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Effects of Sowing Date and Plant Population on Snap Bean (*Phaseolus vulgaris* L.) Growth and Pod Yield in Khartoum State

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Abstract This study was conducted to find an optimum sowing date and plant population for bean cultivars suitable for export in Khartoum State. A field experiment was conducted in winter in 2011-2012, at the College of Agricultural Studies, Sudan University of Science and Technology, Sudan. Two sowing datesS_1 and S_2 (7^{th} and 26^{th} of November, respectively) and six plant populations obtained by three plant spacing (10, 15 and20cm plant spacing) and two planting densities (2 and 3 plants/hill) on 70cm ridges were tested in completely randomized block design in four replications. The results showed that early sowing date (S_1) had positive effects on both growth and pod yield and quality compared to late sowing (S_2), irrespective of plant population. Increasing of plant population increased plant height but decreased pod yield. The highest pod yield (105.9 g) was obtained at early sowing (S_1) by 2plants/hill and 20cm plant spacing which was almost double that (56.3 g) obtained at the same plant population at late sowing (S_2). Pod yield /ha was higher at S_1 at all plant population than S_2. However, the highest pod yield/ha was obtained at S_1 by the highest plant population (3plant/ hill at 10cm spacing) and the lowest at S_2 by the lowest plant population (2plants/hill at 20cm spacing). Moreover, all pod quality parameters were positively affected by planting density irrespective of plant spacing. It could be concluded that for optimum green pod yield and quality of beans for export it should be sown as early as the first week of November at 2 plant/hill and 10 cm or 3 plants/hill at 15cm plant spacing on 70cm ridges in Khartoum State and areas of similar conditions.

Keywords Snap Bean, Sowing Date, Plant Spacing, Planting Density, Pod Yield

1. Introduction

Snap bean (*Phaseolus vulgaris* L.) belongs to the family *Fabaceae*. It is used for its fresh pods or dry seeds which are a good source of vitamins A and C and calcium, in addition to proteins [1]. It is grown in large scale for export especially in Egypt, Kenya, Tanzania and Uganda [2]. In Sudan, it also becomes increasingly important and more efforts were done by the Ministry of Agriculture in Khartoum State, to produce snap beans for export. However, its yield and quality are still low due to poor cultural practices. Recently new hybrid cultivars which are suitable for export were introduced and more efforts on the improvement of cultural practices were done [3]. One of the important cultivars introduced is New star 2052, but some of its cultural practices such as sowing date and plant population should be tested to have high yield and quality and at the proper time for markets.

The optimum temperature range for optimum bean growth is 16- 30^0C [4]. Nonnecke [5] reported that the main daily temperature during the growing season of beans should be in the range of 15-30°C. Temperature below or above that range had deleterious effects on plant performance. Seeds would not germinate or might be decayed at temperature below 10°C [6]. Hot dry or wet weather results in flower and pod shedding. Its growth could be improved by its sowing on the proper date. References [7-11] evaluated four sowing dates (5^{th} and 20^{th} of October and 4^{th} and 19^{th} of November) of French bean. They found that sowing on 4^{th} of November produced the tallest plant, with the highest leaf number. Similarly [12] compared three sowing dates (1^{st}, 5^{th} and 30^{th} of November). He found that early sowing (1^{st} of November) had significant positive effects on bean growth. References [13-15], in Egypt and [16], in Mexico, reported that sowing in November, in warm regions and in February and May, in temperate regions, increased plant dry weight and green pod yield and quality.

Plant spacing affects plant growth and yield due to increased competition with increased plant population. Moreover, the optimum plant population differs with the availability of soil moisture, relative humidity and nutrients. Higher plant population i.e. close plant spacing reduced plant growth and yield components but increased yield per unit area [17]. References [18-21] pointed that seed, pods and

straw yields per plant were increased by increasing row spacing. Aguiar *et al*. [22] obtained the highest pod yield per unit area at 25plants /m^2.

Abubaker [23] found that the highest early yields (73% and 71%) were obtained at plant densities 20x30 cm and 30x 30cm, respectively. This study was conducted to asses which sowing date and plant population would be optimum for bean cultivars suitable for export in Khartoum State.

2. Materials and Methods

A field experiment was conducted during the winter season of the year 2011-2012, at the College of Agricultural studies, Sudan University of Science and Technology, (lat.15 ^{0} 40N, long. 32 ^{0}32E, and the altitude of 380m above the sea level),Sudan. It was executed in randomized complete block design with four replications. Plot size was 3.5x3 m2, (2.5 ridge length, and 70cm spacing). The seeds were sown on northern side of the bed, at two different sowing dates (7th and 26th November), three within ridge spacing (10, 20, and 30cm), and two different planting density (2 and 3plants/hill). The seeds were treated with Thiram (seed dresser) before planting. Three to four seeds were sown per hill, and thinned later (after 16 days from sowing) into two to three plants. The cultural practices were done as recommended.

The vegetative growth was evaluated as plant height, leaf area index, and shoot fresh and dry weights at 50% flowering and the green pod yield and quality were evaluated as number of pods per plant, pod weight, yield per hectare and pod length and diameter. The data were analyzed using the soft ware package MSTATC and means were separated using the least significant difference (LSD) at P≤ 0.05 [24].

3. Results and Discussion

As in Table1 the plants sown at S_1 (7th November) were significantly higher than those sown at S_2 (26th of November), whereas there were no significant differences in plant height due to plant spacing and planting density. However, the highest plants (16.2 cm) were obtained at S_1 and 3plants per hill at 15cm spacing. The leaf area was significantly higher at S_2 and higher plant population, where, the highest leaf area (173.5 cm^2) was obtained at 3plants per hill and 15cm plant spacing. Similar effects of sowing date and plant population (plant spacing x plants/hill) were also noticed on both shoot fresh and dry weight, where, the highest values were obtained at the late sowing date (S_1) with 2plants/ hill at 15cm spacing (Table2).

No significant differences on early flowering and number of pods/ plant due to early sowing (S_1) or increased plant population (plant spacing x plants/ hill (Table3) were noticed, however, early flowering and higher pod number were obtained at the early sowing (S_1) and at the lowest plant population (2 and 3 plants / hill at 20cm spacing). Generally there was an increase in yield/plant (Table4) with early sowing (S_1) and widest plant spacing (20 cm spacing). The highest plant yield (105.9 g) was obtained at early sowing (S_1) by 2 plants/hill and 20cm plant spacing which was almost double that (56.3 g) obtained at the same plant population at late sowing (S_2). Pod yield /ha was higher at S_1 at all plant population than S_2. However, the highest pod yield/ha was obtained at S_1 by the highest plant population (3 plants/ hill at 10cm spacing) and the lowest at S2 by the lowest plant population (2 plants/hill at 20cm spacing).

Table 1. Effect of sowing date ($S_1$and S_2) and plant spacing x plants/ hill) on plant height and leaf area index of snap beans

Parameter	Plant height(cm)			Leaf area index(cm^2)		
Plant spacing×	Sowing date(7th and 26th of November)					
Plant/hill	S_1	S_2	Mean	S_1	S_2	Mean
10cm:2 plants	14.3	12.9	13.6	115.9	145.1	130.5
10cm:3 plants	14.7	13.8	14.2	130.7	148.5	139.6
15cm:2 plants	14.9	13.2	14.1	121.4	171.1	146.3
15cm:3 plants	16.2	13.1	14.6	128.9	173.5	151.2
20cm:2 plants	14.7	12.6	13.7	126.0	135.4	130.7
20cm:3plants	14.4	12.7	13.6	131.9	152.8	142.4
Mean	14.9	13.1		125.8	154.4	
LSD at P≤0.05			1.4			21.6

Table 2. Effect of sowing date (S_1 and S_2) and plant spacing x plants/ hill on shoot fresh and dry weight of snap bean

Parameter	Shoot fresh weight(g)			Shoot dry weight(g)		
Plant spacing ×Plant/hill	Sowing date(7th and 26th of November)					
	S_1	S_2	Mean	S_1	S_2	Mean
10cm:2 plants	24.2	23.4	23.8	3.6	3.8	3.6
10cm:3 plants	22.2	21.2	21.7	3.2	3.3	3.3
15cm:2 plants	28.2	35.7	31.9	3.4	5.4	4.4
15cm:3 plants	23.1	32.0	27.5	3.5	5.3	4.4
20cm:2 plants	26.0	30.2	28.1	3.8	4.5	4.2
20cm:3plants	24.6	30.6	27.6	3.6	4.9	4.3
Mean	24.7	28.8		3.5	4.5	
LSD at P≤0.05			8.9			1.3

Table3. Effect of sowing date (S_1 and S_2) and plant spacing x plant/ hill on days to 50% flowering and number of pods/plant of snap bean

Parameter	Days to 50% flowering			Number of pods/plant		
Plant spacing× Plant/hill	Sowing date(7th and 26th of November)					
	S_1	S_2	Mean	S_1	S_2	Mean
10cm:2 plants	44.0	44.5	44.3	16.1	14.3	15.2
10cm:3 plants	43.8	44.8	44.3	15.0	12.0	13.5
15cm:2 plants		42.0	43.8	42.9	20.8	17.9
15cm:3 plants		43.8	43.8	43.8	17.0	12.9
20cm:2 plants		44.0	45.5	44.8	26.7	18.5
20cm:3plants		44.3	44.5	44.4	24.1	15.5
Mean	43.6	44.5		19.9	15.2	
LSD at P≤0.05			2.0			3.6

Table 4. Effect of sowing date (S_1 and S_2) and plant spacing x plants/ hill on pod yield per plant and hectare (ha) of snap bean

Parameter	Pod yield/plant(g)			Pod yield/ha(ton)		
Plant spacing× Plant/hill	Sowing date(7th and 26th of November)					
	S_1	S_2	Mean	S_1	S_2	Mean
10cm:2 plants	57.9	46.3	51.1	16.4	13.3	14.9
10cm:3 plants	56.3	38.6	47.9	24.0	16.4	20.4
15cm:2 plants	70.4	54.6	67.5	15.0	11.7	13.4
15cm:3 plants	68.1	43.1	53.68	21.9	13.8	17.9
20cm:2 plants	105.9	56.3	86.1	15.0	8.1	11.6
20cm:3plants	77.4	50.5	70.2	16.4	12.1	14.3
Mean	76.9	48.4		18.1	15.2	
LSD at P≤0.05			18.6			4.3

Early sowing (S_1) had positive effects on pod quality (pod length, diameter, fresh and dry weight), especially, on pod diameter (Table 5) and dry weight(Table 6) compared to late sowing (S_2). Moreover, all pod quality parameters were positively affected by planting density irrespective of plant spacing.

Table 5. Effect of sowing date (S_1 and S_2) and plant spacing x plants/hill on pod length and diameter of snap bean

Parameter	Pod length(cm)			Pod diameter(mm)		
Plant spacing× Plant/hill	Sowing date(7th and 26th of November)					
	S_1	S_2	Mean	S_1	S_2	Mean
10cm:2 plants	12.0	11.8	11.9	7.6	7.4	7.5
10cm:3 plants	12.5	11.9	12.2	7.9	7.3	7.6
15cm:2 plants	12.2	11.9	12.1	8.2	7.2	7.7
15cm:3 plants	12.4	11.8	12.1	7.9	7.4	7.7
20cm:2 plants	12.6	12.0	12.3	8.5	7.1	7.8
20cm:3plants	12.3	12.2	12.3	7.8	7.4	7.6
Mean	12.3	11.9		8.0	7.3	
LSD at P≤0.05			0.6			0.1

Table 6. Effect of sowing date (S_1 and S_2) and plant spacing x plants /hill on pod fresh and dry weight of snap bean

Parameter	Pod fresh weight(g)			Pod dry weight(g)		
Plant spacing× Plant/hill	Sowing date(7th and 26th of November)					
	S_1	S_2	Mean	S_1	S_2	Mean
10cm:2 plants	3.5	3.2	3.2	0.33	0.19	0.26
10cm:3 plants	3.9	3.3	3.3	0.27	0.18	0.23
15cm:2 plants	3.8	3.1	3.1	0.30	0.17	0.24
15cm:3 plants	3.9	3.2	3.20	0.27	0.19	0.23
20cm:2 plants	4.3	3.1	3.1	0.32	0.17	0.25
20cm:3plants	3.7	3.3	3.3	0.32	0.20	0.26
Mean	3.8	3.2		0.30	0.18	
LSD at P≤0.05			0.4			0.04

It was clear that snap bean sowing as early as the first week of November (S_1) has positive effects on plant height but the reverse was noticed on leaf area index, which was higher at the late sowing (S_2). Both growth parameters were increased by high planting density (plants/hill) irrespective of plant spacing. Similar results were obtained by [25] who reported a decrease of plant height, stem width and number of branches with delayed sowing, which was attributed to short growth period.

Also [26] reported an increase in plant height but a decrease in number of branches at higher plant densities. Taleei *et al*. [27] reported maximum growth of beans at 50plants/m^2 compared to 35plants/m^2. This might be attributed to the differences among cultivars as reported by [28] in cowpea. They stated that cultivars with upright growth forms had higher plant population than vining or semi vining types, as the upright forms performs much better in narrow rows. The non significant effect of sowing date on days to flowering might be attributed to the suitable weather conditions (the average temperature was around 24°C in November and December but dropped to 21°C in January). References [25,29] reported a significant earliness of plant flowering with an increase of air temperature at a range of 21-28°C). Nevertheless, to maximize biomass accumulation, the life cycle and particularly the timing of reproductive development and growth, they must be timed to match the available resources [30].

The significant positive effects of sowing date on pod yield and quality and their components were also confirmed by [31,7] who reported improvement of both quantitative and qualitative traits of bean depended on sowing on the proper date. References [14, 16,15] found that early sowing of bean in November (in winter in warm regions) and in February and May (in spring in temperate regions) increased plant dry matter and green pod yield and quality.

Similar effect of planting density on yield and quality were also shown by [27,32]. They stated that plant density had significant effect on number of pods per plant, yield per unit area and harvest index. It could be concluded that beans should be sown as earlier as November to avoid the effect of high temperature on flowering and fruit setting late in the season. Increasing of plant density to 3plants per hill and at medium plant spacing of 15cm or 2plants/hill at the narrowest spacing 10cm gave maximum pod yield per unit area and quality. Therefore, snap bean for export in Khartoum State and areas of similar environmental condition should be sown within the first week of November and at 2 or 3plants/ hill at 10 or 15cm spacing, respectively.

REFERENCES

[1] S. Mayhew and A. Penny. Tropical and Sub-Tropical foods. MacMillan Education LTD. London, England, 1988.

[2] A.M.R. Abdel Mawgoud, M. El Desuki, S.R. Salman and S.D Abu Hussein Performance of some snap bean varieties as affected by different levels of mineral fertilizers. Agronomy Journal, Vol.4, No.3: 242-247, 2005.

[3] A.H. AL-amin. Response of two cultivars of snap bean

(Phaseaolus vulgaris L.) to micronutrients foliar fertilizer and rhizobum inculastion. M. Sc. Thesis, University of Khartoum, Sudan, 1998.

[4] R. Nonnecke. Vegetables Production. Van Notrand Reinhold. New York, USA, 1989.

[5] M. Yamaquchi. World Vegetables. Principles, Production and Nutritive Values. Ellis Horwood Limited, Publishers. Chichester, England, 1983.

[6] R.P. Poincelot. Horticulture Principles, Practical Applications. Prentice Hall, Inc. New Jersy, USA. 1980.

[7] A.H. Amer, O.M. Sawan and S.R. Salman. Water requirements of snap bean (Phaseoulus vulgaris L.) as affected by sowing date under newly reclaimed soil at Shark AL-Owainat region. Journal of Agricultural Science, Mansoura University, Vol. 27, No. 9: 6135-6145, 2002.

[8] Y. Gross and I.J. Kigel. Differential sensitivity to high temperature of stages in the reproductive development of common bean (Phaseolus vulgaris L.). Journal of Field Crop Research, Vol. 36: 201-212, 1994.

[9] B. Mouhouche, F. Ruget and R. Delecolle. Effects of water stress applied at different phenological phases on yield components of dwarf bean (Phaseolus vulgaris L.). Agronomie, Vol. 18 : 197-205, 1998.

[10] F.J. Ibarra-Perez, D. Barnhart, B. Ehdaie, M. Kniok and J.G.Wains. Effects of insect tripping on seed yield of common bean. Crop Science, Vol.39 : 428-433, 1999.

[11] O.R. Singh. Effect of dates of sowing and graded doses of nitrogen on growth and yield of French bean cv Contender in eastern U.P. Orissa. Journal of Horticulture, Vol. 27, No. 2: 39-42, 1999.

[12] F.I. Rehab. Effect of sowing dates and VA-mycorrhizal inoculation on growth attributes, yield and its components of three varieties of of faba bean Vicia faba, L. Advance Agricultural Research, Vol. l4, No. 3: 963-981, 1999.

[13] M.T. Tolba, E.S. Ameen and A.M. Moghazi. Effect of sowing date as well as nitrogen fertilizer level on growth, yield and dry seed quality of cowpea plant. Journal of Agricultural Science, Vol. 27, No.11: 7611-7622, 2002.

[14] A.H. Amer. Effect of sowing dates on gene action of some snap bean (Phaseolus vulgaris L.) varieties under the conditions of Shark Al-Owinat region. Zagazig Journal of Agricultural Research, Vol. 31, No.5: 2077-2095, 2004.

[15] A. B. Ewas. Effect of some treatments on the tolerance of snap bean plants to early planting dates. PhD. Thesis, Ain Shams University, Cairo, Egypt, 2010.

[16] S. Ramirez, N.E. Estrada, J.A. Gonzalez and M.T. Montes. Yield and quality of snap bean (Phaseolus vulgaris L.) through planting dates. Revista Fitotenca Mexicana, Vol. 31, No. 3: 235-241, 2008.

[17] M.N. J. Wanns, D. H. Denes and R.J. Barcen. Effects of planting density and design on pod yield of bush snap bean (Phaseolus vulgaris L.). Canadian Journal of Plant Science, Vol. 66: 669-675, 1986.

[18] S. P.Singh, N.P. Singh and R.K. Pandey. Performance of Faba bean varieties at different plant densities. FABIS Newsletter, Vol.30: 29-31, 1992.

[19] H. Stutzel, W. Aufhammer and A. Lober. Effect of sowing technique on yield formation of (Vicia faba L.) as affected by population density, sowing date and plant type. Journal of Agricultural Science, Vol. 122, No. 2: 255-264, 1994.

[20] S. Al Ghamdi. Genetic behavior of some selected faba bean genotypes. African Crop Science Proceedings, Vol. 8: 709-714, 2007.

[21] A.A.M. Osman, S.O. Yagoub and O.A. Tut. Performance of faba beans (Vicia faba L.) cultivars grown in new agro-ecological regions of Sudan (South Sudan). Australian Journal Basic and Applied Science, Vol. 4, No. 11: 5516-5521, 2010.

[22] J. Aguiar, F. Laemmlen, A. Baameur and K. Mayberry. Snap Bean Production in California, Vegetable Production Series, University of California Publication, 7240, USA, 1998.

[23] S, Abubaker. Effect of planting densities on flowering date, yield and quail ty attributes of bush bean (Phaseolus vulgaris L.) under center pivot irrigation system. American Journal of Agricultural and Biological Sciences, Vol. 3, No. 4: 666-668, 2008.

[24] R. G. D .Steel, J. H. Torrie and D. A. Dickie. Principles and Procedures of Statistics. 3rd. Edn. Mc Graw Hill Book Co., New York, USA, 1997

[25] D.H. Wallace, P.A. Gniffke, P. N. Masaya and R.W. Zobei. Photoperiod, temperature, and genotype interaction effects on days and nodes required for flowering of bean. Journal of American Society of Horticultural Science, Vol. 116, No. 3: 534-543, 1991.

[26] S.J. Shirtliffel and A.M. Johnston. Yield density relationships and optimum plant population in two cultivars of solid seededdry bean (Puaseolus vulgaris L. grown in Saskatchewan. Canadian Journal of Plant Science, Vol. 83: 521-529, 2002.

[27] A. Taleei, K., Poustini and C.D. and Emami. Effect of plant population density on physiological characteristics of common bean (Phaseolus vulgaris L.). Iranian Journal of Agricultural Sciences, Vol. 31, No. 3: 477-487, 2000.

[28] C. R. Werber, R. M. Shibles and D.E. and Byth. Effect of plant population and row spacing on soybean development and production. Agronomy Journal,Vol. 58: 99-102, 2007.

[29] R.P. Shiringani. Effects of planting dates and location on phenology and yield and yield componentsamong selected cow pea varieties. M.Sc. Dissertation, Faculty of Sciences and Agriculture, University of Limpopo, South Africa, 2007.

[30] M.M. Ludlow and R.C. Muchow. A critical evaluation of traits for improving crop yields in water limited environments. Advances in Agronomy, Vol. 43:107-153, 1990.

[31] H.N. Mishra, A.K. Mohapatra, S. Sahoo and A.K.B. Mohapatra. Performance of french bean under different dates of sowing in eastern ghat high land zone of Orissa .Annals of Agricultural Research, Vol. 19, No. 1: 83- 84, 1998.

[32] E. Kazemi, N. Rahim, Z. Karimi and T. Imami. Variability of grain yield and yield component of white bean (Phaseolus vulgaris L.) cultivars as affected by different plant density in Western Iran. American- Euroasian Journal of Agriculture and Environmental Sciences, Vol. 12, No. 1:17-22, 2012.