INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2007/09–4–559–563
http://www.fspublishers.org

Growth and Yield Response of *Gossypium hirsutum* to Plant Spacing and *Trianthema portulacastrum* Density

F.H. ANJUM, A. TANVEER†[1], M. TAHIR†, M.A. NADEEM† AND A. ALI†
Directorate of Wheat, Ayub Agricultural Research Institute Faisalabad, Pakistan
†Department of Agronomy, University of Agriculture, Faisalabad–38040, Pakistan
[1]Corresponding author's e-mail: drasiftanveeruaf@hotmail.com

ABSTRACT

A field experiment was conducted for two years to study the effect of three plant spacings of cotton and five densities of carpet weed (*Trianthema portulacastrum* L.) on growth, yield and yield components of cotton. Cotton plant spacings were 15, 22.5 and 30 cm whereas carpet weed densities were check (weed free), 5, 10, 15 and 20 plants per square meter. Decreasing trend in leaf area index and crop growth rate of cotton was noted with increased cotton plant spacing and density of carpet weed. All weed densities caused significant reduction in sympodial branches, total number of bolls per plant, and seed cotton weight per boll compared with weed free treatment. Minimum seed cotton yield (1455 kg ha^{-1}) was obtained at highest weed density (20 plants m^{-2}) of carpet weed compared with maximum seed cotton yield (2274 kg ha^{-1}) in weed free plots. Lint yield showed decreasing trend with increase in weed density.

Key Words: Cotton; Plant spacing; *Trianthema portulacastrum*; Weed density; Yield

INTRODUCTION

Carpet weed (*Trianthema portulacastrum* L.) is an annual broad-leaved summer weed. Its characteristics such as creeping and spreading growth habit, vigorous growth, high seed production potential and competitive ability make it a highly problematic weed in cotton fields. Uncontrolled spread of carpet weed sometimes results in complete crop failure. Crop losses usually depend upon the extent and duration of its spread, crop plant spacing and other management practices. Plant spacing, especially in weed infested field, is important because it provides the optimum number of plants per unit area and increases the competitive ability of plants with the weeds (El-Din, 1997). Appropriate plant spacing also enables crop plants to utilize growth factors at their disposal. Too close spacing interferes with normal root and plant development and increases the inter-plant competition which ultimately results in yield reduction (Siddiqui *et al.,* 2007) while wider inter-plant spacing may results in more vigorous growth of weeds. Bararpour *et al.* (1994) recorded 47, 57 and 85% reduction in seed cotton yield for 5, 10 and 50 *Euphorbia maculata* plants m^{-1} of cotton row, respectively.

Percent reduction in cotton height, leaf area, dry weight, boll numbers, and seed cotton yield increased as *E. maculata* density increased. According to Rogers *et al.* (1996) lint yield was reduced by 29.7 kg ha^{-1} (3.9%) for each plant of ivy leaf morning glory 10^{-1} m of cotton row up to nine plants of ivy leaf morning glory with an additional lint loss of 3.6 kg ha^{-1} (0.7%) for each weed above the density of 9.0 10 m^{-1} of row. For each increase of one plant of *Palmer amaranth* 10 m^{-1} of cotton row, lint yield reductions were 63 kg ha^{-1} (10.7%) and 59 kg ha^{-1} (11.5%) at two places respectively (Rowland *et al*., 1999). Lint yield was reduced by 5.2 to 9.3% for each increase of one kg of weed biomass per plot (m^{-3}). Wood *et al.* (1999) noted 30.7 to 36.2 kg ha^{-1} (3.8 to 6.9%) reduction in cotton lint yield at one place and 35.4 to 36.4 kg ha^{-1} (3.9 to 6.0%) at other place for each increase of one *Ipomoea hederacea* plant 10 m^{-1} of cotton row. This paper evaluates the growth and yield behavior of cotton grown at various intra-row spacings, with different densities of carpet weed.

MATERIALS AND METHODS

Investigations were conducted for two consecutive years, from 1999-2000 and 2000-2001 at the Agronomy Research Area, University of Agriculture, Faisalabad. Soil type was sandy loam. Cotton (*Gossypium hirsutum* L. cv. CIM-443) was sown on 22nd and 24th May during 1999 and 2000, respectively on a fine seed bed prepared with four ploughings and three plankings. The crop was sown with "dibble" in 75 cm apart rows at three plant spacings i.e. 15, 22.5 and 30 cm. Densities of carpet weed were 0 (weed free), 5, 10, 15 and 20 plants m^{-2}. These densities were maintained throughout the growing season. The field history served as guidance for the availability of naturally occurring carpet weed population in experimental plots exceeded than maximum required. Weeds in excess of the required level were removed every four days pulling by hand.

Experiments were laid out in RCBD with split plot arrangement having three replications. Plant spacing of cotton was randomized in main plots and densities of carpet weed in sub-plots. Plot size was 4 x 3 m. The crop was fertilized with recommended dose of N (170 kg ha^{-1}) and P_2O_5 (57 kg ha^{-1}) in the form of urea and triple superphosphate, respectively. The entire quantity of P_2O_5 along with 1/3 N was side-dressed with the help of a hand drill at the time of sowing of crop. The remaining N was applied in equal splits at first irrigation and flowering initiation. Six irrigations, each of 7.5 cm depth were applied to the crop. Methamedaphos, Cyfluthrin+Methamedaphos, Biphenthrin and Immidachlopride twice each were sprayed to protect the crop from insects. Two cotton pickings were done each year. During 1999 cotton was picked on 25th October and 20th November while in 2000 it was picked on 23rd October and 21st November.

To record growth parameters of cotton a row segment of 90 cm length was taken from each plot after crop emergence at different intervals. Each sample was separated into plant parts as green leaves, stalks and bolls (if present). The fresh weight of each fraction was recorded. A sub-sample of 10 g of green leaves was used to record leaf area on a leaf area meter (Licor Model 3100) and leaf area index (LAI) was calculated by method as suggested by Hunt (1978). A sub-sample of 20, 40, 50 g of green leaves, stalks and bolls respectively was taken from each plot sample and oven dried at 80°C to a constant weight to record dry weight. Mean crop growth rate was calculated by method as outlined by Hunt (1978). Number of sympodial branches and total bolls per plant was counted from five and ten randomly selected plants respectively from each plot. Seed cotton was picked from twenty bolls from each treatment, sun dried and weighed to record seed cotton weight per boll. A 100 g seed cotton sample from each treatment was dried in the sun and ginned with a single roller electric ginner to record lint yield.

Data were analyzed using analysis of variance function of the "MSTAT" statistical package. Least significant difference test at 5% probability level was applied to test the significance of treatment's means (Steel & Torrie, 1984).

RESULTS AND DISCUSSION

Leaf area index of cotton. Leaf area indices were recorded at 55, 70, 85, 100 and 115 days after sowing (DAS). Leaf area index at 100 DAS is presented only because trend was almost similar at other harvests. Data revealed that planting cotton at 15 and 22.5 cm spacing produced similar ($P \leq 0.05$) LAI while a further increase in plant spacing reduced LAI significantly (Table I). Increasing densities of carpet weed up to 10 plants m^{-2} significantly reduced the LAI of cotton that was not influenced with further increase in densities. The interactive effect of plant spacing of cotton and carpet weed densities on LAI of cotton was significant ($P \leq 0.05$) at 100 DAS only during 2000-2001. Weed free cotton at 22.5 cm spacing resulted in maximum LAI at 100 DAS closely followed by weed free cotton at 15 cm spacing. Generally there was a decrease in LAI of cotton with an increase in plant spacing that might be attributed to decrease in number of cotton plants with increasing plant spacing (Samani *et al*., 1999). Maximum LAI of cotton in weed free plots resulted from better growth of cotton plants which enjoyed the environmental resources to the maximum extent in the presence of weed free environments. Decrease in LAI of cotton with increase in density of carpet weed was most probably due to weed-crop competition for available resources. Bararpour *et al*. (1994) reported that percent reduction in leaf area of cotton increased as *E. maculata* densities increased.

Table I. Effect of plant spacing of cotton and carpet weed density on leaf area index of cotton at 100 DAS

Treatments	1999-2000	2000-2001	Mean
Plant spacing (cm) (S)			
S_1 = 15	4.65 a	7.09a	4.46
S_2 = 22.5	4.66 a	6.00b	3.86
S_3 = 30	2.77 b	3.60c	4.43
Significance	*	**	
Weed density (m^{-2}) (D)			
D_0 = Zero	5.80 a	7.42a	6.61
D_1 = 5	4.24 b	6.26b	5.25
D_2 = 10	3.47 bc	5.25c	4.36
D_3 = 15	3.59 bc	4.81c	4.20
D_4 = 20	3.04 c	4.09d	3.57
Significance	**	**	
Interaction (S x D)			
S_1D_0	7.37	8.02b	7.69
S_1D_1	5.03	7.86b	6.45
S_1D_2	4.09	6.76c	5.42
S_1D_3	3.92	7.93b	5.93
S_1D_4	2.85	4.90de	3.88
S_2D_0	6.26	9.26a	7.76
S_2D_1	4.90	6.60c	5.75
S_2D_2	3.98	5.52d	4.74
S_2D_3	4.29	4.11ef	4.20
S_2D_4	3.89	4.51e	4.20
S_3D_0	3.76	4.97de	4.36
S_3D_1	2.80	4.30ef	3.55
S_3D_2	2.36	3.48fg	2.92
S_3D_3	2.54	2.39h	2.47
S_3D_4	2.39	2.84gh	2.62
Significance	NS	**	

Means followed by the same letter in a column do not differ significantly at $P \leq 0.05$

Crop growth rate. Data at 55-100 DAS reveal that individual and interactive effect of plant spacing and carpet weed densities on CGR of cotton was significant and increase in plant spacing and weed density showed a decrease in CGR (Table II). Weed free cotton plants in combination with 15 cm plant spacing in 1999-2000 and 22.5 cm plant spacing during 2000-2001 gained significantly greater CGR. Increasing densities of carpet weed had a negative bearing upon CGR of cotton due to less dry weight of cotton per unit area resulting from lesser number of plants and weed competition. Bararpour *et al.* (1994) had also reported increase in percent reduction in dry weight of cotton with increase in *E. maculata* densities.

Sympodial branches per plant. Plant spacing did not influence sympodial branches per plant of cotton during

Table II. Effect of plant spacing of cotton and carpet weed density on mean growth rate (g m^{-2} day^{-1}) of cotton

Treatments	1999-2000	2000-2001	Mean
Plant spacing (cm) (S)			
S_1 = 15	11.04 a	20.60a	15.82
S_2 = 22.5	10.93 a	16.77b	13.85
S_3 = 30	6.93 b	11.55c	9.24
Significance	*	**	
Weed density (m^{-2}) (D)			
D_0 = Zero	16.65a	22.53a	19.59
D_1 = 5	8.32b	17.18b	12.75
D_2 = 10	8.63b	15.58c	12.10
D_3 = 15	8.17b	14.14d	11.15
D_4 = 20	6.40c	12.10e	9.25
SE	0.434	0.437	0.308
Interaction (S x D)			
S_1D_0	24.33a	24.89b	24.61
S_1D_1	8.20de	23.61b	15.91
S_1D_2	8.31de	19.62c	13.97
S_1D_3	9.51cd	21.26c	15.39
S_1D_4	4.86g	13.61e	9.23
S_2D_0	16.30b	27.91a	22.11
S_2D_1	9.25d	13.75de	11.50
S_2D_2	11.57c	15.83d	13.70
S_2D_3	8.68d	12.97ef	10.83
S_2D_4	8.85d	13.40ef	11.13
S_3D_0	9.33d	14.79de	12.06
S_3D_1	7.50def	14.17de	10.84
S_3D_2	6.00fg	11.29fg	8.65
S_3D_3	6.31efg	8.20h	7.25
S_3D_4	5.49fg	9.30gh	7.39
Significance	**	**	

Means followed by the same letter in a column do not differ significantly at P≤ 0.05

Table III. Effect of plant spacing of cotton and *T. portulacastrum* density on sympodial branches per plant of cotton

Treatments	1999-2000	2000-2001	Mean
Plant spacing (cm) (S)			
S_1 = 15	11.76	13.73	12.75
S_2 = 22.5	12.87	13.49	13.18
S_3 = 30	12.53	14.12	13.33
Significance	NS	NS	NS
Weed density (m^{-2}) (D)			
D_0 = Zero	14.24a	15.53a	15.39
D_1 = 5	12.58b	14.11ab	13.34
D_2 = 10	11.58c	13.51b	12.54
D_3 = 15	11.44c	13.13b	12.29
D_4 = 20	11.09c	12.62b	11.86
SE	0.285	0.519	0.296
Significance	**	**	
Interaction (S x D)	NS	NS	NS

Means followed by the same letter in a column do not differ significantly at P≤ 0.05

both years of study while densities of carpet weed decreased this trait during both the years (Table-III). Significantly increased sympodial branches per plant (14.24) were recorded in weed free plots followed by 12.58 sympodial branches per plant in plots where 5 plants m^{-2} of carpet weed were maintained. Increasing the density of weed during both the years did not further affect sympodial branches per plant. Greater number of sympodial branches per plant in weed free cotton was attributed to greater CGR in the absence of weed competition. On the other hand, linear decrease in number of sympodial branches per plant in cotton with increase in densities of carpet weed might have resulted from increased competition for resources at higher weed densities.

Total number of bolls per plant. Data revealed that effect of plant spacing on total number of bolls per plant in cotton was non-significant while increasing densities of carpet weed linearly decreased it during both the years (Table IV). Interactive effect of cotton plant spacing cotton and carpet weed densities was evident during both the years. Maximum number of bolls per plant was recorded in weed free cotton at 30 cm plant spacing followed by weed free plot at 22.5 cm plant spacing. A minimum boll number per plant was recorded in plots having 15 cm plant spacing of cotton with 20 plants of carpet weed during both the years. Linear decrease in total number of bolls per plant with increasing densities of carpet weed might be ascribed to an intense competition between the components species. More number of bolls per plant was harvested during the year 2000-2001 as compared to 1999-2000. This was due to relatively greater sympodial branches per plant because of more and uniform rainfall during the vegetative growth period of

Table IV. Effect of plant spacing of cotton and *T. portulacastrum* density on total number of bolls per plant of cotton

Treatments	1999-2000	2000-2001	Mean
Plant spacing (cm) (S)			
S_1 = 15	12.91	19.48	16.20
S_2 = 22.5	14.39	20.01	17.20
S_3 = 30	14.47	22.91	18.69
SE	-	-	0.585
Significance	NS	NS	*
Weed density (m^{-2}) (D)			
D_0 = Zero	19.96a	31.36a	25.66
D_1 = 5	14.72b	19.80b	17.26
D_2 = 10	12.91c	19.22b	16.07
D_3 = 15	11.48d	17.07c	14.27
D_4 = 20	10.57e	16.57c	13.56
Significance	**	**	
Interaction (S x D)			
S_1D_0	16.90c	27.73c	22.32
S_1D_1	13.70ef	19.80de	16.75
S_1D_2	12.50fg	19.67de	16.08
S_1D_3	10.97hij	14.93g	12.95
S_1D_4	10.50j	15.27g	12.88
S_2D_0	20.37b	31.93b	26.15
S_2D_1	14.97de	18.33ef	16.65
S_2D_2	14.03de	16.80fg	15.42
S_2D_3	12.03ghi	16.73fg	14.38
S_2D_4	10.53ij	16.27fg	13.40
S_3D_0	22.60a	34.40a	28.50
S_3D_1	15.50cd	21.27d	18.38
S_3D_2	12.20fgh	21.20d	16.70
S_3D_3	11.43ghij	19.53de	15.48
S_3D_4	10.63ij	18.13ef	14.38
Significance	**	*	

Means followed by the same letter in a column do not differ significantly at P≤ 0.05

Table V. Effect of plant spacing of cotton and carpet weed density on seed cotton weight per boll (g)

Treatments	1999-2000	2000-2001	Mean
Plant spacing (cm) (S)			
$S_1 = 15$	2.41	2.58	2.50
$S_2 = 22.5$	2.34	2.58	2.46
$S_3 = 30$	2.34	2.52	2.43
SE	-	-	-
Significance	NS	NS	NS
Weed density (m^{-2}) (D)			
D_0 = Zero	2.54a	2.81a	2.68
$D_1 = 5$	2.38b	2.54b	2.46
$D_2 = 10$	2.36b	2.55b	2.45
$D_3 = 15$	2.28b	2.47b	2.38
$D_4 = 20$	2.24b	2.44b	2.34
Significance	**	**	
Interaction (S x D)	NS	NS	NS

Means followed by the same letter in a column do not differ significantly at $P \leq 0.05$

Table VI. Effect of plant spacing of cotton and carpet weed density on seed cotton yield (kg ha^{-1}) of cotton

Treatments	1999-2000	2000-2001	Mean
Plant spacing (cm) (S)			
$S_1 = 15$	1662.22	2221.49	1941.86
$S_2 = 22.5$	1472.59	1997.08	1734.84
$S_3 = 30$	1455.56	1823.71	1639.63
Significance	NS	NS	
Weed density (m^{-2}) (D)			
D_0 = Zero	1961.73a (-)	2585.27a (-)	2273.50 (-)
$D_1 = 5$	1629.63b (17)	2097.53b (19)	1863.58 (18)
$D_2 = 10$	1486.42c (24)	1903.70c (26)	1695.06 (25)
$D_3 = 15$	1344.45d (31)	1802.47cd (30)	1573.46 (31)
$D_4 = 20$	1228.40e (37)	1681.48d (35)	1454.94 (36)
Significance	**	**	
Interaction (S x D)	NS	NS	NS

Values in parentheses showed percent decrease in seed cotton yield over weed free; Means followed by the same letter in a column do not differ significantly at $P \leq 0.05$.

Table VII. Effect of plant spacing of cotton and carpet weed density on lint yield (kg ha^{-1}) of cotton

Treatments	1999-2000	2000-2001	Mean
Plant spacing (cm) (S)			
$S_1 = 15$	638.29	970.52	804.41
$S_2 = 22.5$	564.17	880.52	722.35
$S_3 = 30$	549.58	783.34	666.46
SE	-	-	-
Significance	NS	NS	NS
Weed density (m^{-2}) (D)			
D_0 = Zero	759.44a	1118.25a	938.84
$D_1 = 5$	623.51b	919.72b	771.62
$D_2 = 10$	565.09c	834.31c	699.70
$D_3 = 15$	509.37d	790.81cd	650.09
$D_4 = 20$	462.66e	727.55d	595.11
Significance	**	**	
Interaction (S x D)	NS	NS	NS

Means followed by the same letter in a column do not differ significantly at $P \leq 0.05$.

cotton in 2000-2001. No significant effect of plant spacing on number of bolls per plant in the individual year is supported by the findings of Palomo and Godoy-Avila (1994) and Palomo *et al*. (2000).

Seed cotton weight per boll. Plant spacing did not influence weight of seed cotton per boll during both the years (Table V). Different densities of carpet weed significantly reduced the weight of seed cotton per boll during both the years. All densities of carpet weed exhibited similar but lower seed cotton weight than the weed free plots during both the years. Interactive effect of plant spacing of cotton and densities of carpet weed on boll weight of cotton was not evident during both the years. Maximum seed weight per boll in weed free cotton was most probably due to more crop growth rate, which favored assimilates production and their partitioning to bolls in greater amounts. Soomro *et al*. (1998) reported that weed free cotton increased boll weight by 9.2% as compared to non-weeding treatment.

Seed cotton yield. Different plant spacing did not affect this attribute during both the years but mean seed cotton yield was affected significantly (Table VI). Cotton planted in 15 cm plant spacing produced greatest mean seed cotton yield of 1941.86 kg ha^{-1} which did not differ significantly from seed cotton yield (1734.84 kg ha^{-1}) of 22.5 cm plant spacing. Generally, there was a decreasing trend in seed cotton yield with increasing plant spacing. Stepwise increase in weed density concomitantly reduced seed cotton yield during both the years in this study. Maintaining weed densities of 5, 10, 15 and 20 plants m^{-2} reduced seed cotton yield by 17-19, 24-26, 31-30 and 37-35 %, respectively compared to weed free plots during both the years. Weed free plots displayed highest seed cotton yield (1962 and 2585 kg ha^{-1} during respective years), although Interactive effect of cotton plant spacing and carpet weed densities seed cotton yield was not seen. These findings are supported by Palomo and Godoy-Avila (1994), Sharma and Tomar (1994), Soomro *et al.* (1996), Bednarz *et al*. (2000) and Franklin *et al*. (2000). The decrease in seed cotton yield with increase in carpet weed density might have resulted due to reduction in fruit bearing branches (sympodial), number of bolls per plant and seed cotton weight per boll. Buchanan *et al*. (1980), Brar *et al.* (1994) and Klingaman and Oliver (1994) also reported a linear decrease in seed cotton yield with increasing weed densities.

Lint yield: Plant spacing of cotton did not influence lint yield significantly (Table VII). Increased densities of carpet weed significantly ($P \leq 0.05$) reduced lint yield of cotton during both the years. Greatest cotton lint yield was recorded in weed free cotton during both the years. A minimum lint yield was recorded in plots where 20 plants of carpet weed were maintained. Interactive effect of plant spacing of cotton and densities of carpet weed on lint yield of cotton was non-significant during both the years. Maximum lint yield in weed free cotton was attributed to more number of bolls per plant and seed cotton weight per boll. Linear decrease in lint yield of cotton with increase in density of carpet weed is supported by the finding of Rogers *et al*. (1996).

CONCLUSION

Carpet weed density at 5 plants m^{-2} or beyond was critical and resulted in considerable reduction in seed cotton yield (17-37%) over weed free treatment. Plant spacing however, did not influence seed cotton yield.

REFERENCES

Bararpour, M.T., R.E. Talbert and R.E. Frans, 1994. Spotted spurg (*Euphorbia maculata*) interference with cotton (*Gossypium hirsutum* L.). *Weed Sci.*, 42: 553–5

Bednarz, C.W., D.C. Bridges and S.M. Brown, 2000. Analysis of cotton yield stability across population densities. *Agron. J.,* 92: 128–35

Brar A.S., R.J.S. Thind and L.S. Brar, 1994. Bio–efficiency of preplant application of pendimethalin and trifluralin for weed control in cotton. *J. Res.,* 35: 12–7

Buchanan G.A., R.H. Crowley., J.E. Street and J.A. Mcguire. 1980. Competition of sicklepod (*Cassia obtusifolia*) and red rot pig weed (*Amaranthus retroflexus*) with cotton (*Gossypium hirsutum*). *Weed Sci.*, 28: 258–62

El–Din, G.M.S., 1997. Effect of wed control and plant density of cotton on yield, some of its components, fibre properties and associated weeds. *Ann. Agric. Sci.,* 3: 699–714

Franklin, S., N. Hopper., J. Gannaway and R. Boman, 2000. Effect of various intra–row skips, plant populations and irrigation levels on development and yield in cotton. In: *Proceedings Beltwide Cotton Conf*. San Antonio, USA, Vol. I Memphis, USA; National Cotton Council: 604–5

Hunt, R, 1978. *Plant Growth Analysis*. pp. 26–38. Edward Arnold, U.K.

Klingaman, T.E. and L.R. Oliver, 1994. Influence of cotton (*Gossypium hirsutum*) and soyabean (*Glycine max*) planting date on weed interference. *Weed Sci.*, 42: 61–5

Palomo, G.A. and S. Godoy–Avila, 1994. Effect of plant population on agronomic characteristics of two cotton cultivars. *Agri. Tecnica en Mixco*, 20: 99–111

Palomo, G.A., A.G. Mascorro and S. Godoy–Avila, 2000. Response of four cotton cultivars to plant density. I. Yield and yield components. ITEA. *Prod. Vegetal*, 96: 95–102

Rogers, D.K., D.S. Murray, L.M. Verhalen and P.L. Claypool, 1996. Ivy leaf morning glory (*Ipomoea hederacea*) interference with cotton (*Gossypium hirsutum* L.). *Weed Technol.*, 10: 107–14

Rowland, M.W., D.S. Murray and L.M. Verhalen, 1999. Full season interference with cotton (*Gossypium hirsutum* L.). *Weed Sci.*, 47, 305–9

Samani, M.R.K., M.R. Khajehpour and A. Ghalavand, 1999. Effect of row spacing and plant density on growth and dry matter accumulation in cotton in Isfahan. *Iranian J. Agri. Sci.*, 29: 667–9

Sharma, R.K. and R.S.S. Tomar, 1994. Response of upland cotton (*Gossypium hirsutum*) to plant spacing and nitrogen under rainfed conditions. *Indian J. Agron.,* 39: 274–6

Siddiqui, M.H., F.C. Oad and U.A. Buriro, 2007. Plant spacing effects on growth, yield and lint of cotton. *Asian J. Plant Sci.*, 6: 415–8

Soomro, A.R., W.A. Siddiqui, M.H. Arain, A.W. Soomro and G.H. Nachnani, 1996. Performance of *Gossypium hirsutum* strains under different sowing dates and plant spacings. *The Pakistan Cottons*, 40: 48–52

Soomro, A.W., R. Uddin, G.H. Nachnani, A.S. Arain and G.H. Mallah, 1998. Relative contribution of fertilizer, plant protection and weeding towards seed cotton yield and its components. *The Pakistan Cottons*, 42: 54–60

Steel, R.G.D. and J.H. Torrie, 1984. *Principles and Procedures of Statistics*. pp. 172–7. McGraw Hill Book Co. Inc. Tokyo

Wood, M.L., D.S. Murray, R.B. Westerman, L.M. Verhalen and P.L. Claypool, 1999. Full season interference of *Ipomoea hederacea* with *Gossypium hirsutum* L. *Weed Sci.*, 47: 693–6

(Received 15 April 2007; Accepted 20 May 2007)