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Influence of different tillage and cropping systems on weeds density and crops yield under rainfed condition

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Abstract

In rainfed areas main reason of poor crops stand is the weed infestation as well as mono cropping and conventional tillage practices round the year. Different tillage practices and cropping systems can suppress weeds growth and ultimately can improve crops yield. The present field experiment was conducted to assess the effect of different tillage practices and cropping system on weeds density, moisture conservation and crops yield at University Research Farm Koont Rawalpindi (Pakistan) during 2013-2015. Different tillage and cropping systems used during the experiment were T_1= 3 cultivations (Drill sowing), T_2= Mold board+ 2 cultivations (Drill sowing), T_3= Chisel + 2 cultivations (Bed planting), and T_4= Minimum tillage + Glyphosate (Drill sowing) CS_1= Wheat- Fallow- Wheat Fallow, CS_2 = Wheat + Brassica- Fallow- Wheat + Brassica- Fallow, CS_3 = Wheat + Chickpea- Fallow- Wheat + Chickpea- Fallow, CS_4 = Wheat- Guar (Green manuring) - Wheat- Guar (Green manuring) . Strip plot design was used to carry this experiment with three replications. Weed density and yield and yield components of wheat, brassica and chickpea were recorded during the experiment. The study showed that tillage treatment T_2 along with cropping system CS_3 followed by CS_2 controls weeds population density more affectively. Whereas, yield of crops also enhanced by tillage treatment T_2 along with cropping system CS_3 followed by CS_2.

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Introduction

Conventional tillage practices and mono cropping systems in rainfed regions are the main reason of low net farms income, low cropping intensity and limited yield index (Arif and Malik, 2009). The present mono cropping systems in rainfed areas does not make proficient use of rainfall (Arif, 2009). Deep tillage during monsoon and inter cropping limits the weeds growth, enhanced water infiltration and can improve yield of different crops (Singh *et al*., 2011).

Disturbance of land again and again by using deep tillage practices not only promotes weed densities but also nutrients loss occurs to great extent as compared tointercropping and less disturbance of soil under rainfed condition (Lima *et al.,* 2010). Water use efficiency can be enhanced by doing intercropping with different crops and by multiple cropping systems as compared to land fallowing in monsoon season, this not only stimulate crops growth but also suppressed weeds of the area which otherwise compete with our main crops (Ofosu and Limbani, 2007).

The soil moisture conservation techniques by year-long fallow sometimes good for transplanting of winter crops but in case when these rainfalls are not sufficient, which mostly occur, limit the estimated crop yield. So, it is essential to bring the cropping system in such a way that it follows the rainfalls of the area (Arif and Malik, 2009). The crop yield of rainfed areas can be enhanced by improving the yield potential of a crop and by growing of more than a single crop per unit area besides leaving it fallow (Aslam and Mehmood, 2003). Broad leaf species of weeds adapt better a frequently more disturbed habitat and mono cropping for a long period of time so, they grow faster in conventional tillage and cropping systems (Streit *et al*., 2003).

Different tillage and cropping system are very crucial for better weed control and getting of good crops yield. Under mono cropping weeds becomes dominant on that particular area and more frequency of land disturbance like under conventional tillage systems promotes that particular weed to great extent which ultimately deteriorate quality and quantity of main agricultural crops (Bolliger *et al.,* 2006). So, there was a need to conduct such an experiment under rainfed condition which not only suppressed weeds but also gave good crops yield, that's why we performed such sort of experiment whicg not only suppressed weeds on the area but also improved crops yield.

The present study was designed to investigate how different tillage and cropping systems affect the weeds density and also to know that how the yields of different crops can be enhanced as farmers of rainfed regions spend more money for weeds control than on other crop inputs.

Materials and methods

Experimental location and treatments

Two years field experiment was conducted during 2013-2015 to know the influence of different tillage and cropping systems on weeds density and crops yield under rainfed condition at University Research Farm, Koont Rawalpindi (Pakistan) which lies from about 32.5˚N to 34.0˚N Latitude and from about 72˚E to 74˚E Longitude. The soil of this area is medium textured to clay-loam with pH ranges in 7.5 - 8.5.

The cropping systems which were used as follows:

CS_1= Wheat- Fallow- Wheat- Fallow, CS_2= Wheat + Brassica- Fallow- Wheat + Brassica- Fallow, CS_3=Wheat+ Chickpea- Fallow- Wheat+ Chickpea- Fallow, CS_4= Wheat -Guar (Green manuring) -Wheat -Guar (Green manuring).

The tillage treatments which were used as under:

T_1= 3 cultivation (Drill sowing), T_2= Mold board + 2 cultivations (Drill sowing), T_3= Chisel + 2 cultivations (Bed plant sowing), T_4= Minimum tillage + Glyphosate (Drill sowing)

Methodology

The experiment was conducted in a field, using strip-plot design having three replications with a plot size

of 6m × 8m. A total of 16 plots in each replication were present. Crops varieties of wheat, brassica, chickpea and guar which were sown during the experiment includes; Chakwal-50, Shiralee, PAK-86 and BR-99 respectively. Wheat (*Triticum aestivum*) was sown @ 100 Kg ha^{-1} with row spacing of 25 cm apart. The fertilizer NPK was applied @ 90-60-60 kg ha^{-1} in the form of Urea, Diammonium Phosphate (DAP) and Potassium Sulphate, respectively. Brassica (*Brassica napus*) was sown @ 4 Kg ha^{-1} with row spacing of 40 cm apart. The fertilizer NPK was applied @ 50-45-45 kg ha^{-1}, respectively. Chickpea (*Cicer arietinum*) was sown @ 60 Kg ha^{-1} with row spacing of 45 cm apart. The fertilizer NPK was applied @ 25-50-20 kg ha^{-1}, respectively. Guar (*Cyamopsis tetragonoloba*) was sown @ 75 Kg ha^{-1} with row spacing of 35 cm apart. The fertilizer NPK was applied @ 25-50-50 kg ha^{-1}, respectively. Glyphosate a non-selective herbicide was sprayed at recommended dose to control the weeds during fallow period by using hand knap sack sprayer equipped with T-Jet nozzle. During whole the experiment weeds data was not recorded from fallow plots and the plots having guar (used as green manuring). Only the soil moisture contents were taken from these plots.

In tillage treatment (T_1) 3 cultivations was done by using cultivator during the whole experiment. Seed sowing was done with seed drill. Whereas, in tillage treatment (T_2), one tillage was performed by using mould board plough and two cultivations with cultivator, seed sowing was done with seed drill. While the tillage treatment (T_3) includes one chiseling + 2 cultivations and seed sowing was done by using seed bed planter. In (T_4) tillage system minimum tillage was performed (only tillage operation was done for seed bed preparation by using cultivator) and seed sowing was done with seed drill. In all tillage treatments after each tillage practice planker was used for land leveling.

In first cropping system (CS_1), Wheat crop was sown in winter season of 2013, while no crop was sown in summer season of 2014, again same practice was done during the 2nd experimental year. The 2nd cropping system (CS_2) was started by sowing wheat + Brassica in winter 2013 and no crop was sown in summer season of 2014, same cropping system was followed during 2nd year. In 3rd cropping systam (CS_3) wheat + Chickpea was sown in winter season of 2013 and no crop was sown in summer season of 2014, during next year same practice again performed. In CS_4 cropping system wheat sowing was done in winter season of 2013 and Guar (as green manure) was sown in summer season of 2014, again same cropping system was done during next experimental year. In all cropping systems weeds of the fallow period were controlled by using Glyphosate (Round-Up).

Soil Sampling

Soil data was taken from three soil depths i.e. 0-15cm, 15-30cm and 30-45cm to know the soil moisture contents (MC). Soil data was taken before sowing and after harvesting of all the crops.

Moisture determination

Fresh samples of soil were taken and weighed it before drying in oven at 105°C overnight. Then the samples were weighed again by using electric balance. Moisture of samples was determined and then put these values in following formula.

$$\text{Moisture \%} = \frac{\text{Wet weight} - \text{Oven Dry weight}}{\text{Oven dry weight}} \times 100$$

Different parameters for weeds and crops were studied as follows:

Weed population density (Pw m^{-2})

Weed population density (Pw) was recorded using quadrate method. A quadrate measuring 100 cm x 100 cm was randomly placed at eight places in each plot to record weed density. Individual weed plants were counted to determine average weed density.

Different parameters of wheat, brassica and chickpea which were taken during the whole experiment are as under;

Yield Parameters of Wheat

A quadrate having size 1m * 1m randomly placed at three places and then average was taken to determine numbers of tillers/unit area. 1000 kernals Weight was determined by collecting the sample from each plot after their threshing. Biological yield was determined by taking the all above grounded portion of wheat. Whereas, the grain yield were determined after harvesting the crop at its maturity. Harvest index of wheat was determined by dividing grain yield to biological yield and then multiplied by 100.

Yield Parameters of Chickpea and Brassica

No. of pods per plant of chickpea and brassica were taken by taking ten plants randomly from each plot and then average was taken. No. of seeds per pod were counted by taking ten pods randomly of each plot and their mean value was determined. Biological yield was taken by weighing above ground part of all plants of chickpea and brassica from each plot and total biomass was determined. Grain yield was determined by removing the grain from pods and then average grain yield was converted to kg ha^{-1}. Harvest index was determined by dividing the grain yield to biological yield and then multiplied by 100, by this we find out the values of harvest index of both these crops.

Statistical analysis

The data for all parameters was statistically analyzed using computer software statistics 8.1. Least Significant Difference (LSD) was also determined at 5 % level of significance for the comparison of all treatments means.

Results and discussion

Influence of different tillage practices along with different cropping system on weeds population density, soil moisture contents and on the yield of wheat, brassica and chickpea was investigated during the study years 2013-15. Weeds which were present at the area their data was recorded firstly after 60 days of crops emergence and secondly at maturity of the winter crops. Weeds data was recorded regarding weed population density to know which tillage treatment and cropping system have better effects on weeds suppression. Weeds emerge during the guar growing season were controlled in fallow plots by using round up spray.

Table 1. Mean values of temperature and rainfall during the wheat, brassica and chickpea growing season 2013-2015.

Month	Rainfall (mm)	Mean Temperature (oC)		R.H (%)	Sunshine (Hours/day)	Pan Evaporation (mm/day)
		Minimum	Maximum			
July	169.8	24.6	34.6	67.1	6.7	5.4
August	122.7	24.1	32.4	77.2	6.8	5.0
September	126.0	22.4	33.9	70.9	8.3	4.5
October	24.6	18.3	32.3	59.7	9.2	4.1
November	14.4	7.7	23.5	64.5	7.9	2.2
December	4.3	2.8	20.4	72.1	7.2	1.4
January	0	0.6	17.0	69.3	3.9	1.6
February	37.4	4.9	16.3	70.6	6.2	1.7
March	94.1	7.4	21.5	70.8	5.8	3.7
April	66.0	11.5	28.1	62.6	7.5	5.0
May	67.5	18.3	32.1	50.3	9.2	9.9
June	35.5	22.8	40.0	30.0	9.9	10.5
July	110.1	23.0	36.0	47.6	9.5	7.3
August	151.8	24.0	33.3	66.2	9.1	5.4
September	141.2	21.6	31.8	76.1	7.9	3.8
October	74.8	16.2	29.2	61.3	8.0	3.2
November	0	4.9	24.1	64.9	8.0	1.9
December	0	-0.7	19.4	83.6	7.7	1.3
January	0	0.4	16.2	71.3	3.5	1.4
February	88.6	4.3	15.3	74.6	5.1	1.3
March	109.8	6.9	19.2	72.3	4.8	3.1
April	60.6	10.5	27.4	64.4	7.1	4.8
May	69.8	18.1	31.8	52.4	9.0	9.2
June	37.1	20.4	39.8	32.4	9.6	10

Data which was recorded during the whole experiment discussed as under:

Moisture contents (MC) were determined from three soil depths i.e. 0-15cm, 15-30cm and 30-45cm respectively before sowing and after harvesting of crops. It can be seen through interactive affects of cropping system and tillage treatments from all the three soil depths before sowing of crops significant results were found, T_2 (Mold board + 2 cultivations) with CS_3 (Wheat + Chickpea- Fallow- Wheat + Chickpea- Fallow) interaction gave maximum soil MC ranges (17.81 %- 18.11 %) from all the three depths. T_3 (Chisel + 2 cultivations) with CS_2 showed the 2nd maximum values from all the three soil depths. When we discussed about minimum values of interaction then it can be seen that T_1 with CS_1 gave minimum MC from all the three depths 11.88 %- 12.70 % (Table 2). After harvesting of winter crops significant results were also observed regarding interactive effects of tillage and cropping systems from all the three soil depths. T_2 with CS_3 showed maximum moisture contents ranged from 17.41 %- 17.75 %. Minimum values of interaction obtained from T_1 with CS_1 from all the depths i.e. 11.66 %- 12.40 % (Table 2).

Table 2. Interactive effect of tillage treatments and cropping systems on soil moisture contents (%) before sowing and after harvesting of crop at different soil depths over the two consecutive years.

Soil depth 0-15 cm								
	CS_1 (Before)	CS_1 (After)	CS_2 (Before)	CS_2 (After)	CS_3 (Before)	CS_3 (After)	CS_4 (Before)	CS_4 (After)
T_1	11.88j*	11.66h*	13.30hi*	12.96fg*	13.75fgh*	13.31fg*	13.01i*	12.58g*
T_2	15.75bc	15.05c	16.55b	16.23b	17.81a	17.41a	15.78bc	14.75cd
T_3	14.05efgh	13.53ef	14.71de	14.31cde	15.41cd	15.10c	14.53def	14.18de
T_4	13.03i	12.76fg	13.60ghi	13.35fg	14.35efg	14.28cde	13.65fghi	13.35fg
Soil depth 15-30 cm								
	CS_1 (Before)	CS_1 (After)	CS_2 (Before)	CS_2 (After)	CS_3 (Before)	CS_3 (After)	CS_4 (Before)	CS_4 (After)
T_1	12.53k*	12.25j*	13.66hij*	13.15ghi*	14.35fgh*	13.91fg*	13.33ijk*	12.88hij*
T_2	16.20bcd	15.83c	16.91b	16.68b	17.90a	17.57a	16.55bc	15.98bc
T_3	14.56fg	13.83fg	15.40de	14.91de	15.98cd	15.48cd	14.86ef	14.46ef
T_4	13.10jk	12.71ij	14.06fghi	13.51gh	14.68efg	14.36ef	14.00ghi	13.48ghi
Soil depth 30-45 cm								
	CS_1 (Before)	CS_1 (After)	CS_2 (Before)	CS_2 (After)	CS_3 (Before)	CS_3 (After)	CS_4 (Before)	CS_4 (After)
T_1	12.70j*	12.40i*	13.91hi*	13.80gh*	14.73fg*	14.25fg*	13.53i*	13.21hi*
T_2	16.28cd	16.03c	17.30b	16.93ab	18.11a	17.75a	16.75bc	16.36bc
T_3	14.86efg	13.68gh	15.58de	15.08de	16.11cd	15.75cd	15.21ef	14.08fg
T_4	13.55hi	13.10hi	14.30ghi	13.91fgh	15.03efg	14.66ef	14.31gh	13.76gh

* Means not sharing a letter in common differ significantly at 5% probability level.

Interactive effects were also observed before sowing of guar from all three depths and was found that, T_2 with CS_3 interaction showed maximum soil moisture contents i.e. 16.63 %- 17.10 %. Minimum value of interaction was examined in T_1 with CS_1 ranges 10.93 %- 11.35 % (Table 3). T_3 (Chisel + 2 cultivations) with CS_3 showed higher values than T_1 with CS_2 and T_4 (Minimum tillage + Glyphosate) with CS_2 but less than that of T_2 with CS_3. After green manuring Significant results of interaction were also observed from all the three soil depths. T_2 with CS_3 gave maximum value from all the three depths 18.75 %- 18.88 %. Minimum values of interaction were examined in T_1 with CS_1 from all depths ranges 14.63 %- 15.23 % (Table 3). Moisture contents from all three depths were higher in CS_3 and T_2 after mixing of guar in soil as compared to CS_2 and T_2 after harvesting of winter crops, this is because of the high rain fall during the guar growing period and due to the higher moisture retention capacity of soil ploughed through mold board (MB) plough which not only eradicated the weeds but also conserve moisture during monsoon. Similar findings were observed by (Jin *et al.,* 2007; Arachchi, 2009).

Table 3. Interactive effect of tillage treatments and cropping systems on soil moisture contents (%) before sowing and after mixing of guar from depth-01, 02 and 03 over the two consecutive years.

Soil depth 0-15 cm								
	CS_1 (Before)	CS_1 (After)	CS_2 (Before)	CS_2 (After)	CS_3 (Before)	CS_3 (After)	CS_4 (Before)	CS_4 (After)
T_1	10.93i*	12.80i*	12.13gh*	13.85gh*	12.25gh*	14.63fg*	11.90gh*	13.73h*
T_2	14.45bcd	16.68bc	15.10b	17.45b	16.63a	18.75a	14.50bc	16.96b
T_3	12.75fg	14.95ef	13.70cde	15.60de	14.28bcd	16.11cd	13.58def	15.06ef
T_4	11.80hi	13.65h	12.31gh	13.95gh	13.45ef	15.03ef	12.16gh	13.91gh
Soil depth 15-30 cm								
	CS_1 (Before)	CS_1 (After)	CS_2 (Before)	CS_2 (After)	CS_3 (Before)	CS_3 (After)	CS_4 (Before)	CS_4 (After)
T_1	11.35i*	13.51k*	12.38gh*	14.48hij*	13.00fg*	15.23fgh*	12.10hi*	14.05ijk*
T_2	14.93bc	17.08bcd	15.63b	17.85b	16.76a	18.81a	15.11bc	17.63bc
T_3	13.01fg	15.31fgh	13.96de	16.58de	14.31cd	16.88cd	13.86de	15.80ef
T_4	11.86hi	13.90 jk	12.66fgh	14.95fghi	13.23ef	15.68efg	12.60fgh	14.78ghij
Soil depth 30-45 cm								
	CS_1 (Before)	CS_1 (After)	CS_2 (Before)	CS_2 (After)	CS_3 (Before)	CS_3 (After)	CS_4 (Before)	CS_4 (After)
T_1	11.28j*	13.58i*	12.65ghi*	15.03fgh*	13.30efg*	15.73def*	11.88ij*	14.55gh*
T_2	15.33bc	17.21c	16.23ab	18.15b	17.10a	18.88a	15.51bc	17.68bc
T_3	12.81fghi	15.25efg	13.96de	16.41d	14.56cd	17.21c	13.48efg	16.08d
T_4	12.16hij	14.51h	12.93fgh	15.28ef	13.65def	15.95de	12.65ghi	15.26efg

* Means not sharing a letter in common differ significantly at 5% probability level.

When we talk about the weeds population densities then it can be seen that *Anagallis arvensis* population density (WPD) was determined after 60 days of winter crops emergence and after harvesting of all these crops. Results showed that all the tillage treatments have significant results after 60 days and at maturity of crops (Table 4).

Table 4. Interactive effect of tillage treatments and cropping systems on billi booti *(Anagallis arvensis*), Piazi (*Asphodelus tenuifolius*) and Bathu (*Chenopodium album*) population density (Plant/m²) after 60 days of emergence and at maturity over the two consecutive years.

On billi booti (*Anagallis arvensis*) population density (Plant/m²)								
	CS_1 (After 60 days)	CS_1 (At Maturity)	CS_2 (After 60 days)	CS_2 (At Maturity)	CS_3 (After 60 days)	CS_3 (At Maturity)	CS_4 (After 60 days)	CS_4 (At Maturity)
T_1	7.30a*	20.84a*	5.80d*	16.53d*	6.25bcd*	17.97bc*	6.51bc*	18.89b*
T_2	3.26h	11.11i	2.08i	8.34k	2.46i	9.22jk	2.53i	10.04j
T_3	4.25fg	15.19e	3.10h	11.78i	3.88g	13.05h	4.10g	14.10fg
T_4	6.76ab	17.79c	4.70ef	13.52gh	5.20e	14.58ef	6.11cd	16.38d
On Piazi (*Asphodelus tenuifolius*) population density (Plant/m²)								
	CS_1 (After 60 days)	CS_1 (At Maturity)	CS_2 (After 60 days)	CS_2 (At Maturity)	CS_3 (After 60 days)	CS_3 (At Maturity)	CS_4 (After 60 days)	CS_4 (At Maturity)
T_1	7.41a*	14.63a*	6.16c*	12.63b*	6.93b*	13.10b*	7.08b*	13.43b*
T_2	2.90k	6.93g	1.76m	5.90h	2.63l	6.21gh	3.30j	6.20gh
T_3	4.55fg	9.48e	3.56i	7.81f	4.20h	8.31f	4.35gh	8.56f
T_4	5.70d	11.61c	4.35gh	9.61e	4.65f	10.13de	5.35e	10.45d
On Bathu (*Chenopodium album*) population density (Plant/m²)								
	CS_1 (After 60 days)	CS_1 (At Maturity)	CS_2 (After 60 days)	CS_2 (At Maturity)	CS_3 (After 60 days)	CS_3 (At Maturity)	CS_4 (After 60 days)	CS_4 (At Maturity)
T_1	5.35a*	16.91a*	4.38d*	13.10def*	4.80c*	13.88cd*	5.06b*	15.35b*
T_2	2.73i	10.43i	2.13k	6.75l	2.40j	7.90k	2.51j	9.03j
T_3	3.41fg	12.81efg	2.85i	10.38i	3.10h	10.83hi	3.31fg	11.75gh
T_4	3.80e	14.61bc	3.26gh	12.45fg	3.41fg	13.61cde	3.46f	14.00cd

* Means not sharing a letter in common differ significantly at 5% probability level.

Interactive effect of cropping system and tillage treatments after 60 days and at maturity of crops also revealed significant results, T_1 with CS_1 interaction showed maximum WPD i.e. 7.30 plant/m² after 60 days and 20.83 plant/m² at maturity. When we discussed about minimum values of interaction then it can be seen that T_2 with CS_2 gave minimum WPD after 60 days and at maturity, 2.08 plant/m² was observed after 60 days and 8.34 plant/m² at maturity of the crops. After T_2 with CS_2 it can be seen that T_2 with CS_3 (Wheat + Chickpea- Fallow- Wheat + Chickpea- Fallow) showed minimum values (Table 4). Weed density increased with the passage of time i.e. weed density was more as the data recorded at maturity stage as compare to after 60 days. This is due to the favourable climatic condition at maturity stage and more availability of moisture near the wheat maturity stage. Weeds grow better under favourable moisture and environmental condition (Takim and Yomi, 2010). Deep tillage with MB plough suppressed the weed growth due to the seed extraction from the deeper soil layer which acts as seed reserve. Similar results were also depicted by (Mira and Samota, 2008).

Population density of *Asphodelus tenuifolius* was determined after 60 days of winter crops emergence and after harvesting of all these crops. Interactive effect of cropping system and tillage treatments after 60 days and at maturity of crops also revealed significant results, T_1 with CS_1 interaction showed maximum WPD i.e. 7.41 plant/m² after 60 days and 14.63 plant/m² at maturity. When we discussed about minimum values of interaction then it can be seen that T_2 with CS_2 gave minimum WPD after 60 days and at maturity, 1.76 plant/m² was observed after 60 days and 5.90 plant/m² at maturity of the crops. T_2 with CS_3 gave 2nd minimum values after 60 days and at maturity (Table 4). Deep tillage and favourable cropping system suppress the weeds density and their emergence (Ozpinar and Ozpinar, 2011). CS_2 suppressed the *Asphodelus tenuifolius* density because the less available space due to the intercropping of brassica with wheat and deep tillage via MB plough as compare to other tillage treatments. Our results are also in line with (Nester *et al.,* 2013).

Chenopodium album population density (WPD) was determined after 60 days of winter crops emergence and after harvesting of all these crops. Interactive effect of cropping system and tillage treatments after 60 days and at maturity of crops also revealed significant results, T_1 with CS_1 interaction showed maximum WPD i.e. 5.35 plant/m² after 60 days and 16.91 plant/m² at maturity. When we discussed about minimum values of interaction then it can be seen that T_2 with CS_2 gave minimum WPD after 60 days and at maturity, 2.13 plant/m² was observed after 60 days and 6.75 plant/m² at maturity of the crops. Results also revealed that best control of this weed was also observed in T_2 with CS_3 after T_2 with CS_2 (Table 5). Above results showed that ploughing with MB plough retarded the *Chenopodium album* growth as compare to other tillage operations because its quality of extracting of earlier buried weed seeds. Cropping system CS_2 also reduced the weeds density this might be due to the spreading nature of brassica plants, weeds get less light for their growth. Similar findings regarding different tillage operations and cropping systems also drawn by (Bilalis *et al.,* 2012).

Circium arvense population density (WPD) was taken after 60 days of winter crops emergence and after harvesting of all these crops. Interactive effect of cropping system and tillage treatments after 60 days and at maturity of crops also showed significant results, T_1 with CS_1 interaction gave maximum WPD i.e. 4.61 plant/m² after 60 days and 20.25 plant/m² at maturity. While T_1 with CS_4 showed 2nd maximum value of population density after T_1 with CS_1. When we discussed about minimum values of interaction then it can be seen that T_2 with CS_2 gave minimum WPD after 60 days and at maturity, 2.66 plant/m² was observed after 60 days and 9.88 plant/m² at maturity of the crops (Table 5). Less moisture availability, proper seed bed preparation and deep tillage practices can retards the weeds population density (Dorado and Fando, 2006). Results showed that CS_2 and T_2 retarded weeds density because of shading effect of brassica plant on weeds and less space for

spreading. Same findings had also been reported by (Torresen *et al.,* 2003).

Convolvulus arvensis population density (WPD) was determined after 60 days of winter crops emergence and after harvesting of all these crops. Interactive effect of cropping system and tillage treatments after 60 days and at maturity of crops also showed significant results, T_1 with CS_1 interaction gave maximum WPD i.e. 16.58 plant/m² after 60 days and 30.25 plant/m² at maturity. Minimum values of interaction revealed by T_2 with CS_2 i.e. 9.01 plant/m² was observed after 60 days and 18.31 plant/m² at maturity of the crops. Results also depicted that after T_2 with CS_2 interaction T_2 with CS_3 gave also better population density control (Table 5).

Table 5. Interactive effect of tillage treatments and cropping systems on Leih (*Circium arvense*), Lehli (*Convolvulus arvensis*) and khabbal (*Cynodon dactylon*) population density (Plant/m²) after 60 days of emergence and at maturity over the two consecutive years.

	On Leih (*Circium arvense*) population density (Plant/m²)							
	CS_1 (After 60 days)	CS_1 (At Maturity)	CS_2 (After 60 days)	CS_2 (At Maturity)	CS_3 (After 60 days)	CS_3 (At Maturity)	CS_4 (After 60 days)	CS_4 (At Maturity)
T_1	4.61a*	20.25a*	4.01de*	17.66cd*	4.18c*	18.50bc*	4.38b*	19.56ab*
T_2	3.33h	13.15j	2.66k	9.88l	2.86j	11.95k	2.95ij	12.83jk
T_3	3.56g	15.01gh	3.03i	13.00jk	3.21h	13.48ij	3.31h	14.53hi
T_4	4.11cd	16.95 de	3.73f	14.71gh	3.91e	15.66fg	4.01de	16.56ef
	On Lehli (*Convolvulus arvensis*) population density (Plant/m²)							
	CS_1 (After 60 days)	CS_1 (At Maturity)	CS_2 (After 60 days)	CS_2 (At Maturity)	CS_3 (After 60 days)	CS_3 (At Maturity)	CS_4 (After 60 days)	CS_4 (At Maturity)
T_1	16.58a*	30.25a*	13.88def*	26.50d*	14.36cd*	27.78c*	15.83ab*	28.68b*
T_2	10.63h	22.58h	9.01i	18.31l	9.56hi	19.86k	10.06hi	20.80ij
T_3	13.51def	24.30f	12.26g	20.50jk	12.81fg	21.63i	13.20efg	23.01gh
T_4	15.11bc	27.11cd	13.28def	23.80fg	13.96de	24.48f	14.25cde	25.38e
	On khabbal (*Cynodon dactylon*) population density (Plant/m²)							
	CS_1 (After 60 days)	CS_1 (At Maturity)	CS_2 (After 60 days)	CS_2 (At Maturity)	CS_3 (After 60 days)	CS_3 (At Maturity)	CS_4 (After 60 days)	CS_4 (At Maturity)
T_1	13.96bc*	32.70a*	11.50e*	28.41c*	12.36d*	29.45b*	13.23c*	30.35b*
T_2	9.38g	25.46f	6.66j	20.66i	7.70hi	22.33h	8.41h	23.48g
T_3	11.88de	27.41de	7.40ij	24.10g	10.25f	25.56f	10.60f	26.51e
T_4	15.76a	29.93b	9.41g	26.85e	13.23c	27.38de	14.250b	28.28cd

* Means not sharing a letter in common differ significantly at 5% probability level.

Above results depicted that CS_2 and T_2 proved their self best in suppression of *Convolvulus arvensis* density at both the stages i.e. after 60 days of winter crops growing and at maturity of the crops. This is because of better effect of mold board plough and better combination of wheat and brassica which suppressed the weeds emergence. Montserrat *et al.,* (2005) also depicted that proper tillage and cropping system combination can retards the weeds growth.

Population density of *Cynodon dactylon* was determined after 60 days of winter crops emergence and after harvesting of all these crops. Interactive effect of cropping system and tillage treatments after 60 days and at maturity of crops also showed significant results, T_1 with CS_1 interaction gave maximum WPD i.e. 13.96 plant/m² after 60 days and 32.70 plant/m² at maturity. Minimum values of interaction revealed by T_2 with CS_2 i.e. 6.66 plant/m²

was observed after 60 days and 20.66 plant/m² at maturity of the crops. It was also found that T_1 with CS_3 gave 2nd highest value after T_1 with CS_1 whereas, T_2 with CS_3 showed 2nd minimum value after T_2 with CS_2 (Table 4). *Cynodon dactylon* is the common weed of rainfed areas and can only be controlled if proper cropping and tillage systems are used (Gugliemini and Satorre, 2004). Our results of CS_2 and T_2 showed better control of *Cynodon dactylon* density as because of better uprooting of this weed by deep ploughing capability of MB plough. Our findings are also match with (Ramesh and Kumar, 2014) who reported that mono cropping and shallow tillage operations are not suitable for better weeds density suppression.

Wheat yield as affected by different tillage systems

No. of tillers/unit area were counted by placing the quadrate of 1m * 1m randomly at two places in each plot and then average was taken. Interactive effect of tillage treatments and cropping systems showed significant differences. T_2 (Mold board + 2 cultivations) with CS_3 (Wheat + Chickpea- Fallow-Wheat + Chickpea- Fallow) gave the maximum No. of tillers/unit area i.e. 288 whereas, minimum showed by T_1 (3 cultivations) with CS_1 (Wheat -Fallow-Wheat- Fallow) which was 211. T_2 with CS_2 (Wheat + Brassica- Fallow- Wheat + Brassica- Fallow) after T_2 with CS_3 gave the higher values than the other tillage and cropping systems (Table 6).

Table 6. Interactive effect of tillage treatments and cropping systems on wheat (Triticum aestivum) No. of tillers/unit area, 1000 kernels weight (g), biological yield (kg/hac), grain yield (kg/hac) and harvest index (%) over the two consecutive years.

Interactive effect of tillage treatments and cropping systems on No. of tillers/unit area over the two consecutive years				
Treatments	CS_1	CS_2	CS_3	CS_4
T_1	211o*	217n*	220m*	218n*
T_2	273d	276b	282a	274c
T_3	253h	265f	270e	259g
T_4	225l	228k	241i	228k
Interactive effect of tillage treatments and cropping systems on 1000 kernels weight (g) over the two consecutive years				
Treatments	CS_1	CS_2	CS_3	CS_4
T_1	39.51m*	41.70kl*	43.59ij*	40.593m*
T_2	48.29i	51.01b	53.01a	49.44c
T_3	45.43gh	46.94ef	47.96de	46.27fg
T_4	42.56 jk	45.17gh	46.62f	44.40hi
Interactive effect of tillage treatments and cropping systems on biological yield (kg/hac) over the two consecutive years				
Treatments	CS_1	CS_2	CS_3	CS_4
T_1	6914.4k*	7110.2jk*	8429.8ab	6961.2k*
T_2	8027.6cd	8211.4bc	8482.7a	7908.5de
T_3	7619.5fg	7867.5de	7544.9fgh*	7718.4ef
T_4	7277.3ij	7449.0ghi	7752.9ef	7368.2hi
Interactive effect of tillage treatments and cropping systems on grain yield (kg/hac) over the two consecutive years				
Treatments	CS_1	CS_2	CS_3	CS_4
T_1	2209.7l*	2395.0j*	2859.9c*	2305.5k*
T_2	2729.9fg	2988.1b	3226.5a	2809.9cd
T_3	2594.7h	2791.4de	2744.4efg	2694.5g
T_4	2387.7j	2584.2h	2746.0ef	2503.6i
Interactive effect of tillage treatments and cropping systems on harvest index (%) over the two consecutive years				
Treatments	CS_1	CS_2	CS_3	CS_4
T_1	31.92j*	33.70ghi*	33.99efgh*	33.10hi*
T_2	34.51efg	36.40bc	38.11a	35.52bcd
T_3	34.02efg	35.49cd	36.43b	34.89de
T_4	32.84ij	34.68def	35.44d	33.95fgh

* Means not sharing a letter in common differ significantly at 5% probability level.

Number of tillers depends on seed variety, nutrients management and better plant health (Khan *et al.,* 2011). In our experiment T_2 and CS_2 gave more number of tillers/unit area, because deep tillage conserve moisture during monsoon used wheat plant during water deficient period. Also wheat- brassica and wheat-chickpea intercropping used moisture efficiently as compare to single cropping. (Tomm and Foster, 2001) had also drawn the similar findings regarding deep tillage operation and intercropping in rainfed areas.

1000 kernels Weight was determined by taking the sample from each plot and after their threshing. Interactive effect of tillage treatments and cropping systems showed significant differences. T_2 with CS_3 showed the maximum kernals weight i.e. 53.01 g whereas, minimum showed by T_1 with CS_1 which was 39.51 g. T_4 (Minimum tillage + Glyphosate) with CS_1 also showed minimum values after T_1 * CS_1 i.e. 42.56 g (Table 6). As in T_2 and CS_3 plant growth was proper due to efficient utilization of moisture so, these two tillage and cropping system gave healthy seeds. In T_1 i.e. conventional tillage or farmer practice number of tillage operations were more so the moisture loss occurred and plant not utilize moisture efficiently, while in T_3 shallow tillage has not conserve the moisture properly during monsoon season that is why wheat plant remained weak and not prepare healthy seeds. (Verhulst *et al.,* 2011) had also reported the similar findings.

Biological yield was found by taking the all above grounded portion of wheat. Interactive effect of tillage treatments and cropping systems gave significant differences. T_2 with CS_3 showed the maximum biological yield i.e. 8482.7 kg/hac whereas, minimum showed by T_1 with CS_1 which was 6914.4 kg/hac (Table 6). Healthy plants have more biological yield and proper moisture availability at vegetative stage play crucial role in biological yield production (Ehsanullah *et al.,* 2013). T_2 and CS_3 because of proper utilization of moisture and nutrient gave better biological yield but better biological yield is not the surety of more grain yield. Our findings are also in accordance with (Mikanova *et al.,* 2012).

Grain yield was determined after harvesting the crop at its physiological maturity. Interaction of tillage treatments and cropping systems also gave significant differences. T_2 with CS_3 showed the maximum grain yield i.e. 3226.5 kg/hac whereas, minimum showed by T_1 with CS_1 which was 2209.71 kg/hac (Table 6). Grain yield related to spike length and number of tillers/unit area, as T_2 and CS_3 gave more spike length and number of tillers so the grain yield was also found maximum in T_2 and CS_3. (Mohammad *et al.,* 2012) were also found similar findings.

Harvest index was determined by dividing grain yield to biological yield and then multiplied by 100. Interactive effect of tillage treatments and cropping systems showed significant differences. T_2 with CS_3 depicted maximum harvest index i.e. 38.11 % whereas, minimum showed by T_1 with CS_1 which was 31.92 %. After T_1 with CS_1 minimum value of harvest index gave by T_4 with CS_1 (Table 6). Harvest index obtained by dividing grain yield to biological yield of the crop and then by multiplying with 100. Harvest index is also used to judge the efficiency of the end result of a treatment. As grain yield was greater in T_2 and CS_3 so, these two also gave maximum harvest index and proved that T_2 and CS_3 are the best practices in rainfed regions as compare to other conventional practices. Minimum tillage practices to some extent proved itself better than conventional tillage practices but not better then T_2 and T_3. (Beiranvand *et al.,* 2013) also depicted the similar findings of their trials.

Brassica yield parameters

Cropping system CS_2 (Wheat + Brassica- Fallow-Wheat + Brassica- Fallow) only have brassica with main crop wheat as an intercrop and yield data which was taken during both the study years discussed as under;

No. of pods/plant was counted at maturity stage. Results depicted that mean values of the combination of tillage practice T_2 (Mold board + 2 cultivations)

and the cropping system CS_2 gave maximum No. of pods/plant i.e. 333 while the minimum found in combination of tillage practice T_1 (3 cultivations) and cropping system CS_2 which was 273 (Table 7). Number of pods also related to better plant health a healthy plant can give more number of pods. As tillage operation T_2 was found best in conserving moisture and eradication of weeds so number of pods were also found maximum in T_2. (Ranjbar *et al.,* 2014) also documented the similar findings.

At maturity of brassica No. of seeds/pod were counted and the results showed that mean values of the combination of tillage practice T_2 and the cropping system CS_2 gave maximum No. of seeds/pod i.e. 25.78 while the minimum found in combination of tillage practice T_1 and cropping system CS_2 which was 18.72. T_3 (Chisel + 2 cultivations) and CS_2 also gave better No. of seeds/pod but not higher than T_2 and CS_2 (Table 7). Healthy pods were developed in T_2 because of healthy plant due to this seeds formation was also found better in T_2. Previous soil moisture during monsoon which was conserved in maximum amount in T_2 also played role in more number of seeds formation. (Uzun *et al.,* 2012; Mohammadi *et al.,* 2011) had also drawn the similar conclusion.

At maturity of brassica all the above grounded portion of the brassica was cut down and the mean values from all the plots were taken (Table 7).

Table 7. Mean values of impact of tillage and cropping system on brassica and chickpea parameters over the two consecutive years.

Mean values of impact of tillage and cropping system on brassica parameters over the two consecutive years						
Treatments	Cropping system	No. of pods/plant	No. of seeds/pod	Biological yield (kg/hac)	Grain yield (kg/hac)	Harvest index (%)
T_1	02	273d	18.72d	11672.38d	2049.11d	17.61d
T_2	02	333a	25.78a	13233.98a	2593.07a	19.60a
T_3	02	311b	21.19b	12711.67b	2384.58b	18.76b
T_4	02	291c	19.54c	11959.82c	2140.68c	17.91cd
Mean values of impact of tillage and cropping system on chickpea parameters over the two consecutive years						
T_1	03	34d	2.13d	5272.14d	1060.06d	20.10d
T_2	03	45a	2.93a	5792.54a	1297.74a	22.40a
T_3	03	37b	2.50b	5767.44b	1207.46b	20.93b
T_4	03	36bc	2.33c	5710.69bc	1192.59bc	20.88c

Results depicted that mean values of the combination of tillage practice T_2 and the cropping system CS_2 gave maximum biological yield i.e. 13233.98 kg/hac while, the minimum found in combination of tillage practice T_1 and cropping system CS_2 which was 11672.38 kg/hac. Biological yield related to better crops stand, tillage operation T_2 gave maximum biological yield because of healthy plant stand in early stages while the minimum biological yield was given by T_1 because of poor crops stand as less moisture conservation. Different researchers (Madejon *et al.,* 2007) had also depicted the similar findings.

Results showed that mean values of the combination of tillage practice T_2 and the cropping system CS_2 gave maximum grain yield i.e. 2593.07 kg/hac while, the minimum found in combination of tillage practice T_1 and cropping system CS_2 which was 2049.11 kg/hac (Table 7). Grain yield related to number of pods development and healthy seeds formation. As T_2 gave maximum number of pods so grain yield was also found maximum in T_2. (Qayyum *et al.,* 2013) had also revealed same findings.

Harvest index was determined by dividing the grain yield to biological yield and then multiplied by 100. Results depicted that mean values of the combination of tillage practice T_2 and the cropping system CS_2 gave maximum harvest index values i.e. 19.60 % while, the minimum found in combination of tillage

practice T_1 and cropping system CS_2 which was 17.61 % (Table 7). Due to better biological and grain yield in T_2 harvest index was also found maximum in T_2. Inter cropping conserve the moisture which otherwise losses due to mono cropping. (Xing-bin *et al.,* 2014) had also found that deep tillage and inter cropping are the key components in getting better crop yield and eradication of weeds.

Chickpea yield components as affected by different tillage systems

With our main crop wheat, only chickpea was sown in cropping system CS_3 (Wheat + Chickpea- Fallow-Wheat + Chickpea- Fallow) as an intercrop and yield data which was recorded discussed as under;

No. of pods/plant was counted at maturity stage. It can be seen from the results that mean values of the combination of tillage practice T_2 (Mold board + 2 cultivations) and the cropping system CS_3 gave maximum No. of pods/plant i.e. 45 while the minimum found in combination of tillage practice T_1 and cropping system CS_3 which was 34. T_3 (Chisel + 2 cultivations) and T_4 (Minimum tillage + Glyphosate) values were close to each other and greater than T_1 (Table 7). As in tillage treatment T_2 (Mold board + 2 cultivations) plant height and number of branches per plant were more so, more number of pods per plant were produced. Climatic factors at the time of pods formation also favoured the maximum number of pods formation. Our results are also in accordance with (Wozniak, 2013).

No. of seeds/pod were counted at chickpea maturity stage and the results revealed that mean values of the combination of tillage practice T_2 and the cropping system CS_3 gave maximum No. of seeds/pod i.e. 2.93 while the minimum found in combination of tillage practice T_1 and cropping system CS_3 which was 2.13 (Table 7). Greater number of seeds formation depends on seed variety and healthy development of plant (Serraj *et al.,* 2004). MB plough in T_2 mix the nutrients properly in the soil and chickpea plants get these nutrients efficiently in the soil and develop more seeds/pod. Similar findings had also been reported by (Azhar *et al.,* 2013).

At maturity of chickpea all the above grounded portion was cut down and the mean values from all the plots were taken (Table 7). Results showed that mean values of the combination of tillage practice T_2 and the cropping system CS_3 depicted maximum biological yield i.e. 5792.54 kg/hac while, the minimum found in combination of tillage practice T_1 and cropping system CS_3 which was 5272.14 kg/hac. Biological yield related to healthy plant structure. A healthy plant have more biological yield, as in T_2 better crop stand was found due to which biological yield was also found more in T_2. Intercropping with wheat was also a factor to produce more biological yield as intercropping suppressed the weeds. Similar findings regarding biological yield has also been reported by (Lithourgidis *et al.,* 2011).

Results of our findings showed that mean values of the combination of tillage practice T_2 and the cropping system CS_3 prove their self best and gave maximum grain yield i.e. 1297.74 kg/hac while, the minimum yield found in combination of tillage practice T_1 and cropping system CS_3 which was 1060.06 kg/hac (Table 7). Due to better pods and number of seeds formation in T_2, highest grain yield was found in T_2. (Onyari *et al.,* 2010) also found that better pods formation and better nutrient management can give more grain yield.

Harvest index of chickpea was determined by dividing the grain yield to biological yield and then multiplied by 100. Results showed that mean values of tillage practice T_2 and the cropping system CS_3 combination gave maximum harvest index values i.e. 22.40 % while, the minimum found in combination of tillage practice T_1 and cropping system CS_3 which was 20.10 %. It can also be seen that T_3 and CS_3 combination gave closest value to T_2 and CS_3 i.e. 20.56 (Table 7). Better biological and grain yield can give the highest values of harvest index. Harvest index is also the proof of the better results of a treatment. T_2 as compare to other tillage operations gave highest value of harvest index as because of better and healthy crop

stand under rainfed condition by providing moisture during all the crop grown season. (Lenssen *et al.,* 2007) had also drawn the similar conclusion.

Weather data

During both the study years weather data was recorded (Table 1). Maximum rainfall was recorded during the month of July 2013 (169.8 mm) whereas, minimum during the month of January 2014 and November, Dec and Jan 2015 (0 mm). Mean minimum temperature was recorded during the month of Dec 2014 (-0.7 C^{o}) while mean maximum temperature was recorded during the month of June 2014 (40 C^{o}). Weather data revealed that in early months of wheat growing season i.e. Oct- Jan during 2013-2014 and Nov- Jan during 2014-2015 rainfall was not sufficient and mean maximum and minimum temperature during both the study years Oct-Nov were also high due to which moisture loss occurred from the soil surface and winter crops growth was not efficient. This might be the reason that crop stand was poor in all cropping systems but in conventional tillage T_1 (farmer or controlled tillage treatment) and cropping system CS_1 (Wheat- Fallow -Wheat- Fallow) it was severe. During monsoon in both years deep tillage with mold board and intercropping gave better crops yield due to proper moisture conservation and by proper eradication of weeds. In both the years it can also be seen from the weather data that during Feb-May rainfall was sufficient which recover the poor crops stand to great extent in intercropping systems but it did not recover yield properly in wheat-fallow system. Weather data depicted that moisture deficiency in rainfed areas can be controlled if deep tillage practices performed during monsoon as well as by doing intercropping practices.

Conclusion

Growing of single crop in rainfed regions is the main cause of weeds infestation and also the low yield of the main crop i.e. wheat. Conventional tillage operations are unsuitable for moisture conservation during monsoon season as well as eradication of weeds. So, the growing of more than one crop or intercropping of leguminous crops with main crop wheat was found best. This not only increased the wheat yield but also suppressed the weeds of the season. Conventional tillage operations were found useless in weeds control as well as moisture conservations because of more frequency of tillage, conventional tillage not only degrade the soil but also run off and nutrients loss occurred. Deep tillage with mold board plough along with two tillage practices with cultivator and intercropping of wheat with chickpea found best because by this we not only conserve more moisture during monsoon season but it was also found affective in eradication of previous weeds seeds and their roots which otherwise again germinate every year.

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References

Ali S, Malik MA, Ansar M, Qureshi R. 2014. Weed growth dynamics associated with rainfed wheat (*Triticum aestivum L.*) establishment under different tillage systems in Pothwar. Plant Animal and Environmental sciences **4,** 146-154.

Arachchi VLP. 2009. Effect of deep ploughing on the water status of highly and less compacted soils for coconut (*Cocos nucifera L.*) production in Sri Lanka. Soil and Tillage Research **103,** 350-355.

Arif M. 2009. Agro-economic studies of various cropping patterns under Pothwar conditions. Ph.D Thesis, University Arid Agriculture Rawalpindi, Pakistan.

Arif M, Malik MA. 2009. Economic feasibility of proposed cropping patterns under different moisture regimes of Pothwar plateau. Agricultural Biology **11,** 27–32.
http://www.fspublishers.org

Aslam M, Mehmood G. 2003. Economic feasibility

of crop rotations under different rainfall zones. Agriculture **35,** 23-27.

Azhar MR, Javanmard A, Shekari F, Pourmohammad A, Esfandyari E. 2013. Evaluation of yield and yield components chickpea (*Cicer arietinum L.*) in intercropping with spring barley (*Hordeum vulgare* L.), Cercetari Agronomice in Moldova, 75-85 p. http://dx.doi.org/10.2478/v10298-012-0106-6.

Beiranvand M, Mehranzadeh M, Shahrbanoonezhad M. 2013. The Effect of No-tillage method and the amount of consumed seed on wheat yield. Zoological Research **2,** 103-108. http://scholarsresearchlibrary.com/archive.html

Bilalis D, Karkanis A, Pantelia A, Patsiali S, Konstantas A, Efthimiadou A. 2012. Weed populations are affected by tillage systems and fertilization practices in organic flax (*Linum usitatissimum L.*) crop. crop sciences **6,** 157-163.

Bolliger A, Magid J, Amado TJC, Neto FS, Santos Ribeiro MF, Calegari A, Ralisch R, Neergaard AD. 2006. Taking stock of the Brazilian "Zero Till Revolution. A review of landmark research and farmers' practice. Adv. Agronomy **91,** 47–110.

Dorado J, Pez-Fando L. 2006. The effect of tillage system and use of a paraplow on weed flora in a semiarid soil from central Spain. Weed Research **46,** 424-431. http://www.10.1111/j.1365-3180.2006.00526.x

Ehsanullah Khan, Qamar R, Ghaffar A, Mustafa G. 2013. Impact of tillage and mulch on water conservation in wheat (*Triticum aestivum L.*) under rice-wheat cropping system. Agriculture Research 121-129.

Govaertsa B, Sayreb KD, Deckers J. 2005. Stable high yields with zero tillage and permanent bed planting. Field Crops Research **94,** 33-42.

Gugliemini AC, Satorre EH. 2004. The effect of non-inversion tillage and light availability on dispersal and spatial growth of cynodon dactylon. Weed Research **44,** 366-374.

Hadda MS, Arora S. 2006. Soil and nutrient management practices for sustaining crop yields under maize-wheat cropping sequence in sub-mountain Punjab, India Dept. of soils, Punjab Agri Uni. Soil and Environ Ludhiana, India **25,** 1-5.

Hassan MU, Qayyum A, Razzaq A, Ahmad M, Mahmood I, Khan SU, Jenks MA. 2013. Evaluation of maize cultivars for drought tolerance based on physiological traits associated with cell wall plasticity. Jokull **63,** 466-478.

Hossain IM, Karim SMR, Hossain MI, Islam MS, Mandal RI, Tiwary TP. 2012. Weed growth and grain yield in wheat and rice as affected by tillage system and weed management practices in rice-wheat cropping system in Bangladesh. Weed Science Research **18,** 775-783.

Hugar HY, Palled YB. 2008. Effect of intercropping vegetables on maize and associated weeds in maize-vegetable intercropping systems. Agricultural Sciences **21,** 159-161.

Jin H, Hongwen L, Xiaoyan W, McHugh AD, Wenying L, Huanwen G, Kuhn NJ. 2007. The adoption of annual subsoiling as conservation tillage in dryland maize and wheat cultivation in northern China. Soil and Tillage Research **94,** 493-502. http://www.elsevier.com/locate/permissionusematerial

Khan MI, Jan A, Hussain N, Jan MT, Qadoos M. 2011. Rainfed wheat response to tillage and nitrogen, Sarhad Agriculture, 54-67.

Lenssen AW, Johnson GD, Carlson GR. 2007. Cropping sequence and tillage system influences annual crop production and water use in semiarid Montana. USA, Field Crops Research **100,** 32-43.

http://www.researchgate.net/publication/222397089

Lima CLR, Reinert DJ, Reichert JM, Suzuki LEAS. 2010. Yield of crops and soil resistance to penetration of the Alfisol under different management. Pesq. Agropec. Bras **45,** 89-98.

Lithourgidis AS, Dordas CA, Damalas CA, Vlachostergios DN. 2011. Annual intercrops: an alternative pathway for sustainable agriculture. Crop Sciences **4,** 396-410.
http://www.researchgate.net/publication/224934832

Madejon E, Moreno F, Murillo JM, Pelegrn F. 2007. Soil biochemical response to long-term conservation tillage under semi-arid Mediterranean conditions. Soil Tillage Research **94,** 346-352.
http://www.researchgate.net/publication/223062263

Mikanova O, Simon T, Javurek M, Vach M. 2012. Relationships between winter wheat yields and soil carbon under various tillage systems. Plant Soil Environment **58,** 540-544.

Mira K, Ranogajec L, Samota D. 2008. Effects of soil tillage and herbicides on weeds and winter wheat yields. Faculty of Agri, Josip Juraj Strossmayer Uni in Osijek. Tara Lesna, Slovakia, 56-63.

Mohammad W, Shah SM, Shehzadi S, Shah SA. 2012. Effect of tillage, rotation and crop residues on wheat crop productivity, fertilizer nitrogen and water use efficiency and soil organic carbon status in dry area (rainfed) of north-west Pakistan. Soil Science and Plant Nutrition **12,** 715-727.
http://dx.doi.org/10.4067/S071895162012005000027

Mohammadi K, Eskandar M, Heidari G, Nezhad MTK. 2011. Brassica traits and some soil biological parameters in response to fertilization and tillage management. Biotechnology **10,** 14067-14072.
http://www.academicjournals.org/AJB

Montserrat JES, Granados FL, Andujar JLG, Torres LG. 2005. Characterizing Population growth rate of convolvulus arvensis in wheat-sunflower no-tillage systems. Crop Sciences **45,** 2106-2112.

Nester M, Madakadze C, Twomlow S, Nyamangara J, Hove L. 2013. Crop yield and weed growth under conservation agriculture in semi- arid Zimbabwe. Dept of Plant Production and Soil Sci; University of Pretoria. Weed Science Research **19,** 109-121.
http://oar.icrisat.org/id/eprint/6019

Ofosu-Anim J, Limbani NV. 2007. Effect of intercropping on the growth of cucumber and okra as affected by intercropping. International Journal of Agriculture and Biology **9,** 594-597.
http://dx.doi.org/10.5402/2012/485810

Onyari CAN, Ouma JP, Kibe AM. 2010. Effect of tillage method and sowing time on phenology, yield and yield components of chickpea (*Cicer arietinum L.*) under semi-arid conditions in Kenya. Applied Biosciences **34,** 2156-2165.

Ozpinar S, Ozpinar A. 2011. Influence of tillage and crop rotation systems on economy and weed density in a semi-arid region. Agricultural Sciences **13,** 769-784.
http://www.researchgate.net/publication/264886956

Page AL, Miller RH, Keeney DR. 1982. Methods of soil analysis, part 2. 2nd ed. Am. Soc. No. 9. Madison USA, 506-509.

Qayyum A, Sadiq M, Awan IU, Khan EA, Ullah HURK, Ullah R, Khattak MS. 2013. Weed management in wheat-oilseeds inter/relay cropping system and planting patterns. Pakistan Weed Sciences Research **19,** 503-511.

Ramesh SS, Kumar RS. 2014. Weed dynamics and

productivity of maize-wheat cropping system as influenced by tillage/planting techniques. International Sciences **3,** 1059 -1070.

Ranjbar H, Mansouri M, Salar MR, Ala A. 2014. Effects of different tillage system, seeding method and rates on yield and seed oil percentage of rapeseed. Advance Biology Biom Research **2,** 192-201.

Serraj R, Krishnamurthy L, Kashiwagi J, Kumar J, Chandra S, Crouch JH. 2004. Variation in root traits of chickpea (*Cicer arietinum L.*) grown under terminal drought. Field Crops Research **88,** 115-127. http://www.researchgate.net/publication/222673144

Singh Y, Singh VP, Singh G, Yadav DS, Sinha RKP, Johnson DE, Mortimer AM. 2011. The implications of land preparation, crop establishment method and weed management on rice yield variation in the rice–wheat system in the Indo-Gangetic plains. Field Crops research **121,** 64-74.

Streit B, Rieger SB, Stamp P, Richner W. 2003. Weed populations in winter wheat as affected by crop sequence, intensity of tillage and time of herbicide application in cool and humid climate. Weed Research **43,** 20-32.

Subedi H. 2013. Wheat weed identification and management under cereal production system Nepal. Sustain Sociology **3,** 74-85. http://www.10.11634/216825851302470

Takim FO, Yomi OF. 2010. Influence of tillage and cropping systems on field emergence, growth of weeds and yield of maize (Zea mays L.) and cowpea (*Vigna unguiculata L.*) Dept of Agron; Uni of Ilorin, Nigeria. Agricultural Engineering **1,** 141-148.

Tomm GO, Foster RK. 2001. Effect of intercropping wheat with forage legumes on wheat production and ground cover, Pesq agropec. Brasilia **36,** 465-471. http://dx.doi.org/10.1590/S0100204X2001000300010

Torresen KS, Skuterud R, Tandae THJ, Hagemo MB. 2003. Effects on weed flora, weed seedbank and grain yield. Crop Protection **22,** 185-200.

Uzun B, Yol E, Furat S. 2012. The influence of row and intra-row spacing to seed yield and its components of winter sowing brassica in the true mediterranean type environment. Agricultural Sciences **18,** 83-91.

Verhulst N, Ken D, Vargas SM, Crossaa J, Deckers J, Raes D, Govaerts B. 2011. Wheat yield and tillage-straw management system × year interaction explained by climatic co-variables for an irrigated bed planting system in northwestern Mexico. Field Crops Research **124,** 347-356. http://dx.doi.org/10.1016/j.fcr.2011.07.002

Wozniak A. 2013. The yielding of pea (*Pisum sativum L.*) under different tillage conditions. Acta Science **12,** 133-141.

Xing-bin DU, Chen C, Li-jun L, Long-ping X, Kang L, Yin-hua C, Xin-qiao YU. 2014. Long-term no-tillage direct seeding mode for water-saving and drought-resistance rice production in rice-rapeseed rotation system. Rice Science **21,** 210-216.