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Article

WEEDS BIOMASS AS AFFECTED BY TILLAGE PRACTICES AND CROPPING SYSTEMS UNDER A SEMIARID ENVIRONMENT

Biomassa de Plantas Daninhas Afetada por Práticas de Lavoura e Sistemas de Cultivo em Ambiente Semiárido

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ABSTRACT - Tillage practice has a significant role on weeds eradication and soil water conservation in crop production. Under semiarid agriculture, the monsoon rains (65%) are major source of water in Potohar, Pakistan, which can effectively be used mostly for winter crops production. To evaluate the impact of different tillage system for prevailing cropping systems and their weeds biomass under semiarid conditions, field experiment was conducted at the Arid University Research Farm Koont Rawalpindi (Pakistan) during crop growth seasons 2013-14 and 2014-15. Tillage systems as treatments were (a) three cultivations with a cultivator, as control treatment, (b) mold-board with two cultivations, (c) chisel-plough with two cultivations and (d) minimum tillage (only tillage performed at sowing time) with glyphosate. Sowing was made using drill for all cropping systems i.e. a, b, and d except c which was planted on bed (made by bed planter). In addition to ploughing treatments, different cropping systems (a) wheat - fallow (b) wheat and brassica - fallow, (c) wheat and chickpea - fallow and (d) wheat - cluster bean (green manure crop) were also used for minimum two years rotations. On average in both study years, interactive effect of treatments (mold board with 2 cultivations) for the rotation wheat and brassica - fallow showed a reduction in weeds dry biomass of *Anagallis arvensis* (blue pimpernel, 55.6%), *Asphodelus tenuifolius* (jungle onion, 42.3%), *Chenopodium album* (common goosefoot, 40.8%), *Circium arvense* (creeping thistle, 53.1%), *Convolvulus arvensis* (field bind weed, 56.6%) and *Cynodon dactylon* (vilfa stellata, 45.8%) within 60 days after sowing (DAS) as compared with the control treatment (three cultivations on a wheat - fallow cropping system). Similar trends were observed at the crop maturity stage. Results of the experiment showed that better weed biomass suppression can be achieved by using moldboard plough for cultivation with followed by wheat-brassica cropping system and/or wheat - chickpea intercropping for semiarid soil condition in Pakistan.

Keywords: tillage, cropping systems, weeds, biomass, semiarid.

RESUMO - A prática do plantio direto tem papel significativo na erradicação das plantas daninhas e na conservação da água do solo na produção agrícola. Na agricultura semiárida, as chuvas de monção (65%) são a principal fonte de água em Potohar, no Paquistão, que pode ser efetivamente usada sobretudo para produção de culturas de inverno. A fim de avaliar o impacto de diferentes sistemas de preparo do solo nos sistemas de cultivo predominantes e na biomassa de suas plantas daninhas em condições semiáridas, foi realizado um experimento de campo na Fazenda de Pesquisa da Universidade Árida de Koont Rawalpindi (Paquistão) durante as safras 2013-14 e 2014-15. Os sistemas de preparo do solo, como tratamentos, foram: (a) três cultivos com cultivador, como tratamento controle; (b) placa de molde com dois cultivos; (c) arado de cinzel com dois cultivos; e

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(d) preparo mínimo (somente o plantio realizado no momento da semeadura) com glifosato. A semeadura foi feita com broca para todos os sistemas de cultivo, ou seja, a, b e c, exceto c, que foi plantada no canteiro (feita pelo plantador de canteiros). Além dos tratamentos de lavra, diferentes sistemas de cultivo [(a) trigo - pousio, (b) trigo e brássica - pousio, (c) trigo e grão-de-bico - pousio e (d) trigo-feijoeiro (cultura de adubo verde)] também foram utilizados para rotações de dois anos. Em média, nos dois anos de estudo, o efeito interativo dos tratamentos (placa de mofo com dois cultivos) para a rotação trigo e brássica - pousio mostrou redução na biomassa seca de plantas daninhas de ***Anagallis arvensis*** *(pimpernel-azul, 55,6%),* ***Asphodelus tenuifolius*** *(cebola-da-selva, 42,3%),* ***Chenopodium album*** *(arrepio-comum, 40,8%),* ***Circium arvense*** *(cardo-rastejante, 53,1%),* ***Convolvulus arvensis*** *(planta daninha, 56,6%) e* ***Cynodon dactylon*** *(****Vilfa stellata****, 45,8%) dentro de 60 dias após a semeadura (DAS), em comparação com o tratamento controle (três cultivos em sistema de cultivo de trigo e pousio). Tendências semelhantes foram observadas no estágio de maturidade da cultura. Os resultados do experimento mostraram que uma melhor supressão de biomassa de plantas daninhas pode ser alcançada usando o arado de aiveca para o cultivo, seguido pelo sistema de cultivo de trigo-brássica e/ou consórcio de trigo/grão-de-bico para condições de solo semiárido no Paquistão.*

Palavras-chave: cultivo, sistemas de cultivo, plantas daninhas, biomassa, semiárido.

INTRODUCTION

Short duration crops like chickpea, groundnut, barley and millets are frequently found in semiarid fields of Pakistan (Naz et al., 2010). Growing of single crop in semiarid region has promoted weeds growth (Anderson, 2017). Deep tillage at low rainfall areas suppressed weeds growth and gave better yield with efficiently conserving moisture in soil layers compared with no tillage and/or shallow tillage practices (Triplett and Dick, 2015). Appropriate inter-cropping with a suitable tillage may suppress weeds growth and could support main crop growth (Wolfe et al., 2008). Inter-cropping and deep tillage practices in rainfed areas conserved moisture efficiently, which otherwise lost due to field exposure to the solar radiation with single cropping round the year (Xing-Bin et al., 2014).

Weeds such as *Anagallis arvensis, Asphodelus tenuifolius, and Chenopodium album* are the most extensive class of many crops like chickpea, groundnut, barley and millets which cause partial to complete crop damage over the wide areas in world mainly in the South Eastern countries (Taghinazhad et al., 2012).Weeds infestation have reduced crop yield and reduce the quality of end product. Weeds bigger in size have an adverse effect on yield of many crops (Heckman et al., 2016). Weeds not only compete with crops for soil fertility, moisture, nutrients, space and light but also contaminated quality of the produce (Lemaire et al., 2014). Losses in yield are recorded up to 80% in many field crops e.g. in Pakistan weeds growth is out of control (Parker, 2016). Tillage practices with appropriate cropping systems seems to be more effective in controlling weeds, diseases and pest (Abawi and Widmer, 2017). The introductions of modern weed control techniques include cropping patterns proved effective in increasing productivity (Passioura, 2013). It is also found that a number of weeds (e.g. Perennial weeds) have declined rapidly and becomes extinct by techniques of different cropping systems (Liebman and Davis, 2015).

The objective of this study was to identify a tillage practice suits better with the cropping system that is relatively effective in controlling weeds population e.g. *Anagallis arvensis* (blue pimpernel), *Asphodelus tenuifolius* (jungle onion), *Chenopodium album* (common goosefoot), *Circium arvense* (creeping thistle), *Convolvulus arvensis* (field bind weed) and *Cynodon dactylon* (vilfa stellata).

MATERIALS AND METHODS

Experimental site

A field experiment was laid down at University Research Farm, Koont Rawalpindi (Pakistan). Impact of different tillage practices and cropping systems was conducted on weeds biomass under semiarid condition during the growth season 2013-14 and repeated in 2014-15. Soils of this region are mostly clay-loam with pH 7.5 to 8.5.

Tillage treatments and cropping systems which were applied are: T_1 = three cultivations/ control (drill sowing), T_2 = mold board + two cultivations (drill sowing), T_3 = chisel + two cultivations (bed plant sowing) and T_4 = minimum tillage + glyphosate (drill sowing), whereas cropping system include; CS_1 = wheat - fallow, CS_2 = wheat + brassica - fallow - CS_3 = wheat + chickpea - fallow and CS_4 = wheat - cluster bean (green manuring).

Experiment was conducted by using randomized complete block design with strip-plot arrangements in three replications. Each plot size have dimension of 6 m × 8 m for both cropping seasons. The experimental design contains four horizontal tillage strips in each replication in which four cropping systems were randomized accommodated vertically. Tillage treatments included (T_1) 3 cultivations which were performed by using cultivator during the experiment. One tillage treatment was performed before start of onset of the monsoon (i.e. 120 days before sowing of crops) and other two were performed before sowing of crop. In T_1 sowing was performed with seed drill and in all treatments of tillage planker was used for land leveling. In tillage practice (T_2), single cultivation was done by using mould board plough before start of monsoon and two cultivations with cultivator before sowing of crop, while the seed was sown with seed drill. In T_3 one chisel ploughing with two cultivations were performed, and seed was sown with seedbed planter. Chisel plough was operated before start of monsoon season (i.e. 120 days before sowing of crops) and two ploughing with cultivator were performed before sowing of the crop. In tillage treatment (T_4) minimum tillage was performed i.e. the only a single tillage practice was done for seedbed preparation by using cultivator. In T_4 Sowing of seed was done with seed drill.

Cropping system (CS_1) contains wheat in winter 2013-14 followed by no crop in summer 2014. In the 2nd cropping system (CS_2) wheat with brassica sown in winter 2013-14 and no crop was planted in summer 2014. In the 3rd cropping system (CS_3) wheat with chickpea was sown in winter 2013-14 and no crop was planted in summer 2014. In cropping systems i.e. CS_1, CS_2 and CS_3 weeds of fallow period were eliminated by applying glyphosate (Round Up). Wheat was sown in CS_4 in winter 2013-14 followed by Cluster bean (as green manure) in summer 2014. Wheat (*Triticum aestivum*) variety 'Chakwal-50' was used with a seeding rate of 100 kg ha^{-1} by planting in rows spaced 25 cm. Fertilizers were applied yielding N 90, P_2O_5 60 and K 60 (kg ha^{-1}) from urea, di-ammonium phosphate (DAP) and potassium sulphate, sources, respectively. Chickpea (*Cicer arietinum*) variety PAK-86 was planted in rows spaced at 45 cm, using a seed rate of 60 kg ha^{-1}. Fertilizer was applied N 25 m, P_2O_5 50 and K 20 (kg $ha^{-1)}$ from the sources explained for wheat crop. Brassica (*Brassica napus*) cultivar Shiralee was obtained from National Agriculture Research Centre (NARC), Islamabad, Pakistan and was sown with a seed rate of 4 kg ha^{-1} in rows spaced 40 cm. The fertilizer was used at the rate of 50-45-45 kg ha^{-1} N-P-K, respectively. Cluster bean (*Cyamopsis tetragonoloba*) cultivar BR-99 was sown with seed rate of 75 kg ha^{-1} in rows spaced 35 cm. The fertilizer dose was 25-50-50 kg ha^{-1} N-P-K. Controlling weeds in fallow period, non-selective herbicide (glyphosate) was sprayed at the rate of 1 lit $acre^{-1}$ by using hand knap sack sprayer. Tillage and cropping systems interaction was observed on different weeds dry biomass on two stages of crops i.e. after 60 days and at maturity. Plots having cluster bean were used green manuring purpose.

Weed biomass (g m^{-2})

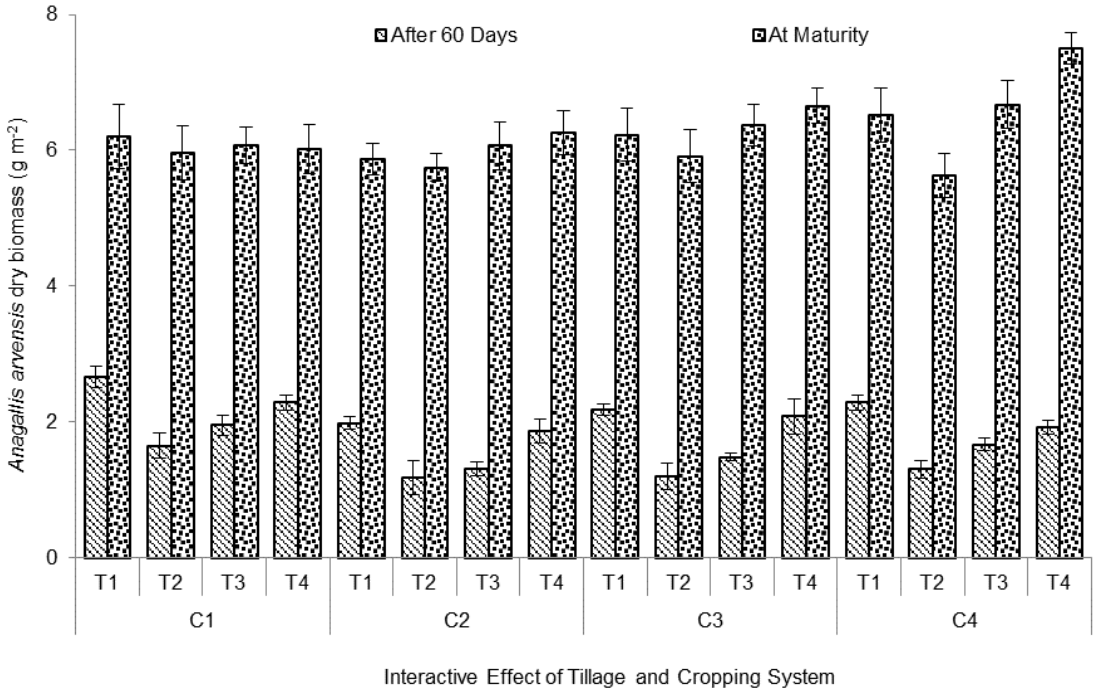
After recording the fresh biomass of weeds samples brought to laboratory for recording their oven-dry biomass. The samples were kept in oven at 65 °C till a constant weight achieved, i.e. about 48 hours. It was expressed as dry biomass per meter. Weeds dry biomass was calculated after 60 days and at maturity of winter crops.

Statistical Analysis

Analysis of variance was determined and means were compared by employing Least Significant Difference (LSD) test at 5% level of probability. The statistical work was done using the computer based statistical package MSTATC following Steel et al. (1997).

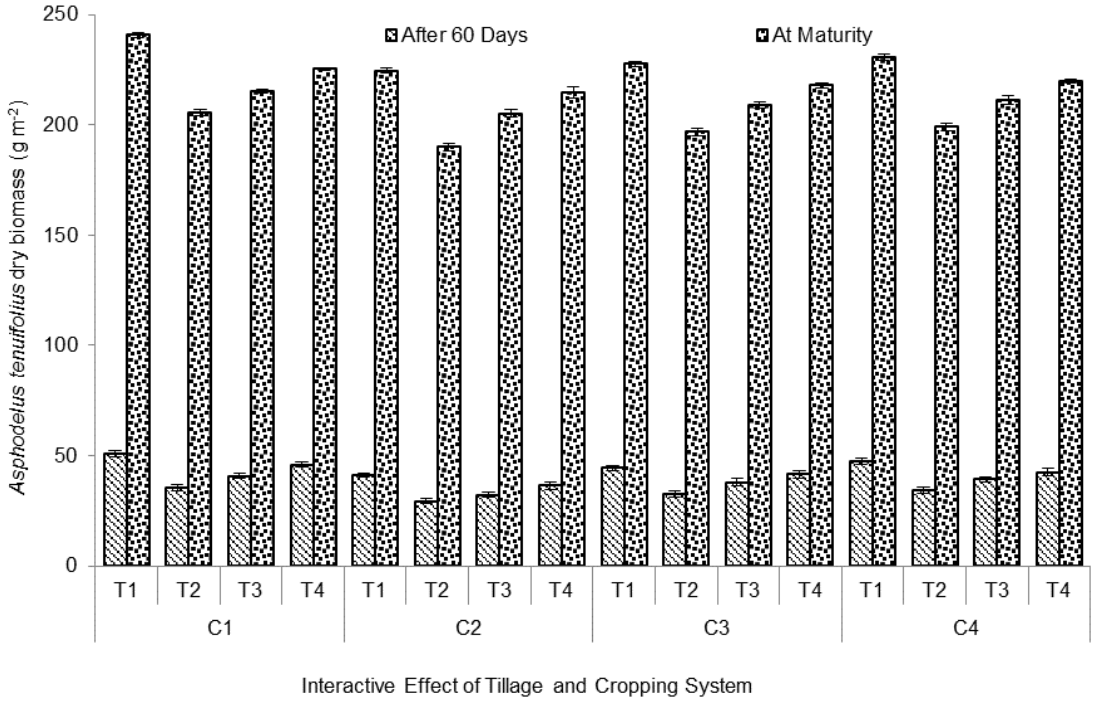
RESULTS AND DISCUSSION

Interactive effect for tillage and cropping systems on *Anagallis arvensis* dry biomass was determined at two stages i.e. after 60 days and at maturity of crops. Results revealed that dry biomass of *Anagallis arvensis* were significant at both the stages during couple of the study years. T_1 (3 cultivations/control) with CS_1 (wheat-fallow – wheat-fallow) interaction showed highest weed dry biomass after 60 days and at maturity. T_4 (minimum tillage + glyphosate) with CS_1 gave 2nd highest values after T_1 with CS_1 after 60 days and at maturity. The lowest values of interaction revealed by T_2 (mold board + 2 cultivations) with CS_2 (wheat + brassica- fallow- wheat + brassica-fallow) at both stages (Figure 1). After 60 days T_2 with CS_2 gave 55.6% less weed dry biomass as compared to T_1 with CS_1 and 74.7% less at maturity stage. *Asphodelus tenuifolius* dry biomass was also determined after 60 days of crops emergence and at maturity of crops. Interactive effect of tillage and cropping systems at both the stages also gave significant differences. T_1 with CS_1 interaction showed highest weed dry biomass i.e. 50.70 g m^{-2} after 60 days and 240.67 g m^{-2} at maturity. Lesser values of interaction showed by T_2 with CS_2 at both stages; 29.25 g m^{-2} were observed after 60 days and 189.87 g m^{-2} at 2nd stage of crops. After the interaction of T_2 with CS_2 2nd lowest values was recorded in T_3 with CS_2 at both the stages (Figure 2). Results of the study revealed that *Chenopodium album* dry biomass at both stages of crops gave significant differences. T_1 interaction with CS_1 reflected the highest values of weed dry biomass. The lowest values can be seen in interaction of T_2 with CS_2 at both stages. T_3 with CS_2 also revealed lower values than T_1 with CS_2 and T_4 and CS_2 (Figure 3). Interaction between T_2 with CS_2 produced 40.9% less dry biomass of *Chenopodium album* after 60 days and 55.1% less at maturity as compared to T_1 with CS_1 during both the study years. Weed dry biomass of *Circium arvense* was also determined and the interactive effect of tillage and cropping systems at both the stages depicted significant results. T_1 with CS_1 interaction showed the highest weed dry biomass at both the stages. The lowest values of interaction can be observed in interaction between T_2 with CS_2 at both stages (Figure 4). *Convolvulus arvensis* data regarding dry biomass also gave significant results. T_1 with CS_1 interaction revealed the highest weed dry biomass at both the stages. After T_1 with CS_1 it



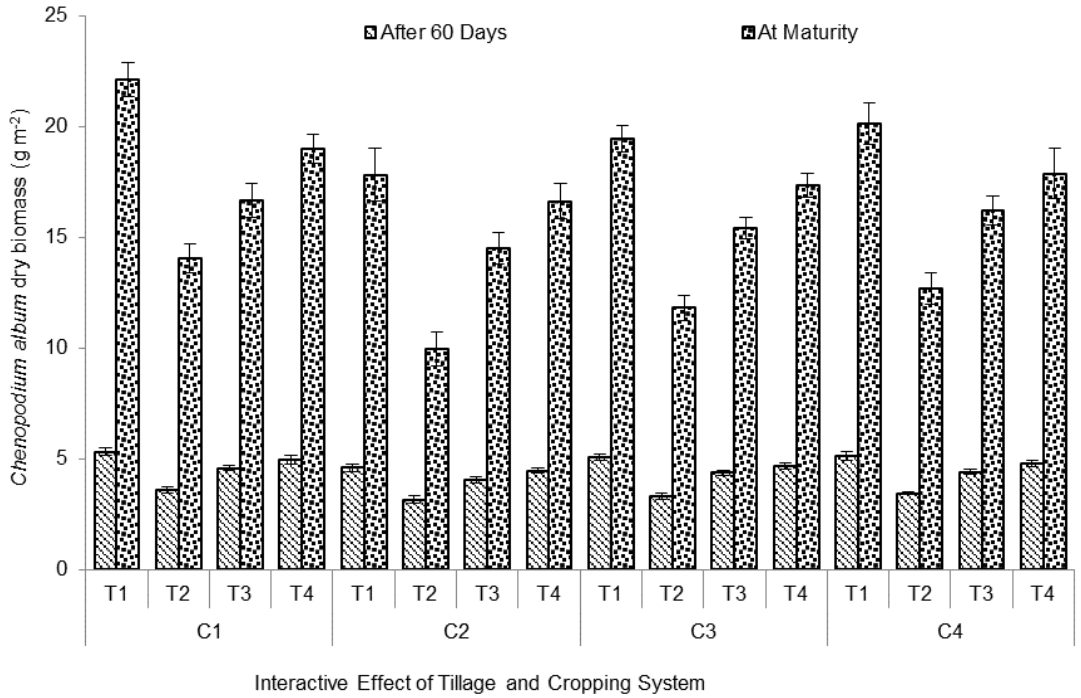
Whereas, T_1 = 3 cultivations/control (drill sowing), T_2 = mold board + 2 cultivations (drill sowing), T_3 = chisel + 2 cultivations (bed planting), T_4 = minimum tillage + glyphosate (drill sowing), CS_1 = wheat - fallow- wheat – fallow/control, CS_2 = wheat + brassica - fallow - wheat + brassica - fallow, CS_3 = wheat + chickpea- fallow - wheat + chickpea- fallow, CS_4 = wheat- cluster bean (green manuring) - wheat-cluster bean (green manuring).

Figure 1 - Study of Interaction between tillage treatments and cropping systems on *Anagallis arvensis* dry biomass (g m^{-2}) after 60 days and at maturity of crops over two years.



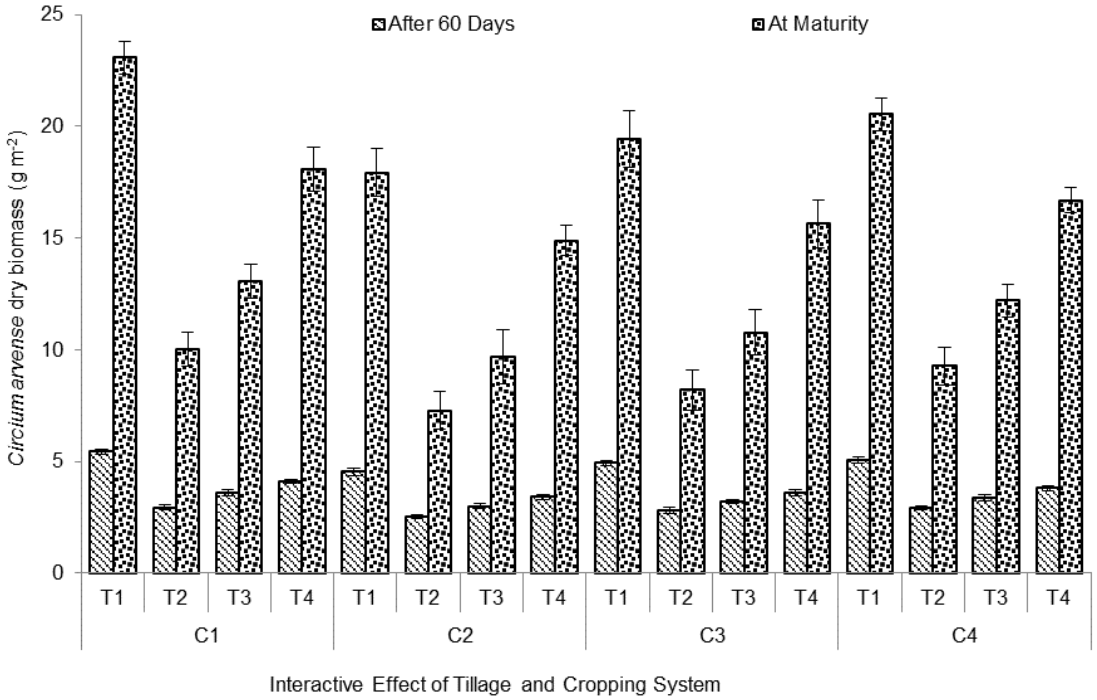
Whereas, T_1 = 3 cultivations/control (drill sowing), T_2 = mold board + 2 cultivations (drill sowing), T_3 = chisel + 2 cultivations (bed planting), T_4 = minimum tillage + glyphosate (drill sowing), CS_1 = wheat - fallow- wheat – fallow/control, CS_2 = wheat + brassica - fallow - wheat + brassica - fallow, CS_3 = wheat + chickpea- fallow - wheat + chickpea- fallow, CS_4= wheat- cluster bean (green manuring) - wheat- cluster bean (green manuring).

Figure 2 - Study of Interaction between tillage treatments and cropping systems on *Asphodelus tenuifolius* dry biomass (g m^{-2}) after 60 days and at maturity of crops over two years.



Whereas, T_1 = 3 cultivations/control (drill sowing), T_2 = mold board + 2 cultivations (drill sowing), T_3 = chisel + 2 cultivations (bed planting), T_4 = minimum tillage + glyphosate (drill sowing), CS_1 = wheat - fallow- wheat – fallow/control, CS_2 = wheat + brassica - fallow - wheat + brassica - fallow, CS_3 = wheat + chickpea- fallow - wheat + chickpea- fallow, CS_4= wheat- cluster bean (green manuring) - wheat- cluster bean (green manuring).

Figure 3 - Study of Interaction between tillage treatments and cropping systems on *Chenopodium album* dry biomass (g m^{-2}) after 60 days and at maturity of crops over two years.

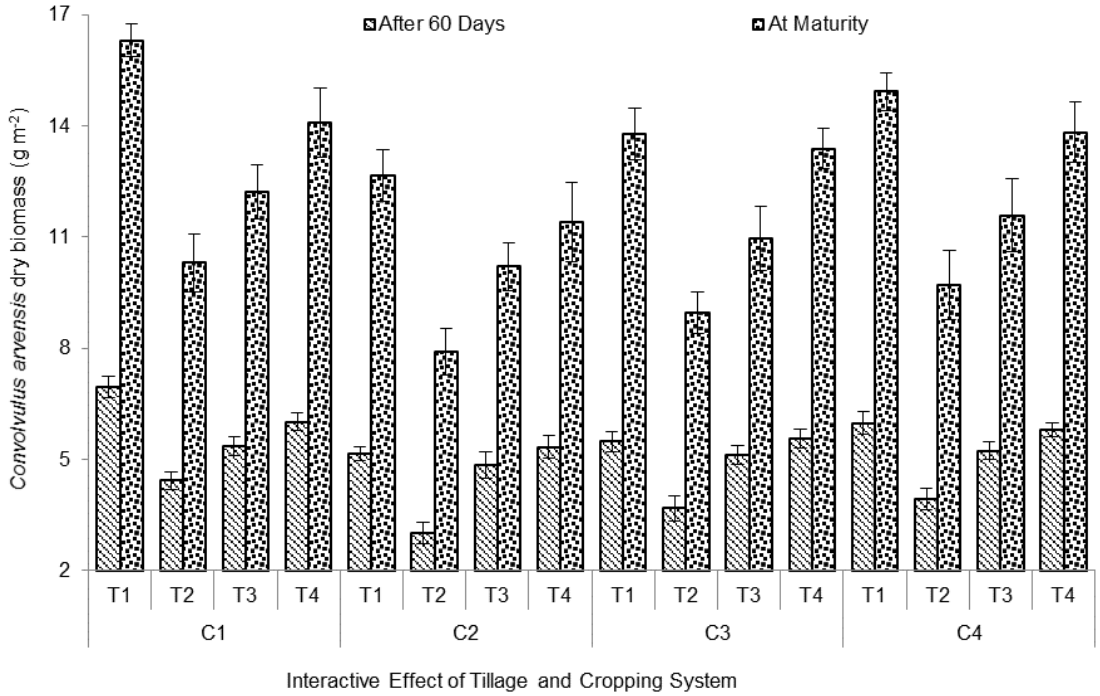


Whereas, T_1 = 3 cultivations/control (drill sowing), T_2 = mold board + 2 cultivations (drill sowing), T_3 = chisel + 2 cultivations (bed planting), T_4 = minimum tillage + glyphosate (drill sowing), CS_1 = wheat - fallow- wheat – fallow/control, CS_2 = wheat + brassica - fallow - wheat + brassica - fallow, CS_3 = wheat + chickpea- fallow - wheat + chickpea- fallow, CS_4 = wheat- cluster bean (green manuring) - wheat- cluster bean (green manuring).

Figure 4 - Study of Interaction between tillage treatments and cropping systems on *Circium arvense* dry biomass (g m^{-2}) after 60 days and at maturity of crops over two years.

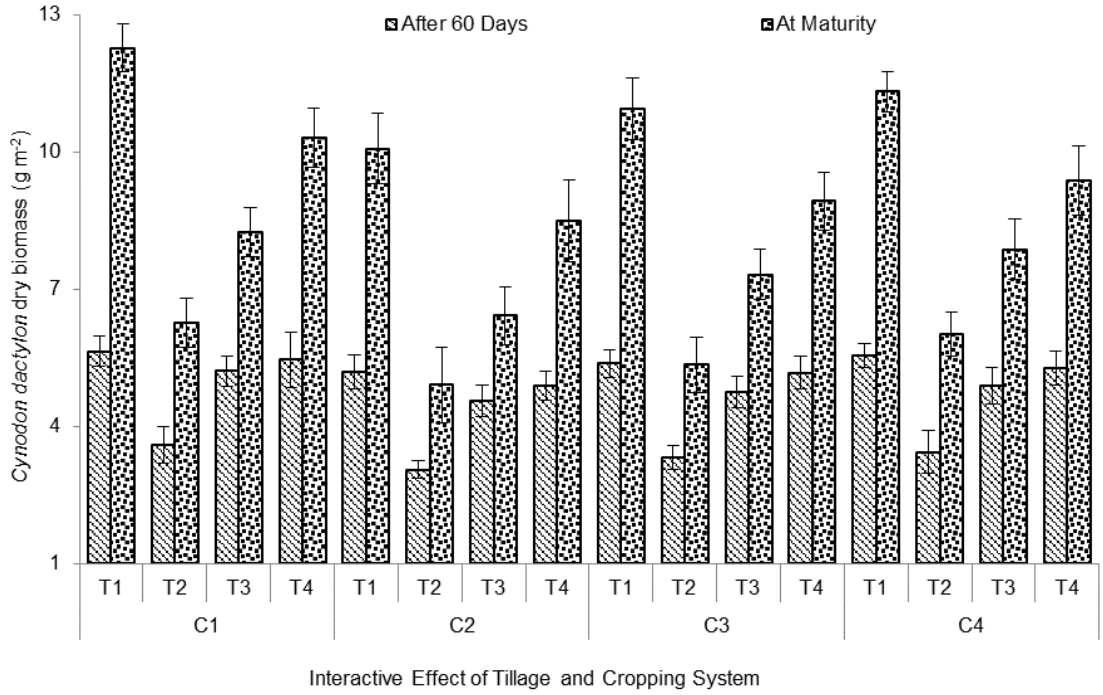
can be observed that T_4 with CS_1 provided 2nd maximum value at both the stages. The lowest values of interaction were observed in interaction of T_2 with CS_2 at both stages. T_3 with CS_2 also revealed lesser dry biomass than T_1 with CS_2 and T_4 with CS_2 (Figure 5). Weed dry biomass of *Cynodon dactylon* revealed significant results at both stages. T_1 with CS_1 interaction revealed the highest weed dry biomass. The lowest values of interaction were obtained by the interaction of T_2 with CS_2 at both stages of crops. T_3 (chisel + 2 cultivations) with CS_2 after T_2 with CS_2 gave 2nd minimum (Figure 6). The interaction of T_2 with CS_2 at first stage produced 45.8% less weed dry mass and 60% less at maturity stage as compared to the interaction of T_1 with CS_1 during both study years (Figure 6).

Results of the findings described that *Anagallis arvensis* dry biomass after 60 days of crops growth showed less values as compared to maturity of the crops. This might happened due to less availability of moisture during early stage of crops growth. The abrupt increase in dry biomass revealed that presence of sufficient moisture can enhanced this weed growth vigorously. Wheat intercropping with brassica and chickpea retard the weed growth, as these crops due to their spreading nature provided less space to this weed to spread. Tillage treatment T_2 i.e. deep tillage with mold-board plough also control *Anagallis arvensis* dry biomass efficiently by conserving moisture during monsoon. The conserved moisture used the crops during winter and competes with weeds. These results are also in line with (Chauhan et al., 2012; Mirsky et al., 2010; Brainard et al., 2013) who described that *Anagallis arvensis*dry biomass can be suppressed if deep tillage operations along with intercropping of spreading nature crops done under rainfed condition. Most of the weeds have capability to tolerate drought and can survive under harsh climatic conditions, such as *Asphodelus tenuifolius* under arid and semi-arid condition can survive and grow vigorously if not control at proper time (Teasdale and Mohler, 2016). In T_2 deep tillage with mold board plough showed better suppressive effect of this weed dry biomass as compared to rest of tillage operations. By doing conventional tillage weeds seeds again enter in soil and grow again and again. Due to the dominance they increase their growth and ultimately their dry biomass. In cropping system CS_1 only wheat grow round the year which promoted this weed



Whereas, T_1= 3 cultivations/control (drill sowing), T_2= mold board + 2 cultivations (drill sowing), T_3= chisel + 2 cultivations (bed planting), T_4= minimum tillage + glyphosate (drill sowing), CS_1= wheat - fallow- wheat – fallow/control, CS_2= wheat + brassica - fallow - wheat + brassica - fallow, CS_3 = wheat + chickpea- fallow - wheat + chickpea- fallow, CS_4= wheat- cluster bean (green manuring) - wheat- cluster bean (green manuring).

Figure 5 - Study of Interaction between tillage treatments and cropping systems on *Convolvulus arvensis* dry biomass (g m^{-2}) after 60 days and at maturity of crops over two years.



Whereas, T_1= 3 cultivations/control (drill sowing), T_2= mold board + 2 cultivations (drill sowing), T_3= chisel + 2 cultivations (bed planting), T_4= minimum tillage + glyphosate (drill sowing), CS_1= wheat - fallow- wheat – fallow/control, CS_2= wheat + brassica - fallow - wheat + brassica - fallow, CS_3 = wheat + chickpea- fallow - wheat + chickpea- fallow, CS_4= wheat- cluster bean (green manuring) - wheat- cluster bean (green manuring).

Figure 6 - Study of Interaction between tillage treatments and cropping systems on *Cynodon dactylon* dry biomass (g m^{-2}) after 60 days and at maturity of crops over two years.

growth due to land fallowing during summer, mono cropping and improper moisture conservation. Similar conclusion was also reported by Parihar (2014). Crops that have spreading nature if intercropped properly then they can suppress *Chenopodium album* dry biomass. Crops plants retard the weeds if they are more in number as they use the nutrients efficiently which otherwise weeds plant absorbs (Robbins, 2012). Shallow tillage with chisel plough and cultivator is also not affective because these practices not uproot the previous weeds. That is the reason that in our experiment except T_2 all tillage treatments not controlled this weed effectively. Similar findings regarding shallow tillage and intercropping effect on this weed also reported by Peigne et al. (2016) and Bàrberi (2015). *Circium arvense* growth can be controlled if proper tillage operations and cropping systems performed at proper time. Intercropping with suitable crops in semiarid area along with deep tillage practices can control this weed growth affectively Gour (2014). During second year of study tillage treatment T_2 and cropping system CS_2 gave better results in regard of this weed control followed by T_3 as compared to other tillage and cropping systems. T_1 and CS_1 not conserved the moisture properly during monsoon for better crop growth and this weed become dominant under these systems. Relevant findings had also been discussed by (Chauhan et al., 2012). The interaction for T_1 and CS_1 produced the highest weed dry biomass and due to better control lowest values of interaction gave by T_2 and CS_2 regarding *Convolvulus arvensis* dry biomass. This weed is also the dominant weed of rainfed as well as sandy loam areas and can grow efficiently under water deficit condition. In our experiment deep tillage with mold board plough uproot the remains of previous plant of this weed very affectively as compared to other tillage operations. In CS_2 intercropping with brassica, whereas, in CS_3 intercropping with chickpea suppressed this weed growth; this might be due to spreading nature of these crops. Similar findings regarding different tillage treatments and shading effect of spreading nature crops on weeds growth also documented by Barroso et al. (2014), Mashingaidze et al. (2012) and Locke et al. (2012). *Cynodon dactylon* because of its perennial nature can grow under all climatic conditions, even under less amount of moisture available to this weed. Improved cropping systems as well as multiple cropping systems can suppressed the growth of this weed Kornecki et al. (2017). Results of our findings also showed that tillage treatment T_2 performed best to control this weed. Mono-cropping and less deep tillage practices were not good to suppress this weed, as in mono-cropping more space available to this weed to spread vigorously growth because of its deep ploughing capability, which otherwise caused nutrients deficiency Terefe et al. (2012).

It can be concluded that growing of more than one crop on a piece of land or intercropping with legume such as chickpea is the most appropriate technique for effective weed biomass control of Blue pimpernal, Jungle onion, Common goosefoot, Creeping thistle, Field bind weed and vilfa stellata. Soil tillage made by mold board plough with two cultivations adopting the cropping system of wheat and brassica – Fallow may give better suppression of above mentioned weeds under semiarid condition in Pakistan.

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