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Estimation of Essential Hybrid Vigor Levels for Economical Hybrid Cotton Production

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Abstract: Exploitation of hybrid vigour provides a potential mean to enhance cotton production, provided some of the basic shortcomings are adequately managed. Beside labour, number of crossed bolls after manual emasculation and fertilization and number of seeds per crossed boll are important determinants of ultimate cost of hybrid seed production. It was intended to determine the essential hybrid vigour level in upland cotton to compensate the extra cost incurred on the production of cotton hybrid seed. The results of the present study indicated that the period and time of pollination are important factors in increasing crossed boll setting percentage. Maximum crossed boll retention was found from 1st to 3rd week of September where as flower pollinated before 1000 h had maximum chance of survival. Essential hybrid vigour level was determined to 35%. Specific combinations showing less than 35% heterosis would not be commercially economical.

Key words: Cotton, essential hybrid vigour, heterosis, boll setting

INTRODUCTION

The importance of cotton in the economy of Pakistan is well established. It contributes more than 60% to the total foreign exchange earning of the country (Anonymous, 2000). Cotton yields are stagnant for the last several years due to a number of factors including leaf curl virus incidence, insect pressure, weather adversaries and improper production technology. Exploitation of hybrid vigour in cotton offers a potential mean to increase yield per unit area. In India yields have been ascending due to cultivation of hybrid cotton on more than 28% of the area under cotton (Basu, 1993)

Success of hybrid cotton in India and China has revived endeavors for its exploitation in other countries. In the absence of efficient CMS or GMS and fertility restorer system, hybrid cotton seed is produced mainly through manual emasculation and crossing. The procedure is labour intensive and makes hybrid seed production expensive. The expenses for hybrid seed production vary with the labour cost and setting percentage of the crossed bolls. Cheaper labour (as in India) and higher setting percentage of the crossed boll helps to reduce the cost of hybrid seed. Heterosis in cotton was reported by Mell in 1894 and the foundation of modern concept of heterosis was laid by shull in 1908 (Randhawa and Singh, 1994). Heterosis was commercially exploited for the first time in 1970 in India with the release of an intra hirsutum hybrid. H4, which gave 138% heterosis (Patel, 1971). Findings of Minhas *et al.* (1994), Patil and Chopde (1985) and Gupta and Singh (1987) which depicted mid parent heterosis 0.19 to 122.7% and better parent heterosis 0.02 to 93.83% suggested that there appears to be a potential of increasing cotton yields through exploitation of hybrid vigour.

Cotton plant produces more fruiting sites than mature bolls (Kerby and Buxton, 1976). Among the primary causes of low boll retention, high temperature and relative humidity results in decreased boll setting (Ehling and LeMert, 1973; Powel, 1969). Afzal (1947) studied the flowering and fruiting pattern of three upland cotton varieties for six years at Lyallpur (Faisalabad) and found that all these varieties reached peak flowering period during the month of September. Khan (1960) reported that in upland cotton the most effective flowering period was the month of September. Khan and Khan (1966) concluded that the first fortnight of September was the most crucial period for boll setting.

Hybrid vigour has been exploited in cotton for enhancing yield quantity. A specific combination may help to increase hybrid vigour in cotton but the benefit for cotton grower will start when realized heterosis is more than "Essential Hybrid Vigour Level". Essential hybrid vigour level is the increase in yield, due to hybrid vigour, required to meet the extra expenses made for hybrid seed production. (Rashid *et al.*, 2000).

It was therefore, intended to assess the level of essential heterosis available and crossed boll setting percentage at different pollination times to estimate the feasibility of hybrid cotton production in the country.

MATERIALS AND METHODS

The reported study was conducted at Cotton Research Institute, Faisalabad during the years 1999-2000 and 2000-01. In the Punjab (Pakistan) the month of

September is peak flowering and boll setting period. The bolls set during or after the last week of September usually open late and are liable to frost damage. A crossing programme was undertaken from 2nd September to 25th of September 1999 and observations were recorded for the crossed boll setting percentage, number of seeds per crossed boll and number of crossed bolls required to calculate the seed requirement for one acre. Flower buds were emasculated in the evening from 1700 to 1900 h and pollinated on the next morning from 0830 to 1100 h. Thirty-three F_1 crosses along with their parents and two commercial check viz., NIAB-Karishma and FH-634 were sown in a triplicate randomized complete block design during the year 2000-01. Each entry was sown as a single row of 9 m length per replication. Row to row and plant-to-plant distances were 75 and 45 cm, respectively. Seed cotton yield was recorded on plot basis and was converted to per plant to compute percent increase/decrease in yield over mid parent and commercial varieties.

Seed requirement per acre was calculated by using three seeds per hole for a crop stand of 18000 plants per acre. This required number of seed was divided by number of seeds per crossed boll (Table 2) to get the required number of crossed bolls. Essential Hybrid Vigour Level were calculated at 45, 40, 35 and 30% boll setting.

RESULTS AND DISCUSSION

The range of heterotic effects exhibited by various cross combinations is presented in Table 1. The level of commercial heterosis ranged from 63.1 to 126%. The result indicated that specific combinations could be obtained in intra hirsutum crosses, which could be used as commercial hybrids.

The time of pollination (temperature) affects fertilization and thus boll retention. Fig. 1 depicts that number of retained boll decreased in pollinations attempted after 1000 h. Maximum crossed flower retention was obtained in pollinations between 0800 to 1000 h. Maximum boll retention was observed between 1st and 3rd week of September.

Since the hybrid seed is produced by manual crossing, the economics of hybrid cotton production mainly depends on the extra expenses made on hybrid seed production and increase in yield achieved as a result of hybrid vigour. Cost of hybrid seed production is inversely related to crossed boll setting percentage. High boll setting percentage means more seed produced and vice versa at a given cost. Fig. 1 shows that on average basis, crossed-boll setting percentage of 45.1% was achieved. Maximum boll setting (58.31%) was achieved

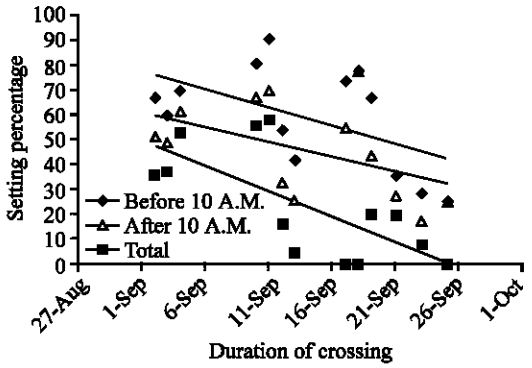

Fig. 1: Boll setting trend during crossing periods

when flowers were pollinated before 1000 h as compared to boll setting of 30.0% obtained when pollination were made after 1000 h. It further revealed that crossed boll setting was higher irrespective of time of pollination before 10th of September but after that higher crossed boll setting percentage was observed only when pollination were made before 1000 h. After 20th September, crossed boll-setting percentage reduced to a significant extent, irrespective of the pollination time. Similar findings have been reported by Afzal (1947), Khan (1960), Khan and Khan (1966).

Out of 33 crosses, 18 crosses failed to exceed the mid parent yield and 15 crosses exhibited positive heterosis over mid parent. Positive heterosis range from 6.81 to 104.32% over mid parent value, 0.17 to 126.07% over one commercial check, NIAB-Karisham and 1.74 to 81.69 over second commercial check, FH634, showing that there is a good possibility of increasing yield by exploiting hybrid vigour confirming the reports of Patil and Chopde (1985) and Gupta and Singh (1987).

Economics of hybrid cotton production was work out by calculating "Essential Hybrid Vigour Level" at various cross boll-setting percentages (Table 3). It was observed that with the decrease in crossed boll setting percentage from 45 to 30%, the essential hybrid vigour level increased from 20.63 to 31.01%, indicting that a minimum level of 32% hybrid vigour would be required for profitable hybrid cotton production programme. Crossed boll setting percentage was the most important determinant of the profitability of hybrid seed production. In the present study, more that 45% crossed boll setting was observed with skilled labour. In case, where the crossing will be carried out by unskilled labour, not only the boll setting percentage will drop but also the quantity of emasculation and pollination will also decrease. Increase in hybrid vigour would increase cotton production but the profit for the cotton grower could ensue only when hybrid vigour level exceed the Essential Hybrid Vigour Level. Therefore,

Table 1: Yield performance of cotton hybrids in terms of hybrid vigour

Cross No.	Yield of F_1 (g/plant)	Av. yield of parents (g/plant)	Percent increase or decrease over		
			Mid parent	Karishma (Check)	FH634 (Check)
H-622	33.00	70.69	-53.32	-54.09	-63.10
H-581	61.67	97.30	-36.62	-14.20	-31.05
H-626	48.00	74.53	-35.60	-33.22	-46.33
H-583	59.75	89.83	-33.48	-16.88	-33.20
H-637	58.00	82.74	-29.90	-19.31	-35.15
H-586	48.00	63.93	-24.92	-33.22	-46.33
H-644	72.00	89.89	-19.90	0.17	-19.50
H-585	58.50	72.75	-19.59	-18.61	-34.59
H-621	43.50	52.53	-17.19	-39.48	-51.36
H-639	85.67	103.05	-16.87	19.18	-4.22
H-647	54.33	64.53	-15.81	-24.42	-39.26
H-612	66.00	78.20	-15.60	-8.18	-26.21
H-616	61.00	70.78	-13.82	-15.14	-31.80
H-580	93.60	106.52	-12.69	30.22	4.65
H-582	95.00	105.80	-10.21	32.16	6.22
H-638	76.33	84.28	-09.43	6.19	-14.66
H-645	73.67	81.11	-09.17	2.49	-17.63
H-623	72.50	79.47	-08.77	0.66	-18.94
H-584	116.00	108.60	06.81	61.38	29.70
H-618	94.00	81.63	15.15	30.77	5.10
H-593	74.33	62.28	19.35	3.41	-16.89
H-603	94.00	75.67	24.22	30.77	5.10
H-598	124.50	98.30	26.65	73.21	39.20
H-629	82.00	61.40	33.55	14.08	-8.32
H-631	103.00	63.70	61.69	43.29	15.16
H-594	131.50	81.05	62.24	82.94	47.03
H-602	121.00	72.88	66.03	68.34	35.29
H-595	160.00	96.22	66.28	122.59	78.89
H-619	118.00	70.78	66.71	64.16	31.93
H-648	139.50	83.30	67.47	94.07	55.97
H-620	91.0	48.48	86.32	26.60	1.74
H-630	85.00	44.93	89.18	18.25	-4.96
H-599	162.50	79.53	104.32	126.07	81.69

Table 2: Description of different parameters for crosses and parents

Parameter	1999-2000		2000-01	
	Crosses	Parents	Crosses	Parents
Total Bolls	281	295	1327	350
Total Number of Seeds	4918	6929	28917	9090
100 Seed weight (g)	8.51	8.03	7.90	8.31
Number of Seeds per Boll	17.50	23.65	21.79	26.1

Table 3: estimation of essential hybrid vigour level at different boll setting levels

a) Calculation of number of crossed bolls required to get hybrid seed for one acre
Plant population per acre = 18000
Number of seeds per hole = 3
Total number of sees required per acre = 54000
Number of seeds obtained per crossed boll = (17.5 + 21.79)/2 = 19.64
Number of crossed bolls required to get 54000 seeds = 2749.5 bolls

b) Items Required	Cross Boll Setting (%)			
	45	40	35	30
	Number			
• Crosses to be made to get required 3085.7 bolls	6841.9	7714.25	8816.25	10285.6
• Straw boxes required	7	8	9	11
• Number of tags required	7000	8000	9000	10500
c) Cost of Items Required	Rupees			
• Labor Charges for crossing (100 crosses/day/man @ Rs.40/-per man/day)	2726.76	3080.00	3520.00	4114.00
• Cost of tags @Rs. 120/1000 tags	840.00	960.00	1080.00	1260.00
• Cost of straws @Rs. 10 per box	70.00	80.00	90.00	110.00
Total Cost (Rs.)	3646.76	4120.00	4690.00	5484.00
d) Yield increase (in kg) Required to meet the extra expenses made for hybrid seed production.	182.34	206.00	234.50	274.20
e) Essential Hybrid Vigour Level required to meet the extra expenses made for hybrid seed production	20.63	23.26	26.56	31.01

Note: Economics are calculated on the basis of following:
Average seed cotton yield per acre = 880 kg
Average price of seed cotton per kg = Rs. 20/-

to enhance the profitability of hybrid cotton production, we have to minimize the expenses of hybrid seed production. Expenses on hybrid seed production can be reduced by;

- Employing maximum skilled labour during the most favourable boll setting period i.e. from 1st to 3rd week of September to get high crossed boll setting percentage.
- Bushy plant type can be used to minimize the hybrid seed requirement per acre.
- Feasibility of using F_2 seed as cotton hybrid seed should also be explore to enhance profitability of hybrid cotton production as F_2 seed production is much more cheaper than F_S hybrid seed.

Cotton leaf curl virus (CLCuV) and increasing pest problem, especially boll worms, are serious problems of contemporary cotton culture, therefore, resistance to CLCuV and insect pest should be incorporated in future commercial cotton hybrids.

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