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Comparative Performance of Yard Long Bean (*V. unguiculata* subsp, *sesquipedalis* (L.) Verdcourt) Crosses for Vegetative and Yield Characters under Open Field and Rainshelter

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ABSTRACT

Ten yard long bean crosses, selected based on the specific combining ability and *per se* performance from previous study, and a commercial hybrid check NS 634 were evaluated under open field and under rainshelter in Randomized Block Design with three replications, to study the mean performance among the crosses for vegetative and yield characters and to compare the performance under open and shade. All the crosses exhibited significant variability for all the characters studied, under both conditions. VS 34 × VS 50 and VS 50 × VS 26 were found to be the highest yielders under both open field and rainshelter conditions, whereas VS 54 × VS 26 exhibited the highest pod length and pod girth. Highest number of pods plant^{-1} was recorded in VS 50 × VS 13. Pods plant^{-1} and yield plant^{-1} were higher for crosses grown under open field conditions compared to rainshelter.

Keywords Yard long bean, Crosses, Yield characters, Open, Shade.

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INTRODUCTION

Yard long bean (*V. unguiculata* subsp. *sesquipedalis* (L.) Verdcourt), a trailing type of vegetable cowpea (2n = 24), is an important member of the Fabaceae family, grown for its long, tender and succulent pods. It is also known as asparagus bean, string bean, snake bean, snake pea, snap pea, long podded bean etc. Yard long bean is a rich source of protein (3.5 g), calcium (72 mg), iron (2.5 mg), riboflavin (0.09 mg), phosphorus (59 mg) and vitamin A (564 mg per 100 g^{-1} of edible pod) (Yamaguchi,1983). It also supplies vitamin C, folate, magnesium and manganese. Occurrence of yard long bean has been sporadic, mainly grown in Southeast Asia and West Africa. The Tropical Vegetable Research Center (TVRC), Thailand maintains a rich germplasm of yard long bean .collected from all parts of Asia (Rambabu *et al*. 2016). In India, yard long bean is extensively cultivated in South India and some parts of North India, covering an area of about 7.7 million ha (Yadav *et al*. 2004). Because of its quick growth habit and enrichment of soil fertility by

fixing atmospheric nitrogen (70- 240 kg ha^{-1} of nitrogen per year), it has become an essential component of sustainable agriculture.

Despite its wide variability, crop improvement works in yard long bean have been limited due to the self-pollinated nature. In general, exploitation of heterosis in vegetable cowpea is also difficult because of poor crossing success and less number of seeds per pod. As a result, no public sector hybrids have been released in yard long bean so far and farmers are forced to depend on private seed companies for hybrid seeds. Hence crop improvement through breeding and development of high yielding hybrids with resistance to biotic and abiotic stresses require more attention in cowpea research. Inheritance of yield and yield contributing characters investigated by Rahman and Saad (2000) using generation mean analysis in four crosses of *Vigna sesquipedalis* revealed the presence of dominance gene action for pod yield $plant^{-1}$ and pods $plant^{-1}$, which suggested scope for improvement of these characters through heterosis breeding. Hence, the present experiment was undertaken to study the mean performance of ten yard long bean crosses for vegetative and yield characters, to identify superior and promising cross combinations and to compare the performance in open field and rainshelter.

MATERIALS AND METHODS

Ten yard long bean crosses, selected based on the specific combining ability and *per se* performance from the previous study, and a commercial hybrid check NS 634 (Source: Namdhari Seeds Private Limited) were evaluated for vegetative and yield characters under rainshelter and open field at the Department of Vegetable Science, College of Agriculture, Vellayani from September 2016 to February 2017. Seeds of the ten crossess were produced in a crossing block during April 2016 – September 2016. In the crossing block, unopened flowers of the female parent were emasculated and bagged on the evening of previous day of crossing. For crossing, stigma of the emasculated flowers were dusted with pollen collected from freshly opened flowers of the male parent and then rebagged. Pollination was carried out during early morning hours, from 6.30 am to 9.00 am, when the flowers remain open. The bags were kept intact for one day in order to ensure successful fertilization and fruit set. The pods were allowed to dry on the vine itself and seeds were extracted from the dried pods. Details of the crosses are given in Table 1. Hybrid seeds were sown in pro-trays and 14 days old seedlings (3-4 true leaf stage) were transplanted in furrows at a spacing of 1.50 x 0.45 m. Two separate experiments were conducted- one under rainshelter and another in open field condition. Both the experiments were laid out in Randomized Block Design (RBD) with 11 treatments (10 crosses + NS 634 as check) in three replications. The crop was raised according to the Package of Practices Recommendations (KAU 2011). Observations on vegetative characters like vine length at final harvest, number of primary branches per plant, length and breadth of leaflets and yield characters like pod length, pod girth, pod weight, number of pods per plant, number of seeds per pod, hundred seed weight and pod yield per plant were recorded. Analysis of variance (ANOVA) for individual character was carried out as suggested by Panse and Sukhatme (1967) for Randomized Block Design.

Table 1. List of crosses performed in the crossing block.

Sl. No.	Parents	Cross combinations
1	VS 34 × VS 50	Githika × KAU Deepika
2	VS 50 × VS 26	KAU Deepika × Vellayani Jyothika
3	VS 34 × VS 13	Githika × Neyyattinkara local
4	VS 50 × VS 13	KAU Deepika × Neyyattinkara local
5	VS 50 × VS 16	KAU Deepika × Pattom local
6	VS 16 × VS 38	Pattom local × Palayam local
7	VS 54 × VS 26	Thirupuram local × Vellayani Jyothika
8	VS 34 × VS 54	Githika × Thirupuram local
9	VS 13 × VS 26	Neyyattinkara local × Vellayani Jyothika
10	VS 50 × VS 38	KAU Deepika × Palayam local

RESULTS AND DISCUSSION

Analysis of variance of eleven crosses for all the characters under open field and rainshelter conditions were studied separately. The treatments were significantly different under both experimental conditions for all the characters studied. Vine length at final harvest is a major factor that determines the plant vigour.

Table 2. Mean performance of ten crosses and check for vegetative characters in open field and rainshelter.

	Vine length at final harvest (cm)		Primary branches plant^{-1}		Terminal leaf length		Length and breadth of leaflets (cm) Lateral leaf length (cm)		Terminal leaf width (cm)		Latera leaf width (cm)	
Treatments	Open	Rain-shelter	Open	Rain-shelte	Open	Rain-shelte	Open	Rain-shelte	Open	Rain-shelte	Open	Rain-shelte
VS 34 × VS 50	400.73	389.53	4.53	3.93	14.27	16.25	12.97	15.00	8.95	9.58	8.02	9.53
VS 50 × VS 26	303.33	399.87	4.60	3.73	17.25	17.03	13.06	15.20	10.23	9.78	9.02	9.65
VS 34 × VS 13	264.87	388.00	3.00	3.00	14.17	15.84	12.23	14.41	9.07	8.43	8.09	8.29
VS 50 × VS 13	312.13	369.93	4.00	4.27	13.09	14.28	12.08	14.15	8.45	9.23	8.05	8.97
VS 50 × VS 16	416.93	309.67	4.53	2.40	14.07	17.75	14.02	16.04	9.77	10.97	9.53	10.87
VS 16 × VS 38	302.00	385.13	4.73	4.00	15.08	15.70	14.97	14.82	9.80	9.76	9.34	9.75
VS 54 × VS 26	370.93	320.07	4.00	3.33	13.10	14.93	12.21	13.18	9.10	9.52	8.09	9.19
VS 34 × VS 54	341.00	310.93	4.07	2.27	16.11	16.76	14.13	15.17	10.08	9.51	9.52	9.19
VS 13 × VS 26	390.20	329.53	4.00	4.00	11.86	17.77	10.61	15.03	7.58	10.24	7.29	9.99
VS 50 × VS 38	329.13	377.07	4.33	4.20	17.63	17.67	16.07	16.02	11.03	10.49	10.28	10.23
NS 634	270.67	285.27	3.00	2.67	18.39	18.33	18.11	17.97	11.75	11.71	11.71	11.71
Mean	336.54	351.36	4.07	3.44	15.00	16.57	13.68	15.18	9.62	9.93	8.99	9.76
CD (0.05)	2.686	2.198	0.300	0.286	0.132	0.194	0.136	0.244	0.153	0.450	0.123	0.162

Vine length at final harvest was the highest in VS 50 VS 16 (416.93 cm) in open field, whereas under rainshelter, VS 50 x VS 26 exhibited the highest vine length (399.87 cm) (Table 2). The shortest vine length was reported in VS 34 x VS 13 (264.87 cm) under open field and NS 634 (285.27 cm) under rainshelter. The mean vine length observed was 336.54 cm and 351.36 cm in open field and rainshelter respectively. Similar trend was observed for vine length in yard long bean by Huque *et al.* (2012), Hossain *et al*. (2013) and Hinge *et al.* (2015). Number of primary branches per plant is an important growth parameter which contributes to the plant vigour and total per plant yield. Number of primary branches per plant varied from 3.00 to 4.73 in open field with a mean of 4.07 and from 2.27 to 4.27 under rainshelter with a mean of 3.44. Under open field conditions, the cross VS 16 x VS 38 produced the highest number of primary branches per plant (4.73), VS 50 x VS 26 (4.60), VS 34 x VS 50 (4.53) and VS 50 x VS 16 (4.53) being on par. VS 50 x VS 13 produced the highest number of primary branches per plant (4.27) under rainshelter, which was on par with VS 50 x VS 38 (4.20), VS 13 x VS 26 (4.00) and VS 16 x VS 38 (4.00). VS 34 x VS 13 (3.00) and NS 634 (3.00) recorded the lowest number of primary branches per plant under open field and VS 34 x VS 54 (2.27) under rainshelter. Mishra and Dash (2009) made similar observations for number of primary branches (2.23 to 5.08) in yard long bean.

Length and breadth of leaflets determine the photosynthetic efficiency of the crop and thereby the biological yield. Leaf area, measured in terms of dimensions of terminal and lateral leaves, showed that the hybrid check, NS 634 recorded the highest terminal leaf length (18.39 cm, 18.33 cm), lateral leaf length (18.11cm, 17.97 cm), terminal leaf width (11.75 cm, 11.71 cm) and lateral leaf width (11.71 cm, 11.71 cm) respectively, under both open field and rainshelter conditions. VS 13 x VS 26 recorded the lowest terminal leaf length (11.86 cm), lateral leaf length (10.61 cm), terminal leaf width (7.58 cm) and lateral leaf width (7.29 cm) under open field conditions. Under rainshelter, VS 50 x VS 13 recorded the lowest terminal leaf length (14.28 cm), VS 54 x VS 26 the lowest lateral leaf length (13.18 cm) and VS 34 x VS 13 the lowest terminal leaf width (8.43 cm) and lateral leaf width (8.29 cm). Hossain et al. (2013) reported that terminal leaf length and breadth ranged from 8.67 to 12.34 cm and from 2.78 to 4.64 cm respectively among fifty-six genotypes of yard long bean.

Mean performance of crosses for vegetative characters such as vine length, petiole length and length and breadth of leaflets was higher under rainshelter than open field. Similar results were obtained by Gokul (2015) where, the highest vine length and internodal length were recorded inside polyhouse and rainshelter conditions than open field in the cowpea

Table 3. Mean performance of ten crosses and check for pod characters and yield in open field and rainshelter.

Treatments	Pod length (cm)		Pod girth (cm)		Pod weight (g)		Pods plant^{-1}	
	Open	Rainshelter	Open	Rainshelter	Open	Rainshelter	Open	Rainshelter
VS 34 x VS 50	49.23	52.71	3.05	3.17	20.64	22.10	71.53	53.13
VS 50 x VS 26	60.96	61.00	3.11	3.11	26.35	27.08	66.00	52.73
VS 34 x VS 13	46.38	46.70	2.77	2.81	16.50	16.17	70.20	51.20
VS 50 x VS 13	55.23	55.48	3.10	3.03	22.28	22.87	72.27	55.67
VS 50 x VS 16	59.42	59.77	3.23	3.17	28.69	27.34	59.33	51.73
VS 16 x VS 38	46.97	47.61	3.12	3.09	15.73	14.89	57.07	48.47
VS 54 x VS 26	69.36	68.42	3.34	3.32	27.47	27.59	50.20	45.87
VS 34 x VS 54	61.94	61.69	3.24	3.20	23.30	25.51	61.53	49.47
VS 13 x VS 26	53.24	52.93	3.05	3.02	22.49	22.73	52.87	50.47
VS 50 x VS 38	47.33	47.04	3.23	3.23	22.53	24.03	54.33	49.10
NS 634	57.72	57.66	3.27	3.21	24.16	25.47	50.67	44.27
Mean	55.25	55.55	3.14	3.12	22.74	23.25	60.55	50.19
CD (0.05)	0.799	1.810	0.109	0.102	1.024	1.236	5.246	5.383

variety, Vellayani Jyothika. Kumar and Arumugam (2010), Cheema *et al*. (2013) and Rajasekhar *et al.* (2014) also reported similar results in several vegetables under protected conditions. Carbon dioxide (CO_2) released by plants during night gets trapped inside the protected structure, resulting in higher humidity, which in turn results in higher photosynthetic rate during day leading to higher vegetative growth (Dixit 2007).

Pod length and pod girth are important characters that contribute to consumer preference and yield. Pod length was the highest in VS 54 x VS 26 under both open field (69.36 cm) and rainshelter (68.42 cm), whereas the lowest was in VS 34 x VS 13 (46.38 cm and 46.70 cm respectively) (Table 3). The mean pod length in open field was 55.25 cm and under rainshelter, 55.55 cm. Pod girth was the highest in the cross VS 54 x VS 26 both under open field (3.34 cm) and rainshelter (3.32 cm). NS 634 (3.27 cm) and VS 34 x VS 54 (3.24 cm) were on par under open field, while VS 50 x VS 38 (3.23 cm) was on par under rainshelter. VS 34 x VS 13 exhibited the lowest pod girth under both open field (2.77 cm) and rainshelter (2.81 cm) conditions. Pod weight and pods per plant also directly influences pod yield. In open field, pod weight varied from 15.73 g in VS 16 x VS 38 to 28.69 g in VS 50 x VS 16, with a mean value of 22.74 g and under rainshelter from 14.89 g in VS 16 x VS 38 to 27.59 g in VS 54 x VS 26 with a mean weight of 23.25 g. VS 50 x VS 16 (27.34 g) and VS 50 x VS 26 (27.08 g) were on par with VS 54 x VS 26 under rainshelter conditions. VS 50 x VS 13 exhibited the highest number of pods plant^{-1} (72.27), which was on par with VS 34 x VS 50 (71.53) and VS 34 x VS 13 (70.20) in open field conditions. Under rainshelter conditions also, VS 50 x VS 13 recorded the highest number of pods per plant (55.67) which was statistically on par with VS 34 x VS 50 (53.13), VS 50 x VS 26 (52.73), VS 50 x VS 16 (51.73), VS 34 x VS 13 (51.20) and VS 13 x VS 26 (50.47). Lowest number of pods per plant was recorded by VS 54 x VS 26 (50.20) in open field and by NS 634 (44.27) under rainshelter. A mean number of 60.55 and 50.19 pods plant^{-1} was recorded in open and rainshelter respectively. Similar results were obtained by Lakshmi (2016), who evaluated twenty- eight hybrids of yard long bean for growth, yield and quality traits and reported that pod length varied from 36.40 to 71.27 cm, pod girth from 2.67 to 3.77 cm, pod weight from 11.33 to 30.67 g and number of pods per plant from 24.67 to 107.17. Significantly higher number of pods plant^{-1} in open field was also reported by Gokul (2015) in a comparative study on the performance of yard long bean grown under polyhouse and rainshelter in relation to open field cultivation.

Pods with more number of seeds are longer, which is preferred most by consumers. The highest number of seeds pod^{-1} was observed in VS 34 x VS 50 both in open field and under rainshelter (20.93 and 20.67 respectively), which was on par with VS 34 x

Table 4. Mean performance of ten crosses and check for seed characters and yield in open field and rain shelter.

Treatments	Seeds pod^{-1}		100 seed weight (g)		Yield (g plant^{-1})	
	Open	Rainshelter	Open	Rainshelter	Open	Rainshelter
VS 34 x VS 50	20.93	20.67	18.33	17.56	1058.20	689.67
VS 50 x VS 26	19.73	19.93	18.17	21.63	973.27	674.00
VS 34 x VS 13	18.87	20.20	15.86	15.12	761.33	576.80
VS 50 x VS 13	19.40	20.47	18.01	18.70	951.07	583.67
VS 50 x VS 16	19.60	19.33	20.69	18.22	894.53	520.60
VS 16 x VS 38	17.93	18.20	17.06	22.54	700.93	430.87
VS 54 x VS 26	18.20	18.53	22.68	22.93	721.00	464.87
VS 34 x VS 54	20.40	20.40	18.17	21.43	705.87	479.53
VS 13 x VS 26	18.20	17.20	19.72	21.46	668.53	468.33
VS 50 x VS 38	19.87	19.33	20.52	19.53	652.47	556.27
NS 634	18.73	18.33	19.42	17.73	561.93	534.87
Mean	19.26	19.33	18.97	19.71	786.28	543.59
CD (0.05)	0.688	0.626	1.241	1.426	127.671	33.91

VS 54 (20.40) in open field and with VS 50 x VS 13 (20.47), VS 34 x VS 54 (20.40) and VS 34 x VS 13 (20.20) under rainshelter (Table 4). Mean number of seeds pod^{-1} was 19.26 in open field and 19.33 under rainshelter. The lowest number of seeds per pod was observed in VS 16 x VS 38 (17.93) and VS 13 x VS 26 (17.20) in open field and rainshelter conditions respectively. The results are in conformity with that of Hossain *et al*. (2013), who recorded a maximum number of 19.33 seeds per pod in yard long bean. Seeds per pod ranged from 13.58 to 18.73 in yard long bean as reported by Hinge *et al.* (2015).

Hundred seed weight is an important parameter considered for good quality seed. Hundred seed weight ranged from 22.68 to 15.86 g in open field and from 22.93 to 15.12 g under rainshelter. The highest hundred seed weight was recorded in VS 54 x VS 26 and the lowest in VS 34 x VS 13 under both open field and rainshelter conditions. VS 16 x VS 38 (22.54 g) and VS 50 x VS 26 (21.63 g) were on par under rainshelter. Mean values recorded were 18.97 g and 19.71 g, in open field and rainshelter respectively. Mishra and Dash (2009) reported a range of 9.88 g to 19.68 g for hundred seed weight in yard long bean. Lakshmi (2016) also reported similar findings among twenty nine yard long bean hybrids evaluated.

The major objective of any breeding program is higher yield. All the crosses surpassed the commercial check NS 634 for the most important trait, green pod yield. According to Valarmathi and Surendran (2007), superior performance is an important criterion to evaluate the value of hybrids. Pod yield per plant exhibited a range from 561.93 to 1058.20 g in open field with a mean value of 786.28 g. Under rainshelter, yield plant^{-1} varied between 430.87 g and 689.67 g, with a mean yield of 543.59 g. Among all the treatments, VS 34 x VS 50 was the highest yielder under both conditions. VS 50 x VS 26 (973.27 g plant^{-1}) and VS 50 x VS 13 (951.07 g plant^{-1}) were on par in open field, while VS 50 x VS 26 (674 g plant^{-1}) was on par under rainshelter. NS 634 was the lowest yielder (561.93 g plant^{-1}) in open field and VS 16 x VS 38 (430.87 g plant^{-1}) under rainshelter. The results are in agreement with that of Lakshmi (2016), who recorded yield in the range of 353.43 g to 1414.55 g plant^{-1} in yard long bean hybrids. Similar results were earlier reported by Mishra and Dash (2009), Sivakumar (2012) and Hossain *et al.* (2013) in yard long bean. Average pod yield per plant was highest in open field (786.28 g) than rainshelter (543.59 g). Lower fruit set percentage and lower number of pods per plant may have contributed towards lower yield under rainshelter. Reduction in light intensity may be one of the factors causing yield reduction under rainshelter. Kamaruddin (2007) observed that the presence of roof covering and structural frames reduce sunlight from being transmitted directly inside the rainshelter. Jinchao *et al.* (2009) reported that light intensity under rainshelter was reduced by 29.45 to 31.37% depending on the thickness of the film. Greater yield under

open conditions in yard long bean was recorded by Ranasinghe (1999) compared to 40 and 60% shade. The monthly average rainfall received during the period of study was only 6.15 mm. Report of lower yield under rainshelter than open field was given by Palada and Ali (2007) in yard long bean, who reported that the benefit from rainshelter may not be realized when seasonal rainfall is relatively low.

From the present study, it can be concluded that among the yard long bean crosses studied, VS 34 x VS 50 and VS 50 x VS 26 were found to be the highest yielders under both open field and rainshelter conditions, whereas VS 54 x VS 26 exhibited the highest pod length and pod girth. Highest number of pods plant^{-1} was recorded in VS 50 x VS 13. Pods plant^{-1} and yield plant^{-1} were higher for crosses grown under open field conditions compared to rainshelter.

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