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Standardization of spacing and nitrogen dose for Yard long bean (*Vigna unguiculata* sub sp. *sesquipedalis* L. Verdcourt) under Konkan agro- climatic conditions

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Abstract
The present investigation was carried out at College of Horticulture, Dapoli, Dist. Ratnagiri during *rabi* 2020-2021. The experiment was laid out in Split Plot Design with three replications. There were 12 treatment combinations comprised of three different spacing *viz*., S_1 (90 cm x 15 cm), S_2 (90 cm x 30 cm), S_3 (90 cm x 45 cm) and four nitrogen levels *viz*., N_1 (45:60:30 NPK kg/ha), N_2 (60:60:30 NPK kg/ha), N_3 (75:60:30 NPK kg/ha), N_4 (90:60:30 NPK kg/ha). The obtained results showed that all the parameters were markedly affected by different spacing, nitrogen levels. Among various spacing and nitrogen levels significantly maximum pod yield per hectare (31.10 t/ha) were recorded in S_2N_3. Hence, evaluation of production revealed that growing of Yard long bean @15t FYM/ compost at 90 cm x 30 cm spacing with fertilizer application at the rate of 75:60:30 NPK kg/ha was most remunerative option to get higher yield and more return under Konkan agro climatic conditions.

Keywords: yard long bean, *Vigna unguiculata* sub sp. *sesquipedalis* spacing, nitrogen levels, yield

1. Introduction

Yard long bean (*Vigna unguiculata* sub. sp. *sesquipedalis* (L.) Verdcourt 2n=22) belonging to family Leguminosae is one of the economically important leguminous crop. It is cultivated mainly for its crisp and tender green pods which are consumed both fresh as well as in cooked form. It is also known as long-podded cowpea, Chinese long bean, bodi/boda (West Indies), *dau gok* (China), *pole sitao* (Philippines), snake bean, pea bean, asparagus bean, body bean due to its long slender pods. However, it is popularly known as '*wali'* in Konkan region of Maharashtra. Yard long bean is considered to be originated in Central Africa and widely distributed in India, Indonesia, Philippines and Sri Lanka. According to Verdcourt (1970), cowpea has five sub- species, which are cylindrical, *Sesquipedalis*, *dekindtiana*, *unguiculata* and *manensis*. Among them, *cyndrical*, sesquipedalis and *unguiculata* are cultivates species, whereas *dekindtiana* and *menensis* are wild.

It is a vigorous climbing annual vine; requires trellis to support to flourish. Depending upon the cultivar types, it bears blue to violet flowers after about 6-10 weeks of sowing. Flowers remain open overnight and only seen in the early morning. Numerous pencil thin, tender light green, flexible- textured pods appear after about 2-4 weeks of flowering. Once the beans production starts, they need harvesting at least twice a week. To ensure continuous production, uninterrupted supply of sufficient moisture and nutrients extend its lifecycle upto 7 to 8 months. The fleshy, pendulous pods are usually harvested while they are immature and eaten as green vegetables as raw or cooked. The pods vary in length which ranges from 30-80 cm. It is widely grown in Southeast Asia, South China, Indonesia, Philippines, Taiwan, and Thailand (Rachie, 1985). It is one of the choicest vegetable especially in south Konkan i.e. Sindhudurg district and south part of Ratnagiri district as well as in Goa, costal Karnataka and Kerala. Its long slender, tender pods are cooked to prepare excellent tasty dish with potato. The pod fetches attractive market price and having great demand in local as well as in nearby metropolitan markets like Panaji, Mhapusa, Madgao, Kolhapur, Mumbai, Ratnagiri, etc.

Being leguminous vegetable, it is known for its nutritive value. It contains a good amount of digestible protein both in pods (23.5 -26.3%) as well as in leaves. Yard long beans are a good source of vitamins A and C, providing 17% and 31% of the recommended daily intakes of these vitamins respectively. It is also rich in calcium (72.0 mg), phosphorus (59 mg), iron (2.5 mg), carotene (564 mg), thiamine (0.07 mg), riboflavin (0.09 mg) and vitamin C (24 mg) per 100 g of edible pods.

It is also a good source of micronutrients containing 102.69 - 120.02 mg kg^{-1} of iron, 32.58-36.66 mg kg^{-1} of zinc, 2.92-3.34 mg kg^{-1} of manganese, and 0.33- 0.57 mg kg^{-1} of cobalt (Ano and Ubochi, 2008) [2].

Konkan is a region of high rainfall with lateritic soils where rice based cropping system is popularly practiced and after withdrawal of rains vegetable cultivation is followed wherever irrigation is available. It enriches soil fertility by fixing atmospheric nitrogen. Because of its quick growth habit, it has become an essential component of sustainable agriculture. The average temperature required for its optimum growth and development during the growth period is 20ºC to 30ºC. It prefers full sunshine during growth and development, whereas cloudy and rainy weather cause low yield due to poor fruit set and dropping of young pods. It can be grown in various soil types from sandy loam to clay, but loam and sandy loam soils with pH 6.2-7.0 are the best for yard long bean production. The agro-climatic conditions of the region are very much suitable for yard long bean cultivation. Hence it has secured a key position in rice based cropping system of Konkan.

Yard long bean is gaining commercial importance especially along the entire coastal region in recent year and emerging as popular vegetable cash crop, however, so far very limited attempt has been made to study the various production practices for maximization of yield yard long bean. Being multiple harvest crop the yield ultimately depends upon the plant population and growth of the plant which intern depends on the nutrient supply. The recommendations regarding proper spacing and fertilizer dose will help the farmers to maximize yield of yard long bean which will help to increasing the returns.

2. Materials and Methods

The present investigation was conducted during *rabi* 2020-2021 at College of Horticulture, Dapoli Dis. Ratnagiri (MS) to standardize the spacing and nitrogen levels for optimum growth and yield of yard long bean var. DPL-YB-10 under Konkan agro climatic conditions. The experiment was laid out in Split Plot Design with spacing (S) as main plot and Nitrogen levels (N) as a subplot treatment with three replications. The experimental treatments comprised of three different spacing *viz*., S_1 (90 cm x 15 cm), S_2 (90 cm x 30 cm), S_3 (90 cm x 45 cm) and four nitrogen levels *viz*., N_1 (45:60:30 NPK kg/ha), N_2 (60:60:30 NPK kg/ha), N_3 (75:60:30 NPK kg/ha), N_4 (90:60:30 NPK kg/ha). The soil of the experimental plot was lateritic loamy soil having pH in the range of 5.5 to 6.5. Well decomposed FYM @15 t/ha was incorporated in the soil. A basal dose of 22.5 kg, 30 kg, 37.5 kg, 45 kg nitrogen as per treatment details, 60 kg phosphorous and 30 kg potash per hectare was applied through urea, single super phosphate and murate of potash. The spot application of NPK fertilizer levels as per the treatment details were done. Seeds were sown on flat bed at the spacing as per the treatment details. The various growth parameters, flowering parameters, yield and yield attributing characters and physical parameters was recorded during the experimental period from five randomly selected plants from each plot. Statistical analysis of the data recorded carried out by standard method of analysis of variance described by Panse and Sukhatme (1995) [14].

3. Result and Discussion

3.1 Effect of on growth parameter

Various growth parameters were affected significantly by various spacing and nitrogen levels (Table 1). Among various spacing significantly maximum length of vine (361.24 cm), number of nodes (25.11) and number of leaves (98.57) were reported in S_2. Whereas maximum number of primary branches were reported in S_3 (14.77). It might be due to due to increase in availability of nutrient, sunlight and water for individual plant and other environmental resources. The varied nitrogen levels showed non-significant effect on various growth parameter. Among interaction between spacing and nitrogen levels maximum length of vine was observed in S_2N_2 (369.17cm). Medium plant spacing and moderate nitrogen dose produced comparatively maximum length of vine. It might be due to greater competition for space, light and nutrients thereby forcing the plants to grow taller. Increase in the number of plants per unit area coupled with high plant to plant competition leads to lower amount of light intercepted by a single plant resulting into higher length of vine. Number of primary branches per plant also differed significantly in all the growth stages. Maximum average primary branches per plant were recorded in S_3N_2 (15.10). It might be due to the fact that the number of primary branches increases with decrease in plant density. The increased number of primary branches at the wider plant spacing and moderate nitrogen levels could be attributed to more interception of sunlight for photosynthesis and adequate amount of nutrients for growth which may have resulted in production of more assimilates for partitioning towards the development of higher branches. The spacing and nitrogen levels had significant effect on number of nodes per plant. Maximum number of nodes was revealed in S_2N_2 (25.60). It might be due to the variation in spacing and availability of nutrients creating favourable micro-climate for growth. Hence higher number of nodes per plant was observed in medium spacing and moderate nitrogen levels. The spacing and nitrogen levels also had significant effect on number of leaves per plant. The maximum number of leaves was reported in S_2N_2 (100.27). The higher number of leaves was reported in medium spacing and moderate nitrogen dose may be due to fact that plants with a medium spacing will receive more light than plants in closer spacing which might have increased the photosynthetic activity allowing the plant to produce maximum number of leaves.

These findings are in line with the results reported by Parameswari *et al*. (2003) [15] in pigeon pea, Pawar *et al*. (2007) [16] in french bean, Shrikant *et al.* (2007) [18] in lablab beans. Chakravorty *et al.* (2009) [5] in french bean, Naimah *et al.* (2010) in cow pea, Kadam and Khanvilkar (2015) [10] in green gram, Nersekar (2016) [13] in yam bean, Dandile (2017) [7], Bam (2018) [3] and Manjesh (2019) [11] in yard long bean.

3.2 Effect on flowering parameters

Different spacing and nitrogen levels had significant effect on days for initiation of flowering and days for fifty percent of flowering (Table 2). Among spacing S_3 reported lowest days for initiation of flowering (55.0 days) and days to fifty percent flowering (55.40 days). It might be due to adequate sunlight, water, and nutrient availability throughout vegetative and reproductive growth which might lead to more photosynthesis and more accumulation of carbohydrates. Among nitrogen levels lowest days for initiation of flowering (55.03 days) was reported in N_2 and N_3 whereas, lowest days for fifty percent flowering were recorded in N_2 (55.16 days). It might be due to be due to availability of adequate supply of nitrogen for optimum vegetative growth followed by reproductive growth.

Among interaction between spacing and nitrogen S_2N_2 reported significantly lowest number of days *viz*., 54.27 days and 54.40 days for initiation of flowering and fifty percent flowering respectively. The low population density delayed the maturity due to higher number of leaves and higher availability of nutrients lead to profuse vegetative growth which delayed the reproductive phase (Manjesh, 2019) [11].
These findings were in confirmatory with Shrikant *et al*. (2008) in lablab bean Nersekar (2016) [13] in yam bean, Dandile (2017) [7] and Bam (2018) [3] in yard long bean.

Table 1: Effect of spacing, nitrogen levels and their interaction on growth parameter at 120 DAS.

	Length of vine				Number of primary branches				Number of nodes				Internodal length				Number of leaves per plant			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	327.07	365.53	365.23	352.61	12.40	14.53	14.90	13.94	23.33	24.40	25.37	24.37	14.02	14.98	14.40	14.47	94.77	99.17	97.03	96.99
N_2	336.20	369.17	357.80	354.39	12.67	15.00	15.10	14.26	23.67	25.60	25.20	24.82	14.21	14.42	14.20	14.28	96.00	100.27	96.07	97.44
N_3	342.07	357.33	359.63	353.01	12.53	15.07	14.70	14.10	24.20	25.40	24.40	24.67	14.14	14.07	14.78	14.33	92.93	96.80	98.27	96.00
N_4	352.73	352.93	352.47	352.71	13.20	14.40	14.37	13.99	24.60	25.03	25.07	24.90	14.34	14.10	14.06	14.17	95.83	98.03	96.47	96.78
Mean	339.52	361.24	358.78	353.18	12.70	14.75	14.77	14.07	23.95	25.11	25.01	24.69	14.18	14.39	14.36	14.31	94.88	98.57	96.96	96.80
	RES	Sem±	CD		RES	Sem±	CD		RES	Sem±	CD		RES	Sem±	CD		RES	Sem±	CD	
S	SIG	1.10	4.32		SIG	0.04	0.14		SIG	0.16	0.63		NS	0.08	-		SIG	0.52	2.05	
N	NS	1.13	-		NS	0.11	-		NS	0.19	-		NS	0.13	-		NS	0.34	-	
SXN	SIG	1.95	5.80		SIG	0.19	0.58		SIG	0.34	1.00		NS	0.22	-		SIG	0.60	1.77	

Table 2: Effect of spacing, nitrogen levels and their interaction on flowering parameter.

	Number of days for initiation of flowering				Number of days for 50% flowering			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	56.67	54.93	55.80	55.80	57.27	55.40	55.20	55.96
N_2	56.20	54.27	54.63	55.03	56.47	54.40	54.60	55.16
N_3	54.80	55.73	54.57	55.03	58.20	55.60	55.40	56.40
N_4	56.67	56.97	55.00	56.21	57.73	57.20	56.40	57.11
Mean	56.08	55.48	55.00	55.52	57.42	55.65	55.40	56.16
	RES	Sem±	CD		RES	Sem±	CD	
S	SIG	0.14	0.55		SIG	0.07	0.28	
N	SIG	0.09	0.27		SIG	0.10	0.30	
SXN	SIG	0.15	0.46		SIG	0.17	0.51	

3.3 Effect on yield and yield attributing characters

Influence of various spacing and nitrogen levels on yield and yield attributing characters was found to be significant (Table 3). Among various spacing lowest days from flowering to harvesting (8.95 days), maximum number of pods per plant, (40.27), number of pickings (15.35), duration of harvest (53.92 days), pod yield per plot (22.04 kg), pod yield per hectare (30.12) was reported in S_2. This could be due to the availability of limited space for vegetative growth, which encouraged pod development there by increase in pod yield. Among nitrogen levels maximum pod yield per plant (0.66 kg), pod yield per plot (18.19 kg), pod yield per hectare (24.81 t/ha) were recorded in N_3. It might be due to adequate availability of nutrients space, moisture to the individual plant. Among interaction between spacing and nitrogen levels Significantly lowest number of days to first picking (66.40 days), lowest number of days from flowering to harvesting (8.60 days), maximum number of pods per plant (42.42) as well as longest duration of harvest was reported in S_2N_2. It might be due to adequate availability of light intensity, space, moisture and nutrient availability and less competition among the plants than closer spacing. Significantly pod yield per plant was highest in S_3N_2 (0.87 kg) followed by S_3N_3 (0.85 kg). Increase in pod yield as a result of higher net assimilation rate and reduction of competition in wider spacing and also adequate availability of nutrient, moisture and light. Maximum yield per plot (22.97kg), yield per hectare was reported in S_2N_3 which was superior among all treatment combinations. The reason for the higher yield may probably be due to less competition for light, nutrients, water and space in wider row-spacing compared to closer ones.
These findings are in confirmatory with Bokade (2008) [4] in yard long bean, Chaudhary (2009) [6] in French bean, Dandile (2017) [7], Ajeet *et al*. (2018) [1] in French bean, Bam (2018) [3] in yard long bean.

3.4 Effect on physical parameter of pod

A critical appraisal of the data given in Table 4 revealed that spacing and nitrogen levels had significant effect on physical parameter of pod. Among spacing maximum length of pod (63.28 cm) were recorded in S_2 whereas, girth of pod (0.86) and number of seeds per pod (20.68) were recorded in S_3. Wider spacing provided the highest girth of pod as well as more seeds per pod, which might be due to the availability of sufficient space for the plants to develop and attain optimum growth of pod. Among nitrogen levels significantly maximum number of seeds were reported in N_2 whereas, maximum weight of fresh seeds was recorded in N_3 might be due to sufficient nutrients for vegetative and reproductive growth resulting in more seeds per pod. Among interaction between spacing and nitrogen levels maximum length of pod (64.81 cm) and highest number of fresh seeds per pod was observed in S_2N_2. The reason for longer pods and more number of seeds per pod might be the availability of favourable conditions, i.e. moisture, light, nutrients and less competition of plants among themselves in medium spacing. Higher pod girth (0.88 cm) was reported in S_3N_3 may be due to availability of light, space, moisture, nutrients etc. was more as compared to closer spacing. However, highest weight of seeds per pod was reported in which might be due to availability of sufficient spacing and optimum dose of nitrogen which enhanced the rate of photosynthesis, respiration and metabolic activities of plants resulted in maximum weight of grains per pod.
Similar findings were quoted by Bokade (2008) [4] in yard long bean Dandile (2017) [7], Bam (2018) [3] and Manjesh (2019) [11] in yard long bean.

Table 3a: Effect of spacing, nitrogen levels and their interaction on yield and yield attributing characters.

	Days to first picking				Days from flowering to harvesting				Number of pods per plant				Number of pickings			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	71.20	68.20	68.13	69.18	10.47	9.07	8.97	9.50	13.34	38.77	40.01	30.71	15.02	14.06	13.68	14.25
N_2	71.00	66.40	67.47	68.29	10.27	8.60	9.10	9.32	14.75	42.42	41.33	32.83	15.53	16.40	14.78	15.57
N_3	73.50	67.80	67.07	69.46	11.07	8.80	9.00	9.62	15.53	41.33	39.43	32.10	15.35	15.11	14.30	14.92
N_4	71.60	69.33	68.20	69.71	11.20	9.33	8.77	9.77	15.81	38.55	37.47	30.61	15.66	15.84	14.07	15.19
Mean	71.83	67.93	67.72	69.16	10.75	8.95	8.96	9.55	14.86	40.27	39.56	31.56	15.39	15.35	14.21	14.98
	RES	Sem±	CD		RES	Sem±	CD		RES	Sem±	CD		RES	Sem±	CD	
S	SIG	0.30	1.18		SIG	0.14	0.55		SIG	0.30	1.16		SIG	0.17	0.66	
N	SIG	0.32	0.95		SIG	0.10	0.29		SIG	0.32	0.95		SIG	0.19	0.57	
SXN	SIG	0.56	1.65		SIG	0.17	0.50		SIG	0.55	1.65		NS	0.33	-	

Table 3b: Effect of spacing, nitrogen levels and their interaction on yield and yield attributing characters.

	Duration of harvest				Pod yield per plant (kg)				Pod yield per plot (kg)				Pod yield per hectare			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	51.47	53.60	52.67	52.58	0.27	0.78	0.82	0.62	14.44	21.11	14.74	16.76	19.80	28.96	20.22	23.00
N_2	49.47	55.27	53.93	52.89	0.27	0.81	0.87	0.65	14.40	22.10	15.72	17.41	19.77	30.27	21.56	23.87
N_3	46.93	54.47	53.53	51.64	0.30	0.84	0.85	0.66	16.36	22.97	15.23	18.19	22.44	31.10	20.90	24.81
N_4	50.77	52.33	52.80	51.97	0.31	0.81	0.74	0.62	16.81	21.99	13.24	17.35	23.06	30.16	18.16	23.79
Mean	49.66	53.92	53.23	52.27	0.29	0.81	0.82	0.64	15.50	22.04	14.73	17.43	21.27	30.12	20.21	23.87
	RES	Sem±	CD		RES	Sem±	CD		RES	Sem±	CD		RES	Sem±	CD	
S	SIG	0.44	1.73		SIG	0.01	0.06		SIG	0.28	1.10		SIG	0.42	1.63	
N	SIG	0.16	0.47		SIG	0.01	0.03		SIG	0.27	0.81		SIG	0.34	1.02	
SXN	SIG	0.27	0.81		SIG	0.02	0.06		SIG	0.47	1.41		SIG	0.59	1.76	

Interaction on physical parameter of pod.

Table 4a: Effect of spacing, nitrogen levels and their

	Length of pod (cm)				Girth of pod (cm)				Number of seeds per pod				Weight of green pod (g)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	61.35	62.16	61.95	61.82	0.75	0.83	0.85	0.81	19.58	19.12	19.87	19.52	20.12	20.19	20.51	20.27
N_2	62.24	64.81	62.00	63.02	0.74	0.84	0.86	0.82	20.10	20.81	20.45	20.46	18.19	19.29	21.13	19.54
N_3	62.31	62.31	64.32	62.98	0.76	0.78	0.88	0.81	20.55	19.36	19.97	19.96	19.54	20.33	21.46	20.44
N_4	61.23	63.83	61.24	62.10	0.78	0.83	0.84	0.82	18.10	19.50	19.25	18.95	19.70	21.14	19.61	20.15
Mean	61.78	63.28	62.38	62.48	0.76	0.82	0.86	0.81	19.59	19.70	19.88	19.72	19.39	20.23	20.68	20.10
	RES	Sem±	CD		RES	Sem±	CD		RES	Sem±	CD		RES	Sem±	CD	
S	SIG	0.27	1.04		SIG	0.01	0.04		SIG	0.05	0.19		NS	0.59	-	
N	NS	0.40	-		NS	0.01	-		SIG	0.10	0.29		NS	0.41	-	
SXN	SIG	0.70	2.08		SIG	0.01	0.04		SIG	0.17	0.51		NS	0.70	-	

Table 4b: Effect of spacing, nitrogen levels and their interaction on physical parameter of pod.

	Weight of edible flesh per pod (g)				Weight of fresh seeds (g)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	16.67	16.74	16.88	16.76	3.45	3.44	3.63	3.51
N_2	14.85	16.04	17.56	16.15	3.34	3.25	3.57	3.39
N_3	16.05	16.60	17.76	16.80	3.50	3.73	3.70	3.64
N_4	16.60	17.13	16.14	16.62	3.10	4.01	3.48	3.53
Mean	16.04	16.63	17.08	16.58	3.35	3.61	3.59	3.52
	RES	Sem±	CD		RES	Sem±	CD	
S	NS	0.56	-		NS	0.09	-	
N	NS	0.41	-		SIG	0.05	0.14	
SXN	NS	0.72	-		SIG	0.08	0.25	

4. Conclusion

The present study, revealed that among various spacing S_2 (90 cm x 30 cm) was found superior with respect to various vegetative growth parameter like vine length, number of branches, number of nodes as well number of leaves. S_2 (90 cm x 30 cm) was also found superior in various yield and yield attributing characters. Among various nitrogen levels N_3 (75:60:30 kg NPK/ha) was found superior in various yield and yield attributing characters. Hence from present investigation it can be concluded that under Konkan agro-climatic conditions yard long bean should be planted at spacing of 90 × 30 cm with application of fertilizer dose 75:60:30 kg NPK/ha.

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