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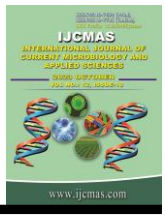

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Estimation of Standard Heterosis for Yield and its Component Traits in Hybrid Rice (*Oryza sativa* L.)

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A B S T R A C T

A field experiment was conducted in randomized block design in rice crop to estimate standard heterosis for yield and its component traits in hybrid rice (*Oryza sativa* L.)". 6 hybrids of rice along with 3 popular standard check varieties namely IR64, MTU1010, sonum were evaluated for estimation of standard heterosis for grain yield and its component traits. The result showed highly significant variations among the genotypes for all the traits under study. The hybrid BS144 had significant positive standard heterosis over all three checks IR64, MTU1010, sonum for characters namely, grain yield per plant followed by harvest index, number of filled grains per panicle, number of effective tillers per plant, biological yield per plant, grain fertility, number of unfilled grain per panicle should be utilized in designing high yielding plant ideotype.

Introduction

Rice (*Oryza sativa* L.) is a cereal crop belongs to the genus *Oryza*, family Poacea with chromosome no.2n=24. It is cultivated in 114 countries across the globe, but 90% of world's rice grown in Asia (FAO, 2016) and it is originated in South East Asia. Rice is the most important food crop in the world. It occupies a fundamental place since it forms the staple food for about two thirds of the world's population, provides approximately 43 % calories necessity in addition to 20-25 % agriculture income (Kumar *et al.*, 2018). Rice overfills 80% of the nutritional requirements of half of the world's population. It contains 80% carbohydrate, 7-8% protein, 3% fat and 3% fibre (Juliano, 1985) and also a good source of thiamine, riboflavin and niacin.

Hybrid rice technology is one of the most promising, sustainable, and proven technologies for increasing rice production and productivity over modern pure line varieties. The first rice hybrid APRH1 was released by APRRI, Maruteru, Andhra Pradesh in 1993-1994. At present, 117 rice hybrids (36 from public sector and 81 from private sector) were developed. They are suitable for different ecological conditions having 15-20% yield superiority with

maturity duration of 115-150 days. Rice hybrid covered area about 3.0mha, which accounted for about 7.0% of the total rice acreage in India. (Varietal Improvement Progress report) and (Technical Bulletin 2019, Indian Institute of Rice Research IIRR, Hyderabad). Heterosis or hybrid vigor refers to the phenomenon of superior performance of a hybrid over its parent or standard variety in terms of biomass production, development rate, grain yield, and stress tolerance. Utilization of heterosis has tremendously increased productivity of many crops, globally. The term heterosis was first coined by Shull (1914), denotes superiority of F_1 hybrids over both of its parents in terms of yield or any other character. First reported heterosis in rice and observed a tremendous increase in culm number and grain yield in F1 hybrids compared to their parents. Heterosis is the superiority of F_1 over the mid parent or over the better parent or over the standard check (Hayes *et al.,* 1956) with respect to agronomically useful traits.

The commercial usefulness of hybrid varieties would primarily depend on its performance in comparison to the best commercial variety of the concerned crop species. The better parent of the hybrid variety may be inferior to the commercial variety. In such situations, it is desirable to estimate standard heterosis in relation to the best commercial variety of the crop so that the objective of present study is to identify standard heterosis of popular hybrids over popular pure lines (IR64, MTU1010 and Sonum) which are growing in this region by the farmers.

Materials and Methods

Field Experiment

This investigation was carried out at, Instructional Farm, JNKVV, College of Agriculture, Rewa (M.P.) during month of July of Kharif 2021 cropping season. The experimental material was comprised of 6 hybrids along with 3 popular standard check varieties namely IR64, MTU1010, Sonum of rice were included for an effectual comparison with hybrids. Hybrids were planted in Randomized Block Design (RBD) with three replications and each replication consisted of 6 hybrids along with 3 popular standard check varieties with spacing of 20cm × 15 cm. Recommended agronomic practices were followed to raise a good crop observations were recorded on five randomly selected plants with respect to twelve yield and yield attributing traits viz., Days to 50 % flowering, Days to maturity, Plant height, Number of effective tillers per plant, Panicle length(cm), Number of filled grains per panicle, Number of unfilled grains per panicle, Grain fertility (%), Biological yield per plant (gm), Harvest index (%), 100 grain weight (gm), Grain yield per plant (gm). The character means of each replication was subjected for analysis of variance (Panse and Sukhatme, 1985) and estimation of standard heterosis. The significance of standard heterosis was then tested by comparing the calculated 't' value with the tabulated student's 't'-value for appropriate error degrees of freedom at 5 per cent and 1 per cent level of significant (0.05 and 0.01 level of probability), respectively.

$$t' \text{ cal for Standard heterosis} = \frac{F_1 - \text{Mean of check}}{\sqrt{2}\text{EMSS}/r}$$

Where,

EMSS= Error mean sum of square

r= Number of replication.

Results and Discussion

Analysis of variance for all the characters revealed presence of highly significant differences among the genotypes. It was observed that all the hybrids and check varieties showed sufficient amount of variability for all the characters. Thus, there is ample scope for the selection of various quantitative traits for rice improvement. Significant genetic differences among the rice genotypes were also reported by Gyawali *et al.,* (2018).

Estimation of heterosis

Heterosis is usually expressed into three ways, depending on the criterion used to evaluate the performance of a hybrid. These are mid-parent heterosis, better parent heterosis or called heterobeltiosis and standard heterosis. Heterosis breeding is a vital genetic tool that could assist in yield improvement from 30% to 40% as well as helps to augment many other desirable quantitative and qualitative traits in crops (Gupta *et al.,* 2020). Both the positive as well as negative heterosis is useful in crop improvement program, usually depends on breeding objectives. Generally, positive heterosis is desirable for yield while negative heterosis in concern to early maturity followed by early flowering. Exploitation of heterosis is of utmost importance for increasing agricultural productivity and also one of the most successful examples in many crops including rice (Lv *et al.,* 2020; Singh *et al.,* 2019). One of the objectives of present study was to estimate the extent of heterosis for various traits and to isolate promising hybrids over standard checks (IR64, MTU1010, sonum) for commercial exploitation of yield and its contributing traits. The nature and magnitude of heterosis for seed yield and its contributing traits is helpful in heterosis breeding. The maximum utilization of heterosis is possible when the variance due to additive and non-additive gene actions are fully exploited because they play a significant role in determining the magnitude of expression of yield and its component characters. Therefore, in the present investigation character wise superiority of the hybrids were estimated over standard checks to judge the potential of hybrids to be exploited in heterosis breeding programme.

Days to 50 % flowering

The estimate of standard heterosis for days to 50% flowering presented in Table1.2. Heterosis for days to 50 per cent flowering is desirable in negative direction. Out of six hybrids, 3 hybrids BS076, BS008, BS022 were showed significant negative standard heterosis when compared with check IR64 and MTU1010. However, none of the hybrids showed positively significant standard heterosis over sonum. All the six hybrids recorded negatively significant standard heterosis minimum in BS076 and maximum in BS133 when compared with sonum. Negative heterosis is desirable for days to 50% flowering because this will help the hybrid to mature earlier. Short duration varieties are of breeders interest for multiple cropping, therefore, heterosis in negative direction is desirable for days to % flowering. These hybrids BS076, BS008, BS022, BS133 recorded higher significant negative heterosis and indicated that these hybrids are suitable for days to 50% flowering. Presence of standard heterosis in negative direction were reported by Chaitali *et al.,* (2011); Sahu *et al.,* (2017); Thorat *et al.,* (2017); Naik *et al.,* (2018); Begum *et al.,* (2020).

Days to Maturity

The estimate of standard heterosis for days to maturity presented in Table 1.2. Hybrid BS008 recorded significant negative value and BS175, BS144 recorded significant positive standard heterosis over IR64. It indicates that both these hybrids was suitable for medium maturity condition as they indicates significant positive standard heterosis. None of the hybrid showed significant positive standard heterosis over MTU1010 but some of the hybrids like BS076, BS008, BS133, BS022 recorded significant negative standard heterosis when compared with MTU1010. Hybrids BS008, BS076, BS133 showed negatively significant standard heterosis over sonum. Most of the hybrids showed significant negative values which indicates that that these hybrids are suitable for early maturing condition. Presence of both positive and negative standard heterosis over checks for days to maturity were observed by Hussain *et al.,* (2012); Borah *et al.,* (2017); Gokulakrishnan *et al.,* (2018); Kahani *et al.,* (2018); Chuwang Hijam *et al.,* (2019); Singh *et al.,* (2019); Ray *et al.,* (2021).

Plant height

The estimation of standard heterosis for plant height presented in Table 1.2. In plant height BS008,

BS133 showed significant positive standard heterosis while hybrid BS076 showed significant negative standard heterosis when compared with IR64. Hybrids which showed significant negative standard heterosis indicates that these hybrids were suitable for dwarf height group. None of the hybrid showed significant negative standard heterosis over MTU1010. Hybrids like BS008, BS133, BS175, BS144 showed significant positive standard heterosis over MTU1010. It indicates that these hybrids were suitable for tall height group. BS076 exhibited significant negative standard heterosis whereas BS008, BS133 exhibited significant positive value over Sonum. Both positive and negative standard heterosis over checks were observed by Singh *et al.*, (2012); Bhatti *et al.*, (2015); Gokulakrishnan *et al.*, (2018); Naik *et al.*, *(*2018); Kencharahu *et al.*, *(*2019); Sari *et al.*, (2019); Shama *et al.*, (2019).

Number of effective tillers per plant

The estimation of standard heterosis for number of effective tillers per plant presented in Table 1.2. For Number of effective tillers per plant, out of six hybrids, three hybrids BS076, BS008, BS022 exhibited negative significant standard heterosis when compared with IR64. while four hybrids namely BS076, BS008, BS175, BS022 showed negative significant value over check MTU1010. None of the hybrid showed positive significant standard heterosis over sonum but some of the hybrids like BS076, BS008, BS175, BS022 showed negative significant value when compared with Sonum.

Out of six hybrids, Two hybrids BS133 and BS144 exhibited positive significant standard heterosis when compared with IR64 and MTU1010. Number of effective tillers per plant play major role in grain yield and heterosis over standard checks in positive direction is considered highly desirable for this character. The hybrids BS133 and BS144 showed highpositive significant standard heterosis. Similar findings for positive significant standard heterosis were observed by Kumar and Adilakshmi *et al.*, (2016); Kumar *et al.*, (2017); Thorat *et al.*, (2017); Chuwang Hijam and Singh *et al.*, (2019); Ray *et al.*, (2021).

Panicle length

The estimation of standard heterosis for panicle length presented in Table1.2. In panicle length, hybrid BS144 recorded positive significant standard heterosis and BS008, BS022 exhibited negative significant value when compared with IR64. Hybrids BS133, BS144 showed positive significant standard heterosis while none of hybrids revealed significant negative standard heterosis over MTU1010. A hybrid with longer panicle length is desirable since the spikelets attached to number of panicles would increase proportionately with the enhancement of panicle length. Hybrids BS144 exhibited positive significant standard heterosis and BS008, BS022 exhibited negative significant value over Sonum. Hybrids BS144 and BS133 recorded positive significant standard heterosis and it indicates that long panicle is desirable for more grain yield. similar observations were supported by Ghara *et al.*, (2014); Kumar *et al.*, (2017); Sahu *et al.*, (2017); Gokulakrishnan *et al.*, (2018); Ram *et al.*, *(*2020); Meena *et al.*, (2021).

Number of filled grains per panicle

The estimate of standard heterosis for number of filled grains per panicle presented in Table 1.2. In number of filled grains per panicle, hybrids BS133, BS144 showed positive significant standard heterosis and BS076, BS008 showed negative significant value when compared with IR64. Hybrids like BS133, BS144 exhibited positive significant standard heterosis while BS076, BS008, BS175, BS022 showed negative significant value over MTU1010. However Hybrids namely BS076, BS008, BS175, BS022recorded negative significant standard heterosis and BS133, BS144 exhibited positive significant standard heterosis when compared to Sonum. Hybrids namely BS133, BS144 exhibited positive significant standard heterosis. It indicates that these two hybrids had high number of

filled grains per panicle which promotes the grain yield. Similar findings were supported by Latha *et al.,* (2013); Bhuiyan *et al.,* (2014); Kumar and Adilakshmi *et al.,* (2016); Chuwang Hijam and Singh *et al.,* (2019); Gokulakrishnan *et al.,* (2018); Naik *et al., (*2018); Ray *et al.,* (2021).

Number of unfilled grains per panicle

The estimate of standard heterosis for number of unfilled grains per panicle presented in Table 1.2.In number of unfilled grains per panicle, out of 6 hybrids only two hybrids BS133, BS144 exhibited negative significant standard heterosis over IR64. Hybrids BS076, BS008 showed positive significant standard heterosis but hybrids like BS144 recorded negative significant standard heterosis when compared with MTU1010. None of the hybrids positive significant standard heterosis but hybrids like BS133 and BS144 recorded negative significant standard heterosis over Sonum. This character is desirable in negative direction. Hybrid BS144, BS133 showed negativesignificant standard heterosis which indicates that these hybrids had high number of filled grain per panicle which promotes grain yield. Hybrids BS076, BS008 showed positive significant standard heterosis which indicates both had high number of unfilled grains per panicle and are low yielders. Similar findings were observed for standard heterosis in negative direction by Hussain *et al.,* (2012); Bhuiyan *et al.,* (2014); Kumar *et al.,* (2017); Das *et al.,* (2017); Devi *et al.,* (2017); Thorat *et al.,* (2017); Ray *et al.,* (2021).

Grain fertility

The estimate of standard heterosis for Grain fertility presented in Table 1.2. In Grain fertility, None of the hybrids recorded negative significant standard heterosis while BS133 and BS144 recorded positive significant standard heterosis over IR64.Out of six hybrids, only two hybrids BS133, BS144 exhibited significant positive standard heterosis and rest of four hybrids BS076, BS008, BS175, BS022 recorded negative significant standard heterosis over MTU1010.

However, hybrids namely BS076, BS008, BS175, BS022 showed significant negative standard heterosis and BS133, BS144 recorded significant positive standard heterosis when compared with check Sonum. Grain fertility percentage desirable in positive direction.

Hybrids BS133, BS144 showed significant positive standard heterosis and indicates that they promotes grain yield. Similar observations were studied by Hussain *et al.,* (2012); Sahu *et al.,* (2017); Ram *et al.,* (2019); Sari *et al.,* (2019).

Biological yield per plant

The estimate of standard heterosis of for biological yield presented in Table 1.2. For biological yield per plant, two hybrid BS133, BS144 recorded significant positive standard heterosis and two hybrids BS076 and BS008 showed significant negative standard heterosis when compared with check IR64. One hybrid BS133 showed significant positive value over check MTU1010, while four hybrids viz. BS076, BS008, BS175, BS022 showed significant negative standard heterosis over MTU1010.

Table.1 List of hybrids along with check varieties

S. No.	Name of Genotype	S. No.	Name of Genotype
1	BS076	6	BS022
2	BS008	7	IR64
3	BS133	8	MTU1010
4	BS175	9	Sonum
5	BS144		

Table.2 Analysis of Variance for Yield and its Component Traits

Source of Variation	Df	DTF	DTM	PH (cm)	NTPP	PL (cm)	NFGPP	NUGPP	GF %	BYPP (gm)	HI %	100 GW (gm)	GYPP (gm)
Replication	**2**	3.59	5.59	0.95	0.08	2.01	1.06	5.84	0.83	2.43	4.53	0.037	2.84
Treatments	**8**	43.84**	61.73**	133.46***	2.57**	9.63***	2302.43***	161.97***	80.26***	116.71***	53.45**	0.059**	52.22***
Error	**16**	2.21	4.25	3.26	0.05	1.27	20.27	20.23	2.72	1.97	2.97	0.012	1.51

Table.3 Estimate of Standard Heterosis

	Days to 50 % Flowering			Days to Maturity			Plant Height (cm)		
Name of Hybrid	**Check**								
	IR64	**MTU1010**	**Sonum**	**IR64**	**MTU1010**	**Sonum**	**IR64**	**MTU1010**	**Sonum**
1.BS076	-12.50**	-15.25**	-16.37**	-2.67	-8.29**	-6.65**	-4.80**	-2.95	-5.02**
2.BS008	-6.48**	-9.42**	-10.62**	-4.00**	-9.55**	-7.93**	17.02**	19.30**	16.75**
3.BS133	0.93	-2.24	-3.54*	1.60	-4.27**	-2.56	10.58**	12.74**	10.33**
4.BS175	0.00	-3.14	-4.42*	4.53**	-1.51	0.26	2.52	4.52**	2.29
5.BS144	0.00	-3.14	-4.42*	4.27**	-1.76	0.00	2.41	4.41*	2.18
6.BS022	-4.17*	-7.17**	-8.41**	-1.60	-7.29**	-5.63**	-0.93	1.00	-1.15
	Number Of Effective Tillers Per Plant			**Panicle Length (cm)**			**Number of Filled Grain Per Panicle**		
1.BS076	-19.56**	-21.98**	-25.51**	-2.20	1.88	-3.41	-7.42**	-14.04**	-27.55**
2.BS008	-20.44**	-22.84**	-26.34**	-9.99*	-6.24	-11.11**	-11.03**	-17.40**	-30.38**
3.BS133	8.89**	5.60*	0.82	7.68	12.71**	6.35	33.60**	24.03**	4.54*
4.BS175	-4.00	-6.90*	-11.11**	3.06	7.35	1.78	-0.77	-7.88**	-22.36**
5.BS144	12.00**	8.62**	3.70	12.73**	17.43**	11.34**	39.76**	29.76**	9.36**
6.BS022	-13.33**	-15.95**	-19.75**	-8.83*	-5.03	-9.96*	-1.55	-8.60**	-22.96**
	Number of Unfilled Grain Per Panicle			**Grain Fertility %**			**Biological Yield per plant (gm)**		
1.BS076	0.46	20.37**	0.57	-2.51	-9.25**	-9.03**	-8.82**	-16.93**	-19.30**
2.BS008	0.62	20.55**	0.72	-3.81	-10.46**	-10.25**	-11.77**	-19.62**	-21.91**
3.BS133	-14.89*	1.97	-14.81*	12.53**	4.76*	5.00*	24.97**	13.85**	10.62**
4.BS175	-6.11	12.49	-6.02	1.67	-5.36**	-5.14*	1.73	-7.32**	-9.96**
5.BS144	-33.13**	-19.88**	-33.06**	19.09**	10.85**	11.11**	13.46**	3.37	0.43
6.BS022	-7.24	11.14	-7.15	1.82	-5.22*	-5.00*	-0.87	-9.69**	-12.26**
	Harvest Index %			**Seed Weight (gm)**			**Grain Yield Per Plant (gm)**		
1.BS076	-8.99	-17.94**	-20.80**	3.15	-12.24**	-4.97	-17.08**	-31.87**	-36.09**
2.BS008	-11.32*	-20.03**	-22.82**	2.10	-13.14**	-5.94	-21.81**	-35.75**	-39.73**

3.BS133	7.12	-3.41	-6.78	4.80	-10.84**	-3.45	33.82**	9.97	3.16
4.BS175	3.41	-6.76	-10.01*	5.40	-10.33**	-2.90	5.11	-13.63*	-18.98**
5.BS144	29.27**	16.57**	12.50**	13.49**	-3.44	4.56	46.60**	20.47**	13.01**
6.BS022	-6.00	-15.24**	-18.20**	-2.10	-16.71**	-9.81*	-6.87	-23.47**	-28.21**

However, BS133 showed significant positive standard heterosis and hybrids namely BS076, BS008, BS175, BS022 exhibited significant negative standard heterosis in comparison with MTU 1010. BS133, BS144 showed higher significant positive standard heterosis. It indicates that these hybrids showed luxuriant growth. Similar findings were supported by Tiwari *et al.,* (2011); Hussain *et al.,* (2012); Bhatti *et al.,* (2015); Kumar *et al.,* (2017); Alok *et al.,* (2020).

Harvest index

The estimate of standard heterosis for harvest index presented in Table 1.2.In harvest index, BS008 recorded significant negative standard heterosis and BS144 showed positively significant value when compared with check IR64. Hybrids namely BS076, BS008, BS022 showed negatively significant value and BS144 showed positively significant value over check MTU1010. BS144 showed significant positive standard heterosis over Sonum, while BS076 (-20.80), BS008, BS175, BS022 showed significant negative standard heterosis when compared with Sonum. Hybrid BS144 recorded significant positive standard heterosis over all three checks. Harvest index indirectly enhance the grain yield per plant. Similar findings were reported heterosis in positive direction for harvest index by Samrath *et al.,* (2016); Kumar *et al.,* (2017); Thorat *et al.,* (2017); Singh *et al.,* (2019); Meena *et al.,* (2021).

100 Grain weight

The estimate of standard heterosis for 100 grain weight presented in Table 1.2.100 grain weight is considered as an important yield contributing character in rice, as higher yields are mostly associated with varieties having longer grains with good filing. In 100 grain weight, none of the hybrids showed significant negative heterosis when compared with IR64 while BS144 showed significant positive standard heterosis over check IR64. None of the hybrids recorded significant positive heterosis when compared with MTU1010 and Sonum. BS076, BS008, BS133, BS175, BS022 showed significant negative heterosis over IR64 and BS022 exhibited significant negative heterosis when compared with Sonum. Maximum hybrids exhibited significant negative standard heterosis and generally associated with low test weight Hybrid BS144 recorded significant positive standard heterosis. It indicates that this hybrid was bold seeded with more test weight and promotes grain yield. Similar observation were observed by Sahu *et al.,* (2017); Thorat *et al.,* (2017); Naik *et al.,* (2018); Kahani *et al.,* (2018); Shama *et al.,* (2019); Huang *et al.,* (2020).

Grain yield per plant

The estimate of standard heterosis for grain yield per plant presented in Table 1.2. Grain yield per plant is a sum of several basic components of yield. Increased grain yield is certainly the result of positive heterotic effect of a combination of characters. In grain yield per plant, the maximum significant positive standard heterosis were observed in hybrid BS144 followed by BS133 when estimated over IR64 as check, while significant negative standard heterosis were recorded by BS008 and BS076 over IR64. Hybrid BS144 exhibited significant positive standard heterosis over MTU1010 while maximum significant negative heterosis were recorded by hybrids like BS022 followed by BS008, BS076, BS175 over MTU1010. Maximum significant negative standard heterosis were recorded by hybrids namely, BS008 followed by BS076, BS022, BS175 while hybrid BS144 exhibited significant positive standard heterosis when compared with check sonum.

In comparison to all three checks IR64, MTU1010, sonum hybrid BS144 showed highly significant positive standard heterosis and hybrid BS076 and BS008 showed highly significant negative standard heterosis.

Hybrid BS144 had highly significant positive standard heterosis for following characters namely, number of effective tillers per plant, panicle length, number of filled grain per panicle, grain fertility, biological yield per plant, harvest index, 100 grain weight, grain yield per plant which directly leads to increase in grain yield. Whereas hybrid BS076 and BS008 had significant negative standard heterosis in number of effective tillers per plant, panicle length, number of filled grain per panicle, grain fertility, biological yield per plant, harvest index, 100 grain weight, grain yield per plant which directly showed both are low yielders.

It indicates that hybrid BS144 gave better performance in grain yield and considered as high yielders and may be recommended for commercial cultivation after multilocation yield testing.

Significant positive standard heterosis for grain yield per plant were reported by many researchers viz, Kahani *et al.*,(2018); Parimala *et al.,* (2018); Prasad *et al.,* (2019); Chuwanghijam and Singh *et al.,* (2019); Ranjith *et al.,* (2019); Sari *et al.,* (2019); Ram *et al.,* (2020); Meena *et al.,* (2021).

Out of 6 hybrids studied, the significant standard heterosis for grain yield is observed in one hybrid viz., was identified as promising hybrids based on mean performance, and standard heterosis estimation for grain yield per plant. Hence, this hybrid may be further tested over locations and years for commercial exploitation.

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