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Studies on Heterosis for Pod Yield and Protein Content in Yardlong Bean (*Vigna unguiculata* (L.) Walp. ssp. *Sesquipedalis* Verdc.)

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A set of 29 genotypes including 7 parents, their 21 resultant hybrids and one commercial check variety (Arka Mangala) were sown during summer, 2019 at the College Instructional Farm, College of Horticulture, Venkataramannagudem to study the magnitude of heterosis using half diallel analysis for eleven characters. Significant differences were observed among the parents and hybrids indicating considerable genetic variation among these genotypes. Significant standard heterosis and high *per se* performance with regards to fruit yield per plant were recorded by the crosses *viz.*, Babli x Lola , Babli x Bobbili Local, Babli x Trivendrum Local, Bobbili Local x Lola, Bobbili Local x Trivendrum Local and Lola x Trivendrum Local.

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Keywords: Yardlong bean; heterosis; breeding programmes; yield; quality.

1. INTRODUCTION

Yardlong bean (*Vigna unguiculata* (L.) Walp. ssp. *sesquipedalis* Verdc.) belongs to the family Fabaceae with chromosome number 2n=2x=22. Yardlong bean has a typical leguminous flower and is predominantly a self pollinated crop. However, cross pollination up to 10 percent has been reported [1]. It is a distinct form of cowpea grown as a vegetable crop throughout Asia especially in South and South East Asian countries including India. It is also known as asparagus bean, chinese long bean, pea bean, string bean, snake bean, snake pea, snap pea, borbati *etc*., in different parts of the world.

Area under vegetable crops is mostly covered by the F_1 hybrids which are in great demand because of manifold advantages such as high yield, quality, uniformity and biotic/ abiotic stress tolerance and yardlong bean is no exception. However, there are no F_1 hybrids of yardlong bean released from either public sector or private organizations and only open pollinated varieties are being cultivated commercially. Thus, there is a need to test the scope for developing such hybrids in yardlong bean which can stand test of time for yield and quality.

2. MATERIALS AND METHODS

The experimental material consisted of seven parental lines *viz.,* Geethika, Babli, Vizianagaram Local, Bobbili Local, Lola, Trivendram Local and Bhuvaneswar Local which were crossed in diallel fashion excluding reciprocals during *Rabi*, 2018. The resultant 21 F_1 hybrids along with seven parents and one check were evaluated in randomized block design with three replications with spacing of 1.0 x 1.0 m during *Summer*, 2019. Observations were recorded on five randomly selected plants from each plot for yield and quality attributing traits *viz.,* number of clusters per plant, number of pods per cluster, number of pods per plant, pod length (cm), pod girth (cm), pod weight (g), number of seeds per pod, 100 seed weight (g), pod yield per plant (kg), TSS (^{0}Brix) and protein (%).

3. RESULTS AND DISCUSSION

The exploitation of heterosis in crop plant is regarded as one of the major breakthrough in the field of plant breeding. The application of heterosis is considered to an outstanding application of principles of genetics to agriculture. The scope of exploitation of hybrid vigour depends on direction and magnitude of heterosis and type of gene action involved.

In the analysis of mean squares the differences due to the treatments were significant for all the characters studied. The treatment means were further divided into parents, hybrids and parents versus hybrids. The parents and hybrids were significantly differ for all the characters studied while parents versus hybrids were significantly differ for all the characters studied except for number of seeds per pod (Table-1).

For the character number of clusters per plant, significant positive heterosis was observed in 3 crosses over the mid parent and 4 hybrids were significantly superior over better parent. Four hybrids were significantly superior by exhibiting significant positive heterosis over check Arka Mangala. These results are in conformity with the findings of Kalpana et al. [2] and Kakde et al. [3] in mung bean. Seven hybrids expressed significant positive relative heterosis. The heterobeltiosis was positively significant for only one cross and fourteen hybrids recorded significant positive standard heterosis and proved superior to the check Arka Mangala for the character number of pods per cluster. These results are in conformity with the findings of Shirisha et al. [4] and Kakde et al. [3] in mung bean. For the character number of pods per plant, significant positive heterosis was observed in 16 hybrids over the mid parent and in 13 hybrids over better parent. Fourteen hybrids were significantly superior by exhibiting significant positive heterosis over check Arka Mangala These results are in conformity with the findings of Sharma et al. [5] in cowpea, [6] in mung bean and Sasane et al. [7] in chick pea (Table-2).

For the character pod length, significant positive heterosis was observed in 14 hybrids over the mid parent and 4 hybrids exhibited significant superiority over better parent. Three hybrids were significantly superior to the check Arka Mangala by exhibiting significant positive heterosis. These results are in conformity with the findings of Mehta and Lal [8], and Kakdeet al [3] in mung bean. For pod girth, six hybrids and three hybrids showed significant positive relative heterosis and heterobeltiosis respectively. Eight hybrids were significantly superior by exhibiting significant positive heterosis over check Arka

Table 1. Analysis of variance for yield and quality traits 7 x 7 half diallel in yardlong bean

Source	Df	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Pod girth (cm)	Pod weight (gm)	Number of seeds per pod	100 seed weight (gm)	Pod yield per plant (kg)	TSS (^{0}brix)	Protein (%)
Treatments	27	10.931**	0.512**	867.170**	204.942**	0.169**	24.500**	7.671**	16.116**	1.091**	0.396**	0.309**
Parents	6	3.795**	0.827**	342.725**	279.403**	0.076**	22.599**	8.477**	17.538**	0.279**	0.112**	0.289**
Hybrids	20	13.284**	0.399**	847.359**	186.168**	0.199**	11.860**	7.799**	15.010**	0.690**	0.346**	0.299**
Parent Vs.Hybrids	1	6.671**	0.869**	4410.070**	133.664**	0.114**	288.707**	0.267	29.726**	13.968**	3.085**	0.620**
Error	54	0.709	0.081	16.869	2.056	0.005	1.400	0.281	0.204	0.022	0.006	0.008

*** 1% level of significance, * 5% level of significance*

Table 2. Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for number of clusters per plant, number of pods per cluster and number of pods per plant in yardlong bean

Cross combinations	Number of clusters per plant			Number of pods per cluster			Number of pods per plant		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
Geethika x Babli	0.73	-1.28	-1.43	-0.68	-12.05 **	17.74 **	10.78 **	-1.14	17.13 **
Geethika x Vizianagaram Local	-1.85	-3.32	-7.32 *	12.70 *	10.94	14.52 *	12.53 **	10.73 **	2.97
Geethika x Bobbili Local	-8.58 **	-13.82 **	-6.69	3.03	0.00	9.68	-0.13	-7.54 *	0.94
Geethika x Lola	-11.54 **	-14.55 **	-12.10 **	0.00	-4.29	8.06	2.80	-1.78	0.27
Geethika x Trivendrum Local	-8.82 **	-10.29 **	-11.15 **	-2.16	-9.33	9.68	0.81	-6.18	1.28
Geethika x Bhuvaneswar Local	-9.40 **	-10.30 **	-14.01 **	2.40	0.00	3.23	6.52	5.44	-1.96
Babli x Vizianagaram Local	-2.89	-6.22	-6.37	-13.10 **	-24.10 **	1.61	-3.10	-14.74 **	1.01
Babli x Bobbili Local	12.01 **	7.65 *	16.56 **	7.28	-2.41	30.65 **	31.64 **	26.47 **	49.83 **
Babli x Lola	15.95 **	14.24 **	17.52 **	9.80 *	1.20	35.48 **	34.64 **	25.33 **	48.48 **
Babli x Trivendrum Local	9.53 **	9.09 **	8.92 **	1.27	-3.61	29.03 **	26.27 **	20.66 **	42.95 **
Babli x Bhuvaneswar Local	-1.07	-3.99	-4.14	-5.56	-18.07 **	9.68	15.64 **	2.28	21.17 **
Vizianagaram Local x Bobbili Local	-7.91 **	-14.41 **	-7.32 *	10.77 *	5.88	16.13 **	20.38 **	9.82 **	19.89 **
Vizianagaram Local x Lola	-6.67 *	-11.15 **	-8.60 *	4.55	-1.43	11.29	16.39 **	9.51 **	11.80 **
Vizianagaram Local x Trivendrum Local	-13.10 **	-15.76 **	-16.56 **	6.57	-2.67	17.74 **	8.72 **	-0.31	7.62 *
Vizianagaram Local x Bhuvaneswar Local	-11.41 **	-11.86 **	-17.20 **	17.07 **	16.13 **	16.13 **	11.24 **	10.58 **	0.74
Bobbili local x Lola	1.66	-0.88	7.32 *	11.59 *	10.00	24.19 **	30.10 **	25.88 **	37.42 **
Bobbili local x Trivendrum Local	-1.08	-5.29	2.55	6.29	1.33	22.58 **	21.68 **	21.00 **	32.10 **
Bobbili local x Bhuvaneswar Local	-14.33 **	-20.00 **	-13.38 **	11.63 *	5.88	16.13 **	21.21 **	11.18 **	21.38 **
Lola x Trivendrum Local	2.21	0.31	3.18	7.59	4.00	25.81 **	30.79 **	27.23 **	37.36**
Lola x Bhuvaneswar Local	4.53	8.67**	-6.05	14.50**	7.14	20.97**	24.12**	17.44**	19.89**
Trivendrum Local x Bhuvaneswar Local	-7.26*	-9.65**	-10.51**	5.88	-4.00	16.13**	19.11**	9.81**	18.54**
Range	**-14.33 to 15.95**	**-20.00 to 14.24**	**-17.20 to 17.52**	**-13.10 to 17.07**	**-24.10 to 16.13**	**1.61 to 35.48**	**-3.10 to 34.64**	**-14.74 to 27.23**	**-1.96 to 49.83**

*** 1% level of significance, * 5% level of significance*

Table 3. Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for pod length (cm), pod girth (cm) and pod weight (g) in yardlong bean

Cross combinations	Pod length (cm)			Pod girth (cm)			Pod weight (g)		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
Geethika x Babli	-0.03	-16.44 **	-11.35 **	-15.89 **	-20.19 **	-4.75	15.15 **	7.11 *	27.07 **
Geethika x Vizianagaram Local	44.93 **	33.31 **	-5.00 *	7.89 **	3.11	10.46 **	29.16 **	18.73 **	21.18 **
Geethika x Bobbili Local	-3.27	-17.15 **	-17.20 **	-15.51 **	-18.26 **	-6.34 *	8.80 **	2.89	17.81 **
Geethika x Lola	18.31 **	11.67 **	-10.36 **	-5.58 *	-7.52 **	3.33	10.55 **	5.66	18.31 **
Geethika x Trivendrum Local	12.80 **	4.75	-12.92 **	-12.88 **	-14.73 **	-4.60	10.14 **	7.48	15.27 **
Geethika x Bhuvaneswar Local	8.21 **	2.96	-18.75 **	-14.74 **	-17.01 **	-11.09 **	13.90 **	13.42 **	15.76 **
Babli x Vizianagaram Local	0.91	-21.09 **	-16.28 **	-7.67 **	-16.07 **	0.16	12.79 **	-2.93	15.16 **
Babli x Bobbili Local	4.46 **	1.43	7.61 **	6.10 **	3.98	24.09 **	11.57 **	9.62 **	30.05 **
Babli x Lola	16.72 **	2.52	8.76 **	7.82 **	4.38	24.56 **	19.04 **	15.70 **	37.25 **
Babli x Trivendrum Local	11.13 **	-0.90	5.14 *	6.79 **	3.45	23.45 **	21.08 **	15.27 **	36.75 **
Babli x Bhuvaneswar Local	-13.80 **	-24.84 **	-20.26 **	-8.26 **	-15.14 **	1.27	11.56 **	3.36	22.62 **
Vizianagaram Local x Bobbili Local	-17.65 **	-34.17 **	-34.21 **	-17.70 **	-23.79 **	-12.68 **	19.57 **	4.46	19.61 **
Vizianagaram Local x Lola	9.23 **	-4.68	-23.48 **	-2.35	-8.51 **	2.22	19.55 **	5.46	18.09 **
Vizianagaram Local x Trivendrum Local	-6.98 **	-20.01 **	-33.50 **	-15.43 **	-20.82 **	-11.41 **	22.35 **	9.98 **	17.95 **
Vizianagaram Local x Bhuvaneswar Local	6.42 *	-6.44 *	-26.17 **	4.14	2.19	3.65	30.61 **	20.52 **	21.97 **
Bobbili local x Lola	13.93 **	2.72	2.66	7.14 **	5.81 *	21.24 **	19.14 **	17.82 **	34.90 **
Bobbili local x Trivendrum Local	6.77 **	-2.21	-2.26	4.13	2.90	17.91 **	21.10 **	17.27 **	34.26 **
Bobbili local x Bhuvaneswar Local	5.86 **	-5.28 **	-5.33 **	-1.54	-7.19 **	6.34 *	13.87 **	7.26 *	22.81 **
Lola x Trivendrum Local	21.37 **	19.28 **	-0.84	5.88 **	5.81 *	18.38 **	19.11 **	16.59 **	30.55 **
Lola x Bhuvaneswar Local	8.11**	8.88**	-26.86**	3.05	7.52**	3.33	5.99	0.89	12.97**
Trivendrum Local x Bhuvaneswar Local	-1.49	-3.99	-20.18**	-9.21**	-13.46**	-3.17	8.65**	5.59	13.24**
Range	**-17.65 to 44.93**	**-34.17 to 33.31**	**-33.50 to 8.76**	**-17.70 to 7.89**	**-23.79 to 5.81**	**-12.68 to 24.56**	**8.80 to 30.61**	**-2.93 to 20.52**	**12.97 to 37.25**

*** 1% level of significance, * 5% level of significance*

Table 4. Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for number of seeds per pod, 100 seed weight (g) and pod yield per plant (kg) in yardlong bean

Cross combinations	Number of seeds per pod			100 seed weight (g)			Pod yield per plant (kg)		
	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
Geethika x Babli	-6.34**	-7.72**	-0.40	13.33**	-2.99	-1.45	20.06 **	6.95 *	34.20 **
Geethika x Vizianagaram Local	8.94**	-3.03	1.59	31.28**	21.34**	3.41	32.18 **	32.10 **	29.56 **
Geethika x Bobbili Local	-12.52**	-14.02**	-9.92**	10.36**	-1.78	-8.93**	22.41 **	12.87 **	31.14 **
Geethika x Lola	-3.95	-4.49	1.19	26.63**	13.16**	3.96*	25.81 **	20.19 **	29.45 **
Geethika x Trivendrum Local	-7.54*	-9.47**	-5.16	-1.85	-17.45**	-12.48**	29.26 **	25.60 **	30.58 **
Geethika x Bhuvaneswar Local	-12.40**	-19.70**	-15.87**	11.25**	3.33	-12.86**	30.17 **	28.85 **	28.99 **
Babli x Vizianagaram Local	-5.86*	-17.28**	-10.71**	9.83**	0.98	2.59	16.47 **	3.70	30.12 **
Babli x Bobbili Local	6.26**	2.94	11.11**	9.66**	4.88**	6.55**	39.64 **	34.48 **	68.74 **
Babli x Lola	5.38*	4.41	12.70**	10.73**	5.43**	7.11**	50.36 **	39.71 **	75.31 **
Babli x Trivendrum Local	4.38	0.74	8.73**	6.20**	3.98**	10.24**	43.44 **	31.14 **	64.55 **
Babli x Bhuvaneswar Local	0.81	-8.82**	-1.59	9.46**	0.17	1.76	19.08 **	7.04 *	34.31 **
Vizianagaram Local x Bobbili Local	-14.10**	-22.35**	-21.43**	5.46**	1.19	-6.17**	25.75 **	15.89 **	34.65 **
Vizianagaram Local x Lola	-3.17	-14.23**	-9.13**	8.85**	4.92*	-3.62*	22.36 **	16.82 **	25.82 **
Vizianagaram Local x Trivendrum Local	-12.85**	-20.95**	-20.63**	-5.93**	-15.16**	-10.05**	23.39 **	19.83 **	24.58 **
Vizianagaram Local x Bhuvaneswar Local	10.80**	7.27*	-6.35*	18.17**	17.55**	0.19	28.87 **	27.49 **	27.63 **
Bobbili local x Lola	3.45	1.12	7.14**	17.57**	17.03**	8.51**	44.26 **	38.99 **	61.49 **
Bobbili local x Trivendrum Local	2.76	2.35	3.57	8.26**	1.47	7.57**	43.21 **	35.67 **	57.64 **
Bobbili local x Bhuvaneswar Local	6.95**	-0.39	0.79	-10.67**	-14.71**	-20.91**	16.54 **	8.48 *	26.05 **
Lola x Trivendrum Local	1.15	-1.50	4.37	7.02**	-0.12	5.89**	39.43 **	37.01 **	47.57 **
Lola x Bhuvaneswar Local	5.13*	4.12	1.59	9.42**	13.13**	-20.20**	30.38**	26.08**	35.79**
Trivendrum Local x Bhuvaneswar Local	6.55**	-0.40	0.00	-20.13**	-28.30**	-23.98**	19.76**	17.54**	22.20**
Range	**-14.10 to 10.80**	**-22.35 to 7.27**	**-21.43 to 12.70**	**-20.13 to 31.28**	**-28.30 to 21.34**	**-23.98 to 10.24**	**16.47 to 50.36**	**3.70 to 39.71**	**24.58 to 68.74**

*** 1% level of significance, * 5% level of significance*

Table 5. Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for TSS (^{0}brix) and protein content (%) in yardlong bean

Cross combinations	TSS (^{0}brix)			Protein content (%)		
	RH	Hb	SH	RH	Hb	SH
Geethika x Babli	-17.30 **	-18.92 **	-8.36 **	-16.90 **	-21.63 **	-16.11 **
Geethika x Vizianagaram Local	-16.76 **	-19.30 **	-12.38 **	0.51	-1.01	-6.09 *
Geethika x Bobbili Local	-17.89 **	-22.90 **	-16.29 **	-21.49 **	-23.72 **	-23.27 **
Geethika x Lola	-19.66 **	-20.80 **	-11.51 **	-6.45 **	-8.53 **	-9.19 **
Geethika x Trivendrum Local	-26.34 **	-27.06 **	-19.22 **	-18.62 **	-23.01 **	-18.14 **
Geethika x Bhuvaneswar Local	-17.99 **	-18.40 **	-11.40 **	-8.67 **	-18.49 **	-22.67 **
Babli x Vizianagaram Local	-20.40 **	-24.30 **	-14.44 **	-12.23 **	-18.39 **	-12.65 **
Babli x Bobbili Local	-7.76 **	-14.99 **	-3.91	-1.84	-4.79	1.91
Babli x Lola	-12.75 **	-13.26 **	-1.95	0.29	-3.34	3.46
Babli x Trivendrum Local	2.18	1.15	14.33 **	0.56	0.22	7.28 **
Babli x Bhuvaneswar Local	-16.69 **	-18.73 **	-8.14 **	-6.77 **	-20.96 **	-15.39 **
Vizianagaram Local x Bobbili Local	-7.87 **	-10.86 **	-9.12 **	-24.16 **	-27.40 **	-26.97 **
Vizianagaram Local x Lola	-35.37 **	-38.19 **	-30.94 **	-19.15 **	-22.12 **	-22.67 **
Vizianagaram Local x Trivendrum Local	-24.35 **	-27.35 **	-19.54 **	-29.00 **	-33.78 **	-29.59 **
Vizianagaram Local x Bhuvaneswar Local	-14.26 **	-16.46 **	-10.21 **	-4.95	-14.01 **	-20.88 **
Bobbili local x Lola	9.39 **	1.36	13.25 **	5.91 *	5.22	5.85 *
Bobbili local x Trivendrum Local	7.48 **	0.00	10.75 **	-5.77 *	-8.31 **	-2.51
Bobbili local x Bhuvaneswar Local	1.71	-4.04 *	3.15	9.48 **	-4.74	-4.18
Lola x Trivendrum Local	-15.37 **	-15.74 **	-5.86 **	-1.57	-4.83	1.19
Lola x Bhuvaneswar Local	18.57**	20.12**	-10.75**	2.75	10.10**	-10.74**
Trivendrum Local x Bhuvaneswar Local	-11.64**	-12.94**	-3.58	6.14*	-9.76**	-4.06
Range	**-35.37 to 18.57**	**-38.19 to 20.12**	**-30.94 to 14.33**	**-29.00 to 9.48**	**-33.78 to 10.10**	**-29.59 to 7.28**

*** 1% level of significance, * 5% level of significance*

Mangala. Similar findings were reported by Chinapolaiah et al. [9] in velvet bean and Khaimichho et al. [10] in mung bean. For pod weight, twenty hybrids exhibited significant positive relative heterosis and twelve hybrids exhibited significant and positive heterosis over better parent. All 21 hybrids registered significant and positive standard heterosis and were found superior over Arka Mangala. Superiority of this trait was earlier observed in cowpea and other vegetables by Sharma et al. [11] in cowpea, Borwal et al. [12], Sen et al.[13] and Shirisha et al. [4] in Indian bean which support the findings of the investigation (Table-3).

Seven, one and eight hybrids were significantly superior by exhibiting significant positive heterosis over mid, better parents and Arka Mangala respectively for the character number of seeds per pod. These results are in conformity with the findings of Kalpana et al. [2] and Kakde et al.[3] in mung bean. Seventeen, nine and seven hybrids exhibited significant positive heterosis for 100 seed weight over mid parent, better parent and Arka Mangala (check) respectively. These findings are in accordance with earlier reports of Hiral et al. [14], Joshi et al. [15] in cowpea, Nath and Maloo [16] in mung bean. For pod yield per plant, significant positive heterosis was observed in all 21 hybrids over the mid parent and over check Arka Mangala and in 20 hybrids over better parent. These results are in conformity with findings of Kakde et al. [3] in mung bean and Sen et al. [13] in Indian bean (Table-4).

For character TSS, Three, one and three hybrids recorded significant positive heterosis mid, better parents and Arka Mangala respectively. The results are in conformity with earlier reports of Kumar et al. [17] in pea. For protein content, Three, one and two hybrids significantly recorded high heterosis over mid, better parents and Arka Mangala respectively The superiority of this trait also was observed by Anitha et al. [18], Srivastava and Singh [19] and Joshiet al. [15] in cowpea, Kalpana [2] and Kakde et al. [3] in mung bean (Table-5).

4. CONCLUSION

The cross combinations, Babli x Lola, Babli x Bobbili Local, Babli x Trivendrum Local, Bobbili Local x Lola, Bobbili Local x Trivendrum Local and Lola x Trivendrum Local recorded highest pod length, pod girth, pod weight, seeds per pod, 100 seed weight, TSS and protein content which contributed towards highest pod yield per plant.

CONFERENCE DISCLAIMER

Some part of this manuscript was previously presented in the conference: 6th International Conference on Strategies and Challenges in Agricultural and Life Science for Food Security and Sustainable Environment (SCALFE-2023) on April 28-30, 2023 in Himachal Pradesh University, Summer Hill, Shimla, HP, India. Web Link of the proceeding: https://www.shobhituniversity.ac.in/pdf/Souvenir-Abstract%20Book-Shimla-HPU-SCALFE-2023.pdf

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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