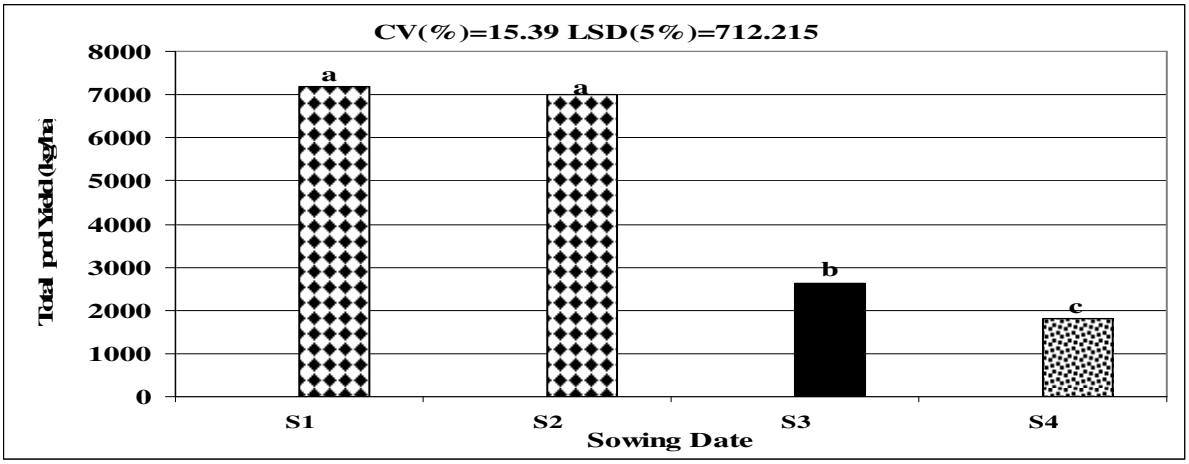

Figure 6. Effect of sowing date on total pod yield green bean (kg/ha)

Significantly more numbers of branches were counted from plants spaced at 30 cm by 15 cm while the least number of branches was recorded from plants established at 50 cm x 7cm (Table 8). The possible reason could probably be due to lower competition between plants under the lower density planting for different resources that are essential for the growth and development as compared to the high density wherein competition would be sever between plants which concomitantly might have lead to the production of less number of primary branches. Lucas and Milbourn (1976) reported that although number of branches per plant generally decreased with increasing density due to the occurrence of high competition among plants.

Total Pod Yield

The highest total pod yield (kg/ha) was obtained due to sowing on the 3rd of July. Conversely, the lowest total pod yield was registered from sowing the beans late, the 17th of August (Figure 6). This was probably because of the limited vegetative growth of plants from the late sowing as a result of the limited photosynthates availability. This in turn was attributed to the short rains associated with late sowing. Yoldas and Esiyok (2007) revealed that decreased yield due to a short vegetation period of the crop sown late and the maximum growth and yield was obtained by sowing of beans on July. Lower pod yield in the late planting season was due to a smaller biomass production from a shorter vegetative growth period and moreover, the decline in pod production may simply result from declining flower production as vegetative growth ceases. Late sowing has negative consequences on yield because the reproductive stage occurs when weather conditions are less favorable. The reproductive period of common bean plants coincide with the highest summer temperatures and this cause abscission of many buds and flowers that results in a significant decrease in productivity (Marlene *et al.,* 2008).

Plant spacing at 40cmx7cm resulted in the highest total pod yield. Conversely, the lowest total pod yield was obtained from a green bean spaced at 40cmx10cm (Table 9). There was a difference of 49.43 percent total pod yield between the maximum and the minimum and this perhaps due to the large number of plants per unit area under narrower spacing which limited the unnecessary vegetative growth and favored setting of more pods. Samih (2008) who showed superior yield in the case of high plant populations over that of low

Table 9. Effect of plant spacing on total pod yield (kg/ha) of green beans

Plant Spacing	Parameters TPY (kg/ha)
50cmx7cm	4456[b]
40cmx15cm	4362[b]
40cmx10cm	3866[c]
40cmx7cm	5777[a]
30cmx15cm	4817[b]
Mean	4655.6
CV (%)	17.46
LSD (5%)	813.033

Table 10. Effect of varieties on total pod yield (kg/ha)

Variety	Total Pod Yield (kg/ha)
Melaka-1	4323[b]
Melaka-5	4988[a]
Mean	4655.5
CV (%)	10.986
LSD (5%)	511.560

densities. This could be attributed to the less severe competition among plants for nutrients and other resources under the context of less number plants per unit area. Cutcliffe (1967) also reported yield of green beans increased at the narrow spacing than the wider. Wahab (1986) stated that higher planting densities of green bean gave higher pod yields per unit area than that of lower planting density.

The highest total pod yield was obtained from the variety Melka-5 whereas the lowest total pod yield was obtained from Melka-1 (Table 10). The difference between the two varieties used for the study in respect of total pod yield could mainly be due to the genetic makeup of the varieties. Lemma *et al.* (2006) observed difference in yield between the two varieties of green beans owing to their genetic makeup. The two varieties also manifest differences in respect of earliness and vegetative growth. Cultivars with long vegetative growth duration had generally higher fresh pod yields than those with short vegetative growth duration in the early and normal planting seasons (Marlene *et al.,* 2008). El-Noemani *et al.* (2010) reported that snap bean growth, pods or seed yield and total exportable yield are greatly affected by genotype of variety. Amer *et al.* (2002) concluded that the differences in pods yield of bean varieties might be attributed due to the genetic makeup a variety.

SUMMARY AND CONCLUSION

Green bean is one of the most cultivated leguminous vegetable in the world. Selection of best variety, determining appropriate sowing date and using the optimum plant spacing are very important factors to increase the productivity and marketability of green bean. The present study was conducted to assess the yield of green bean varieties as influenced by different sowing date and plant spacing types under Jimma condition. Considering the growth plants, variety Melka-5 sown on the 17th August registered the maximum plant height while the maximum number of primary branches was recorded from Melka-1 plants established on the 18th of July. Melka-5 sown on the 2nd of August produced the maximum leaf area. The longest tap root was obtained from Melka-1 established at spacing 40cmx7cm and 30cmx15cm and among the sowing dates, the longest tap root was observed at sowing date of 18th July. The interaction between varieties and sowing date resulted in a difference in respect of days to flowering; Melka-5 sown at 40cm x7cm showed the earliest flowering. Pertaining to yield, the highest total pod yield were obtained from green bean plants sown the 3rd of July

Therefore, the result of this study has shown that different sowing date, spacing, and varieties had a significant positive influence on the yield and growth of green bean. Hence, sowing of green bean at 3rd July gives more pod yield as compared to the other sowing date. From this study, it can be concluded that sowing of green bean at 3rd July, spacing at 40cmx7cm, Melka-5 variety, had a potential to increase the yield and growth of green bean under Jimma condition. Hence, farmers and any new commercial growers and/or investors at Jimma and similar agro–ecology areas would use these packages for growing green bean with better quality and yield.

ACKNOWLEDGEMENT

I express my heartfelt gratitude to my beloved wife Ms. Jimmawork Gebre for her unreserved support and love that brings my life into the right truck and honorable support lend a hand for triumph throughout my life.

REFERENCES

Alem MK, Farooque AM, Uddin JA, Nuruzzaman M (2010). Effects of sowing time on the growth and yield of three Radish (*Raphanus Sativus L.*) varieties. Bangladesh Res. Pub. J. 3: 998-1006Anisa et al. (1995)

Amanullah JI, TF Hayat, AI Khan, N Khan (2002). Effect of sowing dates on yield and yield components of mash bean varieties. Asian J. Plant Sci., 1: 622-624.

Amer AH, M El – Desuki, Omaima MS, AM Ibrahim (2002-a). Patentiality of some snap bean (Phaseolus vulgaris L.) varieties under different irrigation levels at Shark El – Owinat Region. Egypt Journal of Applied .Science, 17(1): 327-345.

BPEDORS (2000).Physical and Socio economical profile of 180 District of Oromiya Region. Pp.248-251. Bureau of Planning and Economic Development of Oromiya Regional state (BPEDORS), physical planning Development .Finfinne, Ethiopia

Cutcliffe JA (1967). Effect of seed spacing on yield and size distribution of snap beans. Canadian J. Plant Sci. 47:519-522

El-Noemani AA, HA El-Zeiny, AM El-Gindy, EA El-Sahhar, MA El-Shawadfy (2010). Performance of Some Bean (*Phaseolus Vulgaris* L.) Varieties under Different Irrigation Systems and Regimes, Australian J. Basic and Appl. Sci. 4(12): 6185-6196

FAO (2009). Production year book. Food and Agriculture Organization for the United Nations, Rome Italy.

Gardineri TR, Vietor DM, Craker LE (1978). Growth habit and row width effects on leaf area development and light interception of field beans. Canadian J. Plant Sci. 59:191-199

Gezahegn A, Dawit A (2006). Marketing of Pulses in Ethiopia. 346 - 351pp. In: Kemal Ali; Gemechu Keneni; Seid Ahmed; R. Malhotra; S. Beniwal; K. Makkouk, and M.H. Halila (Eds.). Food and Forage Legumes of Ethiopia: Progress and Prospects. Proceedings of the Workshop on Food and Forage Legumes, 22 – 26 September 2003. Addis Ababa, Ethiopia.

Godfrey-Sam-Aggrey G, Yosef H, Turuwork A (1985). Review of Green Beans Research in Ethiopia and Proposal for Future Research and Development Direction.

Gomez KA, Gomez AA (1984). Statistical procedures for Agricultural Research. 2nd ed. John wily & Sons, New York.

Jadoski SO, Carlesso R, Petry M T, Wolschick D, Cervo L (2000). Plant population and row spacing for irrigated dry bean. I: Plant morphological characteristics. J. Ciência Rural, 30(4): 559-565JARC Department of Metrology (2010)

Kay DE (1979). Food Legumes: Crop and Product Digest, No. 3. London: Tropical Products Institute. Pp 435.

Lemma D (2003). Snap Bean Production and Research Status (*Phasiolus vulgaris*) in Ethiopia. Melkasa Agricultural Research Center. Nazret, Ethiopia.

Lemma D, Shimales A, Selamawit K, Abyote A (2006). Varietal Development of Major Vegetables in the Rift Valley Region. Pp In: Melksa Agricultural Research Center, Werer Agricultural Research Center, EIAR Proceeding of the Inaugural and First Ethiopian Horticultural Science Society Conference, 27-30 March 2006. Addis Ababa, Ethiopia.

Lucas EO, Miboum GM (1976). The effects of density of planting on the growth of two *Phaselous Vulgaris L.* Varieties in England. J. Agric. Sci, 87: 89-99.

Marlene PB, Ana María González AM, Rodiño AP, De Ron AM, Marta SM (2008). Effects of planting season and plant cultivar on growth, development, and pod production in snap bean (*Phaseolus vulgaris* L.) Australian J. Agric. Res. 59:1121 1129.

Ndegwa AM, Muchui MN, Wachiuri SM, KARI-Thika JN (2001). Evaluation of introduced snap bean (*phaseolus vulgaris* l.) Varieties for adaptability and pod quality. Thika, Kenya.

Sam-Aggrey WG, Yosef H (1985). Review of Hot pepper Research in Ethiopia and proposals for future Research and development directions.Pp.206.In:W.G. Horticultural work shop, 20-22 February, 1992. Addis Abeba, Ethiopia.

Samih A (2008). Effect of Plant Density on Flowering Date, Yield and Quality Attribute of Bush Beans (*Phaseolus Vulgaris L.*) under Center Pivot Irrigation System. Ame. J. Agric. Biol. Sci. 3(4): 666-668Singer et al. (1996)

Singer SM, Helmy YI, Sawan OM, El-Abd SO (1996). Effects of plastic tunnels and sowing dates on growth and productivity of bean varieties grown in calcareous soil conditions. Egypt J. Horticulture, 23(2)

Uddin MK, Hasan MK, Alam AK (2007). Effect of Planting Time on Canopy Structure and Biomass Production in Some Soybean Genotypes. J. Agric. Rural Develop. 5(1-2):25-29

Vieira HJ, Bergamaschi H, Amgelocci LR, Libardi L (1990). Performance of tow bean cultivars under two soil water availability regimes. II. Stomata1 resistance to vapour diffusion, transpiration flux density and water potential in the plant. Pesquisa Agropecuβria Brasileira, 24(9): 1045-1053 (English summary).

Wahab MN, Dabbs DH, Baker RJ (1986). Effects of planting density and design on pod yield of bush snap bean (*Phaseolus vulgaris l.*). Canadian J. Plant Sci. 66:669-675

Yoldas F, Esiyok D (2007). Effects of sowing dates and cultural treatments on growth, quality and yield of processing beans. Pakistan J. Biol. Sci. 10:2470-2474.

Yusufali AN, Alagundagi SC, Mansur CP, Hosamani SV, Mummigatti UV (2007). Effect of Date of Sowing and Seed Rate on Fodder Production Potential and Economics of Field Bean Genotypes under Rain fed Condition. Karnataka J. Agric. Sci. 20(1): 13-16

Zhou XB, Chen YH, Ouyang Z (2011). Row spacing effect on leaf area development, light interception, crop growth and grain yield of summer soybean crops in Northern China. Afr. J. Agric. Res. 6(6):1430-1437