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Evaluation of varieties and land races for drought tolerance in rice (*Oryza sativa* L.)

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Abstract

Genetic potentialities of 13 parents and their 40 hybrids was assessed through combining ability studies on 14 yield and drought tolerant traits in rice. ADT 43, ASD 18 and Nootripathu were identified as potential parents based on *per se* performance and *gca* effects. Two cross combinations *viz.*, ADT 43 Nootripathu and ADT 43/Kallurundaikar were recommended for recombination breeding to get desirable segregants in early segregating generations. ASD 18 Norungan, ADT 43/Vellaichitrakar, ADT 43/Kallurundaikar, IR 50/Kallurundaikar, ADT 43/ Varappukudanchan, ASD 16 Vellaichitraikar and ADT 36 Nootripathu may be exploited for heterosis breeding.

Key words: Rice, genetic potentiality, combining ability, drought tolerant traits

Introduction

Rice is the important cereal crop, which is consumed almost exclusively by humans. India has the largest rice area in the world and ranks second in rice production. However, India is far behind several rice growing nations in its productivity. India's very low average yield is mainly due to its very low productivity in rainfed areas. Drought stress is the serious yield limiting factor in rainfed ecologies, which is caused mainly due to inadequate or absence of rainfall and less water efficient irrigation methods. In India, about 58 per cent of total rice area are affected by drought stress, which becomes precarious year after year in terms of both area growth and severity of stress. Thus, this problem receives greater research attention in recent years. However, no high yielding varieties with desired level of tolerance could as yet be evolved inspite of having proven sources of tolerance to moisture stress. In order to design an efficient breeding programme for synthesis of varieties with virtues of drought tolerance and high yielding ability, it is necessary to identify potential parents that combine well for both yield and drought tolerant traits. Hence, an attempt was made to study the combining ability of 13 parents and 40 hybrids for yield and drought related traits through Line × Tester analysis.

Material and methods

Eight high yielding short duration varieties *viz.*, MDU 5 (L_1), ASD 16 (L_2), ASD 18 (L_3), ADT 36 (L_4), ADT 43 (L_5), ADT 45 (L_6), Co 47 (L_7) and IR 50 (L_8) (Lines) were crossed with five short duration local land races *viz.*, Norungan (T_1), Nootripathu (T_2), Varappukudanchan (T_3), Kallurundaikar (T_4) and Vellaichitraikar (T_5) (testers) during *Kharif*, 2001. The F_1 hybrids of the resultant 40 crosses along with parents were raised in a randomized block design replicated thrice with a spacing of 20cm between rows and 15cm between plants during *Rabi*, 2001. Single seedling was transplanted per hill for each hybrid in rows of three metre length.

Imposing drought stress: Irrigation was withheld at 15 days of transplanting (i.e., on 45 days of the crop) in order to impose the crop to drought stress. The crop was maintained as rainfed till harvest.

Recording observations: In each replication, five plants were randomly selected per genotype for recording observations on 14 yield and drought tolerant traits *viz.*, days to 50 per cent flowering, plant height, number of productive tillers plant^{-1}, panicle length, number of grains panicle^{-1}, 100 grain weight, proline content, chlorophyll stability index, relative water content, root length, dry root weight, root:shoot ratio, harvest index and single plant yield. The drought tolerant attributes were recorded as follows:

Proline content: It was estimated at 60 days old plant by collecting sample from the third leaf as suggested by Bates *et al.* [1] and expressed in mg/g.

Chlorophyll stability index: CSI was estimated by the spectrophotometric method suggested by Koloyereas [2] from the third leaf of the selected plants in 60 days old seedings.

Relative water content: The relative water content was estimated at 90 days of sowing as suggested by Weatherly [3].

Root length: Selected plants were uprooted at the time of harvest by giving a deep dig near the base of the plant after watering it and the maximum root length of the longest root was recorded in cm.

Dry root weight: Roots of the selected plants at the time of harvest were cut from the stem, dried moisture free in a hot air oven at 80°C for 48 hours (till attaining constant weight), weighed and recorded in g.

Root: Shoot ratio: The shoot portion separated from the root was dried as said earlier and weighed in g. Root: Shoot ratio was worked out as follows:

Root: Shoot ratio = Root dry weight (g) / Shoot dry weight (g).

The mean data of these traits were used for combining ability analysis following Kempthorne [4].

Results and discussion

The analysis of variance for combining ability revealed significant differences among the hybrids, lines, testers and line × tester interaction for all the 14 characters studied (Table 1).

Evaluation of parents: The success of plant breeding programme largely depends on the correct choice of parents. Singh *et al.* [5] opined that the parents with high order *per se* performance would be of greater importance in breeding programmes. Further, the parents with high *gca* effects are desirable for obtaining useful segregants in early generation. Hence, the potentiality of parents to produce better offsprings with reservoir of superior genes was evaluated based on *per se* performance and *gca* effects (Table 2).

Among the parents, the lines ASD 18 (L_3) and ASD 16 (L_2) recorded significantly high mean performance for single plant yield. The line ASD 18 also recorded significantly high *per se* performance for seven other traits *viz.*, panicle length, number of grains panicle^{-1}, 100 grain weight, proline content, dry root weight, root:shoot ratio and harvest index. Likewise, ASD 16 registered significantly high *per se* performance for number of grains panicle^{-1}, 100 grain weight and dry root weight. Among the testers, Nootripathu (T_2) recorded desirable mean performance for days to 50 per cent flowering, plant height, number of productive tillers plant^{-1}, proline content, root:shoot ratio. The lines ADT 43 (L_5) and ADT 45 (L_6) also recorded high mean performance for three different drought tolerant traits along with two yield contributing traits.

High order *gca* effects was exhibited by the lines ADT 43 (L_5), ADT 36 (L_4), IR 50 (L_8), ADT 45 (L_6) and ASD 18 (L_3) and by the testers Kallurundaikar (T_4) and Nootripathu (T_2) for more number of traits. Among them, ADT 43 (L_5), ADT 36 (L_4), Kallurundaikar (T_4) and Nootripathu (T_2) registered significant *gca* effects for single plant yield. ADT 43 also expressed significant *gca* effects for all other traits except plant height. Similarly, high *gca* effects were recorded by ADT 36 for days to 50 per cent flowering, 100 grain weight and relative water content; Kallurundaikar for number of productive tillers plant^{-1}, panicle length, 100 grain weight, proline content, chlorophyll stability index, relative water content and harvest index and Nootripathu for days to 50 per cent flowering, plant height, number of productive tillers plant^{-1}, number of grains panicle^{-1} and chlorophyll stability index.

Considering both mean performance and *gca* effects, ADT 43 (L_5) was adjudged as the best because of its superior performance for two yield contributing and three drought tolerant traits *viz.*, panicle length, number of grains panicle^{-1}, chlorophyll stability index, dry root weight and root:shoot ratio. The female parent ASD 18 (L_3) could be selected as next superior performer for four yield and drought related traits *viz.*, panicle length, number of grains panicle^{-1}, dry root weight and root:shoot ratio followed by the tester Nootripathu (T_2) for three yield contributing traits *viz.*, days to 50 per cent flowering, plant height and number of productive tillers plant^{-1}. Therefore, crosses involving ADT 43, ASD 18 and Nootripathu would result in identification of superior segregants with favourable genes for quantitative and drought tolerant traits.

Table 1. Analysis of variance of RBD for different traits in rice

Source	df	Mean squares													
		Days to 50 per cent flowering	Plant height	Number of productive tillers plant^{-1}	Panicle length	Number of grains panicle^{-1}	100 grain weight	Proline content	Chloro-phyll stability index	Relative water content	Root length	Dry root weight	Root: shoot ratio	Har-vest index	Single plant yield
Replication	2	0.48	5.58	1.94	3.06	6.45	0.02	0.001	0.03	14.16	2.23	0.04	0.0001	0.001	0.31
Hybrids	39	39.89*	149.32*	17.80*	11.15*	1945.83*	0.17*	0.17*	823.94*	235.61*	12.59*	0.53*	0.001*	0.02*	31.82*
Error	78	0.27	14.72	1.83	1.16	54.56	0.01	0.01	11.56	16.78	3.79	0.03	0.0003	0.001	0.84

*Significant at 5 % level

Table 2. General combining ability effects of parents for different traits in rice

Genotypes	Days to 50 per cent flowering	Plant height (cm)	Number of productive tillers plant^{-1}	Panicle length (cm)	Number of grains panicle^{-1}	100 grain weight (g)	Proline content (mg/g)	Chlorophyll stability index (%)	Relative water content (%)	Root length (cm)	Dry root weight (g)	Root: shoot ratio	Harvest index	Single plant yield (g)
Lines														
L_1	2.17*	–8.13*	2.12*	–0.74*	–16.22*	–0.17*	–0.15*	–1.47	2.60*	–1.72*	–0.11*	0.00	–0.08*	–2.12*
	(86.67*)	(67.88*)	(7.63)	(22.64)	(81.67)	(1.71)	(0.99*)	(40.56*)	(47.31)	(19.40)	(0.98)	(0.05)	(0.36)	(7.71)
L_2	3.83*	–1.86	–0.12	0.14	11.94*	–0.12*	–0.05*	–9.71	0.44	–0.25	0.11*	0.01*	0.01	0.40
	(92.67)	(86.38)	(9.27)	(22.23)	(104.27*)	(2.84*)	(0.78)	(25.60)	(43.95)	(16.36)	(1.84*)	(0.05)	(0.39)	(12.07*)
L_3	2.83*	1.51	–1.19*	1.70*	5.47*	0.04	–0.01	–11.20*	–0.98	0.42	0.21*	0.01*	–0.04*	–1.25*
	(91.33)	(81.25)	(7.97)	(26.11*)	(157.53*)	(2.96*)	(0.97*)	(26.58)	(39.28)	(16.75)	(2.13*)	(0.08*)	(0.41*)	(13.03*)
L_4	–3.03*	–1.53	0.05	–0.08	–2.87	0.07*	–0.04	1.36	3.63*	–0.58*	–0.26*	–0.01*	0.00	0.57*
	(86.00*)	(78.09)	(10.77)	(23.72)	(79.70)	(1.82)	(0.65)	(29.58)	(48.29)	(17.08)	(1.72*)	(0.07*)	(0.36)	(8.98)
L_5	–0.50*	4.85*	2.69*	0.86*	17.99*	0.06*	0.33*	19.54*	6.40*	2.66*	0.60*	0.02	0.10*	5.13*
	(88.67)	(73.57)	(9.77)	(23.91*)	(107.03*)	(1.73)	(0.61)	(42.25*)	(47.71)	(15.69)	(1.86*)	(0.09*)	(0.37)	(8.48)
L_6	–0.77*	3.74*	–2.17*	–0.70*	6.61*	0.10*	–0.10*	1.97*	–6.15*	–0.72	–0.28*	–0.01*	0.02*	0.36
	(91.33)	(68.26*)	(11.83*)	(20.00)	(79.40)	(1.73)	(0.95*)	(25.24)	(64.66*)	(18.73)	(0.90)	(0.04)	(0.45*)	(9.58)
L_7	–1.90*	–1.61	–1.25*	–1.74*	–10.80*	–0.11*	–0.02	5.65*	–6.51*	–0.01	–0.17*	0.00	–0.03*	–1.64*
	(88.67)	(69.10*)	(9.73)	(19.95)	(79.4)	(1.66)	(0.62)	(41.46*)	(45.73)	(17.47)	(1.30)	(0.06)	(0.33)	(7.74)
L_8	–2.63*	3.02*	–0.21	0.56*	–12.11*	0.12*	0.05*	–6.12*	0.57	0.20	–0.11*	0.00	0.02*	0.07
	(88.67)	(66.28*)	(9.40)	(20.83)	(69.97)	(1.71)	(0.73)	(21.76)	(53.80)	(19.65)	(0.98)	(0.04)	(0.31)	(7.39)
SE(5%)	0.13	0.99	0.35	0.28	1.91	0.02	0.02	0.88	1.06	0.50	0.05	0.001	0.01	0.24
Testers														
T_1	–0.67*	1.97*	0.07	–0.25	–5.38*	–0.06*	–0.12*	–3.71	–1.82*	0.21	0.02	0.00	–0.01	–0.24
	(85.67)	(99.73)	(8.63)	(21.97)	(73.37)	(2.44)	(1.21)	(62.01)	(42.05)	(24.24)	(1.89)	(0.07)	(0.39*)	(10.88)
T_2	–0.88*	–2.02*	1.00*	–0.52*	4.74*	–0.04*	0.01	2.41*	–1.18	0.20	0.07	0.00	0.01	0.48*
	(83.67*)	(91.95*)	(11.47*)	(21.17)	(78.47)	(2.32)	(1.31*)	(64.39)	(42.32)	(22.60)	(2.14)	(0.08*)	(0.36)	(10.77)
T_3	–0.84*	2.46*	–1.42*	–0.80*	–4.08*	–0.06*	–0.04*	–0.99	–1.37	–0.25	–0.01	0.00	–0.06*	–1.54*
	(84.00)	(112.08)	(8.10)	(29.13*)	(84.90)	(2.94*)	(1.14)	(61.35)	(41.22)	(21.25)	(1.96)	(0.07)	(0.35)	(10.40)
T_4	1.28*	1.70*	0.73*	0.86*	0.23	0.09*	0.12*	5.86*	4.66*	0.06	-0.05	0.00	0.03*	1.00*
	(83.67*)	(107.50)	(8.20)	(22.87)	(75.17)	(2.74*)	(1.03)	(44.84)	(49.43)	(23.58)	(2.15)	(0.06)	(0.28)	(10.17)
T_5	1.12*	–4.11*	–0.38	0.71*	4.49*	0.07*	0.03	–3.57*	–0.29	–0.22	–0.03	0.00	0.03*	0.30
	(86.00)	(101.46)	(8.97)	(24.93)	(72.40)	(2.34)	(1.18)	(71.84*)	(57.34*)	(23.79)	(2.00)	(0.07)	(0.32)	(9.85)
SE(5%)	0.11	0.78	0.28	0.22	1.51	0.02	0.02	0.69	0.84	0.40	0.40	0.001	0.01	0.19

*Significant at 5% level; Note: Values in parenthesis indicate respective mean values.

Ranking of parents based on *per se* performance and *gca* effects indicated that parallelism between the two does not always exist as reported by Singh and Harisingh [6]. The tester Kallurundaikar (T_4) though had significant *gca* effects for eight different traits including single plant yield, it failed to show high *per se* performance for most of the traits. When *gca* effect is high, it is under the control of additive genes and therefore can also be utilized in hybridization programme to get superior segregants.

Evaluation of hybrids: Hybridization aims to combine the favourable genes present in different parents into a single genotype. The hybrids thus obtained may be utilized in two ways (i) utilizing the F_1 hybrids commercially with a view to exploit heterosis and (ii) selecting superior segregants from the hybrids in subsequent generations and releasing best performing recombinants after attaining homozygosity.

Hybrids for recombination breeding: The criteria for selection of hybrids for recombination breeding is that it should possess non significant *sca* effect with both of its parents showing significant *gca* effects. The idea underlying is that the segregation of these hybrids are likely to throw more recombinants possessing favourable additive genes from both the parents [7]. Hence the hybrids for recombination breeding were selected based on significant *gca* effects of parents and non significant *sca* effects of hybrids for each character (Table 3).

The parents ADT 36 (L_4), ADT 43 (L_5), Nootripathu (T_2) and Kallurundaikar (T_4) possessed significant *gca* effects for single plant yield. Among the four possible combinations involving these parents, ADT 43/Nootripathu ($L_5 \times T_2$) and ADT 43/Kallurundaikar ($L_5 \times T_4$) exhibited non significant *sca* effects and hence recommended for recombination breeding for

Table 3. Hybrids chosen for recombination breeding in rice

Character	Parents with significant *gca* effects	Hybrids chosen based on non significant *sca* effects
Days to 50 per cent flowering	L_4(-3.03 *), L_5 (-0.50*), L_6 (-0.77*), L_7 (-1.90 *), L_8 (-2.63 *), T_1 (-0.67*), T_2 (-0.88*), T_3(-0.84*)	$L_4 \times T_1$ (0.07), $L_4 \times T_2$ (0.62*), $L_4 \times T_3$ (0.91*), $L_5 \times T_1$ (5.21*), $L_5 \times T_2$ (1.42*), $L_6 \times T_1$ (1.81*), $L_6 \times T_2$ (1.35*), $L_7 \times T_1$(0.28), $L_7 \times T_2$ (0.82*), $L_7 \times T_3$ (2.78*), $L_8 \times T_1$ (0.34), $L_8 \times T_2$ (1.55*), $L_8 \times T_3$ (1.18*)
Plant height	L_1 (-8.13*), T_2(-2.02*), T_4(-4.11*)	$L_1 \times T_4$ (–2.06)
Number of productive tillers plant^{-1}	L_1 (2.12*), L_5(2.69*), T_2 (1.00*), T_4(0.73*)	$L_1 \times T_2$ (0.63), $L_1 \times T_4$(–3.60*), $L_5 \times T_2$ (–1.55*), $L_5 \times T_4$ (–0.24)
Panicle length	L_3(l.70*), L_5(0.86*), L_8 (0.56*), T_4(0.86*), T_5(0.71*)	$L_3 \times T_4$ (0.51), $L_3 \times T_5$ (1.19), $L_5 \times T_4$ (–0.91), $L_5 \times T_5$ (–0.31), $L_8 \times T_4$(–1.44*), $L_8 \times T_5$ (–0.28)
Number of grains panicle^{-1}	L_2 (11.94*), L_3(5.47*), L_5 (17.99*), L_6(6.61*), T_2(4.74*), T_5(4.49*)	$L_2 \times T_2$ (–19.92*), $L_3 \times T_2$ (–51.68*), $L_3 \times T_5$ (–50.17*), $L_5 \times T_2$ (–0.70), $L_5 \times T_5$(–9.65*), $L_6 \times T_2$(1.21)
100 grain weight	L_4 (0.07*), L_5 (0.06*), L_6 (0.10*), L_8(0.12*), T_4(0.09*), T_5(0.07*)	$L_4 \times T_5$ (–0.07), $L_5 \times T_4$(0.00), $L_5 \times T_5$ (–0.12*), $L_6 \times T_4$(–0.12*), $L_6 \times T_5$ (–0.09), $L_8 \times T_5$ (0.09)
Proline content	L_5(0.33*), L_8(0.05*), T_4(0.12*)	$L_8 \times T_4$ (0.04)
Chlorophyll stability index	L_5(19.54*), L_6 (1.97*), L_7(5.65*), T_2(2.41), T_4(5.86*)	$L_5 \times T_2$ (–6.95*), $L_6 \times T_2$(0.81), $L_7 \times T_2$ (2.58)
Relative water content	L_1 (2.60*), L_4(3.63*), L_5(6.40*), T_4(4.66*)	$L_1 \times T_4$ (–4.34), $L_4 \times T_4$(1.54)
Harvest index	L_5 (0.10*), L_6(0.02*), L_8 (0.02*), T_4(0.03), T_5(0.03*)	$L_5 \times T_4$ (0.00), $L_6 \times T_4$ (0.01), $L_6 \times T_5$ (0.01), $L_8 \times T_5$ (–0.03)
Single plant yield	L_4(0.57*), L_5(5.13*), T_2 (0.48*), T_4 (1.00*)	$L_5 \times T_2$ (-0.38)

Note: Values in parenthesis indicate the respective *gca* and *sca* effects

improvement of grain yield under drought situations. The hybrid ADT 43/ Nootripathu ($L_5 \times T_2$) could also be suggested for recombination breeding for the improvement of traits *viz.*, days to 50 per cent flowering, number of productive tillers plant^{-1}, number of grains panicle^{-1} and chlorophyll stability index, while ADT 43/ Kallurundaikar ($L_5 \times T_4$) is well suited to recombination breeding for number of productive tillers plant^{-1}, panicle length, 100 grain weight and harvest index.

Hence, the hybrids ADT 43/Nootripathu ($L_5 \times T_2$) and ADT 43/Kallurundaikar ($L_5 \times T_4$) are ideal for recombination breeding to get desirable segregants in early segregating generations for yield and drought tolerant attributes.

Hybrids for heterosis breeding: Exploitation of hybrids for heterosis breeding was judged based on their *per se* performance, *sca* effects and magnitude of heterosis over standard (for yield attributes) and better parents (for drought tolerant traits) in the present study (Table 4). Accordingly, seven hybrids *viz.*, ASD 18/Norungan ($L_3 \times T_1$), ADT 43/Vellaichitraikar ($L_5 \times T_5$), ADT 43/Kallurundaikar ($L_5 \times T_4$), IR 50/ Kallurundaikar ($L_8 \times T_4$), ADT 43/Varappukudanchan ($L_5 \times T_3$), ASD 16/Vellaichitraikar ($L_2 \times T_5$) and ADT 36/Nootripathu ($L_4 \times T_2$) expressed high *per se*, *sca* and heterosis values for five or more traits and hence could be suggested for heterosis breeding.

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Table 4. Promising hybrids for heterosis breeding in rice

Character	Hybrids	ASD 18/Norungan	ADT 43/ Vellaichi-traikar	ADT 43/ Kallurnudai-kar	IR 50/ Kallurun-daikar	ADT 43/ Varappu-kudanchan	ASD 16/ Vellaichi-traikar	ADT 36/ Nootripathu
Days to 50 per cent flowering	Mean	-	83.33*	83.67*	82.33*	83.33*	-	82.33*
	sca	–1.79*	–2.92*	–2.75*	–1.95*	–0.96*	-	-
	d_{iii}	–3.01*	–6.02*	–5.64*	–7.15	–6.02*	-	–7.15*
Plant height	Mean	-	-	-	-	-	86.55*	88.73*
	sca	-	-	-	-	–4.81*	–6.51*	–6.74*
	d_{iii}	-	-	-	-	-	-	-
Number of productive tillers plant^{-1}	Mean	-	17.70*	15.23*	13.77*	14.37*	-	-
	sca	2.50*	3.34*	-	-	-	-	-
	d_{iii}	37.46*	81.17*	55.89*	40.94*	47.08*	-	24.87*
Panicle length	Mean	-	25.01*	-	-	-	27.31	26.13*
	sca	-	-	-	-	-	2.72*	2.98*
	d_{iii}	-	-	-	-	-	14.22*	9.28*
Number of grains panicle^{-1}	Mean	119.63*	101.03*	129.60*	-	-	158.33*	105.33*
	sca	27.34*	-	19.17*	-	-	49.69*	11.26*
	d_{iii}	11.77*	-	21.09*	-	-	47.93*	-
100 grain weight	Mean	2.19*	-	2.22*	2.52*	2.31*	-	-
	sca	0.15*	-	-	0.25*	0.24*	-	-
	d_{iii}	26.59*	20.23	28.32*	45.67*	33.53*	15.03*	17.92*
Proline content	Mean	1.21*	1.57*	1.46*	1.07*	1.26*	1.03*	-
	sca	0.48*	0.34*	0.15*	-	0.10*	-	0.18*
	d_{ii}	-	32.71*	42.11*	-	-	-	-
Chlorophyll stability index	Mean	75.52*	77.83*	80.06*	61.28*	79.21*	-	74.13*
	sca	40.85*	12.27*	5.07*	11.95*	11.08*	6.56*	20.78*
	d_{ii}	21.80*	-	-	36.66*	29.12*	-	15.13*
Relative water content	Mean	67.56*	62.17*	65.74*	67.55*	-	57.07*	68.96*
	sca	20.44*	6.17*	1.76*	12.04*	-	7.01*	16.58*
	d_{ii}	60.65*	-	33.01*	25.55*	14.06*	-	42.79*
Root length	Mean	23.38*	-	26.72*	23.56*	-	23.93	24.12*
	sca	-	-	-	2.89*	-	3.29*	3.39*
	dii	-	-	-	-	-	-	-
Dry root weight	Mean	2.94*	2.87*	2.83	-	3.15	2.68*	2.34*
	sca	0.66*	0.23*	0.21*	0.30*	0.50*	0.54*	0.37*
	dii	26.61	43.50	31.63*	-	60.71*	34.00*	-
Root:shoot ratio	Mean	0.11*	0.11*	0.11*	0.10*	0.12*	0.11*	-
	sca	0.01*	0.01*	0.01*	0.01*	0.01*	0.02*	0.01*
	dii	50.00*	22.22*	22.22*	66.67*	33.33*	57.14*	12.50*
Harvest index	Mean	0.54*	0.60*	0.54*	0.53*	0.48*	0.52*	0.44*
	sca	0.19*	0.06*	-	0.08*	0.04*	0.08*	-
	dii	31.91*	63.41*	46.20*	72.14*	31.25*	35.38*	22.26*
Single plant yield	Mean	18.51*	20.30*	17.90*	14.59*	16.81*	15.18*	15.49*
	sca	8.12*	3.00*	-	1.64*	1.36*	3.41*	2.59*
	dii	118.28*	139.39*	111.08*	72.05*	98.23	79.01*	18.67*

*Significant at 5% level; d_{ij} - Deterobeltiosis; d_{iij} - Standard heterosis