The Bioscan 8(2): 561-567, 2013
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFECT OF SPACINGS AND FERTILITY LEVELS ON GROWTH, YIELD AND QUALITY OF COTTON (*GOSSYPIUM HIRSUTUM* L.) HYBRIDS UNDER RAINFED CONDITION OF VIDARBHA

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KEYWORDS
Cotton
Fertility
Growth
PFP_N, Quality
Spacing
WUE

Received on :
21.11.2012

Accepted on :
02.05.2013

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ABSTRACT

Plants under closer spacing of 60 x 60cm (S_2) produced significantly more LAI, seed cotton yield, crop profitability, crop productivity and PFP_N over wider plant spacing (90 x 60cm), respectively, whereas 9.86% higher lint index was recorded under wider spacing. However, wider spacing produced significantly higher growth attributes *viz.* dry matter, CGR and RGR at 120 DAE and 150 DAE, respectively over closer spacing. Significantly higher dry matter (46.95 and 88.54 g/plant), CGR (0.468 and 1.386g/day/plant), RGR (0.016 and 0.028g/g/day/plant at120 DAE and 150 DAE, respectively), leaf area index, seed cotton yield, crop profitability and crop productivity was produced by MLCH-318 over VBCH-2231 and PKV Hy-2. Among fertility levels the significantly higher dry matter, CGR, RGR, LAI, seed index, seed cotton yield, crop profitability and crop productivity were produced under application of 62.50-31.25-31.25kg N-P_2O_5-K_2O/ha (F_3) over the rest of NPK levels, whereas lowest response to added nitrogen *i.e.* PFP_N (15.55 kg/kg N) was obtained with highest level of nitrogen applied in F_3 treatment. When hybrid MLCH-318 sown at closure spacing and fertilized with F_3 (62.50-31.25-31.25 kg N-P_2O_5-K_2O/ha) recorded significantly higher moisture depletion, consumptive use and WUE.

INTRODUCTION

Cotton, one of the most important cash crops grown in major rainfed areas of central India. In India, cotton occupied on 111.42 lakh hectare with production of 325 lakh bales and productivity is 496 kg lint/ha. Among states, Maharashtra ranks first in acreage with 39 lakh ha and second in production yielding 82 lakh bales next to Gujrat with productivity of 355 kg lint/ha (Anonymous, 2011). Uncertain and poor distribution of rainfall that leads less moisture availability at boll formation stage caused low productivity of cotton in this region (Bhalerao *et al*., 2010 and Dhillon *et al*., 2006). As such the information on suitable crop geometry and fertilization of new cotton hybrid is lacking at present and will be very useful for exploiting its full potentiality to boost up the yield level under rainfed condition. So in the proposed study the attempts have been made to explore the optimum planting spacing and fertilizer level for promising cotton hybrids under rainfed condition of Vidarbha. Significantly higher seed cotton yield was recorded in closer spacing (60 x 30cm) than wider spacing (60 x 45cm) while growth parameters and yield contributing characters were found superior under wider spacing than closer spacing except plant height which showed reverse trend (Bhalerao *et al*., 2010). Among the improved agronomic practices, important yield contributing agro techniques are spacing and fertilizer application. Based on the previous evidence, both closer and wider spacing are recommended for cotton with graded levels of NPK fertilizers (Muhammad Saleem *et al*., 2010 and Rajendran *et al*., 2010). Vishwanath (2007) recorded significantly higher seed cotton yield 150% RDF (2 420 kg/ha) as compared to control (2 139 kg/ha).

Cotton under rainfed conditions normally suffers either due to lack of proper distribution of rains or heavy rains and terminal moisture stress. Exposure of the crop to repeated cycles of low and excess moisture stress during the growth period has adverse effect on growth and development (Ramamurthy *et al*., 2009). Growth and development of a plant in the environment is the result of the interaction of two major components viz. genetic potential of individual and environment (Bhalerao *et al*., 2010). The potential growth and developmental rates for a particular genotype may be decreased by stress factors. The growth rate of plants under particular environment can be measured through classical growth analysis. Dry matter partitioning, crop growth rate (CGR) and relative growth rate (RGR) computed through growth analysis approach are the three parameters having considerable bearing on the assessment of varietal performance in any given set of abiotic conditions and are closely linked with the photo assimilatory capacity of the cultivar (Ramamurthy *et al*., 2009 and Bhat, 1996). Standardization of agricultural practices, of soil and plant variety, is essential for reliable comparison of crop development in successive seasons; otherwise environmental influences on the crop are inseparably mingled with irregularities from other sources. Results of plant spacing and fertilizer application have also shown that it has altered the plant architecture, photosynthetic efficiency of leaves, boll size and fruit production pattern (Bhalerao *et al*., 2010 and Samani *et al*., 1999). Nutrient deficiencies, as a consequence of nutrient depletion over the years, have decreased seed cotton yields due to imbalance and inadequate fertilization that not only affect the fibre quality of cotton, but also cause deleterious effect on physic-chemical and biological properties of soil. It is also important to study the interaction of appropriate fertility levels with judicious selection of hybrids under rainfed regions. The present study was, for such motives, undertaken with the objective to find out and determine the effect of spacings and fertility levels on growth, yield and quality of cotton hybrids under rainfed condition of Vidarbha.

MATERIALS AND METHODS

Experimental site and meteorological information

A field experiment was conducted at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the rainy (*kharif*) season of 2008-09 to study the effect of spacings and fertility levels on growth, yield, quality and economics of cotton (Gossypium hirsutum) hybrids under rainfed condition of Vidarbha. The climatic condition of Akola is semi-arid and located at 22°42′ N latitude and 77°02′ E longitude. The rainfall was very scanty and erratic in nature throughout crop season, particularly from boll formation to first boll opening which drastically reduced yield level. The total raifall recieved during crop season was 429.1mm (Fig.1). The soil of experimental plot was medium black having clayey textural class (61.5% clay, 24.2% silt and 14.3% sand) with low in organic carbon (0.39%) and available N (193.6 kg/ha), medium in P_2O_5 (14.2 kg/ha), but high in K_2O (492.0 kg/ha). Alkaline permanganate method (Subbiah and Asija, 1956), Olsen's method (Watanabe and Olsen, 1965), Neutral normal Ammonium Acetate extract using flame photometer (Hanway and Heidel, 1952) and Walkely and Black method (Jackson,1967) for the determination of available nitrogen (N), phosphorus (P_2O_5) potassium (K_2O) and organic carbon, respectively. The pH and EC of experimental site was determined through 1:2.5 soil and water suspension method (Jackson, 1967). The pH and EC (ds/m) of experimental soil was 7.97 and 0.362, respectively.

Technical programme

The experiment was laid out in split-plot design with three replications. On succeeding cotton crop, 18 treatment combinations comprising of two plant spacing (S_1-90 x 60 cm and S_2-60 x 60cm) and three cotton hybrids (V_1-MLCH-318, V_2-VBCH-2231and V_3-PKV Hy-2) in main-plots and three fertility levels of NPK (F_1-37.50-18.75-18.75, F_2-50-25-25 and F_3-62.50-31.25-31.25 kg N- P_2O_5-K_2O/ha) in sub-plots, were imposed.

Experimental materials used and cultural operations

The source of N, P_2O_5 and K_2O were urea, single super phosphate and murate of potash, respectively. Full dose of P_2O_5 and K_2O and half dose of N were applied to the cotton as basal at the time of sowing as per treatments and remaining half dose of N was applied at 30 days after emergence (square stage) around the plant to keep it in reachable of plants accordance with treatments. The sowing was done on 22 July as per spacing of the treatments through dibbling of 2-3 seeds at each hill with seed rate of 4.5 kg/ha (hybrid) and plant population was maintained by gap filling and subsequent thinning keeping single plant/hill. Two hoeing and two hand weeding were done to keep crop-weed free and conserve soil moisture. The spray of Monocrotophos and Endosulphan (35 EC) plus copper sulphate were applied twice to protect crop from sucking pest. Drought condition was prevailed up to 60 days of emergence of crop coinciding with the important growth stages and fruiting bodies development, which was the main cause of low cotton yield during crop year. During last week of October, small amount of rainfall received, which acted as life saver for plant and boost up growth and development of fruiting bodies of cotton. Overall due to satisfactory growth, development and negligible attack of bollworm, yield level was quite satisfactory.

Experimental design, data collection and analysis

Regarding agronomic characters, five competitive plants were randomly selected from each plot and observations were recorded for growth attributes, yield attributes and yield The data were analyzed as per standard statistical procedure (SPD) suggested by Gomez and Gomez (1984). The estimates of correlation coefficients were worked out using the Mini-Tab programme based on concept developed by Dewey and Lu (1959).

Leaf area index

The leaf area was measured by using leaf area meter (UCOR model LI-3000). From the leaf area, the leaf area index (LAI) was calculated as follows (Watson, 1947):

$$\text{LAI} = \frac{\text{Leaf area/plant}}{\text{Land area occupied/plant}}$$

Lint index

Lint index means the weight of lint obtained from one hundred seeds in grams; however, lint index of each plant was calculated by applying the below given formula. For lint percentage, clean and dry seed cotton picked from bolls of each plant was weighed and then ginned separately with 8-saw gins (Khan *et al.,* 2010):

$$\text{Lint index} = \frac{\text{Seed Index x Lint \%}}{100 - \text{Lint \%}}$$

Ginning percentages

The lint obtained from each plant was weighed and the ginning was worked out by the formula given below (Khan *et al.,* 2010):

$$\text{Ginning (\%)} = \frac{\text{Lint yield (Fibre)}}{\text{Seed cotton yield (Fibre+ Seeds)}} \times 100$$

Crop Growth Rate (CGR)

Crop growth rate define as increase in total dry weight per unit land area of a crop per unit time was measured according to formula given by Hunt (1978):

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, CGR = Crop Growth Rate (g/day); W_2 and W_1: dry matter of plants at the time t_2 and t_1, respectively.

Relative Growth Rate (RGR)

Relative growth rate define as increase in total dry weight per unit time per unit of existing total dry weight was measured according to formula given by Hunt (1978):

$$RGR = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}$$

Where, RGR = Relative Growth Rate (g/g/day); W_2 and W_1: dry matter of plants at the time t_2 and t_1, respectively.

Partial Factor Productivity

Partial factor productivity (kg harvest/ kg applied N) computed through formula given by Cassman *et al*. (1996) to study the response of fertilizer to produced economic yield per unit investment of fertilizers:

$$PFP_N = \frac{\text{Economic yield of crop (kg/ha)}}{\text{Applied nitrogen (N kg/ha)}}$$

Where, PFP_N = Partial Factor Productivity (kg harvest/ kg applied N).

Consumptive use of water

Consumptive use of water expressed as total water use by plant during growing periods that includes moisture depleted from soil profile and moisture contributed through effective rain fall. Amount of rainfall utilized by plant considered as effective rainfall. Although, under rainfed condition whole amount of rain effectively use by plants and considered as effective rainfall. The amount of water-use by the crop (CU) under different treatments was computed in mm by summing up the value of soil-moisture depletion from the profile and effective rainfall by the following formulae (Lenka, 1991):

$$\text{Consumptive use of water} = ER + \sum_{i=1}^{n}\left(\frac{Mbi - Meij}{100}\right) \times Di \times di$$

Where, CU Consumptive use (mm); ER = Effective rainfall; Me_i = Soil moisture (gravimetric) content of the period in the i^{th} layer; Mb_i = Soil moisture content at the beginning of the period in the i^{th} layer; D_i = Depth of the i^{th} soil layer (mm); d_i = Bulk density (g/cm^3) of the i^{th} soil layer; n = Number of layers and Σ = summation.

Water use efficiency

Water use efficiency defined as economic yield produced per unit water consumption and calculated as below (Reddy, 2011):

$$\text{Water use efficiency (kg/ha-mm)} = \frac{\text{Y (kg/ha)}}{\text{ET (mm)}}$$

Where, Y = Economic yield (kg/ha); ET = Evapo-transpiration (mm) = consumptive use of water (mm)

RESULTS AND DISCUSSION

The outcome of the investigation revealed that the dry matter (g/plant), CGR (g/day/plant), RGR (g/g/day/plant), LAI, Lint index, seed cotton yield (kg/ha), crop profitability (₹/ha/day) and crop productivity (kg/ha/day) were found significant among treatments, however, ginning (%) did not influenced by none of the treatment but seed index only significantly influenced by hybrids and fertility levels (Table 1 and Table 2) and depicted the effect of spacing on seed cotton yield in Fig. 2. Plants under closer spacing of 60 x 60cm (S_2) produced significantly more LAI (1.50), seed cotton yield (910 kg/ha), crop profitability (55.89 /ha/day), crop productivity (4.79 kg/ha/day) and PFP_N (18.20 kg/kg N) which was 31.33 %, 15.16%, 31.11%, 15.16% and 15.16% higher over wider plant spacing (90 x 60 cm), respectively. These results are in conformity with the findings of Shukla *et al*. (2013) and Raut *et al*. (2005). Higher LAI might be due to less availability of horizontal space available for individual plant that why plant grows taller in respect of vertical space and produces more no. of leaves sympodial branches/ plant and also accompanied more no. of plant per unit area which leads to caused higher yield under closer spacing (Shukla *et al*., 2013; Sisodia and Khamparia, 2007). However, wider spacing (90 x 60 cm) produced 13.59% and 12.06%, 11.53% and 10.85%, and 35.71% and 24.01% higher dry matter (43.78 and 84.43 g/plant), CGR (0.399 and 1.355g/ day/plant) and RGR (0.014 and 0.025g/g/day/plant) at 120 DAE and 150 DAE, respectively. Approximately 9.86% higher lint index (5.17) was also observed under wider spacing. The marked improvements in growth and yield attributing character was brought due to the more availability of solar radiation that help in synthesis and partitioning of assimilates to individual plant under wider spacing, which ultimately translocates assimilates from source to sink and caused partitioning in dry matter that leads significant increment in growth attributes in respect of weight and diameter of plant (Bhalerao *et al*., 2010 and Dhillon *et al*., 2006). Higher ginning (38.88%) and seed index (8.02g) was recorded under wider crop spacing, but did not found marked difference among treatment. Although, moisture content, depletion (mm), ER (mm), CU (mm) and WUE (kg/ha-mm) were also worked out to know the pattern and production capability of cotton hybrids under different treatments (Table 4). The amount of moisture content at 60cm depth during sowing (265.7mm) and total effective rainfall (429.1mm) was recorded during crop season. The amount of moisture depletion (61.1mm), consumptive use (490.2mm) and water use efficiency (1.85kg/ha-mm) were significantly higher under closer spacing (60 x 60cm). This might be due to more plant population accompanied per unit land which deplete moisture rapidly and utilize in different metabolic activity efficiently which results in more water use efficiency. However, the amount of moisture content at 60cm depth (215.8mm) during harvesting was significantly more under wider spacing due to less no. of plant population per unit area.

The marked variation in dry matter (g/plant), CGR (g/day/plant), RGR (g/g/day/plant), LAI, lint index, seed index, seed cotton yield (kg/ha), crop profitability (/ha/day), crop productivity (kg/

Table 1: Average values of CGR, RGR and LAI of *hirsutum* cotton hybrids as influenced by different treatments

Treatment	Dry matter(g/plant)		CGR(g/day/plant)		RGR(g/g/day/plant)		LAI(120 DAE)
	120DAE*	150DAE	120DAE	150DAE	120DAE	150DAE	
Spacing							
S_1 - 90 x 60 cm	43.78	84.43	0.399	1.355	0.014	0.025	1.03
S_2 - 60 x 60 cm	37.83	74.07	0.353	1.208	0.009	0.019	1.50
SEm±	0.56	0.65	0.009	0.021	0.001	0.002	0.012
CD (P=0.05)	1.77	2.07	0.031	0.065	0.004	0.006	0.037
Hybrids							
V_1 - MLCH-318	46.95	88.54	0.468	1.386	0.016	0.028	1.37
V_2 - VBCH-2231	35.76	70.4	0.307	1.155	0.007	0.018	1.19
V_3 - PKV Hy-2	39.69	78.75	0.352	1.302	0.009	0.020	1.26
SEm±	0.63	0.71	0.017	0.030	0.002	0.003	0.013
CD (P=0.05)	1.98	2.21	0.053	0.094	0.006	0.008	0.041
Fertility levels (N-P_2O_5-K_2O kg/ ha)							
F_1– 37.50-18.75-18.75	33.45	69.72	0.303	1.209	0.008	0.018	1.24
F_2 – 50-25-25	40.35	78.54	0.377	1.273	0.011	0.021	1.26
F_3 - 62.50-31.25- 31.25	48.6	89.7	0.448	1.370	0.015	0.028	1.31
SEm±	0.54	0.68	0.014	0.027	0.001	0.002	0.013
CD (P=0.05)	1.56	1.97	0.046	0.082	0.003	0.005	0.039

*DAE-Days after emergence

Table 2: Lint index, ginning percentage, seed index, seed cotton yield, crop profitability, crop productivity and partial factor productivity (PFP_N) of *hirsutum* cotton hybrids as influenced by different treatments

Treatment	Lint index	Ginning(%)	Seed index(g) yield(kg/ha)	Seed cotton	Crop profitability (₹/ha/day)	Crop productivity (kg/ha/day)	PFP_N(kg harvest /kg N applied)
Spacing							
S_1 - 90 x 60 cm	5.17	38.88	8.02	772	38.50	4.06	15.44
S_2 - 60 x 60 cm	4.66	37.78	7.77	910	55.89	4.79	18.20
SEm±	0.14	1.03	0.23	27.13	0.59	0.18	0.45
CD (P=0.05)	0.44	NS	NS	84.03	1.85	0.56	1.30
Hybrids							
V_1 - MLCH-318	5.17	38.21	8.36	1034	75.38	5.44	20.68
V_2- VBCH-2231	4.35	37.42	7.27	628	14.51	3.39	12.56
V_3 - PKV Hy-2	5.23	39.36	8.05	861	50.74	4.42	17.22
SEm±	0.18	1.26	0.25	33.22	0.65	0.22	0.51
CD (P=0.05)	0.55	NS	0.77	102.04	2.03	0.68	1.48
Fertility levels (N-P_2O_5-K_2O kg/ ha)							
F_1– 37.50-18.75-18.75	3.74	36.82	7.32	736	40.83	3.87	19.63
F_2 – 50-25-25	5.41	38.49	7.88	815	47.42	4.29	16.30
F_3- 62.50-31.25-31.25	5.79	39.73	8.49	972	53.34	5.12	15.55
SEm±	0.15	1.45	0.20	32.03	0.53	0.17	0.36
CD (P=0.05)	0.43	NS	0.59	92.11	1.54	0.51	1.12

Table 3: Effect of interaction between spacing x hybrids on seed cotton yield (kg/ha)

S X V	'MLCH-318'	'VBCH-2231'	'PKV Hy-2'	Mean
S_1 – 90 x 60 cm	900	643	772	772
S_2 – 60 x 60 cm	1168	612	948	910
Mean	1034	628	860	
SE(m) ±	46.78145.24			
CD (*P*=0.05)				

ha/day) and PFP_N could be ascribed on account of their genetic potential to exploit available resources for their growth and development (Table 1 and Table 2) and depicted the effect of hybrids on seed cotton yield in Fig. 2. Among hybrids, MLCH-318 observed significant increased in dry matter (46.95 and 88.54 g/plant), CGR (0.468 and 1.386 g/day/plant) at 120 DAE and 150 DAE, which was 23.83% and 15.46% and, 20.49% and 11.06% in respect of dry matter/plant, whereas 34.40% and 24.79% and, 16.67% and 6.06% in relation to CGR, however, RGR (0.016 and 0.028 g/g/day/plant) at 120 DAE and 150 DAE also recorded 56.25% and 43.75% and, 35.71% and 28.57% higher over VBCH-2231 and PKV Hy-2, respectively. Significantly higher LAI (1.37), seed cotton yield (1034 kg/ha), crop profitability (75.38 /ha/day) and crop productivity (5.44 kg/ha/day) were recorded by MLCH-318. Although, it was 13.14% and 8.03%, 39.26% and 16.23%, 80.75% and 32.68%, 37.62% and 18.87% and, 39.26% and 16.73% higher in respect of LAI, seed cotton yield, crop profitability, crop productivity and PFP_N over VBCH-2231 and PKV Hy-2, respectively. Although, it was at par with PKV Hy-2 in relation to seed index (8.36 g) however, observed increased

Table 4: Average values of moisture, depletion, ER, CU and WUE as influenced by different treatments

Treatment	Moisture (mm)0-60 cm soil depth At sowing	At harvesting	Depletion (mm)	ER(mm)	CU(mm)	WUE(kg/ha-mm)
Spacing (cm)						
S_1 - 90 x 60 cm	265.7	215.8	49.9	429.1	479.0	1.61
S_2 - 60 x 60 cm	265.7	204.6	61.1	429.1	490.2	1.85
SEm±	-	2.73	0.83	-	3.91	0.05
CD (P=0.05)	-	8.52	2.58	-	12.19	0.16
Hybrids						
V_1 - MLCH-318	265.7	205.3	60.4	429.1	489.5	2.11
V_2 - VBCH-2231	265.7	215.8	49.9	429.1	479.0	1.31
V_3 - PKV Hy-2	265.7	210.2	55.5	429.1	484.6	1.77
SEm±	-	3.11	0.89	-	4.19	0.05
CD (P=0.05)	-	9.67	2.75	-	13.07	0.17
Fertility levels (N-P_2O_5-K_2O kg/ ha)						
F_1 - 37.50-18.75-18.75	265.7	212.8	52.9	429.1	482.0	1.52
F_2 - 50-25-25	265.7	210.6	55.1	429.1	484.2	1.68
F_3 - 62.50-31.25-31.25	265.7	207.6	58.3	429.1	487.2	1.99
SEm±	-	2.37	0.71	-	3.45	0.04
CD (P=0.05)	-	6.91	2.07	-	10.05	0.11

Note: ER- Effective Rainfall, CU- Consumptive Use and WUE- Water Use Efficiency

Table 5: Correlation coefficient studies among growth, quality, moisture relation and yield of cotton

	CGR	Lint index	Ginning	Seed index	Depletion (mm)	CU (mm)	WUE (kg/ ha-mm)	Seed cotton yield (kg/ha)
CGR (g/day/plant)	1.000**							
Lint index	0.766*	1.000**						
Ginning (%)	0.740*	0.924**	1.000**					
Seed index	0.927**	0.882**	0.831**	1.000**				
Depletion (mm)	0.321	0.345	0.205	0.564	1.000**			
CU (mm)	0.316	0.338	0.196	0.558	1.000**	1.000**		
WUE (kg/ha-mm)	0.742*	0.622	0.518	0.873**	0.872**	0.869**	1.000**	
Seed cotton yield (kg/ha)	0.720*	0.606	0.500	0.859**	0.887**	0.884**	0.999**	1.000**

Note: Correlation coefficient is significant at *P=0.05 and **P=0.01 level of significance.

in seed index was noticed and recorded 13.04% and 8.03% higher over VBCH-2231 and PKV Hy-2, respectively. However, ginning percentage did not influenced by any of the hybrids. The marked increased in growth attributes might be due to genetic potential of hybrids (MLCH-318 and PKV Hy-2) that results higher seed cotton production under rainfed condition, whereas VBCH-2231 has showed dwarf in nature which ultimately produced fewer no. of growth and yield attributing characters (Shukla *et al.*, 2013). Significantly higher moisture depletion (60.4 mm) and water use efficiency (2.11 kg/ha-mm) recorded by MLCH-318, but it was at par with PKV Hy-2 in relation to consumptive use (489.5 mm) which showed 17.38% and 8.11%, 37.91% and 16.11% and 2.15% and 1.00% higher over VBCH-2231 and PKV Hy-2, respectively, that results significantly lowest availability of moisture content (205.3mm) at harvesting stage due to highest consumptive use (Table 3). This might be due to MLCH-318 extract more moisture to produce the higher yield through concise utilization of moisture leads to higher water use efficiency.

Dry matter (g/ha), CGR (g/day/plant), RGR (g/g/day/plant), LAI, lint index, seed cotton yield (kg/ha), crop profitability (/ha/ day), crop productivity (kg/ha/day) and PFP_N increase significantly with successive increased in levels of NPK up to 62.50-31.25-31.25 kg N-P_2O_5-K_2O/ha (Table 1 and Table 2)

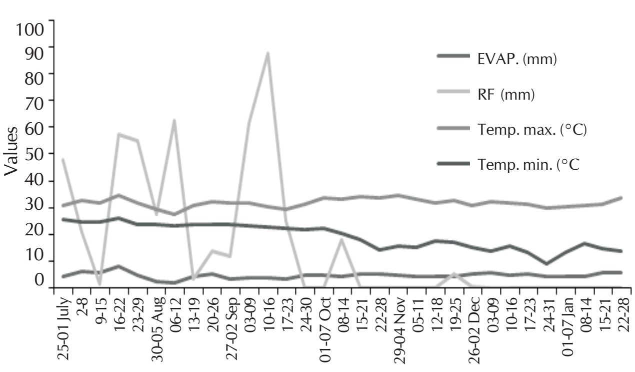

Figure 1: Meteorological trends during cotton growing period

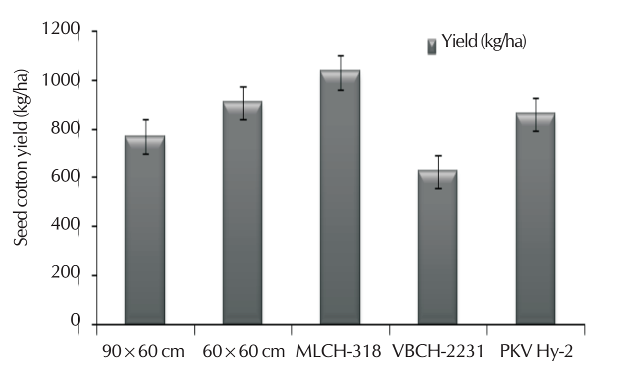

Figure 2: Effect of spacing and hybrids on seed cotton yield of *hirsutum* cotton (standard error bars indicates the CD values)

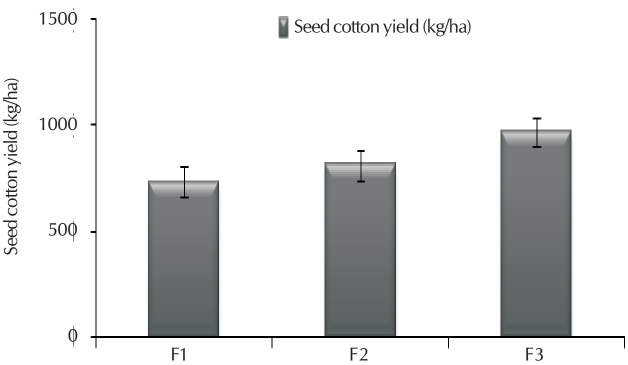

Figure 3: Effect of fertility levels on seed cotton yield of *hirsutum* cotton (standard error bars indicates the CD values)

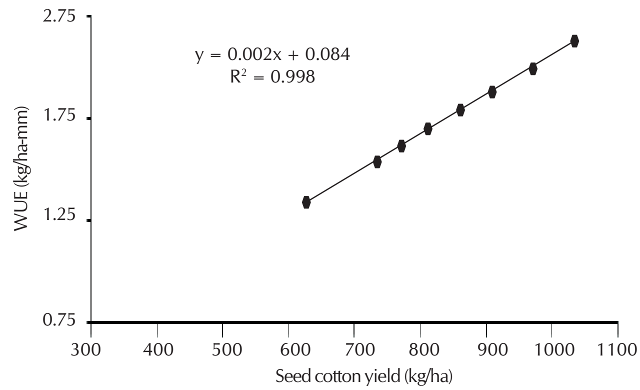

Figure 4: Regression between water use efficiency (kg/ha-mm) and Seed cotton yield (kg/ha)

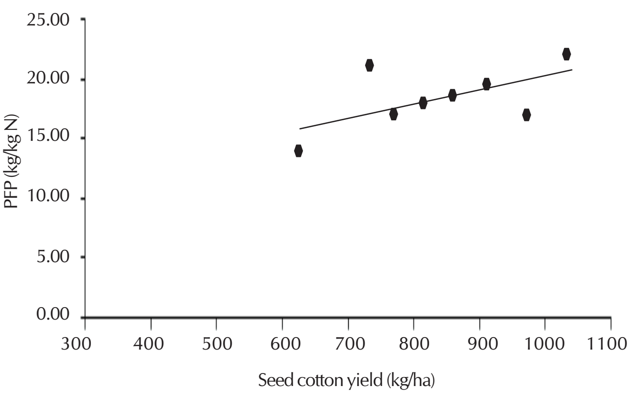

Figure 5: Regression between partial factor productivity (kg/kg N) and seed cotton yield (kg/ha)

and depicted the fertility effect on seed cotton yield in Fig. 3. The significantly maximum dry matter (48.60 and 89.70 g/ plant), CGR (0.448 and 1.370g/day/plant) and RGR (0.015 and 0.028g/g/day/plant) at 120 DAE and 150 DAE, respectively was produced with application of 62.50-31.25-31.25kg N-P_2O_5-K_2O/ha over the rest of NPK levels. LAI (1.31), seed index (8.49g), seed cotton yield (972 kg/ha), crop profitability (53.34 /ha/day) and crop productivity (5.12 kg/ha/day) recorded under highest NPK level (F_3), which was 5.34%, 13.78%, 24.27%, 23.44% and 24.28% over lowest NPK level (F_1), however, it was 3.82%, 7.18%, 16.15%, 11.10% and 16.15% higher over F_2, respectively. As increased in levels of fertility that caused improvement in yield, which are best indicator of responses to the added fertilizers. Macronutrient participates in mitotic cell division that improves efficiency of plant at vegetative and reproductive stage and involved in assimilation of photosynthates toward boll formation site (Moola and Giri, 2006 and Tomar *et al*., 2002). However, PFP_N decreased with increasing dose of nitrogen and the lowest responds to added nitrogen *i.e.* PFP_N (15.55 kg/kg N) was obtained with highest level of nitrogen applied in F_3 (Moola and Giri, 2006). Increased in lint index and seed index was improved due to higher level of fertilization (Dhillon *et al*., 2006). Ginning percentage did not influenced by any of fertility levels, but recorded maximum under highest fertility levels (F_3). Significantly higher moisture depletion (58.3mm) and water use efficiency (1.99 kg/ha-mm) was recorded with the application of 62.50-31.25-31.25 kg N-P_2O_5-K_2O/ha (F_3), which was 9.26% and 23.62%, and 5.49% and 15.58% over F_1 and F_2 levels of fertility (Table 4). Higher consumptive use of moisture (487.2mm) caused lower amount of moisture availability (207.6 mm) under the highest fertility levels (F_3); however, it was at par with each other among fertility levels. Muhammad Saleem *et al*. (2010) reported that plant nutrient enhances the root growth of cotton which leads to improved moisture extraction pattern of plants that results in higher water use efficiency. Seed cotton yield was affected significantly by the interaction effect of hybrids and plant spacing (Table 3). It was revealed that the seed cotton yield (1168 kg/ha) was produced by MLCH-318, when sown at closure plant spacing (60 cm x 60 cm). MLCH-318 could give significantly 47.60% higher seed cotton yield over VBCH-2231, while 18.83% higher over PKV Hy-2. Although, closer plant spacing recorded 15.16% higher seed cotton yield over wider plant spacing (Bhalerao *et al*., 2010 and Anand, 2006).

Water use efficiency and seed cotton yield was positively correlated with correlation co-efficient of 0.998. This was further supported by the regression analysis (equation 1). Thus, unit increase in seed cotton yield caused increase in water use efficiency by 0.002 kg/ha-mm (Fig. 4). The increase in seed cotton yield with increase in water use efficiency was also reported by Katkar *et al*. (2000). However, PFP_N and seed cotton yield was also positively correlated with each other and analyzed correlation coefficient was 0.347. Thus, unit increase in seed cotton yield which caused improvement in PFP_N by 0.011 (Fig 5) and further supported by the regression analysis (equation 2).

$Y = 0.002x + 0.084$

$(R^2 = 0.998)$ .... (1)

$Y = 0.011x + 7.224$

$(R^2 = 0.347)$ .... (2)

Correlation between seed cotton yield and traits is reflected from direct effect of that trait which will help for identifying the traits that contribute directly to improve seed cotton yield (Ahuja *et al.,* 2006). Correlation matrix between growth, quality, moisture relation and yield of cotton were studied to show the association among traits and revealed a significant and positive correlation (Table 5). WUE (r = 0.999), consumptive use (r = 0.884), moisture depletion by cotton (r

= 0.887), seed index (r = 0.859) and CGR (r = 0.720) were significantly and positively correlated with seed cotton yield (kg/ha), whereas, lint index (r = 0.766), Ginning percentage (r = 0.740), seed index (r = 0.927) and water use efficiency (r = 0.742) were also significantly correlated with CGR (g/day/plant). Due to higher depletion of moisture by cotton hybrids from soil profile leads to more consumptive use of water that established positive and significant correlation between water use efficiency (r = 0.872 and r = 0.869) and seed cotton yield (r = 0.887 and r = 0.884), respectively. Lint index were also significantly and positively correlated with ginning percentage (r = 0.924) and seed index (r = 0.882).

The present investigation confirmed that cotton hybrids well performed and produced higher growth and yield attributes that leads to achieved more water use efficiency through better conversion of assimilates in to seed cotton yield under closer spacing and highest fertility levels. Correlation matrix among traits (growth, yield and quality) showed significantly and positively associated with each other. This was further supported by the curve fitted regression analysis and revealed increase in seed cotton yield caused increase in water use efficiency and PFP_N. Comparably MLCH-318 was found to be more efficient when sown at 60 cm x 60 cm and fertilized with 62.50-31.25-31.25 kg N-P_2O_5-K_2O/ha under rainfed condition of Vidarbha region.

ACKNOWLEDGEMENT

The first author is grateful to Indian Council of Agricultural Research for awarding ICAR-Junior Research Fellowship during M. Sc. programme.

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