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Full Length Research Paper

Growth and yield response of green beans (*Phaseolus vulgaris* L.) In relation to time of sowing and plant spacing in the humid tropics of Jimma, southwest Ethiopia

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Time of sowing, plant spacing and variety have paramount significance in improving pod yield, quality and disease severity of green beans. The aim of the study was to determine appropriate sowing time, optimum plant spacing and appropriate varieties and their combination for better productivity of green beans under the humid tropical conditions of Jimma, southwestern Ethiopia. The treatments were five level of spacing (50 cm x 7 cm, 40 cm x 15 cm, 40 cm x 10 cm, 40 cm x 7 cm, 30 cm x 15 cm); four level of time of sowing (July 3rd, July 18th, August 2nd and August 17th) and two pipeline varieties, namely Melka-1 and Melka-5. The experiment was conducted in randomized complete block design with three replications in the 2010/2011 main cropping season. Analysis of variance has shown that most of the yield and yield components studied (pod length, pod diameter, number of pods, average pod weight and number of pods) were significantly affected by the interaction effects of variety and time of sowing. Marketable pod yield was however affected only by the main effects of time of sowing and spacing regardless of the varieties. Hence, the longest pod (13.5 cm) with a wide diameter (0.9 cm) was obtained from variety Melka-1 sown in mid July. The highest marketable pod yield (4,326 kg ha^{-1}) was harvested from plants sown early July (which was on par with Mid July) and spaced at 40 cm x 7 cm. Our data suggested that mid July seems the most appropriate time of sowing and a spacing of 40 cm x 7 cm is adequate for green been production in the humid tropical conditions of Jimma irrespective of the varieties.

Keywords: Green bean, plant spacing, sowing date, pipeline varieties and marketable pod yield

INTRODUCTION

Green bean is one of the most cultivated leguminous vegetables in the world, and it is the most important food legume. Asia and Europe with more than 50 and 30% of world production respectively are the dominant green bean producers, and from the two continents, China and Turkey are the leading countries with more than 17 and 13% of the world production, respectively (Rubatzkey and Yamagucbi, 1999). The annual production of green beans in the world covers an area of greater than 960,272 ha with a total production of 6,814,403 tones (FAO, 2009). Currently, the total area coverage of green bean in Ethiopia is above 15,379 hectare with an average total production of 6803 tones (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). Currently, it is becoming one of the most important vegetables in local market, standard hotels and for festivals used to prepare various dishes. It has been considered as an important protein supplement in cereals and root crops based food habit in the country. It serves as a green vegetables and it provides protein, calories, vitamins and minerals such

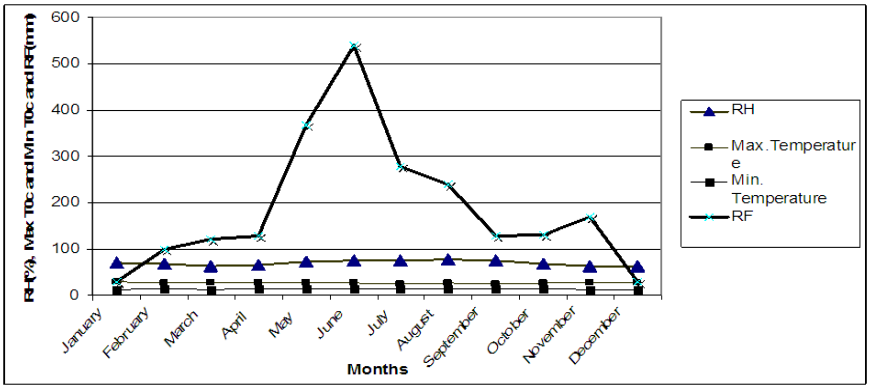

Figure 1: Mean Monthly Metrological Data of Jimma from the Year 2010

as calcium, phosphorus, iron (Lemma, 2003).

According to Godfery et al. (1985), the major production constraints under Ethiopian conditions were: 1) Given the minimum genotype screening undertaken across different climatic zones, the genotype entries had not been consistent 2) Diseases and pests were higher with rain-fed varietals screening than with those under irrigated conditions, when no crop protection measures were taken 3) 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 the various factors, optimum sowing date and best variety are of primary importance to obtain potential yield (Amanullah et al., 2002).

Various variety trails and agronomic experiments in Ethiopia have used a planting density of 50 cm x 25 cm and 40 cm x 20 cm for rain-fed and irrigated conditions, respectively (Godfery et al., 1985). Later, a standard spacing of 40 cm x 10 cm has been adopted; irrespective of the growing conditions and locations which was not clear how this spacing was considered as the standard spacing without having planting density study including number of plants per hill.

Sowing date has the greatest effects on the yield of green bean. Sowing of soybean pods in July 5 gave the highest marketable yield in the Northeastern USA; whereas the lowest marketable yield was obtained when sown on May 22 (Yan-sheng *et al,.*2010). Early sowing of snap bean produced higher yield, plant height but lower pod diameter, dry matter and pod length than the late sowing (Yoldas and Esiyok, 2007). According Marlene et al. (2008) mean pod width (diameter) were greater in the late planting season (17 mm) than in the early planting seasons (15–16 mm). Ismail and Khalifa (1987) reported reduced number of seeds per pod in late sown soybean, which might due to the decrease in day length and moisture following delayed sowing. Higher number of pods was obtained in the earlier sowing than the late sowing (Escalante et al., 1989).

Optimum plant population has a promising impact in improving the productivity of green bean. Marketable pod yield of snap bean increased linearly, as the spacing reduced in different sowing dates (Tyson and Kostewicz, 1986). Superior yield was observed in the case of high plant populations over that of low plant population of beans (Samih, 2008). According to Pawar et al. (2007), dry weight of green bean was increased with increased row spacing (30 cm) as compared to narrow row spacing (22.5 cm). Higher pod dry weight was obtained when bush bean was planted at lower planting densities as compared to higher planting density (Samih, 2008). Wider row spacing (60 cm and 45 cm) gave significantly higher number of pods compared to 30 cm row spacing (Mohammed et al., 1984).

In Ethiopia, particularly in Jimma zone, there has not been green bean production both at small scale and commercial farmers mainly due to lack of appropriate varieties, lack of information on time of sowing and spacing to be used (Lemma, 2003; personal communication with Jimma Agricultural Research Center and Jimma College of Agriculture, 2010). Therefore, this study was conducted with the objectives of determining appropriate time of sowing, optimum plant spacing, varieties and their combination for better yield and yield attributes of green beans under the humid tropical conditions of Jimma, Southwest Ethiopia.

MATERIALS AND METHODS

Description of the experimental site

The experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine Experimental Station, Eladalle which is 7 km from Jimma town in 2010/2011 main cropping season under rain-fed condition. Jimma is geographically located at 346 km Southwest of Addis Abeba at an elevation of 1753 meters above sea level situated at latitude of 7^0 S 42' 9''N and longitude 36^0 47' 6'' E in Ethiopia. The experimental site receives an average annual rainfall of 1,559 mm with maximum and minimum temperatures of 26.8 and 13.6 ^{0}C, respectively; and the average maximum and minimum relative humidity of the area are 67.5 and 37.92 %, respectively (Figure 1). The soil of the

Table I: Detail description of the varieties

Characteristics	Melka-1	Melka-5
Plant height (cm)	26cm	28cm
Flower color	White	Purple
Ground cover	High	Medium
Pod length (cm)	10.80cm	11.80cm
Pod diameter (cm)	1.20	1.10
Fiber ness	Nil	Nil
Pod curvature	Straight	Straight
Pod shape	Round	Round
Yield (kg ha^{-1})	1240-1370	1290-1460

Source: Lemma et al., 2006

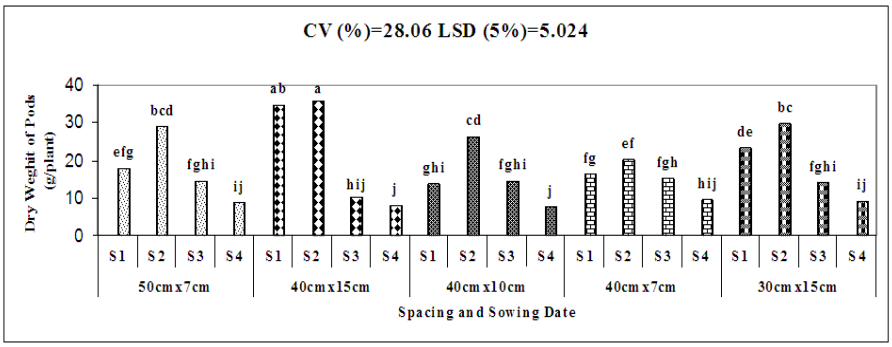

Figure 2: Interaction Effect of Plant Spacing and Sowing Date on Pod Dry Weight of Green Beans
S_1= 3rd July, S_2= 18th July, S_3=2nd August and S_4= 17th August

experimental site is reddish brown clay classified as Nitisol with pH range of 5.0 to 6.0 (BPEDORS, 2000).

Experimental materials, design and management

Two candidate green bean varieties, namely Melka-1 and Melka-5, which were obtained from Melkassa Agricultural Research Center, were used for the study (Table I). 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 in randomized complete block design with three replications. The spacing levels were determined bearing in mind the national recommendation as reference. There were four rows in each plot that were spaced differently as per the respective treatments. The spacing between plots and blocks was 0.5 and 1 m, respectively. The first sowing was on the 3rd of July, 2010 and subsequent sowings for the other treatments were conducted at 15 days interval. All field management practices like weeding; fertilizer application, insect pest and diseases control were carried as recommended (Lemma, 2003).

Data collected

Data on yield and yield components of green beans were recorded from plants in the middle rows in each plot. These include: total marketable pod yield (kg ha^{-1}), total number of pods per plant, pod length (cm), pod diameter (cm), average pod weight (g) and dry weight of pods per plant.

Data analysis

The data was first checked for normality and meeting the assumptions for Analysis of Variance (ANOVA). Then, the data was subjected to ANOVA using Genstat version 11 (VSN International, 2008) with the REML variance components analysis. Means that showed significant differences were separated using Least Significant Differences (LSD) at 5% level of significance (Gomez and Gomez, 1984).

RESULTS

Marketable pod yield

Pod yield was significantly (P<0.05) affected by the main effects of time of sowing and spacing factors but not by any of the interactions. Among the different sowing dates, green bean sown on the 3rd of July resulted in the highest total marketable pod yield (4326 kg ha^{-1}) whilst, the lowest total marketable pod yield (906 kg ha^{-1}) was obtained from green bean sown on the 17th of August (Figure 2). Among the spacing combinations, 40 cm x 7 cm gave in the highest total marketable pod yield (3,473

Table II: Main effect of time of sowing and plant spacing on total marketable pod yield of green bean

Time of sowing	Marketable pod yield (kg ha^{-1})
July 3rd	4326^{a}
July 18th	3965^{b}
August 2nd	1950^{c}
August 17th	906^{d}
Mean	2786.75
LSD (5%)	462.070
CV (%)	16.58
Plant Spacing	
50cmx7cm	2531^{c}
40cmx15cm	2574^{c}
40cmx10cm	2367^{c}
40cmx7cm	3473^{a}
30cmx15cm	2990^{b}
Mean	2787
LSD (5%)	520.992
CV (%)	18.69

Table III: Interaction effect of varieties and sowing date on pod length and average individual pod weight of green bean

Variety	Sowing date	Pod Length (cm)	Average Individual Pod Weight (g/pod)	Pod Diameter(cm)	Dry Weight of Pod(g/plant)
Melka-1	July 3rd	11.09^{e}	4.182^{e}	0.5942^{g}	16.87^{c}
Melka-1	July 18th	13.50^{a}	5.434^{c}	0.9465^{a}	25.41^{b}
Melka-1	August 2nd	12.34^{c}	4.568^{d}	0.8517^{c}	9.22^{d}
Melka-1	August 17th	11.79^{d}	3.638^{g}	0.7175^{e}	8.49^{d}
Melka-5	July 3rd	10.24^{f}	3.927^{f}	0.6559^{f}	25.48^{b}
Melka-5	July 18th	12.80^{b}	5.822^{b}	0.9488^{a}	30.90^{a}
Melka-5	August 2nd	13.64^{a}	6.472^{a}	0.9134^{b}	18.23^{c}
Melka-5	August 17th	12.47^{c}	4.541^{d}	0.7693^{d}	8.67^{d}
Mean		12.24	4.82	0.799	17.91
CV (%)		2.06	5.11	5.07	17.75
LSD (5%)		0.253	0.247	0.041	3.180

kg ha^{-1}) of green beans. The lowest total marketable pod yield (2,531 kg ha^{-1}) was obtained from green bean spaced at 50 cm x 7 cm which was on par with 40 cm x 15 cm, and 40 cm x 10 cm spacing (Table II).

Pod length

Pod length was significantly (P<0.05) affected by the interaction effect of the factors variety and time of sowing. The longest pod (13.5 cm) was obtained from variety Melka-1 sowed on July 18, which was on par with variety Melka-5 sowed on the 2nd of August; whereas the smallest pod length (10.2 cm) was obtained from Melka-5 sowed on the 3rd of July (Table III).

Pod diameter

Pod diameter was significantly (P<0.05) affected by the interaction effect of the factors variety and time of sowing. Thus, the widest pod diameter (0.9 cm) was obtained from Melka-1 sowed on the 18th of July. This value was however statistically similar with that of variety Melka-5 sowed on the 18th of July. The narrowest pod diameter (0.5 cm) was obtained from variety Melka-1 sowed on the 3rd of July (Table III).

Average pod weight

Average weight of individual pods was affected by the

Table IV: Interaction effect of varieties and sowing date on total number of pod per plot of green bean

	Sowing Date				Mean	CV (%)	LSD (5%)
Variety	July 3rd	July18th	August 2nd	August 17th			
Melka-1	422.4[c]	396.4[c]	239.5[e]	193.4[f]	312.93		
Melka-5	539.7[a]	478.9[b]	304.6[d]	146.9[g]	367.53		
Mean	481.05	437.65	272.05	170.15	340.3	14.94	50.838

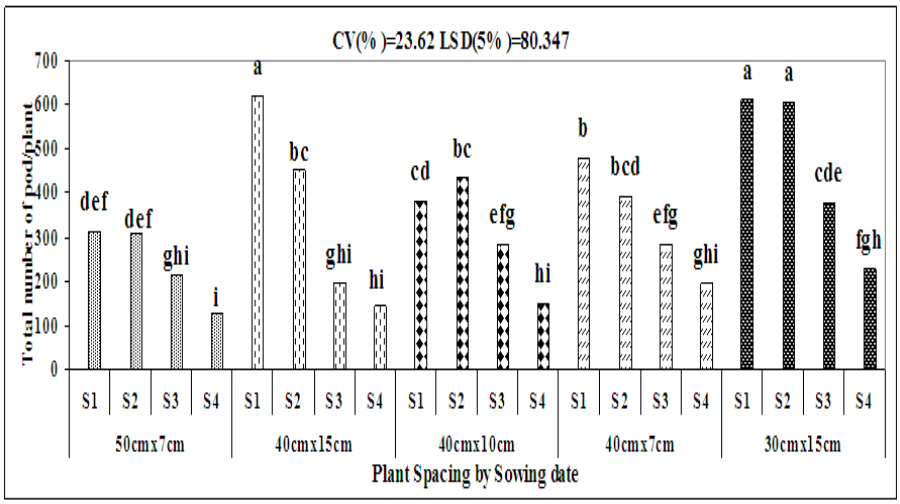

Figure 3: Interaction Effect of Plant Spacing and Sowing Date on Total Number of Pods per plot of Green Bean
S_1= 3rd July, S_2= 18th July, S_3=2nd August and S_4= 17th August

interaction effect of the factors variety and time of sowing. Accordingly, variety Melka-5 sowed on August 2 resulted in the highest average individual pod weight (6.5 g) and the lowest pod weight (3.6 g) was obtained from Melka-1 sowed on the 17th of August (Table III).

Pod dry weight

Pod dry weight was significantly (P<0.05) affected by the interaction effect of the factors spacing and time of sowing as well as by variety and time of sowing and mean values are presented in figure 2. The highest pod dry weight (34.48 and 35.84 g per plant) was recorded from the combination of 40 cm x 15 cm sowed on July 3, and 18th of July. This value was on par with 30cm x 15 cm sowed on July 3 and 50 cm x 7 cm sowed on the 18th of July. The lowest pod dry weight (7.93 and 7.58 g per plant) was obtained from the combination of 40 cm x 15 cm and 40cm x 10cm spacing sowed on 17th of August. In addition, the highest pod dry weight (8.49 g per plant) was found from variety Melka-5 sowed on 18th of July and the lowest (8.67 g per plant) was from both the varieties Melka-1 and Melka-5 sowed on 17th of August.

Number of pods per plant

There was a significant (P≤0.05) interaction effect between varieties and time of sowing and between spacing and time of sowing on the number of pod per plant. Accordingly, the greatest number of pods per plant (540) was obtained from variety Melka-5 sowed on the 3rd of July and the lowest number of pod per plant (147) was recorded from variety Melka-5 sowed on 17th of August (Table IV). Regardless of the varieties and the spacing used, number of pods per plant showed a decreasing trend as time of sowing is extended. Also, sowing of green beans at 40 cm x 15 cm on July 3 gave the greatest number of pods per plant (Figure 3). The lowest number of pods of per plant was obtained from 50 cm x 7 cm spacing sowed on 17th of August.

DISCUSSION

Highest marketable pod yield, pod weight, number of pods per plant was obtained from the earlier sowing and yield and yield components reduced as time of sowing is extended. This could probably be due to the exposure of

the plants for long duration of rainfall in the growing season that resulted in higher vegetative and assimilates production for optimum pod yield. This result is in agreement with the works of Yoldas and Esiyok (2007), Radulovich (1990), Escalante *et al.* (1989) and Ismail and Khalifa (1987) who obtained the lowest yield during the time of late sowing due to a short vegetation period of the crop. Sowing of green bean during mid-season tended to be more vigorous than green bean sowed at the earlier or later sowing and produced more total and marketable snap beans; except when heat and soil moisture stress resulted in flower abortion and pod abscission.

The highest total marketable pod yield of green bean was observed in the narrow spacing than in the wider spacing. This result agree with the work of Tyson and Kostewicz (1986) and Samih (2008) who reported that marketable snap bean pod yields increased linearly as the spacing reduced in different sowing times due to superior yield in the case of high plant populations over that of low plant population of beans. This could be due to less competition for nutrients and moisture among lower number of plants per unit area.

The widest pod diameter was obtained at the late sowing date than early sowing time. This could probably be due to the availability of more moisture at early sowing that enhanced the vegetative growth, which consequently resulted in widest diameter and higher yield (Yoldas and Esiyok, 2007). These authors also reported that early sowing produced higher yield, longest plant height, but lower pod diameter, dry matter and pod length than the late sowing date. This result agrees with the work of Marlene *et al*. (2008), who reported higher pod width (diameter) in late sowing than early sowing.

The highest dry weight of shoot and root and highest dry weight of pods were obtained when green beans were sown at a wider spacing early in the growing season; while the lowest dry weight of shoots, roots and pods was obtained from the interaction effects of narrow spacing sown late in the growing season. This could probably be due the less competition environment between plants in the wider plant spacing for soil nutrients and moisture. This result is in agreement with the works of Pawar *et al.* (2007) and Samih (2008) who reported an increased dry weight of green bean at the wider row spacing (30 cm), as compared to closer row spacing (22.5 cm) and higher values of pod dry weight was reported in a bush bean plant sowed at the lower planting densities as compared to higher planting density.

Among the varieties in our study, Melka-1 produced the longest pod when sown at the mid of July whereas the smallest pod length was obtained from Melka-5 sown at early July. This result could be probably due to the fact that during early sowing, plants could get adequate rainfall that could stimulate higher vegetative growth that can result in higher number of pods but with reduced pod length as a result of competition within pods per plant. This result agrees with the works of Yoldas and Esiyok (2007) and Corokalo et al. (1992).

In conclusion, our data suggested that mid July appears to be appropriate time of sowing and a spacing of 40 cm x 7 cm was adequate for an optimum pod yield and quality of green beans irrespective of the varieties.

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REFERENCES

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

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.

Corokalo O, Micadinovic Z, Zrdsvrokovic M, Brkic S (1992). The Effects of variety and sowing date on the yield of new snap bean lines. Savermena pol Joprivreda 40 (1-2):115-120

Escalante JA, Miranda S, Kohashi SJ (1989). Manual removal of reproductive organs: Their effect on flowering duration and age at physiological maturity in *Phaseohs vulgaris* L; 39(1):40

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

GenStat (2008). GenStat for teaching and learning. VSN International Software for bioscience.11th edition.

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.

Gomez L, Araya R (1986). Evaluation of Planting Dates and Varieties of Common Bean (*phaselous vulgaries)* Intercropped in coffee (*coffea arabica*).Agronomia Costarricense, 10(1-2): 1-11, (Hort. Abst.58 (9), 5753.

Ismail AMA, Khalifa FM (1897). Irrigation, Planting date and Intra- Row Spacing Effects on Soybean Grown under Dry Farming Systems. Qatar Univ. Sci, (7):149-167.

JARC (2010). Annual Meteorological Data. Jimma Agricultural Research Center, Jimma, Ethiopia.

Kay DE (1979). Food Legumes: Crop and Product Digest, No.

3. London: Tropical Products Institute. Pp 435.
Laurie H (1990). Basic Cultural Practices for Commercial Production of Green (Snap) Beans. Extension Historical Materials of Nebraska- Lincoln Extension. University of Nebraska. Lincoln,
Lemma D, Yayeh Z, Helath E (2003). Agronomic studies on Tomato and Capsicum. Pp.153.In:E.Helath and Lemma Dessalegne (Eds). Horticultural Research and Development in Ethiopia. Proceedings of the second Horticultural work shop of Ethiopia, 1-3 December, 1992. Addis Abeba, Ethiopia.
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.
Marlene PB, Ana María González AM, Rodiño AP, De Ron AM, Marta Santalla M (2008). Effects of planting season and plant cultivar on growth, development, and pod production in snap bean (*Phaseolus vulgaris* L.) Austral. J. Agric. Res., 59:1121–1129.
Mohammed JR, Shamsuddin T, Mushtaque AR, Fazel KR (1984). Effects of Row and Plant Spacing on Yield and Yield Components of Soybean. Pakistan J.Agric.Res,; **5:** 2.
Pawar SU, Kharwade ML, Awari HW (2007). Effect of Plant Density on Vegetative Growth and Yield Performance of Different Varieties of French bean under Irrigated Condition. J. Agric. Sci., 20(3):684-685
Qiu-ying Z, Yan-sheng L, Qing-lu G, Herbert SJ, Hashemi AM (2010). Influence of sowing date on phenological stages, seed growth and marketable yield of four vegetable soybean cultivars in North-eastern USA. Afri. J. Agric. Res.5(18):2556-2562
Radulovich RA (1990). AQUA, a model to evaluate water deficits and excesses in tropical cropping. Agricultural and Forest Meteorology, **52**: 253-261
Rangaswamy R (1995). A Text Book of Agricultural Statistics. New Age International Limited. New Delhi. India.
Rubatzkey VE, Yamagucbi M (1999). World Vegetable; Principles Production and Nutritive Values. 2nd edition, Aspen publishers. California. USA
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. Am. J. Agric. Biol. Sci., 3(4):666-668
Tyson RV, Kostewicz (1986). Weed Control in Narrow Snap Bean Production. Proc. Fla State Hort.Soc.99:358-362
Uslu N, Esendal E (1996). Response to Inoculation and Sowing Date of Soybean under Bafra Plain Conditions in the Northern Region of Turkey. Turk. J. Agric. Forestr., 22:525-531
Yan-sheng L, Qiu-ying Z, Qing-lu Gao S, Herbert J, Hashemi A (2010). Influence of sowing date on phonological stages, seed growth and marketable yield of four vegetable soybean cultivars in North-eastern USA. African J. Agric. Res. 5(18):2556 – 2562
Yoldas F, Esiyok D (2007). Effects of sowing dates and cultural treatments on growth, quality and yield of processing beans. Pak. J. Biol. Sci., 10:2470-2474.