COMPETITIVENESS OF HORSE PURSLANE WITH GROWTH AND YIELD OF COTTON

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DOI: https://doi.org/10.28941/pjwsr.v26i3.813

ABSTRACT

Horse purslane (*Trianthema portulacastrum* L.*) is one of the major and problematic weed of summer season in Pakistan that is responsible for yield reduction. A research trial was carried out at Muhammad Nawaz Sharif University of Agriculture Multan during Kharif, 2018 to compare the competitive effect of horse purslane and other weeds for different intervals regarding growth and yield of cotton. Horse purslane is considered the noxious weed of cotton crop. Cotton is an important, fiber and cash crop of Pakistan. Its raw material and other products are exported to other countries. The study was conducted using the randomized complete block design with three replications. The treatments were; horse purslane free crop for whole season, horse purslane free crop for 30 days after sowing (DAS), horse purslane free crop for 60 DAS, horse purslane and other weeds free crop for whole season, horse purslane and other weeds free crop for 30 DAS, horse purslane and other weeds free crop for 60 DAS, weedy check (horse purslane only), weedy check (all weeds except the horse purslane) and weedy check (all weeds including horse purslane). Weed density, weed dry biomass, crop growth and yield related parameters were recorded following standard procedures. All recorded data were analyzed with the help of Fisher's Analysis of Variance. The means of different treatments were separated by using Tukey's HSD test at 5% probability level. Horse purslane reduced the height of cotton plants by 26.51%, crop growth rate in terms of biomass by 28.44%, total dry matter 28.46% and seed cotton yield by 45% as compared to weed free treatment for whole season. The increase in yield in horse purslane free crop for whole season (23.45%), horse purslane free crop for 30 DAS (14.27%), horse purslane free crop for 60 DAS (18.07%), horse purslane and other weeds free crop for whole season (124.03%), horse purslane and other weeds free crop for 30 DAS (63.48%) and horse purslane and other weeds free crop for 60 DAS (103.73%) was recorded as compared to all weeds (weedy check). Treatment having horse purslane and other weeds free crop for whole season gave high seed cotton yield than other treatments. Whereas, the highest benefit cost ratio (1.70) was observed for plot that was kept free from horse purslane and other weeds till 60 DAS.*

Keywords: Competition period, crop, cotton productivity, economic analysis, growth, weed

Citation: Niaz, M.B., A. Ghaffar, K. Mubeen, M.A.Khan, W. Ahmed. 2020. Competitiveness of Horse Purslane with Growth and Yield of Cotton. *Pak. J. Weed Sci. Res., 26(3):* 313-330, 2020

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a major crop that is mostly grown for fiber in Pakistan. The major cotton producing countries of the world are Australia, Brazil, China, Egypt, India, Turkmenistan, United States and Pakistan. Globally, Pakistan ranks as the 5th cotton largest producer in the world. During 2019-2020, it was sown on area of 2527 thousand hectares, the growth rate of cotton was 6.5% and production 9.17 million bales. Cotton has 0.8% share in gross domestic product, and 4.1% in value addition. Average yield of cotton in Pakistan was 618 kg ha^{-1} (GOP, 2020). Globally cotton crop is facing many challenges from sowing to harvest. These challenges may include but not limited to the environmental, agronomic, economic and marketing challenges. These factors greatly influenced the profitability and productivity of the cotton crop (Iqbal *et al*., 2018). Reasons for reduction in yield of cotton were poor seed quality, high prices of inputs, climatic factors (heavy rains and high temperature especially at flowering), sowing time, insect pests, disease, pesticides, nutrients deficiency, boll shedding, poor agronomic practices and weeds infestation. (GOP, 2018). Cotton crop is infested by diverse weed flora comprising of grasses, sedges and broadleaf weeds (Afzal *et al*., 2015). Weeds interference is crucial due to reduction in yield and quality of final produce (Mubeen *et al*., 2014). Weeds infestation and competition varies with crops and locations (Rao *et al*., 2014). Weeds reduce the resource use efficiency, so these must be timely managed to increase productivity of crops (Rao and Chauhan, 2015). Weeds management practices effect on yield and yield attributes (Shrestha *et al*., 2019). The uptake of nutrients were maximum where three weeding was done at 20, 40, and 60 DAS as compared to other weed control treatments (Varsha *et al*., 2019).

Important cotton weeds are purple nutsedge (*Cyperus rotundus L.),* bermuda grass *(Cynodon dactylon L.),* field bindweed *(Convolvolus arvensis L.),* Jungle rice (*Echinochloa colona L.*), pig weed (*Amaranthus viridis L.*), wild cucurbit (*Mukia maderaspatana L.*), Johnson grass *(Sorghum halepense L.),* Canadian horseweed *(Conyza Canadensis L.)* and horse purslane *(Trianthema portulacastrum L.)* (Dongan *et al*., 2014). Horse purslane is annual and noxious herb, it spreads on the ground and its height not exceed from 4-6 ft. It is an indigenous plant to South Africa and occurs in Bangladesh, India, Sri Lanka, West Asia and tropical America. It is commonly known as carpet weed, blacking weed, gudbur, itsit, hog weed and santha (Kumar and Aneja, 2016). It infest the crop fields and competes for moisture, nutrients, light and also decreases the crop productivity and reduce the fiber quality (Jabran, 2016). Competitive characteristics of horse purslane are correlated with plant height, early canopy closure, seedling vigor, rapid leaf area development and branching sequence (Eslami, 2015). Horse purslane alone reduced soybean yield up to 53.28% (Habib *et al*., 2020) and maize yield up to 49.73% (Parvaiz *et al*., 2020) as compared to all other weeds. It is the most noxious weed in many vegetable and agricultural crops i.e, onion, potato, pigeon pea, mustard, mung bean, guar, sesame, sorghum, soybean, maize and cotton (Ray and Vijayachandran, 2013). It has become an invasive weed due to its strong competitive ability and significant reduction in yield of many cultivated crops (Kaur and Aggarwal, 2017). Weeds can adversely affect the crop yield and quality (Dongan *et al.*, 2014). The damages incurred by weeds in cotton field are well documented. However, the relative interference of horse purslane with other weeds and impact on cotton growth and yield is seldom explored. Hence present study was conducted to appraise the competitiveness of horse purslane with growth and yield of cotton.

MATERIALS AND METHODS

The present field study was laid out at Farm of MNS- University of Agriculture, Multan, Pakistan. The Randomized

Complete Block Design (RCBD) was used in field study. Net size of each plot was kept 6 m × 4.5 m. Nine treatments were randomly arranged in RCBD with 3 replications. The study consisted 9 treatments viz; T_1: Horse purslane free crop for whole season, T_2: Horse purslane free crop for 30 days after sowing, T_3: Horse purslane free crop for 60 days after sowing, T_4: Horse purslane and other weeds free crop for whole season, T_5: Horse purslane and other weeds free crop for 30 days after sowing, T_6: Horse purslane and other weeds free crop for 60 days after sowing, T_7: Weedy check (Horse purslane only), T_8: Weedy check (All weeds except horse purslane) and T_9: Weedy check (All weeds including horse purslane). It was manually sown on 24 May, 2018. Cotton variety BS-15 was used, seeds were used at the rate of 15 kg ha^{-1} and spacing between rows was kept 75 cm and between plants 22.5 cm. The recommended dose of fertilizers were used NPK @ 220:88:95 kg ha^{-1} and sources used were urea, diammonium phosphate (DAP) and sulfate of potash (SOP). All P, K and one third N were applied at time of sowing and remaining N was applied into two splits half of N at flowering approximately 55 DAS and half at boll formation approximately 75 DAS. First irrigation was applied 3 DAS, Next three irrigations were applied after a week interval and or further irrigation at 10-15 days interval till 15th October, or as per prevailing weather conditions. Weeds were removed manually and kept free according to treatments. All remaining practices were used same for treatments during the whole season. Picking of seed cotton was done manually after 50% bolls were opened and 2nd picking was done after 15 days of 1st picking. All the collected data were statistically analyzed by using the standard procedure and subjected to Fisher's analysis of variance (ANOVA). Tukey's HSD test at 5.0% probability was used for testing treatments means by using computer software (statistix 8.1).

The data on weed density was taken by an iron quadrate size of 0.5 m × 0.5 m and thrown randomly in each plot twice. An area comprising 1 m (length) and 1 bed & furrow (width) was randomly selected from each plot. The area was marked to count the weeds. It was expressed as number of weeds per meter square and recorded at 15, 30, 45, 60, 75 and 90 DAS in each treatment. Weed species (sedges, grasses and broad leaf weeds) found in marked area. Weed flora was first shade dried for one day and then kept in electrical oven at 60^0 C for 72 hours. After this period weed flora was weighed in weighing balance and recorded the reading. This procedure carried out with each weed sample from each treatments at 15, 30, 45, 60, 75 and 90 DAS. Data regarding dry matter production was obtained by destructive sampling of plants. Plants were randomly selected in one meter length and harvested from the above ground. Dry the collected sample in an oven at 60^0C for 72 hours. After this weighed the sample in weighing balance and converted the data into 1 meter square. Data on total dry matter production per unit ground area was recorded at different interval (30, 60, 90, 120 and 150 days after sowing) by taking on dry weight of samples. Crop growth rate was calculated by using these dry weights with the help of formula suggested by Hunt (1978) as follow:

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

Net assimilation rate (NAR) was recorded by using the formula suggested by Hunt (1978).

$$NAR = TDM / LAD$$

Data on plant height, number of total bolls and opened bolls were recorded from tagged plants and converted into per plant. Average weight of boll was taken from tagged plants in each experimental unit at 1st and 2nd picking of the trial. The picked bolls were weighted and average boll weight was gained by dividing total number of bolls picked. Seed cotton yield was recorded of the whole plots by two pickings in each treatment and it was converted into kg ha^{-1}. Seeds were counted and then weight 100 seed with the help of electrical weigh balance and converted into 1000 seed weight to determined seed index (g). Ginning out

turn taken from 100 g sub sample of seed cotton from yield of each treatment with the help of ginning machine.

GOT (%) = Lint/ total weight × 100

Data were analyzed by using Fisher's analysis of variance. The means of different treatments separated by using Tukey's HSD test at 5% probability level (Steel *et al*., 1997).

RESULTS AND DISCUSSIONS.

Individual weed density and dry weight

The density of *T. portulacastrum* presented (Table 1) statistically significant differences among treatments. The maximum density of *T. portulacastrum* (8.67 plants m^{-2}) was recorded in weedy check (horse purslane only) plot. However, the minimum density of *T. portulacastrum* (2.97 plants m^{-2}) was recorded in plot horse purslane and other weeds free crop for 60 DAS. *T. portulacastrum* was allowed to grow for whole season to determine weed crop competition. Life cycle of *T. portulacastrum* was near to completion at 60 DAS. Our results differed with the findings of Habib *et al.* (2020), who reported that horse purslane density increased with increasing time period till 45 DAE of crop. The probable reasons of differences in outcome can be attributed to the differences in crop type under test with differential growth habit and type compared with cotton, the competition and interactive exposure duration with crop life cycle, differential in sowing method, sowing time, environment and soil conditions and related agronomic management-etc.

The maximum dry weight (75.44 g m^{-2}) of *T. portulacastrum* was obtained from plot having weedy check (horse purslane only) at 60 DAS of crop to increase weed crop competition. The results were statistically significant under test among treatments employed (Table 2). However, the minimum dry weight (4.67 g m^{-2}) was recorded. The maximum dry weight was recorded due to its high density, no competition with other weeds and long period for growth. *T. portulacastrum* greatly reduced the plant growth and yield and yield related attributes. After 2 months *T. portulacastrum* dry weight was started to decline due to completion of its life cycle. The lowest dry weight taken due to manual weeding for whole season for horse purslane. The results were almost same as observed by Nadeem *et al*. (2013) who reported that biomass of horse purslane increased with increase in time period because it is succulent, broadleaf and annual weed.

The number of plants of *Cyperus rotundus* showed (Table 1) statistically significant results among different treatments. The more number of *C. rotundus* (9.13 plants m^{-2}) was recorded from plot having weedy check (all weeds) and minimum density of *C. rotundus* (5.67 plants m^{-2}) was observed from plot horse purslane and other weeds free crop for 60 DAS. Weeds were allowed to grow for whole season to determine the weed crop competition for all inputs applied to crop. The minimum density due to manual weeding till first 60 days to avoid the competition with weed. Our findings were differed with Sandangi and Barik (2007) and Rajput *et al*. (2008) who reported that weeds were controlled using herbicide paraquat dichloride and obtained good results. The reason behind this differential in weed control method (chemical), cultivur under field study and environmental condition.

Dry weight of *C. rotundus* presented in Table 2 and statistically significant results were found during course of study. The maximum dry biomass (74.68 g m^{-2}) of *C. rotundus* was obtained from plot weedy check (all weeds). However, minimum dry weight (18.10 g m^{-2}) was recorded from plot having horse purslane and other weeds free crop for whole season. Maximum dry weight of *C. rotundus* was recorded due to its fast growth, density and other weeds flora. Weeds were allowed to grow for whole season to weed crop competition. *C. rotundus* was dominate weed as compared with other treatments in weedy check (all weeds) plot and observed

highest dry weight. The lowest dry weight was taken due to manually weeding performed for whole season as per treatment to remove the weed crop competition. Our results were not in accordance with the results of Sandangi and Barik (2007) and Rajput *et al*. (2008) who stated that it was the most common and perennial weed, propagation through tubers and seeds may be come with cattle manure. The differences in results might be due to difference in weed control method (post emergence herbicide), weed population, type of cultivar, soil and climatic condition etc.

The density of *Cynodon dactylon* displayed (Table 1) statistically significant differences among treatments. The maximum density of *C. dactylon* (3.45 plants m^{-2}) was recorded from weedy check (all weeds) plot but minimum density of *C. dactylon* (2.33 plants m^{-2}) was observed from plots having treatment horse purslane and other weeds free crop for 60 DAS. *C. dactylon* was less dominant as compared to other weeds. Those plots having minimum density due to manual weeding performed as per treatment. The results of the study were not in accordance with the outcomes of Nadeem *et al*. (2013) when they stated that maximum density was recorded in ridge sowing than flat sowing but lowest number of *C. dactylon* was recorded at harvest by using herbicide (pendimethalin + prometryne) and manual weeding was the most efficiant than chemical practice. The reason might be difference in sowing method, weed control practices (chemical), soil type and climatic factors etc.

Maximum dry biomass (32.32 g m^{-2}) of *C. dactylon* was observed from plot weedy check (all weeds) and data was statistically significant (Table 2). However, the minimum dry weight (4.63 g m^{-2}) was recorded. The maximum dry weight was observed due to its high density and long period of time for growth and allowed to grow to increase weed crop competition. The lowest dry weight could be attributed to slow growth of weed owing to its perennial nature with not aggressive weed crop competition over short time. The results of the study were in accordance with Fuente *et al*. (2014) who also reported that biomass of weed increased with time period but compete with all resources applied to sole crop.

Dactyloctenium aegyptium density showed (Table 1), there were statistically significant differences among treatments. The maximum number of plants of *D. aegyptium* (2.85 plants m^{-2}) was observed. However, the minimum plants of *D. aegyptium* (2.13 plants m^{-2}) was recorded from plot horse purslane and other weeds free situation of crop for 60 DAS. It may be due to the unfavorable condition for growth at initial stages and based on life cycle of the weed. Minimum weed crop competition found due to manual weeding as per treatment applied. Our results were differed from findings of Memon *et al*. (2007) who stated that it was the most devastating weed in cotton crop and seeds disperse by animals manure and wind. The probable reasons may include differences in density due to differences among sampling region, variation in management situations, crop cultivar under test and climatic factors etc.

The dry biomass of *D. aegyptium* presented in Table 2 and results were statistically significant. The maximum dry weight (12.19 g m^{-2}) was observed from weedy check plot but minimum dry weight (8.69 g m^{-2}) was recorded from plots having horse purslane and other weeds free crop for whole season. The maximum dry weight was achieved due to weeds allowed to grow, its high density and maximum time period for its growth. The results of the study differed from findings of Memon *et al*. (2007) who also reported that application of herbicide which reduced the biomass of weed and also minimize the competitive ability. These differences could be owed to differences in weed control practices (chemical+manal), region, differential in sowing method and climatic factors etc.

Panicum glacum density presented in Table 1, there was statistically significant differences among treatments

affected weed crop competition. The maximum (3.67 plants m^{-2}) and minimum (2.71 plants m^{-2}) plants were observed. Our results were differed with the results of Motlagh and Javadzadeh (2011) who reported that different weed management practices (integrated, agronomic and biochemical) were highly effective method rather than using single method. The reason behind this may be diversity of weeds flora, soil type and weed management approaches (integrated, agronomic and biochemical), unfavorable climatic condition for growth and seed dormancy etc.

The highest dry weight (10.56 g m^{-2}) of *P. glacum* was recorded in weedy check plot presented (Table 2). Results of the data were statistically significant. However, the minimum dry weight (7.35 g m^{-2}) was observed from plot horse purslane and other weeds free crop for whole season. It might be due to low density and emergence time. The minimum dry weight of *P. glacum* was observed due to employed manual weeding and minimize weed crop competition. Our findings were not in accordance with the results of Motlagh and Javadzadeh (2011) when they stated that noxious weeds of cotton crop suppressed the growth of *P. glacum*, reduced the biomass and competitive ability. The reason behind this may be diversity of weeds flora, soil type and weed management approaches (chemical, manual) and differential in climatic condition etc.

Table 1. Individual weeds density as affected by horse purslane competitiveness in cotton field.

Treatments	*T. portulacastrum*			*C. rotundus*			*C. dactylon*			*D. aegptyan*	*P. glacum*
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	90 DAS	90 DAS
T_1	0.00 c	0.00 d	0.00 c	6.33 a	7.33 a	7.67 a	2.92 a	2.99 a	3.13 a	2.41 a	2.88 a
T_2	0.00 c	3.33 c	3.67 b	5.67 ab	6.87 ab	7.67 a	2.58 a	2.76 a	2.83 a	2.33 a	2.79 a
T_3	0.00 c	0.00 d	2.97 b	5.67 ab	6.67 ab	7.33 a	2.41 a	2.67 a	2.77 a	2.13 a	2.71 a
T_4	0.00 c	0.00 d	0.00 c	0.00 c	0.00 d	0.00 c	0.00 b	0.00 c	0.00 b	0.00 b	0.00 b
T_5	0.00 c	3.33 c	2.67 b	0.00 c	5.67 bc	7.67 a	0.00 b	1.88 ab	2.88 a	0.00 b	0.00 b
T_6	0.00 c	0.00 d	3.11 b	0.00 c	0.00 d	5.67 ab	0.00 b	0.00 c	2.33 a	0.00 b	0.00 b
T_7	7.33 a	8.33 a	8.33 a	0.00 c	0.00 d	0.00 c	0.00 b	0.00 c	0.00 b	0.00 b	0.00 b
T_8	0.00 c	0.00 d	0.00 c	6.33 a	7.13 a	7.88 a	2.74 a	2.93 a	2.98 a	2.67 a	3.43 a
T_9	2.67 b	4.89 b	4.63 b	7.67 a	8.33 a	9.13 a	3.13 a	3.41 a	3.45 a	2.85 a	3.67 a
HSD Tukey's value	0.8155	1.119	1.312	1.780	1.266	1.812	0.824	1.580	1.436	1.282	1.126

Similar letter showed non-significant differences among treatment means.

T. portulacastrum: *Trianthema portulacastrum*, ***C. rotundus***: *Cyperus rotundus,* ***C. dactylon*****:** *Cynodon dactylon*, ***D. aegptyan*****:** *Dactyloctenium aegyptium*, ***P. glacum*****,** *Panicum glacum*

T_1: Horse purslane free crop for whole season, **T_2**: Horse purslane free crop for 30 days after sowing, **T_3**: Horse purslane free crop for 60 days after sowing, **T_4**: Horse purslane and other weeds free crop for whole season, **T_5**: Horse purslane and other weeds free crop for 30 days after sowing, **T_6**: Horse purslane and other weeds free crop for 60 days after sowing, **T_7**: Weedy check (Horse purslane only), **T_8**: Weedy check (All weeds except horse purslane) and **T_9**: Weedy check (All weeds including horse purslane)

Table 2. Individual weeds dry weight as affected by horse purslane competitiveness in cotton field

Treatments	*T. portulacastrum*			*C. rotundus*			*C. dactylon*			*D. aegptyan*	*P. glacum*
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	90 DAS	90 DAS
T_1	0.00 c	0.00 d	0.00 e	1.24 a	54.75 a	57.78b	2.35ab	22.52a	25.72a	10.19 a	8.63 a
T_2	0.00 c	5.78 c	17.15c	1.15 a	48.56ab	55.68b	2.02bc	17.87a	21.6ab	9.04 a	8.53 a
T_3	0.00 c	0.00 d	15.08c	1.13 a	43.90 b	53.47b	1.94bc	15.32a	20 abc	8.69 ab	7.35 ab
T_4	0.00 c	0.00 d	0.00 e	0.00 b	0.00 d	0.00 d	0.00 d	0.00 b	0.00 d	0.00 c	0.00 c
T_5	0.00 c	4.67 c	16.44c	0.00 b	21.05 c	54.51b	0.00 d	7.37 b	9.62 d	0.00 c	0.00 c
T_6	0.00 c	0.00 d	7.34 d	0.00 b	0.00 d	18.11c	0.00 d	0.00 b	4.63 d	0.00 c	0.00 c
T_7	15.32a	75.44a	74.72a	0.00 b	0.00 d	0.00 d	0.00 d	0.00 b	0.00 d	0.00 c	0.00 c
T_8	0.00 c	0.00 d	0.00 e	1.18 a	51.87 a	60.33b	2.17 b	20.75a	23.13a	11.04 a	9.59 a
T_9	4.60 b	39.37b	47.15b	1.26 a	59.27 a	74.68a	2.53 a	23.91a	32.32a	12.19 a	10.56 a
HSD Tukey's value	0.164	7.707	5.596	0.374	9.765	9.645	0.326	8.86	10.24	3.621	2.174

Similar letter showed non-significant differences among treatment means

T. portulacastrum: *Trianthema portulacastrum*, ***C. rotundus***: *Cyperus rotundus,* ***C. dactylon*****:** *Cynodon dactylon*, ***D. aegptyan*****:** *Dactyloctenium aegyptium*, ***P. glacum*****,** *Panicum glacum*

T_1: Horse purslane free crop for whole season, T_2: Horse purslane free crop for 30 days after sowing, T_3: Horse purslane free crop for 60 days after sowing, T_4: Horse purslane and other weeds free crop for whole season, T_5: Horse purslane and other weeds free crop for 30 days after sowing, T_6: Horse purslane and other weeds free crop for 60 days after sowing, T_7: Weedy check (Horse purslane only), T_8: Weedy check (All weeds except horse purslane) and T_9: Weedy check (All weeds including horse purslane)

Total weeds density (m^{-2}) and dry weight (g m^{-2})

The number of total weeds density presented in Table 3 statistically significant differences among treatments employed. Maximum number of plants (21.53 plants m^{-2}) of total weeds were recorded from plot having weedy check (all weeds). Maximum density of total weeds were observed due to no weeding during the whole season of crop. However, the minimum density (8.33 plants m^{-2}) was observed from plot weedy check (horse purslane only). Weeds were allowed to grow throughout the season and increased with increasing period of weed crop competition. Those plots where weeds were removed manually. The results of the study differed with the results of Mubeen *et al*. (2009) and Nadeem *et al*. (2013) who came up with conclusion that minimum density were recorded by using chemical weed management practice which decrease the weed crop completion for nutrients, space, moisture etc. The likely reason might have been the differences in sowing method and differential in weed control method (chemical, manual, integrated), crop, soil type and climatic factors prevailing etc.

Dry weight of total weeds (Table 3) showed statistically significant effect on dry weight of total weeds as a result of horse purslane interference. The highest dry biomass (163.96 g m^{-2}) of total weeds were recorded from plot weedy check (all weeds). It was statistically at par with dry weight of weedy check (all weeds except horse purslane). However, the lowest dry biomass (25.14 g m^{-2}) of total weeds were observed during study. These competed with crop for space, light, water, nutrients etc. Dry weight of weeds increased with time period of weeds to compete with crop. The reason behind this maximum dry weight obtained due to higher weed density and more period for growth of weeds competition with cotton throughout the season. The lowest dry weight observed due to weeding applied to remove weed crop competition. The results of the study were not in accordance with Mubeen *et al*. (2009), Tauseef *et al*. (2012) and Nadeem *et al*. (2013) as they stated weeds were well adopted in moist soil and persist for long time which increase competiveness characteristics for resources applied to sole crop. The likely reason behind this might be the variation in soil type, weeds prevailing, weed management approaches (chemical, integrated weed management, manual etc) and climatic conditions etc.

Table 3. Total weeds density and dry weight as affected by horse purslane interference in cotton field.

Treatments	30 DAS		60 DAS		90 DAS	
	Total weeds density	Total weeds dry weight	Total weeds density	Total weeds dry weight	Total weeds density	Total weeds dry weight
T_1	9.33 a	4.54 b	12.00 a	85.09 bc	17.33 a	108.84 b
T_2	8.94 a	4.41 b	11.67 a	81.93 bc	15.67 ab	114.27 b
T_3	8.67 a	4.32 b	11.00 a	87.80 bc	15.33 ab	118.63 b
T_4	0.00 b	0.00 c	0.00 d	0.00 e	0.00 e	0.00 e
T_5	0.00 b	0.00 c	9.00 ab	25.83 d	13.67 bc	57.64 c
T_6	0.00 b	0.00 c	0.00 d	0.00 e	9.00 d	25.14 cd

T_7	7.33 a	15.32 a	8.33 abc	75.44 c	8.33 d	84.72 c
T_8	9.33 a	5.56 b	10.67 a	95.30 b	18.33 a	110.74 b
T_9	9.45 a	6.74 b	13.33 a	132.18 a	21.53 a	163.96 a
HSD Tukey's value	2.776	3.374	3.579	18.29	4.626	24.89

Similar letter showed non-significant differences among treatment means

T_1: Horse purslane free crop for whole season, **T_2**: Horse purslane free crop for 30 days after sowing, **T_3**: Horse purslane free crop for 60 days after sowing, **T_4**: Horse purslane and other weeds free crop for whole season, **T_5**: Horse purslane and other weeds free crop for 30 days after sowing, **T_6**: Horse purslane and other weeds free crop for 60 days after sowing, **T_7**: Weedy check (Horse purslane only), **T_8**: Weedy check (All weeds except horse purslane) and **T_9**: Weedy check (All weeds including horse purslane)

Growth parameters

The total dry matter presented in Fig. 1, the effect of weeds on total dry matter production of cotton crop at different stages of crop. Statistical variations found among treatments employed. The graph indicated that dry matter of crop increased with time period till 150 DAS. The dry matter of crop increased (g plant^{-1}) very fast in treatment free from weeds as compared to weedy fields as per different treatments effect. Total dry matter of cotton crop was very low in treatment having severe attack of weeds. However, this reduction in dry matter may be due to weed competition for inputs such as moisture, space, light and nutrients. Dry matter of cotton was significantly affected due to interference with weeds including horse purslane. Our results are similar with the results described by Ghule *et al*. (2013) and Pawar *et al*. (2015) who stated that weeds suppressed the growth of cotton crop and ultimately declined crop growth

at initial stage of crop. Parvaiz *et al*. (2020) also reported that horse purslane was more competitive as compared to all other weeds which reduced the availability of all resources.

Crop growth rate (CGR) (Fig. 2) increased very fast till 120 DAS and then started to slow down. Crop-growth-rate was fast between 60-90 days after sowing in plot horse purslane and other weeds free crop for whole season as compared to other plots. The maximum CGR and uptake of all inputs resources were noticed in plot having no weeds. However, the minimum crop growth rate was observed in weedy check (all weeds) plot due to weeds becoming dominant over cotton. Cotton uptake minimum nutrients and other inputs due to weeds interference in weedy plots. Weeds release toxic materials that create hinders and decreased crop growth and physiological parameters of cotton crop. These results were collaborated with the findings reported by Sivakumari and Mohan (2009) when they reported that weeds were most dominate over sole crop which reduced the dry production.

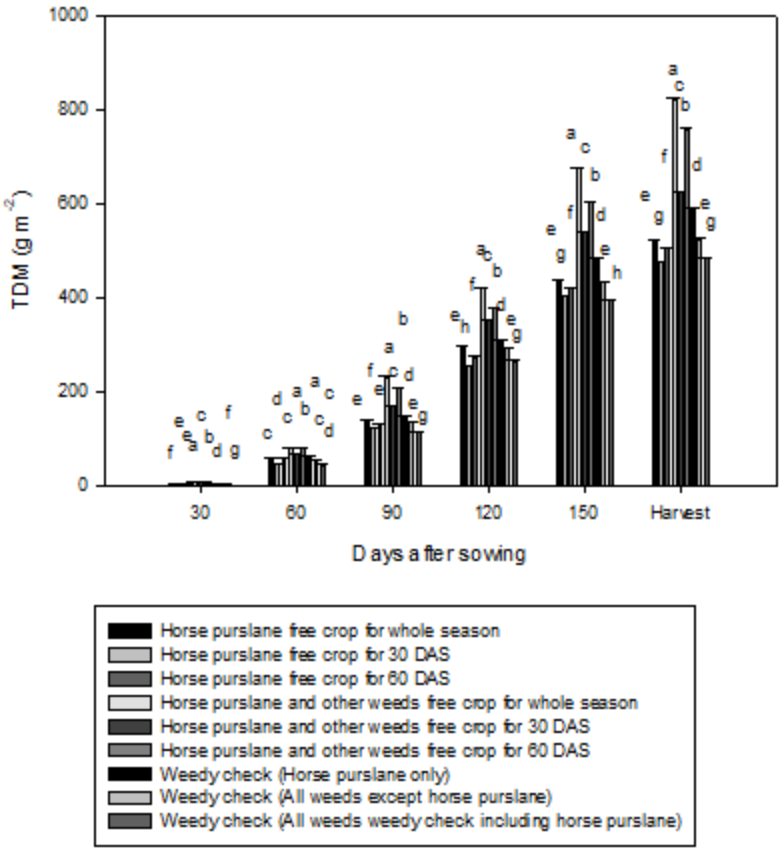

Fig. 1. Total dry matter (TDM) as affected by horse purslane interference in cotton field

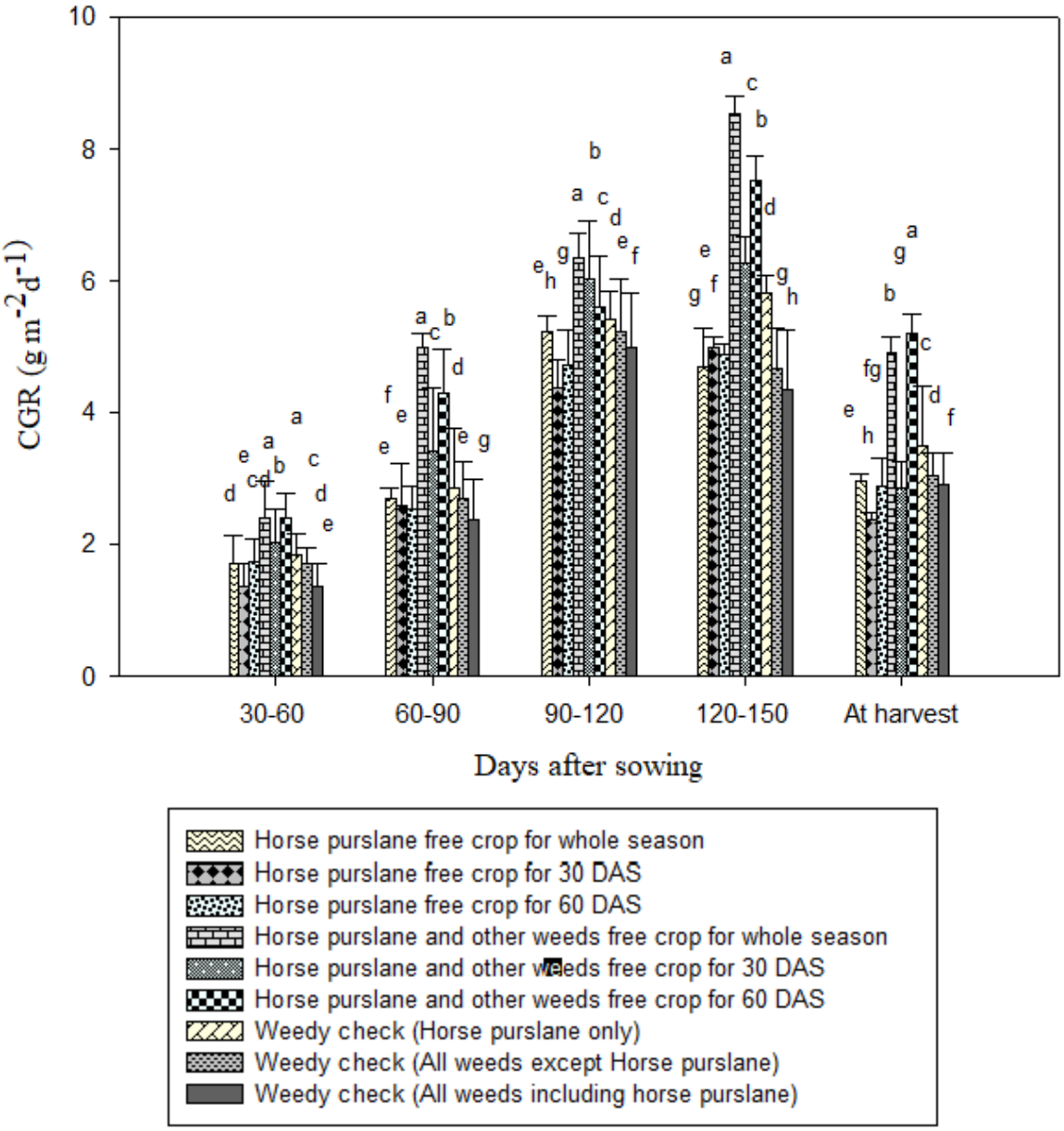

Fig.2. Crop growth rate (CGR) as affected by horse purslane interference in cotton field

Yield related parameters

Plant height of cotton crop at maturity presented in Table 3 showed that statistically significant differences were observed among treatments. The highest plant height was taken in plot having horse purslane and other weeds free crop for whole season (139.67 cm) but this value was statistically different with all other treatments. However, the minimum (83.53 cm) plant height was observed in weedy check (all weeds) plot. Weed free treatment showed maximum height as compared to weedy treatments due to lack of weed-crop interference. However, minimum plant height was taken in treatment having weedy check (all weeds) because weeds allowed to grow for whole season for determining the weed effect on

plant height but height of plant showed linear trend with increase in weed interference duration. This finding is similar with the results reported by Pawar *et al*. (2015) who also reported that maximum plant height was recorded in weed free treatment due to reduction in weed crop competition for nutrients, space, water, moisture etc.

The maximum number of bolls per plant were observed in treatment having horse purslane and other weeds free crop for whole season (38.00) and this value was statistically differed with all other treatments. Weeds had significant effect on total bolls per plant in weedy check (all weeds) as compared with weeds free plot. The minimum (9.27) number of bolls per plant were observed from plot having condition of weedy check (all weeds). The lowest number of bolls per plant were recorded in weedy check treatment to increase weed-crop-competition for inputs. However, these results were similar with the findings of earlier researchers Soliman *et al*. (2014) and Singh and Rathore (2015), when they stated that weeds were major problem in cotton crop which suppressed the crop growth and interfere with crop and reduced the bolls number per plant.

The data on average seed cotton weight per boll (g) was statistically significant among treatments under test. The maximum (2.79 g) average seed cotton weight per boll was recorded from horse purslane and other weeds free crop for whole season plot and this value was statistically at par with treatment having horse purslane and other weeds free crop for 60 DAS. The minimum value (2.08 g) of seed cotton weight per boll (g) was taken in weedy check (all weeds) plot as compared to all other treatments. Weeds reduced the average boll weight due to interference with all resources. Weeds greatly reduced the boll size and average boll weight. However, these results were similar with the findings of earlier researchers Soliman *et al*. (2014) and Singh and Rathore (2015) who also reported that favorable condition for growth provide better utilization of available resources.

Seed index showed statistically non-significant variation among treatments used during study. The maximum seed index (8.00 g) was obtained from plot where horse purslane and other weeds were not allowed to grow for whole season but minimum value (6.00 g) was observed in treatment having weedy check (horse purslane only) condition. In this treatment only horse purslane was allowed to grow for whole season of crop but all other weeds were removed manually from the plot. It showed the relative higher aggressively and interference potential of horse purslane over all other weeds infesting cotton field. It was an important observation while determining the seed index. However the impact of horse purslane interference is quite evident over all other prevailing weeds in weedy check situation in cotton field which can be related with higher interference ability (competition and allelopathic effect) of horse purslane on cotton. The findings for seed index was similar with the results of Chinnusamy *et al*. (2013) and Nadeem *et al.* (2013) who reported that genetic characters and aggressively potential of horse purslane had no change in seed index of cotton crop.

Yield data showed that there was a statistically significant variation among treatments employed. The higher seed cotton yield (3317.3 kg ha^{-1}) was achieved in treatment having horse purslane and other weeds free crop for whole season. Followed by the treatment having horse purslane and other weeds free crop for 60 DAS (3016.7 kg ha^{-1}). The minimum seed cotton yield was recorded in treatment having weedy check (all weeds) (1480.7 kg ha^{-1}). The increase in seed cotton yield was 23.45%, 14.27% and 18.07% in horse purslane free crop for whole season, for 30 DAS, and 60 DAS respectively, as compared to all weeds (weedy check). Similarly the increase in seed cotton yield was 124%, 63.48%, and 104% in horse purslane and other weeds free crop for whole season, for 30 DAS

and for 60 DAS respectively, as compared to all weeds (weedy check). Weeds hinder the growth of crop which results in less number of bolls per plant in weedy plots. The highest yield was obtained in weed free crop for whole growing season as compared to rest of the treatments. In weed free treatment crop growth was fast, plant height, bolls per plant, leaf area index and dry matter production improved due to no interference of weeds up till 60 DAS unlike the weedy treatments. These results were in accordance with the findings of Singh and Rathore (2015) who reported that increase in seed cotton yield may be attributed to good utilization of available resources in weed free treatment as compared to weedy treatments and hence decreased the weed-crop competition and ultimately increased yield.

Ginning out turn (GOT) percentage, showed statistically non-significant differences among treatments employed. The maximum GOT was observed in plot having horse purslane free crop for whole season (42.40%). However, the minimum GOT was taken in treatment having weedy check (all weeds) (40.04%) as compared with other treatments. Weeds interference greatly reduced the GOT. Our results are quite in accordence with findings as reported by Chinnusamy and Chinnagounder (2013) and Nadeem *et al*, (2013) who stated that GOT is varietal character and had no change in results due to any external factors.

Table 4. **Yield related parameters of cotton as affected by horse purslane interference**

Treatments	Plant height (cm)	Total bolls plant^{-1}	Opened bolls plant^{-1}	Boll weight (g	NAR (g m^{-2} d^{-1})	Seed index (g)	Yield (kg ha^{-1})	GOT (%)
T_1	90.07 d	16.87 de	13.13 d	2.13 ef	3.1127 c	6.6667 ns	1828.0 d	42.40ns
T_2	84.50 d	16.07 de	12.83 de	2.04 f	3.0557 c	7.3333	1692.0 ef	42.033
T_3	86.67 d	16.77 de	12.93 de	2.10 ef	3.0843 c	6.6667	1748.3 e	41.533
T_4	139.67 a	38.00 a	30.87 a	2.79 a	3.6857 a	8.0000	3317.3 a	41.533
T_5	109.83 c	28.53 c	21.13 c	2.48 bc	3.1230 c	6.6667	2420.7 c	41.400
T_6	129.40 b	33.63 b	25.43 b	2.64 ab	3.4553 b	7.3333	3016.7 b	41.400
T_7	102.63c	18.27de	12.37de	2.25 cd	3.0830 c	6.0000	1846.0 d	40.433
T_8	91.43 d	15.10 e	11.40 e	2.16 de	3.1133 c	6.6667	1656.0 f	40.067
T_9	87.53 d	9.27f	7.47 f	2.08 f	2.8177 d	6.6667	1480.7g	40.041
HSD Tukey's value	8.277	2.731	1.6865	0.184	0.1356	3.064	65.86	2.8743

Similar letter showed non-significant differences among treatment means

T_1: Horse purslane free crop for whole season, **T_2**: Horse purslane free crop for 30 days after sowing, **T_3**: Horse purslane free crop for 60 days after sowing, **T_4**: Horse purslane and other weeds free crop for whole season, **T_5**: Horse purslane and other weeds free crop for 30 days after sowing, **T_6**: Horse purslane and other weeds free crop for 60 days after sowing, **T_7**: Weedy check (Horse purslane only), **T_8**: Weedy check (All weeds except horse purslane) and **T_9**: Weedy check (All weeds including horse purslane)

Economic analysis

Economic analysis of each treatment was performed to find the competitiveness of weed with cotton. Table 5 indicated that in plots which were kept all weeds free for 60 DAS performed best and gave maximum net return per hectare (Rs. 125418). The highest benefit to cost ratio (BCR) (1.70) obtained from plot where all weeds were not allowed to compete with crop for 60 DAS as compared to all other treatments. Minimum BCR was obtained in treatment weedy check (all weeds except horse purslane) (1.02) than weedy check (all weeds) treatment (1.06) due to differences in weed control practices as per treatment. Cost of weed control practice decreased the net benefit. The results of benefit to cost ratio were in accordance with Saeed *et al*. 2015; Chaudhary *et al*. (2011) and Amir *et al*. (2013) who stated that weeds control practice reduced the net income.

Table 5. Economic analysis

Treatments	Fixed cost (Rs. ha^{-1})	Variable cost (Rs. ha^{-1}) Weeding+ picking	Total cost (Rs. ha^{-1})	Seed cotton kg ha^{-1}	Gross income R.s 101.25 kg^{-1}	Benefit net income (Rs. ha^{-1})	BCR
T_1	141856	22500+ 10968	175324	1828	185085	9761	1.06
T_2	141856	5000 + 10152	157008	1692	171315	14307	1.09
T_3	141856	10000+ 10488	162344	1748	176985	14641	1.09
T_4	141856	45000+ 19896	206752	3316	335745	128993	1.62
T_5	141856	10000+ 14520	166376	2420	245025	78649	1.47
T_6	141856	20000+ 18096	179952	3016	305370	125418	1.70
T_7	141856	33750+ 11076	186682	1846	186907.5	225.5	1.00
T_8	141856	22500 + 9936	174292	1656	167670	-6622	0.96
T_9	141856	0 + 8882.4	150738.4	1480.4	149890.5	-847.9	0.99

BCR: Benefit to cost ratio

T_1: Horse purslane free crop for whole season, **T_2**: Horse purslane free crop for 30 days after sowing, **T_3**: Horse purslane free crop for 60 days after sowing, **T_4**: Horse purslane and other weeds free crop for whole season, **T_5**: Horse purslane and other weeds free crop for 30 days after sowing, **T_6**: Horse purslane and other weeds free crop for 60 days after sowing, **T_7**: Weedy check (Horse purslane only), **T_8**: Weedy check (All weeds except horse purslane) and **T_9**: Weedy check (All weeds including horse purslane)

CONCLUSIONS

From the present study, it can be concluded that horse purslane competitiveness could not increase over the purple nut sedge dry mass and competitiveness due to enriched soil seed bank of purple nut sedge in the study site for its effect on growth and yield of cotton. Farmers should keep an eye on field history for type of weed infesting the cotton field. In field situation the farmers should control all weeds including horse purslane within 60 DAS to reduce weed crop competition for obtaining higher seed cotton yield and economic benefits under agro ecological conditions of South Punjab (Multan) Pakistan.

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