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A CASE STUDY ON EXPLOITATION OF HETEROSIS USING MULTIPLE PEST TOLERANCE IN *GOSSYPIUM HIRSUTUM* L.

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ABSTRACT

Multiple pest tolerant *Gossypium hirsutum* L. strains were crossed with four bollworm susceptible strains. Nine out of 13 hybrids gave 79–149% higher yields of seed cotton over commercial check, and 1.27–153.8% over better parent (BP). The highest yielding hybrid produced 91.10 g seed cotton per plant as compared to 38.4 g of var. Sharada. DS-28 was the male parent in five high yielding hybrids. Number of sympodia, boll number per plant and $BRI_{(y)}$ are predominantly controlled by dominant and/or epistatic gene action. Boll weight is mainly additive with the F_1 values nearly same as mid parental values. Trial strain MPR JK 345-1-2 produced the highest yield (71.7 g/plant) with minimum plant protection. Five hybrids were identified for testing under large scale, with minimum plant protection.

Key words: Heterosis, intra-hirsutum hybrids, multiple pest tolerance.

Commercial exploitation of hybrid vigour in *Gossypium hirsutum* became possible in India with the release of Hybrid- 4, and interspecific hybrids between *G. hirsutum* and *G. barbadense*, Varalaxmi and DCH-32. Intra-hirsutum cotton hybrids like JKHy-1 were also released and widely cultivated in South India. But cutlivation of cotton hybrids is known to be a highly costly affair due to heavy plant protection measures that are needed for successful management of bollworms and sucking pests. Siddhu and Sandhu [1] estimated the loss in yield due to bollworms to be of the order of 80%. Attempts to find out new hybrids in *G. hirsutum* cotton has not met with any success during the last quinquenium [2]. Secondly, it is necessary to appreciably reduce the cost of cultivation of high yielding cotton hybrids. Therefore the present study aims to estimate heterosis for yield and yield contributing characters using the multiple pest tolerant cotton varieties developed by Kadapa et al. [3] and by growing the hybrids with minimum plant protection.

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MATERIALS AND METHODS

Six multiple pest tolerant (MPR) *G. hirsutum* strains [4] were used in crosses with four pest susceptible ones (Tiny Boll, Long Boll, BJR-97-GB, and DS-28). Crosses were made involving tolerant x tolerant, tolerant x susceptible, and susceptible x susceptible parents. The 13 F_1 hybrids along with the parental strains were grown at the Agricultural Research Station, Dharwad Farm, Dharwad, during 1985 crop season by growing 2 rows/plot of 8.4 m length keeping 90 cm spacing between rows and 60 cm between plants for F_1 hybrids and 20 cm for parental strains. Observations on nine characters were recorded on five plants in each replication. The crop was given one plant protection at 20-25 days against sucking pests and one against bollworms at 60-65 days. The recommended plant protection schedule includes two sprays against sucking pests and four sprays against bollworms. Due to the extreme drought conditions when the crop reached flowering stage, one irrigation was given at 60 days and subsequently normal rainfall was received to get a good crop. In this study, only the bolls which produced at least one good locule without being affected by bollworms were counted as bolls/plant. Boll weight was determined by weighing the *kapas* of fully open good bolls. The data were analysed statistically and heterosis over MP, BP and standard check were calculated.

RESULTS AND DISCUSSION

The mean values on individual plant observations in respect of two canopy characters (number of monopodia and sympodia); six yield and yield contributing characters (boll number, boll weight, yield, ginning-out turn (GOT), seed index (SI); lint index (LI); and one earliness character (Bartlett's rate index of yield-BRI_y) are presented in Table 1. All the four bollworm susceptible varieties (BJR-97-GB, DS28, Long Boll and Sharada) gave very low yields of 37.6 to 39.7 g/plant, while the Tiny Boll type produced still lower (27.07 g) seed cotton per plant. On the other hand, all the remaining multiple-pest tolerant strains produced substantially higher yields from 40.0 g (JK 300) to 71.7 g (JK 345-1-2) seed cotton per plant. It may be noted that the crop was grown with only two plant protection sprays, and therefore, the MPR strains proved to be so and showed their high yielding ability with low levels of plant protection. As many as 9 out of 13 hybrids produced significantly higher yield of seed cotton as compared to the check cv. Sharada (38.44 g). The hybrid Tiny Boll x Long Boll (both parents bollworm susceptible) produced the lowest yield of 46.01 g/plant, indicating normal pest population in the season. Significantly higher yielding hybrids yielded from 60.4 g (JK 276-1 x BJR-97-GB) to as high as 95.1 g/plant (JK 345 x DS-28, R x S type), followed by JK 344 x DS 28 (R x S type) with the yield of 79.2 g/plant. In fact, all the four hybrids in which DS 28 figured as male parent produced significantly higher yields, indicating that DS 28 is a good general combiner. This variety is also the female parent of DCH-32 interspecific hybrid. While one R x R combination (JK 300 x JK 345-1-2) produced 68.79 g cotton/plant, other R x R combinations did not give as high yields. This clearly shows that higher productivity of any hybrid depends on the specific cross combination between parental types even when grown with minimum plant protection.

Table 1. Mean values of nine plant characters in intra-hirsutum cotton hybrids and parent varieties

Hybrid or parent variety	Number of mono-podia	Number of sympo-dia	Number of bolls	Boll weight (g)	Yield per plant	% ginning out turn	Seed index	Lint index	Bartlett rate of index of seed yield
JK 324 x JK-344	1.0	15.7**	50.7**	4.7**	58.7*	34.3	8.7	4.6	0.80
JK 324 x JK-345	2.3	16.1**	55.2**	5.1**	50.9	35.2	9.4	5.1	0.82*
Tiny Boll x Long Boll	2.4	15.7**	50.3**	4.7**	46.0	34.8	9.5	5.1	0.74*
JK 300 x JK-345-1-2	2.7*	16.1**	40.9**	4.6**	68.8**	33.5	8.5	6.0	0.81*
JK 344 x DS-28	2.5	17.5**	51.3**	5.3**	79.2**	36.6	9.1	5.2	0.76*
JK 345 x DS-28	2.3	16.8**	56.1**	5.9**	95.1**	38.7**	9.7	6.1	0.77**
JK 276-4 x DS-28	3.1**	14.9**	58.3**	6.0**	69.7**	39.1*	9.5	6.1	0.78*
JK 260 x DS-28	2.3	15.8**	48.3**	5.1**	58.8*	37.9	9.5	5.8	0.75*
JK 344 x BJR-97-GB	2.7*	15.0**	47.7**	4.8**	58.6*	36.8	9.7	5.7	0.77*
JK 345 x BJR-97-GB	2.7*	12.9	47.4**	5.2**	55.0	34.8	10.6	5.6	0.68
JK 276-1 x BJR-97-GB	2.3	11.6	56.0**	5.8**	61.4*	34.9	10.4	5.6	0.73*
JK 258-3 x JK-258-7	2.5	11.2	52.1**	4.5**	51.3	34.9	9.6	5.1	0.82*
JK 300 x JK-260	1.9	12.2	52.2**	5.0**	60.4*	35.9	9.4	5.2	0.83*
JK 324	2.3	12.0	41.4**	4.6**	45.3	32.0	8.8	4.1	0.78*
Tiny Boll	2.1	11.4	45.4**	3.0	27.0	33.8	6.8	3.4	0.89*
JK-300	1.5	12.2	28.0	4.8**	40.0	32.0	8.9	4.2	0.89*
JK 344	2.5	12.7	31.7	4.0	41.4	34.5	9.8	5.0	0.83*
JK 345	2.7**	14.1	40.2**	4.1*	49.9	36.0	8.4	6.4*	0.82*
JK 276-4	3.1	14.5*	48.5**	4.2*	49.4	36.3	8.8	4.9	0.85*
JK 260	2.5	13.8	38.5**	4.1*	50.6	35.1	8.9	4.8	0.82*
JK 276-1	2.7**	14.5*	31.6	4.1*	45.5	35.6	8.4	4.6	0.86*
JK 258-3	2.0	13.8	29.3	4.1*	50.0	33.4	8.5	4.2	0.83*
JK 258-7	1.5	14.7*	29.9	4.3**	55.8	38.0	8.3	5.0	0.72*
BJR-97-GB	1.4	13.2	16.5	8.2**	37.6*	37.1	11.3	5.8	0.72*
DS-28	2.9*	11.3	24.1	5.7**	38.1*	36.1	9.6	5.2	0.73*
JK 345-1-2	2.9**	12.5	24.8	3.6	71.7**	33.7	8.1	4.4	0.87*
Long Boll	2.5	12.5	28.1	3.7	39.7**	34.0	11.1	5.7	0.68
Sharada	2.1	12.9	26.7	3.4	38.4	36.2	9.0	5.1	0.68
C.D. at 1%	0.70	1.9	7.5	0.9	24.3	3.0	—	1.57	0.06
C.D. at 5%	0.63	1.4	5.7	0.7	18.5	2.2	—	1.19	0.05

*,**Significant at 5% and 1% levels, respectively.

The highest yielding hybrid, JK 345 x DS-28, produced 2.30 monopodia/plant as compared with those produced by cv. Sharada (1.1), and so were the majority of high yielding hybrids. But monopodia provide strength for upright stand of the plant, and therefore the hybrids were be found to be nonlodging [5]. The highest number of monopodia (3-10) was found on JK 276-4 (MPR), and this trait appeared to have been transmitted in toto, in the hybrids involving this parent (JK 276-4 x DS 28). Secondly, monopodial branch habit is reported to make the plants late, but if the rate of flowering on monopodia is also high, it would not hinder earliness [6]. All the high yielding hybrids showed the same level of $BRI_{(y)}$ as DS 28, indicating that the hybrids were not very late although produced higher number of monopodia per plant.

All the hybrids possessed significantly high number of sympodia and, therefore the number of bolls produced per plant was as high as 40.9 to 56.0 as compared to only 26.7 in cv. Sharada. The strain BJR-97-GB [7] produced the largest bolls giving 8.27 g kapas/boll as against only 3.02 g/boll in Tiny Boll. All the hybrids produced larger bolls (5.03–6.09 g/boll) as compared to 3.40 g boll weight of cv. Sharada. The two top yielding hybrids had almost the largest bolls as compared to all other hybrids.

The GOT in cotton is a character reflecting its lint productivity. The highest yielding hybrid had 38.7% GOT as compared to 28.2% in cv. Sharada, therefore, lint production of the hybrid was also high. All the strains and hybrids had SI values between 8.40 and 10.6 g, although strains BJR-97-GB and Long Boll had the largest seeds (11.3 and 11.1 g, respectively). Since lint index is dependant on seed size, the highest yielding hybrids also showed higher lint index than that cv. Sharada.

Increased yield due to heterosis in the hybrids over the midparental (MP) and better parental (BP) values generally indicates nature of gene action in the expression of hybrid vigour. When exploitation of heterosis is concerned, it is necessary to compare the hybrid with the best commercial variety. Heterosis observed in respect of nine characters is shown in Table 2. Only four hybrids, viz., JK 344 x DS 28, JK 345 x DS 28, JK 344 x BJR, and JK 276-1 x BJR, exhibited significantly higher heterosis over their respective MP values for yield, indicating that yield was controlled by nonadditive gene action in these hybrids. Of these only one hybrid, JK 345 x DS 28, showed gave yield over BP, depicting nonadditive gene action of dominance and epistatic type in expression of hybrid vigour. In the other three hybrids, partial dominant gene action was exhibited as the F_1 values were intermediate between MP and BP values.

The hybrid JK 345 x DS 28 gave as high as 147.4% increase in yield as compared to cv. Sharada. Three hybrids, JK 300 x JK 345-1-2 (RxR), JK 344 x DS 28 (R x S), and JK 276-4 x DS-28 (R x S), also gave more than 80% higher yield over Sharada. The All India Coordinated Cotton Project has not been able to evolve such high yielding hybrids [2], that too with minimum plant protection, one against sucking pests and one against bollworms. The trial strain, MPR JK 345-1-2 produced 71 g seed cotton/plant. As compared to this, the highest yielding hybrid (JK 345 x DS 28) produced 95 g yield/plant. This clearly shows the high specific combining ability of the two parental types. This hybrid also exhibited 6.9% higher heterosis over the commercial check in respect of lint yield. On the whole, the study revealed

Table 2. Heterosis (%) over midparent (MP), best parent (BP), and commercial

Hybrid	Number of monopodia			Number of sympodia			Number of bolls			Boll weight		
	MP	BP	CC	MP	BP	CC	MP	BP	CC	MP	BP	CC
JK 324 x JK 344	-20.8	-24.0*	-09.5	27.1**	23.6**	21.7**	39.2**	22.4**	89.8**	10.0	3.2	38.8
JK 324 x JK 345	-06.0	-14.8	09.5	23.3**	14.1**	24.1**	35.2**	33.6**	106.7**	17.6*	12.2	50.8**
Tiny Boll x Long Boll	04.3	-04.0	14.2	26.6**	25.6**	21.7**	36.9**	10.8	88.3**	23.2**	19.1	37.3**
JK 300 x JK 345-1-3	22.7	-06.9	25.6*	28.6**	28.6**	24.8**	54.9**	46.0**	53.1**	5.22	-5.1	34.4**
JK 344 x DS-28	-07.4	-13.8	19.0	45.8**	37.8**	35.7**	83.8**	61.8**	92.1**	10.7	-5.4	57.9**
JK 345 x DS-28	-17.6	-20.7**	09.5	32.2**	19.1**	30.2**	74.4**	39.6**	110.1**	20.5**	4.4	74.4**
JK 276-4 x DS-28	03.3	00.0	47.6**	15.5*	04.1	15.5**	60.6**	20.2**	118.3**	23.2**	7.2	79.1**
JK 260 x DS-28	-14.8	-20.7*	09.5	25.8**	14.4**	22.4**	54.0**	25.1**	80.9**	5.7	-8.9	52.0**
JK 344 x BJR	38.4**	06.0	28.6*	15.8**	13.6*	16.2**	97.9**	50.4**	78.6**	3.4	-8.9	52.0**
JK 345 x BJR	31.7**	00.0	28.6*	-05.4	-08.5*	00.0	67.2	17.9	77.5**	12.1	-0.2	55.2**
JK 276-1 x BJR	12.1	-14.8	09.5	-16.2**	-20.0*	-10.0	132.8**	77.2**	109.7**	23.1**	-0.8	70.2**
JK 258-3 x JK 258-7	42.9**	25.0	19.0	-21.4**	-23.8*	-13.1	109.8**	107.7**	132.5*	*6.0	3.6	33.2**
JK 300 x JK 260	05.0	-24.0*	-09.5	-7.9	-12.3*	-06.2	56.4**	34.9**	95.1**	12.28	4.3	47.9**

that it may be possible to develop a high yielding and high ginning intra- hirsutum cotton hybrid that can be cultivated with minimum plant protection.

This hybrid needs to be created again and tested under large scale as early as possible so that an outstandingly high yielding hybrid would be available with reduced cost of cultivation.

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check (CC) in respect of nine characters in *G. hirsutum* intraspecific hybrids

Yield per plant			Ginning out turn			Seed index			Lint index			BRI (y)		
MP	BP	CC	MP	BP	CC	MP	BP	CC	MP	BP	CC	MP	BP	CC
34.9	29.0	52.3	3.7	0.0	4.7	-6.4	-11.2	-3.3	0.2	-8.5	-10.3	-6.2	-3.6	17.6
6.8	1.9	32.4	3.5	-2.2	-2.7	9.3	6.8	4.4	-3.5	-20.5*	-0.7	2.5	0.0	20.6*
6.0	-22.8	19.7	2.9	2.3	-3.8	6.1	-14.4	5.5	12.9	-9.8	0.1	-5.7*	-16.8*	8.8*
23.2	-4.0	78.9**	-1.0	-6.1	-7.4	0.0	-4.4	-5.5	41.6**	40.6**	17.1	-7.9*	-9.0*	19.1*
40.9**	36.9	82.6**	3.7	1.3	1.1	6.1	-7.1	-1.1	1.7	0.0	1.8	-2.6	-8.4*	11.8*
76.1**	153.8**	147.4**	7.3*	7.2*	6.9*	7.8	10.4	2.8	4.9	-4.6	19.0	-0.6	-6.1*	13.2*
29.6	20.6	81.7**	8.0*	7.7*	8.0*	3.2	-1.0	5.5	19.3	16.6	18.6	-1.2	-8.2*	14.7*
8.2	1.2	52.9**	6.4	4.9	6.4	2.7	-1.0	5.5	15.7	11.0	13.0	-3.2	-8.5*	10.2*
48.4**	41.5	52.4**	2.8	-0.8	1.6	8.0	-14.1	7.7	5.0	-1.5	10.3	-0.6	-7.2*	13.2*
25.7	10.1	43.1	-4.8	-6.2	-3.8	7.7	-6.2	17.7	-7.8	-1.6	9.1	-11.6*	-17.3*	0.00
48.0**	35.0	59.9*	-4.5	-5.9	-3.6	5.6	-7.9	15.5	7.8	-2.6	9.1	-8.7*	-17.0**	7.3*
3.7	-8.0	33.6	-3.9	-8.2	-3.6	14.2	12.9	6.6	10.2	1.3	0.3	5.8*	-01.2	20.5*
33.5	19.6	57.3*	7.0	-2.2	-0.8	5.6	5.6	4.4	15.9	8.9	1.7	-2.9	-6.7*	22.0*

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