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Research Article

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Heterosis for Earliness, Yield and Quality Traits in Urdbean (*Vigna mungo* (L.) Hepper)

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ABSTRACT

An investigation was carried out on nine parents and their 36 F_1's obtained through a diallel crossing system to generate information regarding the relative heterosis, heterobeltiosis and standard heterosis. The population was laid out in CRBD with three replications, in kharif 2017 under Palampur (H.P.) conditions. Palampur-93 × KU-553, Palampur-93 × IC-413304, Palampur-93 × HPBU-124, Him Mash-1 × DKU-98, HPBU-111 × KU-553, DU-1 × IC-413304, DU-1 × IC-281994, DKU-98 × IC-413304 and DK-98 × IC-281994 surpassed the standard variety Palampur-93 for earliness by exhibiting high significant negative heterosis for days to flower initiation, days to 50 per cent flowering and days to 75 per cent maturity. HPBU-111 × KU-553 and DU-1 × IC-413304 had standard heterosis for maximum number of traits along with seed yield. HPBU-124 × KU-553, HPBU-124 × DU-1, HPBU-111 × IC-281994, DU-1 × KU-553, DU-1 × DKU-98, KU-553 × IC-413304 and DKU-98 × IC-281994 exhibited standard heterosis for more than three traits. High heterobeltiosis obtained for all the traits indicated the role of non-additive gene action in their inheritance.

Key words: *Heterosis, Urdbean, Standard check, Heterobeltiosis*

INTRODUCTION

Urdbean or blackgram (*Vigna mungo* (L.) Hepper) is an important diploid (2n=22) self pollinated legume, predominantly grown as *kharif* crop in India on water retentive stiff and heavy soils ranging from pH 4.7 to 7.5. It is also grown as an intercrop with maize and in rice fallows during *rabi* in Southern and South-Eastern parts of India. Owing to its low water requirement, it is also suitable for rainfed conditions. In India, small and marginal farmers more often prefer to grow staple cereals for home consumption whereas, others prefer growing cash crops rather than pulses. In Himachal Pradesh, its cultivation is confined to low and mid hills. The limited area where the pulses are grown, suffer from various problems like less water availability, salinity and poor drainage leading to water logging during rainy season which further reduces the yields. The low productivity of urdbean can be further attributed to unavailability of high yielding varieties with good plant type and disease resistance[1].

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Extensive screening of the germplasm collection of this species has not yielded any source of disease resistance. Thus, in crops like urdbean where exploitable natural variability is less, creating new genetic variability is must. The discovery of hybrid vigour by Shull[8] opened a new era of "Heterosis Breeding" for crop improvement. In self pollinated crops like urdbean, where the development of hybrid varieties is a rare possibility, through effective selection inbred lines superior to the heterotic F_1's can be obtained. According to Fasoulas[3], the inbred lines are inferior to hybrids only due to the presence of deleterious genes and once these deleterious genes are removed by efficient selection, the pure line cultivars become more important than hybrids. Also, in order to combine various desirable characters with high yield, most appropriate approach is to adopt recombinant breeding through multiple crossing, which is likely to produce transgressive recombinant lines for number of desirable traits. Keeping these things in mind, an attempt was made to gather information on nature and magnitude of heterosis with respect to earliness, yield and quality traits in 36 crosses.

MATERIAL AND METHOD

Nine genotypes (Palampur-93, Him Mash-1, HPBU-124, HPBU-111, DU-1, KU-553, DKU-98, IC-281994 and IC-413304) were crossed in a half diallel (excluding reciprocals) to obtain 36 F_1's. These parents and crosses along with standard check (Palampur-93) were evaluated in Completly Randomized Block Design in *kharif* 2017. Each genotype was sown in a single row 1.5 m long with row to row spacing of 30 cm and plant to plant spacing of 10 cm. Data were collected on five randomly selected plants from each genotype in each replication on seven traits for earliness (days to flower initiation and days to 75 per cent maturity), yield (pods per plant, seed yield per plant (g) and harvest index (%)) and quality (100 seed weight (g) and crude protein content). The crude protein content (%) was obtained from Inframetic Analysis System.

The mean data on these traits were used to compute relative heterosis (over mid parent), heterobeltiosis (over better parent) and standard heterosis (over standard check). Palampur-93 was used as a standard check due to its high yield and adaptability to Palampur conditions. The formulas used for their estimation and for test of significance are as follows:

$$\text{Heterosis over mid parent (\%)} = \frac{(\overline{F_1} - \overline{MP})}{\overline{MP}} \times 100$$

$$\text{Heterosis over better parent (\%)} = \frac{(\overline{F_1} - \overline{BP})}{\overline{BP}} \times 100$$

$$\text{Standard heterosis (\%)} = \frac{(\overline{F_1} - \overline{CV})}{\overline{CV}} \times 100$$

where,

F_1	=	Mean of F_1
MP	=	Mean mid parental value
BP	=	Mean better parent value
SC	=	Mean value of check variety

The significance of heterosis for each observation and each cross was ascertained by using t-test[7] where,

Calculated't' value = Difference/SE(d)

SE for heterosis = $\sqrt{2Me/r}$

Where,

Me = Mean error variance (from ANOVA of parents and F_1's)

r = Number of replications

RESULT AND DISCUSSION

Results pertaining to the present study are given below under three heads *viz.*, earliness, yield and quality:

1. Earliness

Days to flower initiation

The range of relative heterosis over mid parent was -18.97 per cent (DU-1 × IC-413304) to 32.74 per cent (Him Mash-1 × DU-1). Negative heterosis is desirable for flower initiation with respect to early flowering. Significant negative heterosis was observed in six crosses. The highest magnitude of heterosis in desirable direction was observed in DU-1 × IC-413304 (-18.97%) followed by Palampur-93 × IC-413304 (-9.54%) and HPBU-111 × IC-281994 (-9.37%) (Table1).

Heterobeltiosis ranged from -21.67 per cent (DU-1 × IC-413304) to 32.14 per cent (Him Mash-1 × DU-1). Significant negative heterosis for the trait was observed in 11 crosses out of which DU-1 × IC-281994 (-21.67%) followed by HPBU-124 × DU-1 (-16.42%) and DKU-98 × IC-281994 (-13.64%) had highest magnitude of negative heterosis for the trait.

The standard heterosis for days to flower initiation ranged from -29.85 per cent (DU-1 × IC-413304) to 10.45 per cent (Him Mash-1 × DU-1). Significant negative was observed in 21 crosses out of which the top three were DU-1 × IC-413304 (-29.85%), Him Mash-1 × DKU-98 (-20.90%) and Palampur-93 × DU-1 (-18.66%).

Days to 75 per cent maturity

The relative heterosis ranged from -7.78 per cent (HPBU-111 × KU-553) to 17.04 per cent (HPBU-124 × IC-413304) for days to 75% maturity, and significant negative heterosis was observed in only cross *viz.*, HPBU-111 × KU-553(-7.78%).

Heterobeltiosis for the trait ranged from -9.41per cent (Him Mash-1 × HPBU-111) to 13.97 per cent (HPBU-124 × IC-413304). Only two crosses *viz.*, Him Mash-1 × HPBU-111 (-9.41%) and HPBU-111 × KU-553 (-9.41%) had significant negative heterosis for the trait.

The standard heterosis for days to 75 per cent maturity ranged from -14.12 per cent (Him Mash-1 × DKU-98) to 5.88 per cent (HPBU-124 × KU-553). Significant negative heterosis for the trait was observed in 10 crosses out of which the best three crosses were Him Mash-1 × DKU-98 (-14.12%), DKU-98 × IC-413304 (-14.12%) and Him Mash-1 × HPBU-124 (-12.16%) (Table 1).

2. Yield

Pods per plant

Relative heterosis ranged from -46.27 per cent (Him Mash-1 × IC-413304) to 84.55 per cent (DU-1 × IC-413304) for pods per plant. Significant positive heterosis for the trait was observed in 21 crosses out of which highest magnitude was observed in DU-1 × IC-413304 (84.55%) followed by HPBU-124 × KU-553 (78.74%) and DKU-98 × IC-281994 (78.55%).

Heterobeltiosis ranged from -54.69 per cent (Him Mash-1 × IC-413304) to 76.06 per cent (DU-1 × IC-413304). Significant positive heterosis for the trait was observed in 17 crosses out of which DU-1 × IC-413304 (76.06%) followed by Palampur-93 × DU-1 (69.43%) and HPBU-124 × DKU-98 (55.44%) has maximum values.

The standard heterosis for pods per plant ranged from -54.69 per cent (Him Mash-1 × IC-413304) to 33.10 per cent (DU-1 × IC-413304). Significant positive heterosis was observed in seven crosses out of which the maximum magnitude of heterosis was observed in DU-1 × IC-413304 (33.10%) followed by Palampur-93 × DU-1 (28.08%) and KU-553 × IC-413304 (26.07%) (Table 2).

Seed yield per plant

Significant positive relative heterosis for seed yield per plant was observed in 21 crosses out of which HPBU-124 × IC-413304 (99.56%) followed by HPBU-124 × KU-553 (97.16%) and HPBU-124 × HPBU-111 (91.07) had the maximum magnitude. The heterosis for the trait ranged from -46.44 per cent (Him Mash-1 × IC-413304) to 99.56 per cent (HPBU-124 × IC-413304).

Heterobeltiosis was ranging from -54.08 per cent (Him Mash-1 × IC-413304) to 79.95 per cent (HPBU-124 × HPBU-111) for seed yield per plant. Significant positive heterosis for the trait was exhibited by 18 crosses out of which HPBU-124 × HPBU-111(79.95%) had the maximum magnitude followed by HPBU-124 × IC-413304 (73.15%) and KU-553 × IC-413304 (72.23%).

Standard heterosis ranged from -58.60 per cent (DU-1 × IC-281994) to 27.83 per cent (DU-1 × KU-553) for seed yield per plant. Significant positive heterosis for seed yield was observed in seven crosses out of which DU-1 × KU-553 (27.83%) followed by KU-553 × IC-413304 (25.84%) and DU-1 ×

IC-413304 (24.81%) had the highest magnitude (Table 2).

Harvest Index

The relative heterosis ranged from -33.50 per cent (Palampur-93 × DKU-98) to 50.51 per cent (DKU-98 × IC-281994) for harvest index. Significant positive heterosis for the trait was observed in 10 crosses out of which DKU-98 × IC-281994 (50.51%) followed by DU-1 × KU-553 (49.73%) and DU-1 × IC-413304 (48.42 %) had the maximum magnitude. Heterobeltiosis was ranging from -34.35 per cent (Palampur-93 × DKU-98) to 45.26 per cent (DKU-98 × IC-281994). Nine crosses exhibited significant positive heterosis for the trait out of which maximum heterosis was observed in DKU-98 × IC-281994 (45.26%) followed by HPBU-111 × IC-281994 (44.21%) and DU-1 × KU-553 (42.87%).

Standard heterosis ranged from -46.40 per cent (Palampur-93 × DKU-98) to 27.50 per cent (DKU-98 × IC-281994) for harvest index. Four crosses had significant positive heterosis for the trait out of which DKU-98 × IC-281994 (27.50%) followed by HPBU-111 × IC-281994 (26.57%) and HPBU-111 × IC-413304 (21.24%) had the maximum magnitude (Table 2).

3. Quality

100-seed weight

The heterosis ranged for 100-seed weight, from -44.00 per cent (Him Mash-1 × DKU-98) to 69.57 per cent (HPBU-124 × HPBU-111) but none of the crosses had significant positive heterosis.

The heterosis over better parent ranged from -46.97 per cent (Him Mash-1 × DKU-98) to 66.76 per cent (HPBU-124 × HPBU-111). Significant positive heterosis for the trait was observed in 14 crosses out of which maximum magnitude was observed in HPBU-124 × HPBU-111 (66.76%), HPBU-124 × DU-1 (54.74%) and IC-413304 × IC-281994 (40.86%).

Standard heterosis ranged from -46.97 per cent (Him Mash-1 × DKU-98) to 1.60 per cent (DKU-98 × IC-413304) for this trait. None of the crosses had significant positive heterosis for 100-seed weight (Table 3).

Crude Protein

Relative heterosis for the trait ranged from -7.43 per cent (HPBU-111 × DKU-98) to 52.15 per cent (KU-553 × IC-281994). Significant positive relative heterosis for crude protein was observed in 19 crosses out of which KU-553 × IC-281994 (52.15%) followed by Him Mash-1 × HPBU-111 (40.62%) and Him Mash-1 × KU-553 (29.79%) had the maximum magnitude.

The heterobeltiosis ranged from -15.90 per cent (Him Mash-1 × IC-413304) to 49.26 per cent (KU-553 × IC-281994) for the trait. Significant positive heterosis was observed in 15 crosses out of which the maximum magnitude was obtained in KU-553 × IC-281994 (49.26%), Him Mash-1 × HPBU-111 (38.69%) and KU-553 × DKU-98 (27.90%).

Standard heterosis ranged from -20.95 per cent (HPBU-124 × IC-413304) to 38.69 per cent (Him Mash-1 × HPBU-111). Significant positive heterosis for the trait was observed in 12 crosses out of which maximum magnitude was observed in Him Mash-1 × HPBU-111 (38.69%) followed by KU-553 × IC-281994 (38.07%) and Him Mash-1 × KU-553 (24.92%).

High heterobeltiosis in the desirable direction was reported for all the seven traits. For earliness, negative heterosis for days to flower initiation and days to 75% maturity was desirable. Palampur-93 × KU-553, Palampur 93 × IC-413304, Palampur-93 × HPBU-124, Him Mash-1 × DKU-98, HPBU-111 × KU-553, DU-1 × IC-413304, DU-1 × IC-281994, DKU-98 × IC-4133-4 and DK-98 × IC-281994 surpassed the standard variety Palampur-93 for earliness by exhibiting high significant negative heterosis for days to flower initiation and days to 75 per cent maturity. These results are supported by the findings of Gupta and Ramakant and Srivastava[6] in urdbean who also reported high significant negative heterosis for the days to flowering and maturity. HPBU-124 × KU-553, HPBU-124 × IC-413304, HPBU-111 × KU-553, DU-1 × KU-553, DU-1 × DKU-98, DU-1 × IC-413304 and KU-553 × IC-413304 outperformed

Palampur-93 for seed yield. HPBU-111 × KU-553 and DU-1 × IC-413304 had standard heterosis for maximum number of traits along with seed yield. Other cross combinations having high standard heterosis for more than three traits were HPBU-124 × KU-553, HPBU-124 × DU-1, HPBU-111 × IC-281994, DU-1 × KU-553, DU-1 × DKU-98, KU-553 × IC-413304 and DKU-98 × IC-281994 (Table 3).

The results are in agreement with the findings of Elangaimannan *et al*.[2], who reported high heterobeltiosis for number of pods, seed yield, number of branches, pod length and number of seeds per pod in urdbean, Ramakant and Srivastava[6] for plant height in urdbean and Pandiyan *et al*.[5], in *Vigna* inter-specific hybrids and Yashpal[12] for branches per plant in mungbean-urdbean inter-specific hybrids. High significant positive heterosis for all the traits along with desirable significant negative heterosis for flowering and maturity reported by Thamodharan *et al*.[10], in urdbean also supports the results of present study. Zubair *et al*.[13], and Gafoor *et al*.[4], in mungbean also reported low heterosis for plant height and 100 seed weight. High heterosis for crude protein content has also been reported by Waldia *et al*.[11], in urdbean. High heterobeltiosis and standard heterosis was observed for seed yield which can be attributed to the cumulative effect of high heterosis in the component traits like number of pods per plant[9]. The high magnitude of heterosis for all these traits was indicative of dominance and/or epistasis[6]. The high heterosis obtained in all these traits indicates the presence of dominance and epistasis in the genes governing the traits which can be either exploited as F_1's or can be subjected to the selection to obtain transgressive segregants.

Table 1: Estimates of heterosis (%) for earliness traits *viz.*, days to flower initiation and days to 75 per cent maturity in urdbean genotypes

	Days to flower initiation			Days to 75% maturity		
	M.P.	B.P.	S.C.	M.P.	B.P.	S.C.
Palampur-93xHim Mash-1	5.17	0.83	-8.96 *	6.43*	-2.04	-5.88
Palampur-93 × HPBU-124	-1.18	-5.97	-5.97	5.49	2.04	-1.96
Palampur-93 × HPBU-111	-2.04	-3.23	-10.45 *	-3.60	-5.49	-5.49
Palampur -93 × DU-1	-6.44*	-9.92 *	-18.66 *	2.94	0.00	-3.92
Palampur -93 × KU-553	-2.07	-2.48	-11.94 *	-3.05	-3.25	-6.67*
Palampur -93 × DKU-98	18.42*	11.57*	0.75	8.86*	2.86	-1.18
Palampur -93 × IC-413304	-9.54*	-9.92 *	-18.66 *	0.87	-4.90	-8.63*
Palampur -93 × IC-281994	3.56	-0.76	-2.24	3.78	0.82	-3.14
Him Mash -1 × HPBU-124	-2.04	-10.45 *	-10.45 *	2.99	-2.18	-12.16*
Him Mash-1 × HPBU-111	8.94*	3.23	-4.48	0.22	-9.41*	-9.41*
Him Mash-1 × DU-1	32.74*	32.14*	10.45*	12.59*	6.49	-3.53
Him Mash-1 × KU-553	9.09*	5.00	-5.97	12.83*	3.66	0.00
Him Mash-1 × DKU-98	-2.75	-4.50	-20.90 *	3.30	0.46	-14.12*
Him Mash-1 × IC-413304	15.15*	10.83*	-0.75	15.84*	12.90*	-3.92
Him Mash-1 × IC-281994	-2.06	-9.85 *	-11.19 *	13.04*	6.93	-3.14
HPBU-124 × HPBU-111	-6.20*	-9.70 *	-9.70 *	2.48	-2.75	-2.75
HPBU-124 × DU-1	-8.84*	-16.42 *	-16.42 *	9.57*	9.09*	-1.18
HPBU -124 × KU-553	-0.79	-5.97	-5.97	13.68*	9.76*	5.88
HPBU-124 × DKU-98	15.35*	3.73	3.73	9.17*	6.55	-4.31
HPBU-124 × IC-413304	0.79	-4.48	-4.48	17.04*	13.97*	2.35
HPBU-124 × IC-281994	-5.26	-5.97	-5.97	5.22	4.76	-5.10
HPBU-111 × DU-1	0.00	-4.84	-11.94 *	4.53	-0.39	-0.39
HPBU-111 × KU-553	-2.46	-4.03	-11.19 *	-7.78*	-9.41*	-9.41*
HPBU-111 × DKU-98	25.54*	16.94*	8.21*	7.40*	-0.39	-0.39
HPBU-111 × IC-413304	4.10	2.42	-5.22	8.90*	0.78	0.78
HPBU-111 × IC-281994	-9.37*	-12.12 *	-13.43 *	1.23	-3.53	-3.53
DU-1 × KU-553	-2.59	-5.83	-15.67 *	6.92*	3.66	0.00
DU-1 × DKU-98	12.33*	9.82*	-8.21 *	12.25*	9.09*	-1.18
DU-1 × IC-413304	-18.97*	-21.67 *	-29.85 *	3.12	0.00	-9.41*
DU-1 × IC-281994	-4.10	-11.36 *	-12.69 *	2.60	2.60	-7.06*
KU-553 × DKU-98	15.42*	9.17*	-2.24	3.45	-2.44	-5.88
KU-553 × IC-413304	2.50	2.50	-8.21 *	11.02*	4.47	0.78
KU-553 × IC-281994	-3.97	-8.33 *	-9.70 *	4.82	1.63	-1.96
DKU-98 × IC-413304	3.96	-1.67	-11.94 *	0.69	0.46	-14.12*
DKU-98 × IC-281994	-4.60	-13.64 *	-14.93 *	1.56	-1.30	-10.59*
IC-413304 × IC-281994	2.38	-2.27	-3.73	10.27*	6.93	-3.14
SE	1.17	1.36	1.36	2.34	2.71	2.71

MP: Mid parent; BP: Better parent; SC: Standard Check

*Significance at P= 0.05

Table 2: Estimates of heterosis (%) for yield traits *viz.*, pods per plant, seed yield per plant (g) and harvest index (%) in urdbean genotypes

	Pods per plant			Seed yield/ Plant			Harvest index		
	M.P.	B.P.	S.C.	M.P.	B.P.	S.C.	M.P.	B.P.	S.C.
Palampur-93 × Him Mash-1	25.44*	8.24	8.24	35.63*	16.24	16.24	9.39	-1.79	-1.79
Palampur-93 × HPBU-124	31.14*	11.51	-19.06*	82.20*	58.16*	12.95	41.55*	39.22*	14.54
Palampur-93 × HPBU-111	43.48*	43.04*	3.83	54.87*	41.94*	1.37	-2.22	-6.35	-18.62*
Palampur -93 × DU-1	72.87*	69.43*	28.08*	47.77*	39.40*	12.27	10.47	5.44	-16.11*
Palampur -93 × KU-553	37.15*	28.40*	6.83	38.61*	37.05*	0.14	3.98	-5.09	-24.49*
Palampur -93 × DKU-98	-5.34	-11.13	-35.50*	-18.88	-25.14*	-46.54 *	-33.50*	-34.35*	-46.40*
Palampur -93 × IC-413304	-18.44*	-20.65*	-42.40*	8.20	8.15	-22.69 *	4.64	-1.50	-11.22
Palampur -93 × IC-281994	0.31	-2.23	-25.25*	37.49*	33.40*	-4.73	6.55	1.57	-10.85
Him Mash -1 × HPBU-124	29.18*	-2.56	-2.56	-20.75*	-39.55*	-39.55 *	3.78	-5.41	-5.41
Him Mash-1 × HPBU-111	-12.66*	-24.83*	-24.83*	-11.39	-29.34*	-29.34 *	-11.27	-17.08*	-17.08*
Him Mash-1 × DU-1	-17.33*	-27.42*	-27.42*	-18.15*	-26.11*	-26.11 *	-14.03	-25.93*	-25.93*
Him Mash-1 × KU-553	-17.81	-24.72*	-24.72*	23.41*	6.79	6.79	-7.46	-23.34*	-23.34*
Him Mash-1 × DKU-98	-38.41*	-49.58*	-49.58*	-37.78*	-50.10*	-50.10 *	5.28	-4.38	-4.38
Him Mash-1 × IC-413304	-46.27*	-54.69*	-54.69*	-46.44*	-54.08*	-54.08 *	-15.31*	-19.49*	-19.49*
Him Mash-1 × IC-281994	-3.83	-15.15*	-15.15*	12.10	-6.31	-6.31	-10.56	-16.03*	-16.03*
HPBU-124 × HPBU-111	77.31*	51.14*	9.05	91.07*	79.95*	7.06	6.70	3.86	-9.74
HPBU-124 × DU-1	65.52*	38.43*	4.65	59.94*	32.17*	6.44	2.22	-3.96	-20.99*
HPBU -124 × KU-553	78.74*	43.99*	19.80*	97.16*	69.51*	23.85*	7.07	-3.72	-20.79*
HPBU-124 × DKU-98	72.88*	55.44*	-0.98	64.32*	53.69*	-7.20	20.13*	19.68*	-1.54
HPBU-124 × IC-413304	56.74*	36.42*	-6.35	99.56*	73.15*	23.78*	8.11	3.40	-6.80
HPBU-124 × IC-281994	20.97*	0.71	-23.00*	17.23	4.49	-29.81 *	-16.53*	-19.14*	-29.03*
HPBU-111 × DU-1	7.72	5.26	-20.43*	-10.13	-21.87*	-37.08 *	-28.20*	-34.23*	-42.84*
HPBU-111 × KU-553	48.14*	38.31*	15.07*	86.97*	69.61*	23.92*	8.47	-4.77	-17.24*
HPBU-111 × DKU-98	6.94	0.68	-27.36*	43.05*	42.00*	-14.26	1.23	-1.83	-14.69
HPBU-111 × IC-413304	42.26*	38.81*	0.15	75.82*	61.07*	15.15	36.97*	34.51*	21.24*
HPBU-111 × IC-281994	50.34*	46.11*	11.70	72.29*	62.45*	9.12	44.93*	44.21*	26.57*
DU-1 × KU-553	50.08*	43.22*	19.16*	66.44*	58.72*	27.83*	49.73*	42.87*	3.32
DU-1 × DKU-98	64.06*	51.15*	14.27*	74.90*	53.02*	23.24*	32.00*	24.46*	1.62
DU-1 × IC-413304	84.55*	76.06*	33.10*	64.20*	54.98*	24.81*	48.42*	33.75*	20.56*
DU-1 × IC-281994	-30.55 *	-30.94*	-47.20*	-43.94 *	-48.60*	-58.60 *	-11.02	-18.85*	-28.78 *
KU-553 × DKU-98	-2.11	-13.58	-28.10*	-12.48	-20.08	-41.60 *	-7.60	-16.63	-31.93 *
KU-553 × IC-413304	66.04*	51.52*	26.07*	74.11*	72.23*	25.84*	41.91*	22.66*	10.56
KU-553 × IC-281994	1.36	-2.75	-19.09*	2.64	-1.50	-28.03 *	5.38	-7.87	-19.14 *
DKU-98 × IC-413304	9.56	5.62	-27.50*	-4.16	-11.60	-36.81 *	16.33*	10.86	-0.08
DKU-98 × IC-281994	78.55*	63.66*	25.13*	76.89*	67.96*	12.82	50.51*	45.26*	27.50*
IC-413304 × IC-281994	25.27*	18.87*	-9.12	19.33	15.72	-17.27	-22.46*	-23.48*	-31.03 *
SE	1.31	1.51	1.51	0.36	0.41	0.41	1.57	1.81	1.81

MP: Mid parent; BP: Better parent; SC: Standard Check

*Significance at P= 0.05

Table 3: Estimates of heterosis (%) for quality traits *viz.*, 100-seed weight (g) and crude protein (%) in urdbean genotypes

	100-seed weight			Crude protein		
	M.P.	**B.P.**	**S.C.**	**M.P.**	**B.P.**	**S.C.**
Palampur-93 × Him Mash-1	-14.57	-20.52*	-28.97 *	12.47*	11.01*	11.01*
Palampur-93 × HPBU-124	24.38	8.02*	-16.91 *	1.72	-6.91*	-9.33 *
Palampur-93 × HPBU-111	17.03	3.12	-20.69 *	14.85*	14.76*	11.77*
Palampur -93 × DU-1	8.72	-8.32*	-29.49 *	-5.49*	-9.42*	-11.77 *
Palampur -93 × KU-553	42.69	30.24*	0.17	22.54*	19.47*	16.36*
Palampur -93 × DKU-98	-35.14	-42.63*	-42.63 *	-3.20*	-5.02*	-7.49 *
Palampur -93 × IC-413304	18.74	14.64*	-11.83 *	2.86*	-6.91*	-9.33 *
Palampur -93 × IC-281994	16.02	11.89*	-13.94 *	-5.17*	-9.26*	-11.62 *
Him Mash -1 × HPBU-124	-6.96	-23.98*	-32.06 *	3.13*	-6.73*	-6.73 *
Him Mash-1 × HPBU-111	-27.88	-40.28*	-46.63 *	40.62*	38.69*	38.69*
Him Mash-1 × DU-1	-18.49	-35.17*	-42.06 *	-6.30*	-11.31*	-11.31 *
Him Mash-1 × KU-553	-30.39	-40.47*	-46.80 *	29.79*	24.92*	24.92*
Him Mash-1 × DKU-98	-44.00	-46.97*	-46.97 *	0.71	-2.45*	-2.45 *
Him Mash-1 × IC-413304	-5.50	-14.90*	-23.94 *	-5.98*	-15.90*	-15.90 *
Him Mash-1 × IC-281994	9.24	-1.73	-12.17 *	-1.78*	-7.19*	-7.19 *
HPBU-124 × HPBU-111	69.57	66.76*	-2.23	26.35*	15.72*	12.54*
HPBU-124 × DU-1	60.23	54.74*	-12.29 *	23.27*	17.47*	4.89*
HPBU -124 × KU-553	5.56	-0.09	-36.57 *	-3.53*	-9.59*	-16.36 *
HPBU-124 × DKU-98	28.88	0.97	0.97	4.38*	-2.77*	-8.87 *
HPBU-124 × IC-413304	17.77	5.51	-24.46 *	-1.05	-2.27*	-20.95 *
HPBU-124 × IC-281994	37.91	23.68*	-11.66 *	-0.99	-5.50*	-15.90 *
HPBU-111 × DU-1	-1.23	-6.14	-44.97 *	-5.41*	-9.28*	-11.77 *
HPBU-111 × KU-553	30.84	25.83*	-20.11 *	12.49*	9.75*	6.73*
HPBU-111 × DKU-98	-4.11	-23.94*	-23.94 *	-7.43 *	-9.10 *	-11.61 *
HPBU-111 × IC-413304	19.61	8.78*	-22.11 *	4.86*	-5.03 *	-7.65 *
HPBU-111 × IC-281994	39.28	26.80*	-9.43 *	-0.99	-5.19 *	-7.80 *
DU-1 × KU-553	-5.45	-13.41*	-45.03 *	24.47*	22.31*	13.15*
DU-1 × DKU-98	31.41	0.40	0.40	-5.10 *	-7.34 *	-13.15 *
DU-1 × IC-413304	34.59	16.92*	-16.29 *	4.18*	-1.88	-12.39 *
DU-1 × IC-281994	20.88	5.12	-24.91 *	4.29*	4.11*	-7.03 *
KU-553 × DKU-98	-12.41 *	-28.40*	-28.40 *	28.74*	27.90*	19.88*
KU-553 × IC-413304	16.75	10.14*	-21.14 *	29.71*	20.17*	11.16*
KU-553 × IC-281994	29.18	22.00*	-12.86 *	52.15*	49.26*	38.07*
DKU-98 × IC-413304	18.41	1.60	1.60	17.45*	8.16*	1.38
DKU-98 × IC-281994	-2.27	-16.23*	-16.23 *	-3.26 *	-5.71 *	-11.62 *
IC-413304 × IC-281994	41.03	40.86*	0.86	1.46	-4.30 *	-14.83 *
SE±	0.13	0.15	0.15	0.17	0.19	0.19

MP: Mid parent; BP: Better parent; SC: Standard Check

*Significance at P= 0.05

CONCLUSION

Hybrid production in crop like urdbean is a remote possibility but this does not restrict the scope of hybridization in this crop. The derivatives of the outstanding crosses should be subjected to selection in later generations to obtain the transgressive segregants when the non-additive gene action has converted into the additive gene action. However, the cross predictions for transgressive segregants in later generations on the basis of heterosis are not always reliable and taken for granted.

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