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WEED-CROP COMPETITION EFFECTS ON GROWTH AND YIELD OF SUGARCANE PLANTED USING TWO METHODS

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Abstract

Effect of planting techniques and weed-crop competition periods on yield potential of spring planted sugarcane variety HSF-240 was studied at the Ayub Agricultural Research Institute, Faisalabad, Pakistan. The experiment was laid out in RCBD with a split-plot arrangement, with four replications and net plot size of 3.6m x 10m. In the experiment, two planting techniques viz., 60 cm apart rows in flat sowing technique and 120 cm apart rows in trench sowing technique were randomized in main plots. Seven weed-crop competition periods viz., Zero (weed free), weed-crop competition for 45, 60, 75, 90, 105 days after sowing (DAS) and weedy check (full season weed-crop competition) were randomized in sub-plots. Sugarcane sown by trench method exhibited more leaf area index (LAI), average crop growth rate (ACGR) and yield contributing attributes. Trench sowing by yielding 72.22 and 75.08 t ha^{-1} stripped cane yields, significantly showed superiority over the flat sowing, which gave 64.13 and 66.04 t ha^{-1} stripped cane yields in 2005-06 and 2006-07, respectively. Generally, there was an increase in weed population and biomass but decrease in leaf area index, crop growth rate and yield components with an increase in weed-crop competition period. A decrease of 10.06, 17.90, 22.42, 28.65, 37.64 and 56.89% in stripped cane yield was observed for weed-crop competition periods of 45, 60, 75, 90, 105 DAS and weedy check as compared with zero competition in 2005-06, respectively. In 2006-07, the respective decrease in stripped cane yield was 9.84, 18.76, 22.92, 27.98, 38.75, and 54.98%. Trench sowing at 1.2 m row spacing proved better sowing technique and 45 DAS was the critical period of weed-crop competition.

Introduction

In Pakistan, national average yield of sugarcane (54 t ha^{-1}) is much lower than that of world average, which is 65 t ha^{-1} (Anon., 2008). The reasons for low yield include conventional planting methods, costly inputs, heavy weed infestation, improper land preparation, imbalanced fertilizer application, illiteracy, less support price, lack of coordination between growers and mill owners, natural calamities, shortage of irrigation water, delayed harvesting, attack of insect, pests and diseases, poor management of ratoon crop and salinity. Among these weed infestation is a major cause of low sugarcane yield (Baloch *et al*., 2002; Malik & Gurmani, 2005). Being a long duration crop yield potential of sugarcane crop is affected more than 20-25% due to weeds (Khan *et al*., 2004). In U.S.A. weed-crop competition of 3, 6, and 9 weeks after planting reduces 77.6%, 50.6% and 41.7% yield of sugarcane, respectively (Zimdahl, 1980).

Weeds compete throughout the life cycle of main crop but it is more sensitive to presence of weeds at a specific period during its life cycle. It is known as critical period of weed-crop competition. During this, period weeds cause maximum yield losses. In India, it was reported that critical period of weed crop competition in sugarcane ranged between 27 and 50 days (Srivastava *et al*., 2003).

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Planting method is an important yield-contributing factor. Row spacing in planting method is very important for crop plants and it is determined by the growth habit of the crop and agro-climatic conditions (Devi *et al*., 1990). The conventional flat sowing technique at 60 cm row-to-row distance is another major cause of low yield of sugarcane. The inter tillage operations cannot be done properly, so weed infestation is encouraged as well as lodging occur due to poor earthing up (Mehmood *et al*., 1990). Sowing of sugarcane in trenches at spacing of 120 cm improved 30% yield over flat sowing in furrows at row spacing of 60 cm, with additional facility of interculture, weed control, aeration, earthing-up, control of lodging, saving of irrigation water, and easier fertilizer application (Chattha *et al*., 2004).

Keeping in view the importance of sowing methods and losses caused by weeds, present study was designed to examine weed growth in sugarcane crop planted under two sowing methods and to determine critical period for weed-crop competition in sugarcane under agro-climatic conditions of Faisalabad, Pakistan.

Materials and methods

The proposed study was conducted at the Research Farm of Sugarcane Research Institute, Ayub Agricultural Research Institute, Faisalabad, on a clay loam soil. The experimental field was selected keeping in view the previous weed history of the field to ensure availability of the weeds. Experiment was conducted for two consecutive years (2005-06 and 2006-07). The sugarcane variety HSF-240 was selected for study. The crop was sown in the first week of March each year. The seed rate was 75,000 double budded setts ha^{-1}. Fertilizer was applied @ 168 kg N, 112 kg P_2O_5, and 112 kg K_2O per hectare in the form of urea, single super phosphate, and SOP, respectively. The whole P, K and $1/3^{rd}$ of N was applied as basal dose while remaining N was applied in two splits, $1/3^{rd}$, at completion of germination and $1/3^{rd}$ at the completion of tillering by side dressing.

The experiment was laid out in RCBD with a split-plot arrangement, quad replicated, with net plot size of 3.6m x 10m. Experiment included two planting techniques viz., 60 cm apart rows in flat sowing technique and 120 cm apart rows in trench sowing technique, which were randomized in main plots. Trench and flat sown plots was laid out in a finely prepared seedbed. In trench sowing, setts were placed in double rows at 20-25 cm depth while in flat sowing one row of setts was placed 12-15 cm deep in furrows. Seven weed crop competition periods viz., zero (full season weed free), weed crop competition for 45, 60, 75, 90, 105 days after sowing and weedy check (full season weed-crop competition) were randomized in sub-plots. After prescribed periods, weeds was removed manually with spade from each plot and kept weed free until harvest.

Standard procedures were followed to record data on various crop and weed parameters. Crop growth rate was calculated by the following formula given by Hunt (1978).

$$\text{ACGR } (gm^{-2}\ d^{-1}) = \frac{W_2 - W_1}{T_2 - T_1}$$

where

W_1 is plant dry weight m^{-2} at time T1, W_2 is plant dry weight m^{-2} at time T2, T_1 is time of first harvest and T_2 is time of second harvest.

Leaf area index was calculated by the following formula given by Singh *et al.,* (1987).

$$LAI = \text{Leaf area } m^{-2}/\text{Land area } m^{-2}$$

The agronomic parameters were recorded according to the procedure given by Beadle (1987). Total tillers of a plot were counted at 105 DAS and converted to m^2. All the millable canes of a plot were counted and converted to m^2. Ten randomly selected plants from each plot were taken then plant height, cane length and weight per stripped cane was measured and averaged. However, for stripped cane yield whole of the plot was harvested and yield was recorded and then converted into tones per hectare.

Data recorded on each parameter was tabulated and analyzed statistically by using Fisher's Analysis of Variance technique. Least significant difference (LSD) test at 5% probability was used to compare the difference amongst treatment means (Steel *et al*., 1997).

Results

Table 1 showed non-significant effect of sowing methods but significant effect of weed-crop competition periods on total weed population. The number of weeds went on increasing with subsequent increase in weed-crop competition periods. The significantly more number of weeds i.e., 215.25 and 93.38 m^{-2} was recorded in weedy check during 2005-06 and 2006-07, respectively, followed by 105 DAS weed-crop competition.

Trench sowing showed statistically significant total biomass (288.71 and 304.47 g m^{-2}) than flat sowing during both the years. As regards weed crop competition periods, the data (Table 1) disclosed the fact that total biomass of weeds went on increasing significantly with 15 days increase in each weed-crop competition period from 45 DAS to harvest. However, all weed crop competition periods gave statistically more biomass of weeds than zero competition (full season weed free) during each year of study.

Sowing techniques significantly affected the leaf area index of sugarcane at maturity during both the years of investigation (Table 2). The trench sowing technique by giving 7.48 and 7.29 leaf area index of sugarcane statistically surpassed the flat sowing technique during 2005-06 and 2006-07, respectively.

The weed-crop competition periods affected the leaf area index significantly during each year of investigation. The highest leaf area index of sugarcane was computed for crop kept weed free (zero competition) throughout the season and it was immediately followed by crop, which faced weed competition up to 45 days after sowing during both the years of study. Significantly, the minimum leaf area index of sugarcane was calculated for crop, which faced full season weed competition (weedy check).

The data regarding average crop growth rate (ACGR) given in Table 2 reflected that sowing techniques affected ACGR significantly in 2005-06, but effect was not significant during 2006-07. The data revealed that trench sown sugarcane exhibited significantly more ACGR (7.32 and 7.90 g m^{-2} day^{-1}) than flat sown crop, which showed 7.21 and 7.68 g m^{-2} day^{-1} in 2005-06 and 2006-07, respectively. Weed-crop competition period significantly reduced the ACGR during both the years of study. Weed competition free crop (zero competition) by giving 8.12 and 8.85 g m^{-2} day^{-1} ACGR in both the years proved significantly better than crop facing weed competition up to any duration till harvest (weedy check). Reduction in ACGR was recorded with increasing the weed crop competition during both the years of study.

Table 1. Effect of sowing techniques and weed-crop competition periods on population and biomass of weeds in sugarcane.

	Total weed population (m^{-2})		Total weed biomass ($g\ m^{-2}$)	
	2005-06	**2006-07**	**2005-06**	**2006-07**
(A) Sowing techniques				
Flat sowing	112.93	54.15	257.80 b	273.31 b
Trench sowing	110.25	50.57	288.71 a	304.47 a
LSD	**NS****	**NS**	**12.33**	**9.05**
(B) Competition periods				
Weed competition for	**2005-06**	**2006-07**	**2005-06**	**2006-07**
Zero DAS*	0.00 e	0.00 f	0.00 g	0.00 g
45 DAS	83.13 d	31.13 e	124.20 f	133.94 f
60 DAS	96.13 cd	45.13 d	186.37 e	199.38 e
75 DAS	118.50 bc	57.25 cd	287.88 d	302.50 d
90 DAS	128.38 b	63.13 c	348.88 c	368.50 c
105 DAS	139.75 b	76.50 b	471.75 b	496.88 b
Weedy check	215.25 a	93.38 a	493.75 a	821.00 a
LSD (p 0.05)	**23.08**	**12.71**	**21.22**	**20.14**

*DAS = days after sowing
**NS = non significant
Means sharing the same letter are statistically at par with each other

Table 2. Effect of sowing techniques and weed-crop competition periods on leaf area index (LAI) and average crop growth rate (ACGR) of sugarcane.

	LAI		ACGR ($g\ m^{-2}\ day^{-1}$)	
	2005-06	**2006-07**	**2005-06**	**2006-07**
(A) Sowing techniques				
Flat sowing	7.18 b	7.06 b	7.21 b	7.68
Trench sowing	7.48 a	7.29 a	7.32 a	7.90
LSD	**0.17**	**0.15**	**0.08**	**NS****
(B) Competition periods				
Weed competition for	**2005-06**	**2006-07**	**2005-06**	**2006-07**
Zero DAS*	7.86 a	7.69 a	8.12 a	8.85 a
45 DAS	7.75 ab	7.57 ab	7.61 b	8.27 b
60 DAS	7.65 bc	7.42 abc	7.41 bc	8.06 bc
75 DAS	7.51 c	7.29 bc	7.24 cd	7.80 cd
90 DAS	7.14 d	7.21 c	7.16 cd	7.60 de
105 DAS	6.93 e	6.75 d	7.08 d	7.32 e
Weedy check	6.46 f	6.28 e	6.25 e	6.61 f
LSD (p 0.05)	**0.18**	**0.28**	**0.25**	**0.45**

*DAS = days after sowing
**NS = non significant
Means sharing the same letter are statistically at par with each other

The data regarding tillers m^{-2} (Table 3) that sowing techniques and weed-crop competition periods significantly affected the tillering ability of cane crop during both the years. The trench sowing technique produced significantly more number of tillers (20.29 and 21.75) as compared to flat sowing technique (17.86 and 19.82) in 2005-06 and 2006-07, respectively. Regarding weed-crop competition periods, zero competition although gave statistically the same number of tillers as produced by crop facing weed competition up to 60 days, but significantly surpassed rest of the competition periods. The similar trend was observed in second year of study.

The sowing techniques although significantly affected the number of millable canes during 2005-06, but both the techniques had non-significant effect on number of millable canes during 2006-07. Trench sowing by producing 9.95 and 9.94 millable canes m^{-2} proved significantly better in both the years than flat sowing technique. Weed-crop competition up to 60 days after sowing did not significantly affect the millable canes compared with zero competition. However, prolonged weed-crop competition period resulted in suppression of the millable canes to a significant extent with minimum number in weedy check.

The data regarding plant height of sugarcane is given in table 3, which revealed that sowing techniques and weed-crop competition periods affected the plant height significantly during both the years. The significantly highest (2.93 m) plant height of sugarcane was recorded in trench sowing technique while least (2.84 m) plant height was recorded in flat sowing technique in 2005-06. The similar trend was recorded in 2006-07. In 2005-06, significantly maximum plant height of sugarcane (3.48 m) was recorded in zero competition. It was followed by 45 DAS with 3.13 m plant height. The lowest (2.14 m) plant height was recorded in weedy check (full season weed-crop competition). The similar trend was observed in second year.

Sowing techniques though did not affect significantly the cane length during 2005-06, however, difference among sowing techniques during 2006-07 was significant as trench sowing technique gave 2.29 m and flat sowing technique gave 2.17 m lengthy canes (Table 3). Weed-crop competition periods significantly affected the cane length during each year of investigation. Cane length of 2.64 and 2.68 m was recorded in crop kept weed free throughout the season (zero competition), which was significantly more than that of any other treatment. The shortest cane was produced by the crop subjected to weed competition throughout the season (weedy check).

Table 3 showed that trench sowing technique produced heavier cane than flat sowing technique during each year of investigation. Cane weight of 865.57 and 889.00 g given by trench sowing technique was significantly higher than that of flat sowing technique (829.57 and 845.29 g $cane^{-1}$) during 2005-06 and 2006-07, respectively. Prolonging the weed-crop competition periods also significantly reduced the cane weight during both the years of study. The results of two years confirmed the same trend as the heaviest canes of 1066.50 and 1101.00 g were produced by crop, which was kept weed free though out the season (zero competition) in both the years, while significantly the lightest cane of 474.50 and 512.50 g was given by crop, which faced weed competition throughout the season (weedy check) in both the years.

Effect of sowing techniques (Table 3) on stripped cane yield during 2005-06 was non significant, but during 2006-07 trench sowing by giving 75.08 t ha^{-1} stripped cane yield superseded the flat sowing technique which gave 66.04 t ha^{-1}. The weed-crop competition period affected the cane yield to a significant extent. The data regarding weed crop competition periods revealed that weed-crop competition periods significantly reduced the stripped cane yield. Weed free crop (zero competition) by giving 90.65 and 93.76 t ha^{-1} stripped cane yield in both the years significantly surpassed, the cane yield given by crop subjected to any weed crop competition period. Significantly, the minimum stripped cane yield of 39.08 and 42.21 t ha^{-1} was recorded in weedy check in both the years. Decrease in cane yield due to various weed-crop competition periods was in the range of 10.06 to 56.89% and 9.84 to 54.98% in 2005-06 and 2006-07, respectively.

Discussion

Although sowing techniques did not affect the weed population significantly but effect on weed biomass was significant. The significantly more weed biomass in trench sowing could be attributed to vigorous growth of weeds due to more space. In spite of more weed biomass, maximum leaf area index and average crop growth rate of sugarcane in trench sowing indicate that sugarcane plants can grow vigorously due to more space and better crop establishment. On the other hand Alonso & Scandaliaris (1988) in Argentina reported that LAI was not affected by the row spacing. The difference could be attributed to different environmental conditions and variety behavior. Similarly Ahmed (2002) in Pakistan reported maximum CGR at 90 cm spacing rather than 120 cm spacing. This variability might be due to the variable genetic potential which showed different results in a particular set of environmental and ecological conditions of the experimental crop. Further more sowing techniques also influenced the growth parameters of the crop which contributed towards final yield. More number of tillers, millable canes, plant height and cane length in trench sowing might have been resulted from higher LAI and ACGR which accelerated the growth of the yield parameters. Whereas reason for more weight per stripped cane is more plant height and cane length. More weight per stripped cane in trench sowing could be possible reason of more stripped cane yield in trench sowing. These results are in line with those of Sarwar *et al*., (1998), Sundra (2002) and Chattha *et al*., (2004, 2007). They recorded more number of tillers, millable canes, plant height, cane length and stripped cane yield from wider row spacing in trench sowing technique as compared to narrow row spacing in flat sowing technique.

Increase in weed population with an increase in weed-crop competition period could be due to more time availed by weed seeds to germinate, whereas increase in weed biomass with time was due to utilization of environmental resources by weeds for a longer period of time compared with weed free treatment. Decrease in LAI and ACGR with increased weed-crop competition periods had resulted due to more weed biomass or competition of weeds with crop, which might have reduced availability of environmental resources to crop plants which hampered the establishment of crop canopy. Decrease in LAI and ACGR with an increase in weed-crop competition period could be the reason for decrease in number of tillers, millable canes, plant height and cane length. Furthermore, decrease in plant height and cane length caused reduction in stripped cane weight from 45 to 105 DAS competition and weedy check. Decrease in cane yield ranged from 9.84 to 59.89%. This decrease in stripped cane yield was due to weed-crop competition period which prolonged from 45 to 105 DAS / weedy check. It was mainly due to decrease in

weight per stripped cane. These results are supported by Nayyar (1994) and Patel *et al*., (2007) who concluded that zero weed-crop competition gave more cane yield than different weed-crop competition periods. Chauhan & Srivastava (2002) in India reported 32.0 to 45.45% yield losses due to weed crop competition. Similarly Singh & Tomar (2003) in India reported 20.5, 21.9, 49.7 and 74.5% reduction in cane yield because of weed-crop competition of 30, 45, 60 and 75 days.

The difference in yield loss intensity in our and previous experiments might be attributed to the varying weed crop competition for sunlight, air, space, moisture and nutrients. Varietal characters like growth habit, canopy shapes, weed flora diversity, sowing techniques, cropping season and previous weed history of the field are the factors which also determine yield potential.

Conclusions

Trench sowing at 1.2 m row-to-row distance was the best sowing method which gave significantly more stripped cane yield than flat sowing. The yield of sugarcane was linearly decreased with increasing weed crop competition duration with maximum decrease at 105 DAS. Critical period of weed crop competition was found 45 days after sowing. Weeds should be removed immediately after the emergence to get maximum cane yield.

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