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Short Note

Heterosis for Yield and Quality Traits in Rice (*Oryza sativa* .L)

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A field experiment was conducted with 28 hybrids generated by crossing 8 parents which are resistant to gall midge / blast / BPH in 8 x 8 diallel fashion during *rabi* 2004-05. The mean, heterosis (H_1) and heterobeltiosis (H2) were estimated for yield and quality characters. High amount of heterosis existed only for the yield components *viz.,* panicle weight, 1000-grain weight and productive tillers plant^{-1} whereas, it was very low for the quality traits *viz*., kernel length and length / breadth ratio. The promising cross combinations identified for further use in hybrid rice programme were WGL 32100/ White ponni, JGL 1881/ White ponni and JGL 3844/ MTU 4870. The genotypes *viz*., WGL 32100, JGL 1881 and White ponny are useful for conversion into male sterile lines or identification of restorer lines because they are resistant to gall midge.

Key words: Heterosis, rice, quality traits

Northern Telangana zone of Andhra Pradesh takes a lion share in the area and production of rice in the state. Most of the cropped area is under major projects (Sreeram sagar and Nizam sagar) followed by tanks and wells. Due to delay in transplanting, the incidence of gall midge, BPH and blast became a regular phenomenon resulting in severe yield losses. Earlier, with the release of gallmidge resistant varieties, like Surekha and Kavya and subsequently other varieties, the constraint of yield losses due to gall midge was tackled (Bentur *et al*., 2003) and the productivity increased substantially in the zone. But the yields are static since a longtime and to overcome this problem, few farmers have started growing hybrid rice varieties. In addition to this, seed production of hybrids on commercial basis especially in Jammikunta division of Karimnagar district has become a good practice now. Nevertheless, hybrid varieties are not becoming popular in this region on account of the location specific problems mentioned and the preference towards the fine grained varieties. With a view to solve these problems and break the existing yield barrier, priorities have been recently modified giving more emphasis for hybrid rice research in the zone.

As a part of this programme the first released high yielding gall midge resistant variety (Surekha) was converted into male sterile line at ARS, Warangal. Similarly, several gall midge resistant varieties with excellent grain quality were identified as restorer lines. This gave an idea to use the locally developed gall midge and blast resistant elite lines/ varieties in hybrid rice breeding programme. With this background, the present study was undertaken to evaluate the heterosis levels in 28 hybrids developed by using gall midge resistant cultivars for yield and quality traits.

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Materials and Methods

The material consisted of eight divergent parents whose specific features are described below.

Warangal Sannalu (WGL32100): A cross derivative of Divya/ BPT 5204 with medium duration (135 days) and medium slender grains. It is resistant to gall midge.

JGL-3855 (Pre-release): Derived from cross, BPT 5204/ARC 5984//Kavya is a gall midge resistant culture with dark green foliage, more response to fertilizer with cold tolerance (at vegetative stage), possessing excellent (superfine) grain characteristics and attains maturity in 135 days.

Jagtial Samba (JGL 3844): A cross derivative of BPT 5204/ ARC 5984// Kavya, with 120 days duration and resistance to gall midge. It has medium slender grains with excellent panicle exertion (2-4 cm above flag leaf) and high yield potential.

JGL 7046 (Pre-release): Selected from a cross, JGL 384/Vajram is a very high yielding medium duration variety with medium bold grains.

JGL 1881 (Pre-release) : Derived from BPT 5204/ Kavya cross, has long slender grains and multiple biotype resistance for gall midge.

Deepti (MTU 4870): Derived from the cross, Sowbhagya/ ARC 6650. It is a long duration (145 days) variety with resistance to BPH and medium slender type grains.

Table 1. Mean values of parents

Trait Parents	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle weight (g)	Productive tillers plant^{-1}	1000 grain weight(g)	Grain yield plant^{-1}(g)	Kernel Length (mm)	Kernel breadth (mm)	Kernel L/ B ratio
WGL 32100	109.66	83.66	21.86	3.49	10.73	12.33	16.00	4.23	1.26	3.33
JGL 3855	109.66	86.33	23.60	4.04	9.73	12.33	27.06	4.24	1.24	3.42
JGL 3844	104.66	96.33	24.80	4.21	10.40	13.63	24.93	4.25	1.30	3.27
JGL 7046	114.66	97.00	24.93	4.93	11.33	15.36	26.00	4.37	1.31	3.32
JGL 1881	117.00	93.66	22.86	4.67	10.66	16.93	16.40	4.59	1.30	3.53
MTU 4870	119.33	96.33	24.00	3.61	11.20	19.93	17.73	4.39	1.58	2.79
NLR 34452	104.66	81.00	21.33	3.91	11.80	13.53	13.46	3.74	1.26	2.97
White ponni	104.66	133.00	26.33	3.74	9.66	12.86	24.53	4.30	1.27	3.37

NLR 34452: Selected from cross, IR 72/ BPT 5204. It is a short duration variety with medium slender grains and has resistance to blast.

White ponni: Possessing medium slender grains with excellent cooking quality.

All possible 28 crosses (excluding reciprocals) were made during wet (kharif) season, 2004 and the resultant F_1s along with their parents were grown during post rainy (rabi) season, 2004-05 in a randomized complete block design with three replications at Regional Agricultural Research Station, Jagtial located in Karimnagar district of Andhra Pradesh. Each parent and F_1 was represented by 2 rows in each replication with spacing of 20 x 20 cm and the crop management practices were followed as recommended by ANGRAU. Observations were recorded on ten randomly selected competitive plants in each replication for seven yield characters *viz*., days to 50 per cent flowering, plant height, ear bearing tillers plant^{-1}, panicle length, panicle weight, 1000 grain weight and grain yield plant^{-1} and their quality characters *viz.*, kernel length, kernel breadth and length / breadth ratio. The heterosis (H_1) and heterobeltiosis (H_2) were estimated and tested as per as per the formula of Liang *et al*. (1971).

Table 2. Mean (μ), Heterosis (H_1) and Heterobeltiosis (H_2) of crosses

Cross combination	Days to 50 % flowering			Plant height (cm)			Panicle length (cm)			Panicle weight (g)		
	μ	H_1	H_2	μ	H_1	H_2	μ	H_1	H_2	μ	H_1	H_2
WGL 32100xJGL 3855	108.00	-1.52**	-1.52*	67.00	-21.18**	-22.39**	21.00	-7.62**	-11.02**	2.62	-30.32**	-35.07**
WGL 32100xJGL 3844	119.00	11.04**	8.51**	97.00	7.78**	0.69	25.00	7.14**	0.81	4.63	20.29**	9.97
WGL 32100xJGL7046	117.67	4.90**	2.62**	94.33	4.43*	-2.75	24.13	3.13	-3.21	3.98	-5.54	-19.34**
WGL 32100xJGL 1881	134.67	18.82**	15.10**	75.33	-15.04**	-19.57**	21.67	-3.13	-5.25	3.90	-4.53	-16.62**
WGL 32100xMTU 4870	118.67	3.64**	-0.56	93.00	3.33	-3.46	23.80	3.78	-0.83	4.00	12.77*	10.90
WGL 32100xNLR 34452	112.67	5.13**	2.74**	87.67	6.48**	4.78	22.40	3.70	2.44	2.84	-23.33**	-27.45**
WGL 32100xWhite ponni	113.67	6.07**	3.65**	118.00	8.92**	-11.28**	25.20	4.56	-4.30	4.24	17.27**	13.26
JGL 3855xJGL 3844	102.33	-4.51**	-6.69**	81.00	-11.31**	-15.92**	23.27	-3.86	-6.18*	4.24	2.75	0.63
JGL 3855xJGL 7046	97.00	-13.52**	-15.41**	83.00	-9.45**	-14.43**	23.47	-3.30	-5.88*	4.73	5.46	-4.06
JGL 3855xJGL 1881	88.00	-22.35**	-24.79**	69.33	-22.96**	-25.98**	20.33	-12.48**	-13.84**	2.70	-37.95**	-42.15**
JGL 3855xJGL 4870	101.67	-11.21**	-14.80**	86.33	-5.47**	-10.38**	23.53	-1.12	-1.94	5.19	35.60**	28.38**
JGL 3855xNLR 34452	103.67	-3.27**	-5.47**	85.00	1.59	-1.54	22.27	-0.89	-5.65	3.70	-7.00	-8.50
JGL 3855xWhite ponni	104.00	-2.95**	-5.17**	113.67	3.65*	-14.54**	24.67	-1.20	-6.33*	5.29	35.96**	31.02**
JGL 3844xJGL 7046	116.67	6.38**	1.74**	98.67	2.07	1.72	25.20	1.34	1.07	5.04	10.17*	2.16
JGL 3844xJGL 1881	100.33	-9.47**	-14.25**	84.33	-11.23**	-12.46**	23.67	-0.70	-4.57	4.69	5.63	0.43
JGL 3844xMTU 4870	116.33	3.87***	-2.51**	95.00	-1.38	-1.38	24.13	-1.09	-2.69	5.87	50.15**	39.40**
JGL 3844xNLR 34452	112.00	7.01**	7.01**	91.67	3.38	-4.84*	23.07	0.00	-6.99*	4.03	-0.78	-4.35
JGL 3844xWhite ponni	113.67	8.60**	8.60**	124.67	8.72**	-6.27**	25.87	1.17	-1.77	5.18	30.15**	22.94**
JGL 7046xJGL 1881	98.33	-15.11**	-15.95**	79.67	-16.43**	-17.87**	23.00	-3.77	-7.75**	5.17	7.67	4.87
JGL 7046xMTU 4870	114.00	-2.56**	-4.47**	97.33	0.69	0.34	25.07	2.45	0.53	4.23	-0.94	-14.20**
JGL 7046xNLR 34452	115.33	5.17**	0.58	94.33	5.99**	-2.75	23.40	1.15	-6.15*	3.77	-14.78**	-23.60**
JGL 7046xWhite ponni	113.00	3.04**	-1.45*	127.33	10.72**	-4.26**	25.53	-0.39	-3.04	4.45	2.65	-9.67
JGL 1881xMTU 4870	106.67	-9.73**	-10.61**	93.33	-1.75	-3.11	24.33	3.84	1.39	4.97	20.08**	6.42
JGL 1881xNLR 34452	105.00	-5.26**	-10.26**	86.67	-0.76	-7.47**	23.47	6.18*	2.62	3.58	-16.66**	-23.47**
JGL 1881xWhite ponni	97.67	-11.88**	-16.52**	107.67	-5.00**	-19.05**	24.00	-2.44	-8.86**	4.78	13.46*	2.21
MTU 4870xNLR 34452	122.00	8.93**	2.23**	95.67	7.89**	-0.69	21.53	-5.00	-10.28**	4.30	14.27*	9.89
MTU 4870xWhite ponni	114.33	2.08**	-4.19**	128.67	12.21**	-3.26*	26.07	3.58	-1.01	4.95	34.48**	32.03**
NLR 34452xWhite ponni	114.33	9.24**	9.24**	119.00	11.21**	-10.53**	22.87	-4.06	-13.16**	3.67	-4.22	-6.22

** Significant at 1% level, * significant at 5% level

Results and Discussion

Mean values and heterosis expressed as percent increase or decrease in the mean value of F_1 hybrid over better parent (H_2) and mid parent (H_1) are presented in Tables 1 & 2. Heterosis in negative direction is desirable for certain traits like days to 50 per cent flowering and plant height, when the objective is to evolve dwarf varieties with reduced duration to fit into intensive and multiple cropping systems. Accordingly, for days to 50 per cent flowering out of 28 crosses, nine crosses exhibited significant negative heterosis with a range of - 4.19 (MTU 4870 x White ponni) to - 24.79 (JGL 3855 x JGL 1881) per cent. These cross combinations essentially possessed either JGL 1881 or JGL 3855 as one of their parents. The highest per cent of negative heterosis (-25.98) over better parent for plant height was observed in cross, JGL 3855 X JGL 1881. Whereas, the lowest value of - 4.26 was associated with the cross JGL 7046 x White ponni. Fifteen crosses out of 28 exhibited significant heterobeltiosis in desirable direction for this trait, indicating good scope for development of dwarf hybrids suitable for high input management. It is interesting to note that, the cross combinations which exhibited significant superiority in heterosis for earliness with parents JGL 3855 and JGL 1881 also exhibited superiority for reduced plant height, which clearly indicated that these two parents were highly useful to develop short duration dwarf hybrids.

Table 2. Contd..

Cross combination	Productive tillers plant^{-1}			1000 grain weight(g)			Grain yield plant^{-1} (g)			Kernel length(mm)		
	μ	H_1	H_2	μ	H_1	H_2	μ	H_1	H_2	μ	H_1	H_2
WGL 32100xJGL 3855	10.67	4.23	-0.62	11.40	-7.57**	-7.57**	9.93	-53.87**	-63.30**	3.83	-9.75**	-9.89**
WGL 32100xJGL 3844	13.47	27.44**	25.47**	13.13	1.16	-3.67**	28.60	39.74**	14.71*	3.85	-9.19**	-9.40**
WGL 32100xJGL7046	14.67	32.93**	29.41**	13.57	-2.05	-11.71**	21.20	0.95	-18.46**	4.26	-1.05	-2.67
WGL 32100xJGL 1881	13.20	23.36**	22.98**	15.23	4.10**	-10.04**	21.93	35.39**	33.74**	4.26	-3.47	-7.26**
WGL 32100xMTU 4870	8.13	-25.84**	-27.38**	16.23	0.62	-18.56**	16.13	-4.35	-9.02	4.25	-1.43	-3.26
WGL 32100xNLR 34452	11.13	-1.18	-5.65	14.27	10.31**	5.42**	20.80	41.18**	30.00**	4.26	6.94**	0.71
WGL 32100xWhite ponni	13.40	31.37**	24.84**	14.20	12.70**	10.36**	33.33	64.47**	35.87**	4.02	-5.90*	-6.66*
JGL 3855xJGL 3844	6.27	-37.75**	-39.74**	13.63	5.01**	0.00	13.07	-49.74**	-51.72**	3.79	-10.90**	-10.97**
JGL 3855xJGL 7046	11.60	10.13	2.35	14.47	4.45**	-5.86**	31.27	17.84**	15.52*	4.30	-0.27	-1.75
JGL 3855xJGL 1881	8.93	-12.42	-16.25*	14.33	-2.05	-15.35**	9.47	-56.44**	-65.02**	4.28	-3.24	-6.89**
JGL 3855xJGL 4870	10.60	1.27	-5.36	17.17	6.40**	-13.88**	26.87	19.94**	-0.74	4.28	-1.04	-2.73
JGL 3855xNLR 34452	11.40	5.88	-3.39	13.90	7.47**	2.71*	23.73	17.11*	-12.32	4.31	7.85**	1.41
JGL 3855xWhite ponni	10.93	12.71	12.33	15.80	25.40**	22.80**	25.20	-2.33	-6.90	4.30	0.51	-0.15
JGL 3844xJGL 7046	11.00	1.23	-2.94	14.10	-2.76*	-8.24**	22.07	-13.35*	-15.13*	4.14	-4.06	-5.41
JGL 3844xJGL 1881	10.33	-1.90	-3.13	15.43	0.98	-8.86**	16.73	-19.03**	-32.89**	4.32	-2.41	-6.02*
JGL 3844xMTU 4870	12.20	12.96*	8.93	18.47	10.03**	-7.36**	31.40	47.19**	25.94**	4.35	0.50	-1.14
JGL 3844xNLR 34452	12.30	10.81	4.24	14.03	3.31**	2.93*	26.60	38.54**	6.68	4.24	6.17*	-0.24
JGL 3844xWhite ponni	10.07	0.33	-3.21	16.67	25.79**	22.25**	25.93	4.85	4.01	4.25	-0.74	-1.32
JGL 7046xJGL 1881	13.27	20.61**	17.06*	16.90	4.64**	-0.20	30.67	44.65**	17.95**	4.40	-1.90	-4.21
JGL 7046xMTU 4870	8.40	-25.44**	-25.88**	18.23	3.31**	-8.53**	18.67	-14.63*	-28.21**	4.32	-1.60	-1.82
JGL 7046xNLR 34452	9.67	-16.43**	-18.08**	15.27	5.65**	-0.65	19.27	-2.36	-25.90**	4.28	5.46*	-2.21
JGL 7046xWhite ponni	12.27	16.83**	8.24	16.93	19.95**	10.20**	25.47	0.79	-2.05	4.23	-2.46	-3.27
JGL 1881xMTU 4870	9.13	-16.46**	-18.45**	18.63	1.08	-6.52**	22.40	31.25**	26.32**	4.46	-0.78	-2.90
JGL 1881xNLR 34452	12.57	11.87*	6.50	16.27	6.78**	-3.94**	23.33	56.25**	42.28**	4.32	3.60	-6.02*
JGL 1881xWhite ponni	12.23	20.33**	14.69*	18.00	20.81**	6.30**	29.87	45.93**	21.74**	4.34	-2.44	-5.52*
MTU 4870xNLR 34452	10.93	-4.93	-7.34	17.20	2.79**	-13.71**	27.20	74.36**	53.38**	4.37	7.50**	-0.53
MTU 4870xWhite ponni	11.97	14.70*	6.85	16.37	-0.20	-17.89**	26.33	24.61**	7.34	4.29	-1.38	-2.43
NLR 34452xWhite ponni	12.80	19.25**	8.47	15.73	19.19**	16.26**	23.07	21.40**	-5.98	4.38	8.91**	1.78

** Significant at 1% level, * significant at 5% level

The range of heterosis (%) over better parent for ear bearing tillers plant^{-1} was from 14.69 (JGL 1881 x White ponni) to 29.41 (WGL 32100/ JGL 7046). Ten hybrids over mid parent and six hybrids over better parent registered significant positive heterosis for this component. This finding is confirmatory to the earlier results reported by Lokaprakash *et al.* (1992). However, significant negative heterobeltiosis was also observed in case of seven hybrids. None of the hybrids in the present study expressed significant heterosis for panicle length over their respective better parents. The levels of heterosis were very low for this trait with only two hybrids (WGL 32100 x JGL 3844 and JGL 1881 x NLR 34452) recording significant positive heterosis over mid parental value, which indicated less scope for further exploitation.

Six crosses showed significant positive heterobeltiosis for panicle weight with a range of

Table 2. Contd..

Cross combination	Kernel breadth (mm)			Kernel L/ B Ratio		
	μ	H_1	H_2	μ	H_1	H_2
WGL 32100xJGL 3855	1.22	-2.66	-3.68	3.14	-7.24*	-8.46*
WGL 32100xJGL 3844	1.27	-1.04	-2.31	3.03	-8.32*	-9.19*
WGL 32100xJGL7046	1.27	-1.68	-3.54	3.35	0.65	0.50
WGL 32100xJGL 1881	1.27	-1.17	-2.56	3.35	-2.33	-5.00
WGL 32100xMTU 4870	1.37	-3.63	-13.26**	3.09	0.98	-7.29
WGL 32100xNLR 34452	1.26	-0.13	-0.26	3.38	7.19	1.30
WGL 32100xWhite ponni	1.32	3.94	3.66	3.05	-9.24**	-9.77*
JGL 3855xJGL 3844	1.26	-0.79	-3.08	2.99	-10.65**	-12.65**
JGL 3855xJGL 7046	1.29	0.65	-2.28	3.34	-1.09	-2.53
JGL 3855xJGL 1881	1.27	0.13	-2.30	3.36	-3.31	-4.72
JGL 3855xJGL 4870	1.47	4.13	-7.16**	2.94	-5.31	-14.11**
JGL 3855xNLR 34452	1.25	-0.40	-1.32	3.45	7.97*	0.78
JGL 3855xWhite ponni	1.30	3.71	2.36	3.30	-3.09	-3.79
JGL 3844xJGL 7046	1.30	-0.64	-1.27	3.18	-3.54	-4.31
JGL 3844xJGL 1881	1.31	0.64	0.51	3.29	-3.18	-6.70
JGL 3844xMTU 4870	1.58	9.60**	-0.21	2.77	-8.74*	-15.48**
JGL 3844xNLR 34452	1.30	1.69	0.26	3.26	4.32	-0.51
JGL 3844xWhite ponni	1.37	6.74*	5.64	3.09	-7.07*	-8.49*
JGL 7046xJGL 1881	1.30	-0.76	-1.27	3.38	-1.41	-4.25
JGL 7046xMTU 4870	1.38	-4.60	-12.63**	3.12	2.13	-6.11
JGL 7046xNLR 34452	1.29	-0.26	-2.28	3.33	5.88	0.20
JGL 7046xWhite ponni	1.31	1.42	-0.25	3.22	-3.83	-4.54
JGL 1881xMTU 4870	1.47	2.08	-6.95*	3.04	-3.80	-13.88**
JGL 1881xNLR 34452	1.28	-0.26	-1.79	3.38	3.90	-4.34
JGL 1881xWhite ponni	1.33	3.49	2.30	3.26	-5.50	-7.55*
MTU 4870xNLR 34452	1.28	-9.84**	-18.95**	3.41	18.40**	14.81**
MTU 4870xWhite ponni	1.34	-6.18*	-15.37**	3.20	3.89	-5.13
NLR 34452xWhite ponni	1.29	1.71	1.31	3.39	6.83	0.39

22.94 (JGL 3844/ White ponni) to 39.40 per cent (JGL 3844/ MTU 4870) and on mid parent, twelve combinations exhibited their superiority for this particular trait. The trait 1000-grain weight is an important yield component in the final yield, as the bold grained varieties normally out yield the other types. In the present study, out of 28 crosses nine crosses, exhibited superiority over, their respective better parents with the highest value of 28.80 per cent (JGL 3835/ White ponni) and the lowest value of 2.93 per cent (JGL 3844 x NLR 34452) which were in agreement with the earlier findings by Singh *et al.*,(2006).

Graffius (1959) stated that heterosis for grain yield is the result of interaction of simultaneous increase in the expression of heterosis for individual components. The crosses *viz*., WGL 32100/ White ponny, JGL 1881/ White ponny, WGL 32100/ JGL 1881 and JGL 7046/ JGL 1881 which exhibited significant positive heterosis for yield and also exhibited heterosis at least for one important yield component like productive tillers plant^{-1}, panicle weight and 1000-grain weight.

Among the kernel characters, kernel length has paramount importance as the slender grain having L/B ratio of 3.0 and above commend high premium price in the market. None of the hybrids showed significant heterosis for kernel length over better parent and on the mid value, only six were found to be superior. This indicated that medium types would be obtained when a cross was effected between short and long grained varieties which might be predominantly due to partial dominance rather than over dominance genetic effects. Such low and negative values of heterobeltiosis were also reported earlier by Paramasivam *et.al*. (1996).

Heterosis in negative direction is desirable for kernel breadth to produce slender grains. Six hybrids exhibited significant negative heterobeltiosis for this trait and the promising hybrids were MTU 4870/ White ponni and MTU 4870/ NLR 34452.

The level of heterosis over better parent was very low for kernel length / breadth ratio as in the case of the trait, kernel length with only one hybrid *viz*., MTU 4870/ NLR 34452 showing good performance in the present study. In the studies conducted by Subramanian and Rathinam (1984) and Reddy *et al.* (1991) also, the heterosis for this character was non significant and negative suggesting that none of the F1s were superior in grain fitness to parental lines.

From the foregoing discussion, it could be concluded that high amount of heterosis existed only for the yield components especially panicle weight, 1000-grain weight and productive tillers plant $^{-1}$ whereas, it was very low for the quality traits *viz*., kernel length and length / breadth ratio. The promising cross combinations identified for further use in hybrid rice programme were WGL 32100/ White ponni, JGL 1881/ White ponny and JGL 3844/ MTU 4870. The genotypes *viz.*, WGL 32100, JGL 1881 and White ponni are useful for conversion into male sterile lines or as restorer lines if identified for restorability, because of their possession of resistance to gallmidge.

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