Acta Scientific Agriculture (ISSN: 2581-365X)

Volume 2 Issue 9 September 2018

Research Article

Weed Abundance, Diversity, Dry Matter and Productivity of Spring Maize Under Differt Tillage and Weed Management Method in Mid-Hills of Nepal

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Received: August 03, 2018; **Published:** August 10, 2018

Abstract

Influence of weed control practices on growth and yield of winter maize (*Zea mays* L.) was studied in a field trial at the experimental station of Institute of Agriculture and Animal science, Lamjung Campus, Lamjung. The experiment was laid out in split plot design, with two tillage methods (no tillage and conventional tillage) as main plot factor and seven weed management practices as sub plot factor (sequential application of atrazine @ 0.75 kg a.i. ha-1fb 2,4-D @ 1.5 kg ha^{-1}; pre-emergence tank mix application of atrazine @ 0.75 kg ha^{-1} and glyphosate @ 2.5 ml lit^{-1} of water; pre-emergence tank mix application of atrazine @ 0.75 kg ha^{-1} and pendimethalin @ 2 $mllit^{-1}$ of water; cowpea co-culture; black polythene mulch, weed free and weedy check). Data regarding the weed population, weed dry weight, growth parameters of crops, yield and yield attributes were recorded during the study. Weed flora dominating throughout the research were grasses includes: *Cynodon dactylon, Digitaria ciliaris, Bidens pilosa*; sedges include *Cyperus iria, Cyperus rotundus, Fimbristylis miliacea*; broad leaves which includes *Ageratum conyzoides, Chenopodium album, Brassica tournefortii, Amaranthus spinosus*. Significantly more weed density and dry weight were recorded in conventional tillage as compared to no tillage during most of the observations that resulted higher grain yield in no tillage (5584 kg ha^{-1}) as compared to conventional tillage (3981 kg ha^{-1}). The correlation between grain yield and weed dry weight was found to be negative. All the weed control practices decreased weed density. Black polythene mulch treatment found to be superior in all parameters of maize and lowering the weeds influences on crop, which is even superior to the weed free check. The highest grain yield (7071.06 kg ha^{-1}) obtained from black polythene mulch which was statistically similar to weed free check (5916.29 kg ha^{-1}). The other weed management practices produced intermediate yield between black polythene mulch and weedy check which produced the lowest grain yield (3168 kg ha^{-1}). Among herbicidal application sequential application of atrazine and 2,4-D seemed better than other as it reduced comparatively more weed dry weight. Similarly, cow-pea co-culture also reduced weed dry weight almost similar to herbicidal treatment especially at later stage.

Keywords: Weed; Spring Maize; Tillage; Weed Management

Introduction

Weed, a plant grown where it is not desirable, de¬clines yield and quality of crop plants and leads to higher cost in food production [1,2] and also regarded as greatest limiting factor in efficient crop production. Thus, weed is the major problem for losing the yield potential of crop (37%) as compared to other loss potential i.e. animal pest 18%, fungal and bacterial pathogen 16%, and virus 2% [3,4]. Maize yield losses due to weeds depend on the cultivars, species and number of weeds per unit area, crop-weed competition period and duration. Besides reducing yield, weeds can reduce grain quality, cause irregular maturation and harvesting difficulties, as well as act as alternate hosts for pests and pathogens. Weeds of maize crop broadly classified as broad leaves, grasses, and sedges [5] and cause the yield loss of 40 - 70% [6]. Karki, BK and Mishra [7-10] recorded 48% reduction of grain yield in maize due to weed infestation in the hills of Nepal and yield loss depends upon types of weed flora and severity. Nature of weed problem in Spring maize is quite different from that of the rainy season maize.

In the rainy season emergence of maize and weed start simultaneously and first 20 - 30 days are most critical to crop-weed competition. Contrarily in the Spring maize, weed emerges most often after the first irrigation.

Thus, the need for increasing maize yield has called for better crop management practices including efficient weed control strategies to enhance the productivity. Since, different weed control practices like cultural, physical, biological and chemical are used for weed control. No doubt cultural methods are still useful tools but are laborious, time consuming and getting expensive. Therefore, an attempt was made in order to evaluate the impact of tillage, and weed management on weed dynamics, crop growth, yield attributes and yield of Spring maize in mid-hills and inner terai of Nepal with objectives to evaluate the effect of tillage methods with various weed management practices on weed severity and dynamics in Spring maize.

Materials and Methods

Research was conducted in the research block of Institute of Agriculture and Animal Science, Lamjung Campus, Lamjung, Nepal during Spring season from September 2016 to March 2017. The varieties used in the experiment was hybrid-2. The hybrid RML32/RML17 was used as a parentage and presently developed Rampur hybrid 4, which can be grown in hills area, having yield potential of 6.95 t/ha with grain colour orange. Field was prepared using 2 tillage methods. In no tillage plot field was left as it is weed was killed by treating with glyphosate @ 0.80 lit/ha whereas in conventional tillage field was ploughed by using tractor 10 days prior to sowing to make field fine. Experiment was conducted in split plot design where main-plot factor represent tillage practices and sub-plot factor contained different weed management practices. Details of factor and their levels used in experiment are Main plot: Tillage: No tillage (NT), Conventional tillage (CT) and Sub plot: Weed management practices.

Field was fertilized using common of inorganic fertilizer for hybrid maize i.e. nitrogen, phosphorus, and potash @ 120:60:40 kg NPK/ha were applied through Urea (46% N), DAP (18% N and 46% P_2O_5) and MOP (60% K_2O). Urea as nitrogen source was applied in 3 split doses i.e. at sowing, at knee height stage and tasseling stage whereas Full dose of phosphorus and potash were applied as basal dose at final land preparation. FYM was applied as per required. As per recommended, seed rate of 20 kg ha-1 was used. Cowpea was also sown as intercrop with maize on same days on cowpea treated plot. Weed control method was used according to treatments.

Treatment No	Treatment practice	Frequency and doses
1	Weedy Check	
2	Weedy Free	Hand weeding @ 10 days interval
3	Polythene Mulching	Black Polythene
4	Cowpea intercropping	Maize cowpea 1:2
5	Atrazine+Glyphosat (pre-emergence tank mixture)	Atrazine: 0.75 kg a.i ha^{-1} or 1.5 $kgha^{-1}$ (Pre-emergence application) Glyphosate: 0.80 lt/ha, 1 - 2 kg a.i ha^{-1}
6	Atrazine + Pendimethalin (pre-emergence tank mixture)	Pendimethalin: 2 ml lt^{-1}water (1-1.5) kg a.i ha^{-1}
7	Atrazine fb 2,4-D(sequential application)	2,4-D: 1.5 kg ha^{-1}

Table 1: Sub-Plot Factors (Weed management Practices).

Herbicides	Recommended dose	Application procedure $plot^{-1}$ (24m^2)
Atrazine	0.75 kg a.i ha^{-1} 1.5 kg a.i. ha^{-1}	3.6 gm/plot 7.2 gm/plot
Pendimethalin	1.5 kg a.i ha^{-1}	2.66 ml/plot
Glyphosate	0.80 lit ha^{-1}	1.92 ml/plot
2,4-D	1.5 kg a.i ha^{-1}	3.15 gm/plot

Table 2: Details of herbicides used in ecological weed management experiments at Research Field, Lamjung in 2016/17.

Harvesting of maize was done from net plot area after drying of dehusked cob, grains from cobs were shelled. Shelled grain were cleaned by winnowing and weighed to take economic yield at their exact moisture content and then grain yield was calibrated at 14% moisture content.

Yield attributing characters of maize like, Grain yield and straw yield, Stover yield, Harvest Index (HI). Similarly, Identification of different categories of weed was done into three separate groups i.e. grasses, sedges and broad leaf. Weed sampling was done in every 15 days interval, 5 times in dang and 3 times in every 30 days interval in lamjung till maturity from quadrate of 0.5 × 0.5 m^2. After identification and classification of weeds, the total number of weeds of each categories was counted separately and expressed in number per square meter. Weed samples so obtained was oven dried to measure the dry weight of each categories separately. Drying of weeds was done at temperatures of 70^0C till constant weight achieved and weighed was expressed in gram per square meter. Recorded data was compiled and processed to fit into Zenstat-software. MS EXCEL was used for entering data, simple statistical analysis, construction of graphs, tables and as for data transformation. Microsoft office word was used for word processing. ANOVA was constructed to test the significance difference for each parameter at 5% level of significance. Duncan Multiple Range Test (DMRT) was conducted for mean separation. Correlation and regression analysis was done for group comparison [11]. Interaction graphs were prepared through Sigma Plot.

Result and Discussion

Weed flora observed in the experimental field in Spring maize

Weed flora dominating throughout the research were grasses includes: *Cynodon dactylon, Digitaria ciliaris, Bidens pilosa*; sedges include *Cyperus iria, Cyperus rotundus, Fimbristylis miliacea*; broad leaf includes *Ageratum conyzoides, Chenopodium album, Brassica tournefortii, Amaranthus spinosus*. Mean dry weight of weeds continued to increase up to 60 DAS and found decline at 90 DAS while the density was decreased from 30 DAS.

Total Weed density

Average total weed density of experiment declined from 22.62 weeds per square meter at 30 DAS to 17.63 weeds per square meter at 90 DAS. Declining trend was observed as the result of various weed management treatment. Total weed density at all dates of observations was significantly influenced by tillage methods and weed management practices. Total numbers of weeds per square meter in conventional tillage were 718.44, 556.69 and 451.56 respectively at 30 DAS, 60 DAS and 90 DAS which were significantly higher than no tillage (355.89, 270.67, and 212.44 weeds per square meter respectively at 30 DAS, 60 DAS and 90 DAS). This is due to remarkably and significantly higher soil moisture content retained in conventional tillage as compared to no tillage at sowing and also disturbance of soil layer which assist in germination of weed seeds present at different depth of soil. Similar result was also obtained by Khan and Parvej [12].

Significantly, weed management practices significantly influence total weed dry weight at different observation dates. At 30 DAS, all weed management practices significantly reduced the weed density compared to weedy check. Total weed density recorded in weedy check were significantly higher (714.28 weeds per square meter) than that of all treatments. Whereas, lowest recorded in sequential herbicidal application of atrazine and 2,4-D (437.78 weeds per square meter) treated plot and which was statistically similar with other treatment except tank mix application of atrazine and pendimethalin.

Scientific name	Local name	Common name	Family	Time of appearance		
				30 DAS	60 DAS	90 DAS
Grasses						
Cynodon dactylon (L.) Pers.	Dubo	Bermuda grass	Poaceae	+	+	+
Oxalis corniculata	Chari amilo	Yellow sorrels	Oxalidaceae	+	+	
Digitaria ciliaris (Retz.) Koel.	Chit-trey Banso	Crab grass	Poaceaea	+	+	+
Eluesine indica (L.) Gaertn.	Kode jhar	Goosegrass	Poaceae	+	+	+
Bidens pilosa	Kuro	Cobbler's peg	Asteraceae	+	+	
Sedges						
Cyperus iria L.	Mothe	Rice flat sedge	Cyperaceae	+	+	+
Fimbristylis miliacea	Jwane jhar	Grass like fimbry	Cyperaceae	+	+	+
Cyperus rotundus L.	Mothe	Purple nutsedge	Cyperaceae	+	+	+
Broad leaf weeds						
Ageratum conyzoides L.	Gandhe jhar	Goat weed	Compositae	+	+	+
Euphorbia hirta L.	Dudhe jhar	Garden spurge	Euphorbiaceae	+	+	
Brassica tourneforti	Ban tori	Asian mustard	Brassicaceae	+	+	+
Borreria levis (Burm. F)	Marote	Button weed	Rubiaceae	+	+	
Commelina bengalensis Linn.	Kane jhar	Day flower	Commelinaceae	+	+	
Chenopodium album	Bethe	Lambsquater	Chenopodiaceae	+	+	+
Cannabis sativa	Ganja	Hemp	Cannabaceae	+		
Amaranthis spinosus	Kande lude	Spiny pigweed	Amaranthaceae	+	+	+
Solanum nigrum	Kali gedi	Black night shade	Solanaceae	+	+	
Anagalis arvensis	Nilo jhar	Scarlet pimpernel	Primulaceae	+		

Table 3: Description of weeds recorded at different growth stages of Spring Maize at Lamjung 2016/17.

Similarly, at 60 DAS, highest weed density recorded in tank mix application of atrazine and pendimethalin (510.61 weeds per square meter) in comparison to all treatments and it was statistically similar with tank mix application of atrazine and glyphosate. Lowest weed density was recorded in cowpea co-culture (318.33 weeds per square meter) which was statistically similar with sequential application of Atrazine and 2,4-D, and weedy check. At 90 DAS, The treatment cowpea co-culture (209.44 weeds per square meter) resulted in lowest weed density whereas tank mix application of atrazine and pendimethalin record highest weed density and which was statistically similar with other treatments.

Treatments	Total weed density (numbers of weeds per square meter) at different DAS		
	30DAS	60DAS	90DAS
Tillage methods			
No Tillage	18.64[b] (355.89)	16.23[b] (270.67)	14.39[b] (212.44)
Conventional Tillage	26.60[a] (718.44)	23.41[a] (556.69)	20.87[a] (451.56)
SEm (±)	1.135	0.870	0.597
LSD (=0.05)	6.906	5.295	3.632
Weed management Practices			
Cowpea co-culture	21.64[bc] (504.44)	17.11[c] (318.33)	14.00[b] (209.44)
Atrazine 0.75 kg a.i. ha-1 + Pendimethalin	23.25[b] (551.12)	22.26[a] (510.61)	19.33[a] (378.34)
Atrazine 1.5 kg a.i. ha-1 fb 2,4-D	21.73[bc] (478.22)	19.37[bc] (382.22)	17.48[a] (334.44)
Atrazine 0.75 kg a.i. ha-1 + Glyphosate	20.29[c] (437.78)	21.15[ab] (468.34)	18.50[a] (353.89)
Weedy check	26.20[a] (714.28)	19.23[bc] (388.89)	18.84[a] (383.89)
SEm (±)	0.742	0.891	0.932
LSD (=0.05)	2.226	2.670	2.794
CV,%	22.66	23.41	26.61
Grand Mean	22.62 (537.17)	19.82 (413.68)	17.63 (332.00)

Table 4: Total weed density (numbers of weeds per square meter) as influenced by tillage methods and weed management practices in Spring maize at different date of observation at Lamjung, Nepal, 2015/16.

Note: DAS: Days After Sowing; Data subjected to square-root (√X+0.5) transformation, and figures in the parenthesis are original values; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

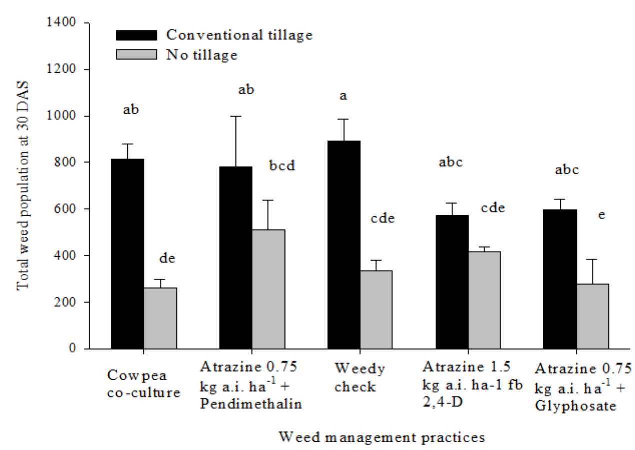

Figure 1: Interaction effect of tillage and weed management practices on total weed population (number of weeds per square meter) at 30 DAS of Spring maize.

The significant interaction of tillage methods and weed management practices for total weed population at 30 DAS was shown in figure. Statistically lowest weed population was found in no tillage than that of conventional tillage. Under conventional tillage all treatments had similar effects for the total number of weeds while tank mixture application of atrazine and glyphosate results significantly lower weed population.

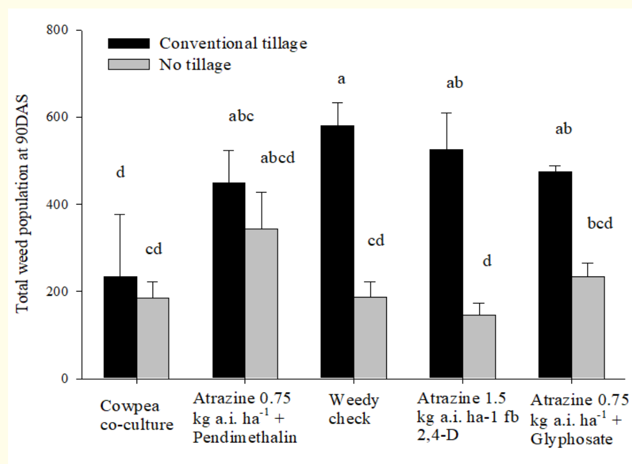

Figure 2: Interaction effect of tillage and weed management practices on total weed population (number of weeds per square meter) at 90 DAS of Spring Maize.

Figure shows the significant interaction effect of tillage and weed management practices on total weed population at 90 DAS. All weed management strategies resulted the similar total weed population under no tillage and conventional tillage at 90 DAS but no till resulted significantly lower as compared to conventional tillage for weedy check and sequential application of atrazine and 2,4-D.

Weed density at 30 DAS

Treatment	Weed density (numbers of weeds per square meter) at 30DAS			
	Grasses	Sedges	Broad leaf	Total
Tillage methods				
No Tillage	14.36^{b} (213.40)	10.47 (128.05)	3.42 (14.44)	18.64b (355.89)
Conventional Tillage	23.49^{a} (559.11)	10.29 (125.56)	5.09 (33.78)	26.60^{a} (718.44)
SEm (±)	0.905	1.640	0.471	1.135
LSD (=0.05)	5.506	ns	ns	6.906
Weed management Practices				
Cowpea co-culture	18.86^{b} (397.78)	7.04 (67.22)	6.09^{a} (39.44)	21.64^{bc} (504.44)
Atrazine 0.75 kg a.i. ha-1 + Pendimethalin	19.00^{b} (377.11)	12.35 (156.23)	3.28^{b} (17.78)	23.25^{b} (551.12)
Atrazine 1.5 kg a.i. ha-1 fb 2,4-D	18.01^{bc} (332.67)	11.61 (139.44)	2.38^{b} (6.11)	21.73^{bc} (478.22)
Atrazine 0.75 kg a.i. ha-1 + Glyphosate	16.71^{c} (319.44)	8.38 (103.89)	3.48^{b} (14.44)	20.29^{c} (437.78)
Weedy check	22.04^{a} (504.28)	12.52 (167.22)	6.06^{a} (42.78)	26.20^{a} (714.28)
SEm (±)	0.532	1.626	0.765	0.742
LSD (=0.05)	1.595	Ns	2.294	2.226
CV,%	28.51	42.82	58.79	22.66
Grand Mean	18.92 (386.26)	10.38 (126.80)	4.26 (24.11)	22.62 (537.17)

Table 5: Weed density (numbers of weeds per square meter) influenced by tillage methods and weed management practices in Spring Maize.

Note: DAS: Days After Sowing; Data subjected to square-root (√X+0.5) transformation, and figures in the parenthesis are original values; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

Tillage methods had significant effect on total weed density and grasses weed density but non-significant effect on density of sedges and broad leaf weeds at 30 DAS (Table 5). Grasses population was higher than that of other weed categories. Grasses density was observed significantly more in conventional tillage (559.11 per square meter) than that of no tillage (213.40 per square meter). Sedges and broadleaf weed population were also higher in conventional tillage but not significant.

Weed management practices had significant effect on grasses, broadleaf and total weed population but non-significant with the sedges population. Weedy check treatment recorded highest grasses, sedges, broad leaf and total density (540.28, 167.22, 42.78, 714.28 per square meter respectively). Lowest grasses density was recorded in tank mix application of atrazine and glyphosate treated plot (319.44 per square meter) which was significantly at par with sequential application of atrazine and 2,4-D. All herbicidal treatment resulted in significantly reduce broad leaf weed population in comparison to weedy check and cowpea co-culture treatment.

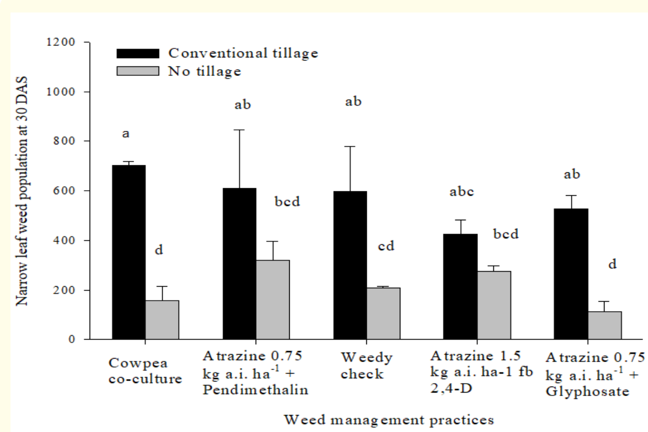

Figure 3: Interaction effect of tillage and weed management practices on narrow leaf weed population (number of weeds per square meter) at 30 DAS of Spring Maize.

Figure showed the significant interaction of tillage methods and weed management practices for narrow leaf weed population at 30 DAS. No tillage results in significantly lowest narrow leaf weed population than conventional tillage. Cowpea co-culture, weedy check, tank mixture application of atrazine and glyphosate significantly reduces the number of narrow leaf weeds for no tillage at 30 DAS while tank mix application of atrazine and pendimethalin and subsequent application of atrazine and 2,4-D resulted statistically similar weeds both for no and conventional tillage.

Weed density at 60 DAS

Tillage methods did not significantly influenced the individual weed categories but total density was significant at 60 DAS. However, conventional tillage resulted in remarkably higher density of grasses, sedges and broad leaf weeds (440.44, 86.69 and 29.56 per square meter respectively).

Weed management practices had significant influenced on weed density of sedges, broad leaf and total but non-significant on grass weed density at 60 DAS. Tank mix application of atrazine and pendimethalin resulted in greatest grasses, broadleaf and total weed population (384.44, 115.05 and 510.61 per square meter respectively) which was statistically similar with tank mix application of atrazine and glyphosate and weedy check for sedges and broad leaf weeds. Lowest weed density of sedges and broad leaf was found in treatment on subsequent application of atrazine and 2,4-D. Cowpea co-culture result in lowest grass and total weed dry weight at 60DAS.

Treatment	Weed density (numbers of weeds per square meter) at 60DAS			
	Grasses	Sedges	Broad leaf	Total
Tillage methods				
No Tillage	13.77 (197.56)	7.69 (65.56)	2.46 (7.56)	16.23[b] (270.67)
Conventional Tillage	20.81 (440.44)	8.50 (86.69)	5.09 (29.56)	23.41[a] (556.69)
SEm (±)	1.278	0.787	0.478	0.870
LSD (=0.05)	Ns	Ns	ns	5.295
Weed management Practices				
Cowpea co-culture	14.78 (240.00)	6.63[b] (56.67)	4.09[ab] (21.67)	17.11[c] (318.33)
Atrazine 0.75 kg a.i. ha-1 + Pendimethalin	18.97 (384.44)	10.67[a] (115.05)	3.14[bc] (11.11)	22.26[a] (510.61)
Atrazine 1.5 kg a.i. ha-1 fb2,4-D	18.33 (346.67)	5.02[b] (27.78)	2.03[c] (7.78)	19.37[bc] (382.22)
Atrazine 0.75 kg a.i. ha-1 + Glyphosate	17.75 (331.67)	9.94[a] (106.67)	5.15[a] (30.00)	21.15[ab] (468.34)
Weedy check	16.63 (292.22)	8.20[ab] (74.45)	4.46[ab] (22.22)	19.23[bc] (388.89)
SEm (±)	0.950	1.021	0.491	0.891
LSD (=0.05)	Ns	3.060	1.473	2.670
CV,%	26.29	41.04	56.38	23.41
Grand Mean	17.29 (319.00)	8.09 (76.12)	3.77 (18.56)	19.82 (413.68)

Table 6: Weed density (numbers of weeds per square meter) influenced by tillage methods and weed management practices in Spring Maize.

Weed density at 90 DAS

Tillage methods significantly influenced total weed density and grasses density but sedges and broad leaf population found non-significant at 90 DAS. Significantly lowest grasses weed density and total weed density was recorded in no tillage and also comparatively broadleaf and sedges density too.

Similarly, grasses were not significantly influenced by weed management practices but sedges, broadleaf and total weed density were significantly influenced at 90 DAS. Cowpea co-culture treatment recorded lowest sedges, broad leaf and total weed population (10.00, 11.67, 209.44 per square meter respectively), may

Treatment	Weed density (numbers of weeds per square meter) at 90DAS			
	Grasses	Sedges	Broad leaf	Total
Tillage methods				
No Tillage	12.29[b] (154.44)	2.58 (8.89)	6.34 (49.11)	14.39[b] (212.44)
Conventional Tillage	18.44[a] (352.67)	4.24 (18.44)	8.32 (80.44)	20.87[a] (451.56)
SEm (±)	0.392	0.339	0.708	0.597
LSD (=0.05)	2.383	ns	ns	3.632
Weed management Practices				
Cowpea co-culture	13.13 (187.78)	2.35[c] (10.00)	3.35[c] (11.67)	14.00[b] (209.44)
Atrazine 0.75 kg a.i. ha-1 + Pendimethalin	16.69 (286.11)	4.47[a] (20.56)	8.33[a] (71.67)	19.33[a] (378.34)
Atrazine 1.5 kg a.i. ha-1 fb 2,4-D	16.01 (281.67)	3.38[b] (13.33)	5.99[b] (39.44)	17.48[a] (334.44)
Atrazine 0.75 kg a.i. ha-1 + Glyphosate	15.32 (251.11)	3.60[b] (13.33)	9.36[a] (89.44)	18.50[a] (353.89)
Weedy check	15.67 (261.11)	3.23[b] (11.11)	9.62[a] (111.67)	18.84[a] (383.89)
SEm (±)	1.018	0.261	0.646	0.932
LSD (=0.05)	Ns	0.782	1.936	2.794
CV,%	27.74	43.42	46.20	26.61
Grand Mean	15.36 (253.56)	3.41 (13.67)	7.33 (64.78)	17.63 (332.00)

Table 7: Weed density (numbers of weeds per square meter) influenced by tillage methods and weed management practices in Spring Maize.

Note: DAS: Days After Sowing; Data subjected to square-root (√X+0.5) transformation, and figures in the parenthesis are original values; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

be due to preventing weed seed germination and reducing weed seedling growth and development by cowpea and also weed seed germination may be inhibited by either complete light interception due to cover crop or allelochemical secretion. The total weed density, density of sedges and grasses was found greatest in tank mixture application of atrazine and pendimethalin, whereas broad leaf population found greatest in weedy check treatment.

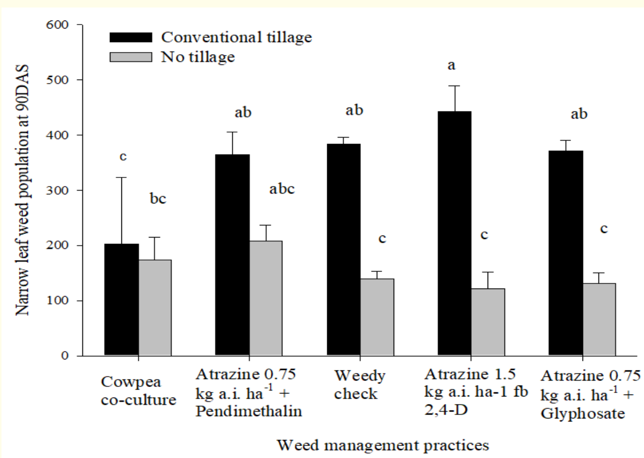

Figure 4: Interaction effect of tillage and weed management practices on narrow leaf weed population (number of weeds per square meter) at 90 DAS of Spring Maize.

Figure showed the significant interaction of tillage methods and weed management practices for narrow leaf population at 90 DAS. Weeds population were statistically similar for no tillage and conventional tillage for cow pea co-culture and tank mix application of atrazine and pendimethalin while weed population was significantly lowered under no tillage for weedy check, tan mix application of atrazine and glyphosate and sequential application of atrazine and 2,4-D.

Figure shows the significant interaction effect of tillage and weed management practices on broad leaf weed population at 90 DAS. All weed management strategies result the similar broad leaf weed population under no tillage and conventional tillage at 90 DAS but no till resulted significantly lower as compared to conventional tillage for weedy check.

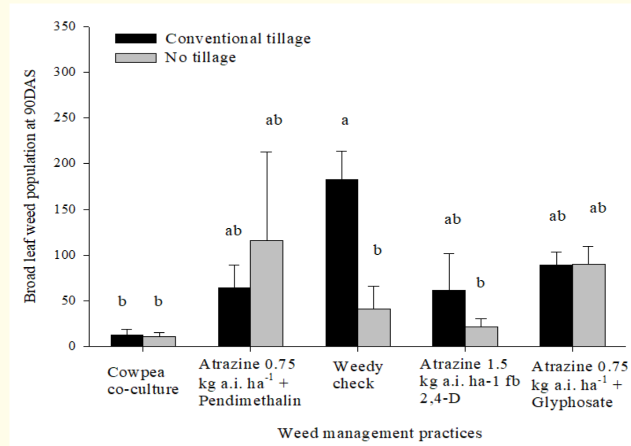

Figure 5: Interaction effect of tillage and weed management practices on broad leaf weed population (number of weeds per square meter) at 90 DAS of Spring Maize.

Total weed dry weight

Grand mean of total weed dry weight was increased from 30 to 60 DAS (206.81 gm^{-2} and 279.12 gm^{-2}) and found declined at 90 DAS (159.82 g m^{-2}). Total weed dry weight were not significantly influenced by tillage method at all dates of observation but weed management practices significantly influenced weed dry weight at all observations. Comparatively higher weed dry weight were comparatively higher under conventional tillage.

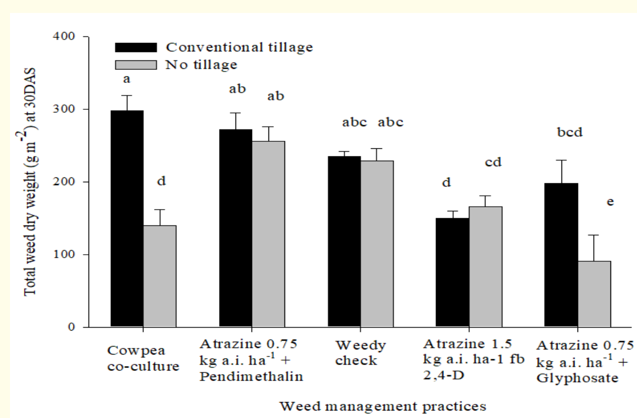

Figure 6: Interaction effect of tillage and weed management practices on total weed dry weight (g per square meter) at 30 DAS of Spring Maize.

All weed management practices significantly reduced the weed dry weight compared to weedy check. At all date of observation weedy check recorded highest weed dry weight. Tank mixture application of atrazine and glyphosate and sequential application of atrazine and 2,4-D were statistically similar to each other and recorded lower weed dry weight at 30 DAS. At 60DAS treatment cowpea co-culture and sequential application of atrazine and 2,4-D recorded lower weed dry weight and was significantly at par with all treatment except weedy check. Finally at 90 DAS, lower weed dry weight recorded in cowpea co-culture treatment and was found significantly similar with all treatment except weedy check and tank mix application of atrazine and pendimethalin.

Treatment	Total weed dry weight (g m^{-2})		
	30 DAS	60DAS	90DAS
Tillage methods			
No Tillage	13.00 (175.53)	15.58 (246.03)	11.83 (145.38)
Conventional Tillage	15.26 (238.08)	17.42 (312.21)	12.98 (174.27)
SEm (±)	0.428	0.902	0.748
LSD (=0.05)	ns	ns	ns
Weed management Practices			
Cowpea co-culture	14.18^{b} (209.38)	14.61^{b} (216.59)	10.50^{c} (112.11)
Atrazine 0.75 kg a.i. ha-1 + Pendimethalin	15.75^{a} (249.17)	16.56^{ab} (274.57)	12.89^{b} (167.06)
Atrazine 1.5 kg a.i. ha-1 fb 2,4-D	12.55^{c} (157.82)	15.59^{b} (246.35)	11.19^{bc} (131.78)
Atrazine 0.75 kg a.i. ha-1 + Glyphosate	11.71^{c} (144.39)	16.87^{ab} (296.15)	12.18^{bc} (152.22)
Weedy check	16.48^{a} (273.28)	18.87^{a} (361.95)	15.28^{a} (235.95)
SEm (±)	0.445	0.784	0.674
LSD (=0.05)	1.334	2.351	2.022
CV, %	19.15	16.13	19.98
Grand Mean	14.13 (206.81)	16.50 (279.12)	12.41 (159.82)

Table 8: Total weed dry weight (g m^{-2}) as influenced by tillage method and weed management practices at different date of observation in Spring maize.

Note: DAS: Days After Sowing; Data subjected to square-root (√X+0.5) transformation, and figures in the parenthesis are original values; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

Figure shows the interaction effect of tillage and weed management practices on total weed dry weight at 30 DAS. Cowpea coculture and tank mix application of atrazine and glyphosate result the significantly lower weed dry weight under no till as compared to conventional tillage while other weed management treatments result the similar weed dry weight.

Weed dry weight at 30 DAS

Treatments	Weed dry weight (g m^{-2}) at 30DAS			
	Grasses	Sedges	Broad leaf	Total
Tillage methods				
No Tillage	9.48 (97.22)	6.45 (46.67)	5.33^{a} (31.64)	13.00 (175.53)
Conventional Tillage	13.36 (183.58)	5.31 (31.04)	4.25^{b} (23.47)	15.26 (238.08)
SEm (±)	0.613	0.593	0.165	0.428
LSD (=0.05)	Ns	ns	1.004	ns
Weed management Practices				
Cowpea co-culture	11.61^{ab} (150.39)	4.27^{c} (19.16)	6.17^{a} (39.83)	14.18^{b} (209.38)
Atrazine 0.75 kg a.i. ha-1 + Pendimethalin	12.19^{ab} (153.11)	8.37^{a} (73.56)	4.52^{b} (22.50)	15.75^{a} (249.17)
Atrazine 1.5 kg a.i. ha-1 fb 2,4-D	10.58^{bc} (113.11)	5.32^{bc} (31.49)	2.60^{c} (13.22)	12.55^{c} (157.82)
Atrazine 0.75 kg a.i. ha-1 + Glyphosate	9.33^{c} (103.11)	4.78^{c} (25.06)	3.98^{bc} (16.22)	11.71^{c} (144.39)
Weedy check	13.37^{a} (182.28)	6.65^{b} (45.00)	6.68^{a} (46.00)	16.48^{a} (273.28)
SEm (±)	0.658	0.574	0.486	0.445
LSD (=0.05)	1.972	1.639	1.457	1.334
CV, %	28.26	36.08	45.71	19.15
Grand Mean	11.42 (140.40)	5.88 (38.85)	4.79 (27.55)	14.13 (206.81)

Table 9: Weed dry weight (g m^{-2}) as influenced by tillage method and weed management practices at 30DAS in Spring Maize.

Note: DAS: Days After Sowing; Data subjected to square-root (√X+0.5) transformation, and figures in the parenthesis are original values; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance.

Tillage methods had non-significant effect on dry weight of grasses, sedges and total dry weight but had significant effect on dry weight of broad leaf weeds at 30 DAS. Lowest broad leaf weed dry weight was found with conventional tillage practices.

In case of weed management practices, grasses, sedges, broad leaf and total dry weight of weed were significantly influenced at 30 DAS. Further dry matter accumulation in grasses was found remarkably higher than that of other category. With respect to weed management practices total weed dry weight recorded in weedy check was significantly higher than other treatments due to uncontrolled weed growth and higher weed population in comparison to other weed control treatments.

Application of herbicides assisted to reduce weed dry weight, among which sequential application of atrazine and 2,4-D treatment gave the best result in reducing weed dry weight of all weed categories. Further, addition of pendimethalin to atrazine and their application as tank mixture didn't gave significant result in reducing weed dry weight. Cowpea co-culture treatment recorded statistically similar result in weed dry weight of grasses and broad leaf with weedy check treatment while significantly reduced the sedges and total dry weight as compared to weedy check.

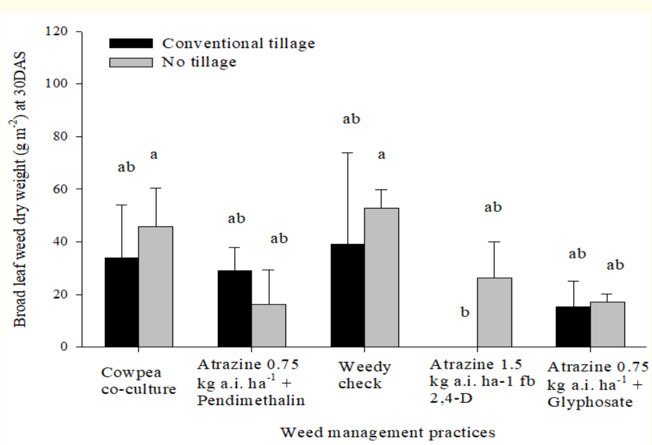

Figure 7: Interaction effect of tillage and weed management practices on broad leaf weed dry weight (g per square meter) at 30 DAS of Spring Maize.

Figure shows the interaction effect of tillage and weed management practices on broad leaf weed dry weight at 30 DAS. All weed management practices resulted the similar broad leaf dry weight in all treatment combination but cowpea co-culture under no tillage resulted the significantly higher weed dry weight than the sequential application of atrazine and 2,4-D under conventional tillage.

Weed dry weight at 60 DAS

Treatment	Weed dry weight (g m^{-2}) at 60DAS			
	Grasses	Sedges	Broad leaf	Total
Tillage methods				
No Tillage	13.49 (185.58)	5.39^{a} (30.59)	4.76 (29.87)	15.58 (246.03)
Conventional Tillage	14.93 (226.99)	4.43^{b} (22.33)	7.37 (62.89)	17.42 (312.21)
SEm (±)	0.808	0.078	0.534	0.902
LSD (=0.05)	Ns	0.474	ns	ns
Weed management Practices				
Cowpea co-culture	12.66^{b} (163.44)	4.45 (21.79)	5.44^{bc} (31.36)	14.61^{b} (216.59)
Atrazine 0.75 kg a.i. ha^{-1} + Pendimethalin	14.47^{ab} (210.49)	4.84 (24.91)	5.96^{abc} (39.17)	16.56^{ab} (274.57)
Atrazine 1.5 kg a.i. ha^{-1} fb 2,4-D	13.94^{ab} (195.99)	3.78 (17.67)	3.85^{c} (32.68)	15.59^{b} (246.35)
Atrazine 0.75 kg a.i. ha^{-1} + Glyphosate	14.11^{ab} (207.50)	5.80 (34.49)	6.80^{ab} (54.16)	16.87^{ab} (296.15)
Weedy check	15.87^{a} (254.00)	5.67 (33.44)	8.27^{a} (74.51)	18.87^{a} (361.95)
SEm (±)	0.659	0.557	0.826	0.784
LSD (=0.05)	1.975	Ns	2.475	2.351
CV, %	14.95	32.27	52.02	16.13
Grand Mean	14.21 (206.28)	4.91 926.46)	6.07 946.38)	16.50 (279.12)

Table 10: Weed dry weight (g m^{-2}) as influenced by tillage method and weed management practices at 60DAS in Spring maize.

Note: DAS: Days After Sowing; Data subjected to square-root ($\sqrt{X+0.5}$) transformation, and figures in the parenthesis are original values; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

At 60 DAS, grasses, broad leaf and total dry weight were not significantly influenced due to tillage methods but tillage methods significantly influenced the sedges dry weight (Table). Grasses, broad leaf and total dry weight was relatively higher under conventional tillage while sedges dry weight was significantly higher under no tillage.

Similarly, weed management practices significantly influenced grasses, broad leaf and total weed dry weight but not the sedges dry weight. Weedy check treatment gave significantly highest weed dry weight of grasses and broad leaf which ultimately effect on the total weed dry weight. Cowpea co-culture treatment record lowest grasses (163.44 gm^{-2}) and total weed weight (216.59 gm^{-2}) and found statistically similar with other treatments except weedy check. Subsequent application of atrazine and 2,4-D resulted comparatively lower sedges dry weight. Similarly the broad leaf dry weight was lowest (32.68 gm^{-2}) for subsequent application of atrazine and 2,4-D applied treatment, it was significantly lower than the weedy check and tank mix application of atrazine and glyphosate while similar with the cowpea co-culture and tank mix application of atrazine and pendimethalin.

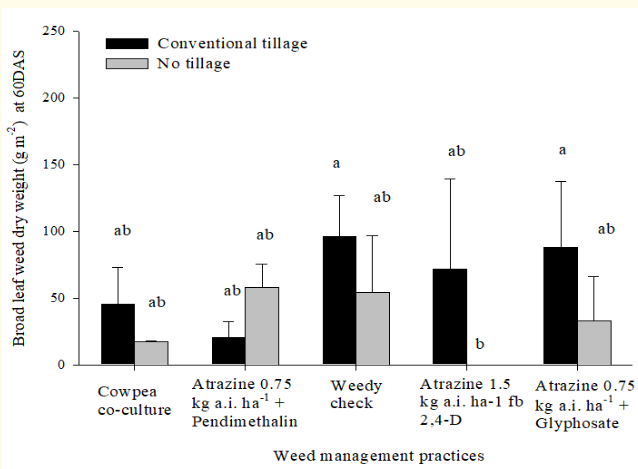

Figure 8: Interaction effect of tillage and weed management practices on broad leaf weed dry weight (g per square meter) at 60 DAS of Spring Maize.

Figure shows the interaction effect of tillage and weed management practices on broad leaf weed dry weight at 60 DAS. All treatment combination resulted the statistically similar dry weight except subsequent application of atrazine and 2,4-D result significantly lower weed dry weight than the dry weight recorded for weedy check and tank mix application of atrazine and glyphosate for conventional agriculture.

Weed dry weight at 60 DAS

Tillage methods also did not significantly influence individual and total weed dry weight at 90 DAS and relatively lower all categories of weed dry weight was observed in no tillage method than in conventional method. Further, with respect to weed management practices, individual weed categories and total weed dry weight were significantly influenced. Dry weight of grasses, sedges, broad leaf and total were significantly higher (175.11, 2.45, 58.39 and 235.95 gm^{-2} respectively). Dry weight of grasses and sedges were found least in treatment cowpea co-culture but sequential application of atrazine with 2,4-D recorded lower dry weight of broad leaf (6.06 gm^{-2}). Least total weed dry weight was obtained from treatment of cowpea co-culture (112.11 gm^{-2}) which was statistically at par with tank mixture treatments.

Treatment	Weed dry weight (gm^{-2}) at 90DAS			
	Grasses	Sedges	Broad leaf	Total
Tillage methods				
No Tillage	10.37 (110.31)	0.83 (1.00)	4.83 (34.07)	11.83 (145.38)
Conventional Tillage	12.05 (152.38)	1.23 (1.89)	4.09 (20.00)	12.98 (174.27)
SEm (±)	0.571	0.1704	0.439	0.748
LSD (=0.05)	Ns	ns	Ns	ns
Weed management Practices				
Cowpea co-culture	9.00^{c} (83.39)	0.22^{c} (0.00)	5.01^{ab} (28.72)	10.50^{c} (112.11)
Atrazine 0.75 kg a.i. ha^{-1} + Pendimethalin	12.01^{ab} (146.72)	0.95^{b} (1.45)	3.80^{ab} (18.89)	12.89^{b} (167.06)
Atrazine 1.5 kg a.i. ha^{-1} fb 2,4-D	10.82^{bc} (124.22)	1.14^{ab} (1.50)	1.88^{b} (6.06)	11.19^{bc} (131.78)
Atrazine 0.75 kg a.i. ha^{-1} + Glyphosate	11.03^{bc} (127.28)	1.33^{ab} (1.83)	4.68^{ab} (23.11)	12.18^{bc} (152.22)
Weedy check	13.20^{a} (175.11)	1.51^{a} (2.45)	6.92^{a} (58.39)	15.28^{a} (235.95)
SEm (±)	0.648	0.1666	0.974	0.674
LSD (=0.05)	1.943	0.4994	2.919	2.022
CV, %	21.58	64.85	61.20	19.98
Grand Mean	11.21 (131.34)	1.03 (1.44)	4.46 (27.03)	12.41 (159.82)

Table 11: Weed dry weight (gm^{-2}) as influenced by tillage method and weed management practices at 90 DAS in Spring Maize.

Note: DAS, Days after sowing; Data subjected to square-root (√X+0.5) transformation, and figures in the parenthesis are original values; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

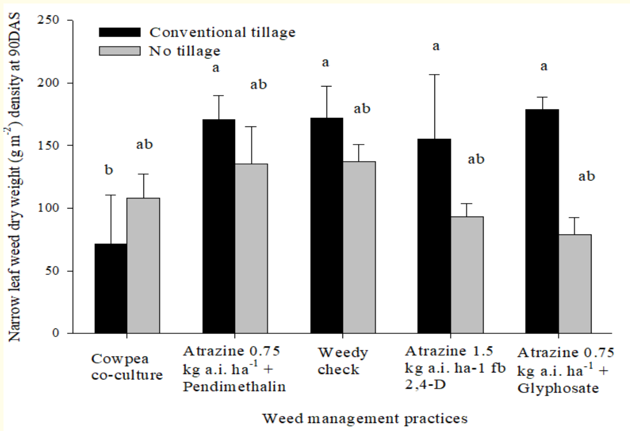

Figure 9: Interaction effect of tillage and weed management practices on narrow leaf weed dry weight (g per square meter) at 90 DAS of Spring maize.

Figure shows the interaction effect of tillage and weed management practices on narrow leaf weed dry weight at 90 DAS. All weed management practices had not influence the weed dry weight under no tillage while cowpea co-culture had significantly lower dry weight as compared to other weed management treatments under conventional agriculture.

Grain yield

Mean grain yield of the experiment was 4782.51 kg ha^{-1} and ranged from 3168.16 to 70.71.06 kg ha^{-1} among the treatments (Table 12). Grain yield were significantly influenced by tillage methods as well as weed management practices.

Grain yield of no tillage (5584.02 kg ha-1) was significantly higher than conventional tillage (3981.00 kg ha-1) as because of highest weed density and dry weight in conventional tillage practice. Weed compete with crop which in turn decreased all growth parameters and yield attributes like number of kernels per ear and thousand grain weight remarkably.

Similarly, among weed management practice black polythene mulch produced the highest grain yield (7071.06 kg ha^{-1}) which was statistically similar with grain yield of weedy free plot (5916.29 kg ha^{-1}) and significantly superior than grain yields obtained from all other weed management practices. The lowest grain yield found in weedy check plot (3168.16 kg ha^{-1}) which might be due to competition from weed which effect yield attribute character and which found statistically similar with treatments cowpea co-culture (4065.57 kg ha^{-1}), tank mixture of atrazine and pendimethalin (4115.14 kg ha^{-1}) and tank mixture of atrazine and glyphosate applied plot (3954.86 kg ha^{-1}).

Treatment	Yield (kg ha^{-1})	Straw dry weight (kg ha^{-1})	Harvest index (%)	WI
Tillage methods				
No Tillage	5584.02^{a}	6280.33^{a}	46.49^{a}	11.48
Conventional Tillage	3981.00^{b}	5231.94^{b}	42.12^{b}	25.11
SEm (±)	96.00	19.70	0.112	3.70
LSD (=0.05)	584.20	120.10	0.679	Ns
Weed management Practices				
Cowpea co-culture	4065.57^{cd}	5909.80^{c}	39.18^{c}	30.79^{ab}
Black polythene mulch	7071.06^{a}	8308.13^{a}	45.93^{abc}	-20.68^{d}
Atrazine 0.75 kg a.i. ha-1 + Pendimethalin	4115.14^{cd}	4563.91^{e}	46.01^{abc}	30.84^{ab}
Atrazine 1.5 kg a.i. ha-1 fb 2,4-D	5186.48^{bc}	4919.48^{de}	50.18^{a}	12.25^{bc}
Atrazine 0.75 kg a.i. ha-1 + Glyphosate	3954.86^{cd}	4867.56^{de}	43.86^{abc}	34.61^{ab}
Weed free	5916.29^{ab}	6693.57^{b}	46.80^{ab}	0.00^{cd}
Weedy check	3168.16^{d}	5030.50^{d}	38.20^{bc}	40.27^{a}
SEm (±)	399.30	118.70	1.980	7.36
LSD (=0.05)	1165.50	346.60	5.779	21.48
CV, %	38.42	25.58	14.85	167.69
Grand Mean	4782.51	5756.14	44.31	18.30

Table 12: Grain yield (kg ha^{-1}), straw yield (kg ha^{-1}), harvest index (%) and weed index (%) as influenced by tillage methods and weed management practices in Spring Maize.

Note: Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance, DAS: Days After Sowing; ns: Non-Significant

Straw yield

Mean straw yield of experiments was 5756.14 kg ha^{-1} ranging from 8308.13 kg ha^{-1} in black polythene mulch to 4563.91 kg ha^{-1} in tank mix herbicidal application of atrazine and pendimethalin. Straw yield was significantly influenced by both tillage methods as well as weed management practices.

Higher straw yield was obtained under no tillage (6280.33 kg ha^{-1}) as compared to conventional tillage (5231.94 kg ha^{-1}). Similarly, black polythene mulch produced highest straw yield and was significantly superior than obtained from all other treatment. Straw yield under tank mix herbicidal applied plot of atrazine and pendimethalin was lowest and was statistically similar with atrazine fb 2,4-D, combination of atrazine and glyphosate as tank mixture.

Harvest index

Average harvesting index in the experiment was 44.13% (Table 12). Tillage methods significantly influence the harvest index, significantly higher harvest index was found in no tillage (46.49%) as compared to conventional tillage practices (42.12%).

Similarly, weed management practice influence the harvest index. Highest harvest index was recorded in sequential application of atrazine fb 2,4-D treated plot (50.18%) and was significantly at par with all treatment except cowpea co-culture and weedy check. Increase in percentage of harvest index as compared to weedy check may be attributed to adequate suppression of weed growth due to some residual effect as well and more availability of plant nutrients to maize crop, which favored better utilization of photo-assimilates for grain yield formation [13]. Lowest Harvest Index was found in cowpea co-culture treated plot and was statistically similar with weedy check.

Weed index

Weed index was not significantly influenced by tillage methods. But it was more than double under conventional tillage as compared to no till (Table 12).

Similarly, weed index was significantly influenced with respect to weed management practices. Highest weed index (WI) was observed in weedy check plot (40.27%) which was statistically similar with tank mix of atrazine and glyphosate, atrazine and pendimethalin and cowpea co-culture plot. Lowest WI was recorded in black polythene mulch which showed the yield increment was 20.68% above the weed free.

Figure showed the significant interaction of tillage methods and weed management practices for stover dry weight (kg ha^{-1}). Under black polythene mulch and weed free plots, both tillage methods resulted in statistically similar stover dry weight. Whereas, for cowpea co-culture, weedy check and all herbicide applied treatment, stover dry weight under no tillage was significantly higher than under conventional tillage.

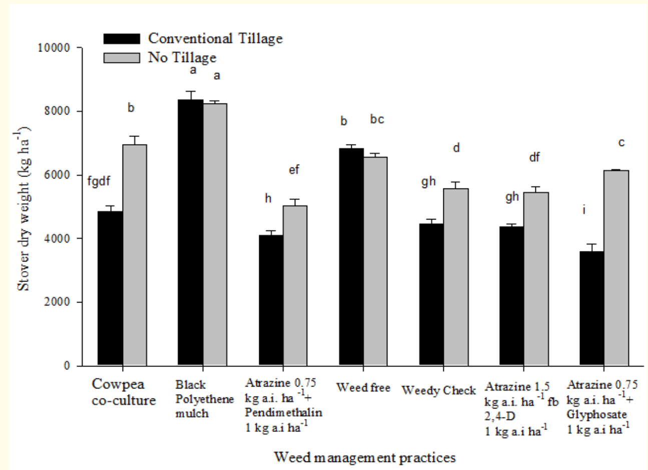

Figure 10: Interaction effect of tillage and weed management practices on Stover dry weight (kg ha^{-1}) of Spring Maize.

The figure 11 showed that that weed density differ with different weed management methods. The abundance of weed directly affect the yield of Maize. Weed density and yield was negatively correlated.

Effect of tillage methods on weed, crop growth and yield

Weeds one of the greatest limiting factors to efficient crop production. Tillage method greatly affect weed, changes in tillage practices can cause shifts in weed species and densities [14].

Weed density was significantly influenced by tillage methods at all date of observation. No tillage resulted the lower weed density and dry weight as compare to conventional tillage, which may be due to weed seed bank below the soil is taken up in conventional tillage creating favorable place for germination of weed seeds. Shrestha, Knezevic, Roy, Coehl and Swanton (2002) also supported this finding. Similar results have been reported by Dahal and Karki [3,4] who found no tillage and residue retained level had significantly lower number of grasses, sedges, broad leaf population and dry weight as compared to conventional tillage and residue removed level during all 30, 60 and 90 DAS observations of maize. But this finding was in contrast with findings of Tangadulratana [15] and Gul, Khan, Hassan, Khan, Hasim and Khan (2009) who reported that weeds tended to be minimum when tillage was imposed and conventional tillage was superior to no-tillage regarding weed infestation.

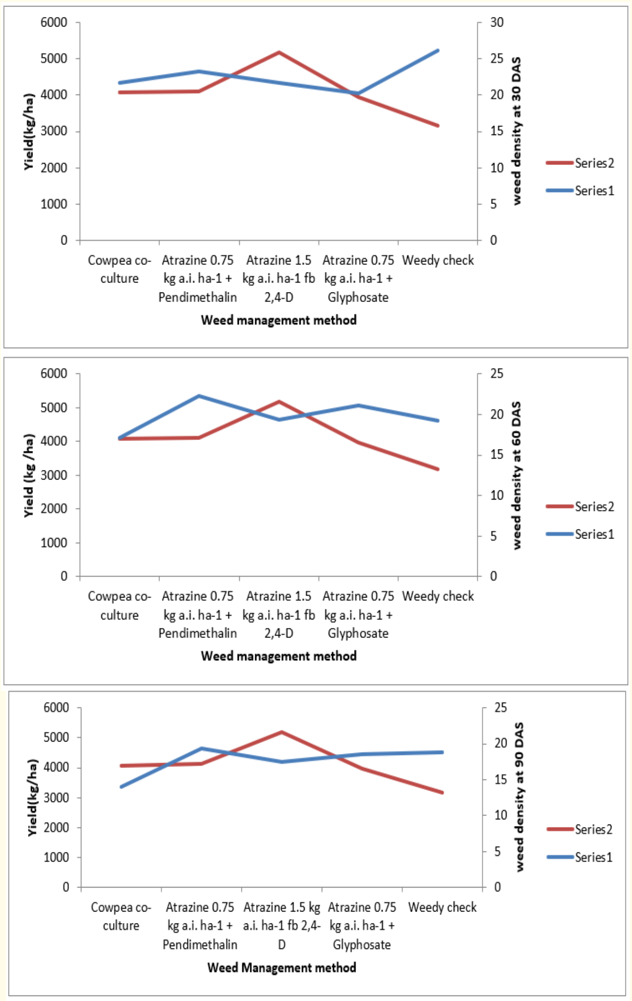

Figure 11: Correlation between weed management to weed density at different stage and influence in yield of spring Miaze.

Conventional tillage recorded significantly higher weed index (25.11%) than that of zero tillage (11.48%) which may be due to higher total weed density and dry weight recorded in conventional tillage in comparison to zero tillage. This indicate 25.11% of grain yield was reduced by higher weed growth in conventional tillage.

Influence of black polythene mulch on weed, crop growth and yield

Weed density and dry weight were significantly influenced by weed management practices. Black polythene mulch resulted significantly lowest weed density and dry weight as mulching reduce weed problems by preventing weed seed germination or by suppressing the growth of emerging seedlings because of which it favors in increasing grain yield. Finding was supported by Zhang, Chen and Zhou [16,17] who reported black plastic mulch controlled 100% of the weeds in plantings of tomato and corn. Rajablariani, Rafezi and Hassankhan (2012) concluded that black plastic mulch reduced weed dry weights by 94.7% in sweet corn. Ngouajio and Ernest (2004) reported that covering or mulching the soil surface can reduce weed problems by preventing weed seed germination or by suppressing the growth of emerging seedlings. Similarly Abdullahi, Gautam and Joy [13] found maximum reduction in density of the weeds at maturity in Paddy straw mulch and black polythene mulch treatments (61.0 no m^{-2}). Black polythene mulch recorded lowest weed index (-20.68) which showed yield increment was 20.68% above weed free.

Grain yield was also significantly higher in polythene mulch which may be due to greater value of all yield attributing characters and lower weed infestation in mulch plot. Use of plastic film mulching increased the number of cobs per unit area, longer cob (19.2 cm) with maximum number of grain per cob (501). This resulted in maximum grain yield due to better moisture conservation [18]. Polythene mulch helps to improve soil structure and soil micro-flora, reduces fertilizer leaching, evaporation and weed problem thus increasing the levels of available nutrients and moisture in the soil. Therefore, polythene mulch has a positive effect on growth, yield and quality of maize (Kulkarni., *et al.* 1998). Similar finding was supported by Wells., *et al.* (1988), Mohapatra., *et al.* [18], Pinjari [19,20], Gosavi [21]. Shah., *et al.* [22] also found that raised bed sowing with mulching showed maximum thousand grain weight (439.2g) of maize and wheat (50.5g) when compared to the flat sowing method without mulch application. Gosavi [21] also reported the highest green cob and stover yield (24.67 and 30.36 t ha^{-1}, respectively) were recorded under polythene mulch than control (19.44 and 23.51 t ha^{-1}, respectively).

Effect of cowpea co-culture on weed, crop growth and yield

Cowpea co-culture resulted in reduction of weed dry weight and density as similar with herbicidal application. Reduction in weed population and dry weight may be due to a higher degree of interspecific competition in mixed stands as compared to the absence of inter-specific competition in monoculture. Similar finding was supported by Hussain., *et al.* (2013) who found intercropping treatment resulted in 35 - 56% reduction in weed population and showed 6.4 to 23.93% increase in maize yield. Similarly, Shah., *et al.* [22] also found weed dry weight was significantly influenced by different intercropping systems and it was reduced under the intercropping of maize with soybean and green gram, while it was higher with maize sown as sole crop.

Number of grain row^{-1} and thousand grain weight. Similar finding was reported by Gangwar and Sharma [23] who found that there was decreased yield of maize due to intercropping of legumes namely cowpea, cluster bean, sunhemp and dhaincha. Iderawumi [24] also found the least grain yield per hectare in cowpea intercropped with Maize at 1:2. However, finding of Chibudu (1998) did not supported this result who found that maize yields were increased about 25 percent and 88 percent on maize-mucuna and maize-cowpea intercropping systems as intercrop with cowpea increase light penetration in the intercrop, reduce water evaporation and improve conservation of the soil moisture. Talebbeigi and Ghadiri [25] also reported that cowpea as living mulch density at 22 plants per square meter improved maize grain yield.

Effect of herbicidal weed control

Four herbicides Atrazine, 2,4-D, Pendimethalin and Glyphosate were used in experiment and three treatment combinations were made as sub-plot levels i.e. sequential application of atrazine and 2,4-D; tank mix pre-emergence application of atrazine and glyphosate; and tank mix pre-emergence application of atrazine and pendimethalin.

Application of herbicides assisted to reduce weed density, weed dry weight and increased grain yield significantly. Herbicidal application of atrazine and 2,4-D in sequence assisted to reduce total weed density and dry weight significantly at all growth stages which could be the reason for obtaining higher grain yield and that might be due to higher chlorophyll content, photosynthetic rate, stomata conductance and nitrate reeducates activity at the different growth stages of the crop over other treatments [26]. Also, better performance of these herbicides might be due to longer persistence effect. Similarly lowest weed index was recorded in atrazine fb 2,4-D treatment (12.25%).

Tank mixture application of atrazine and glyphosate had found significantly reduced in total weed density at initial stage which may be due of the fact that glyphosate is slow in action and controls weeds effectively resulting in higher grain yield. Result was in line with Reddy and Reddy [27]. Singh., *et al.* (2007) reported that reducing weed density and dry weight found due to better efficacy of pre emergence atrazine combined with glyphosate.

Similarly tank mixture application of atrazine and pendimethalin found to reduce the weed dry weight at 60 DAS. Khan., *et al.* [5] found less number of weeds were found in plots where atrazine and metalocholar tank application was sprayed (14.1 numbers per square meter).

Maximum weed dry weight and density in weedy check was perhaps due to excessive weed density and undisturbed or vigorous growth and development of weeds in that treatment. Variation in dry weight of weeds among different weed control treatments might be due to the varying effect of herbicide on the number of weeds and their growth. These results confirm the findings of Ali., *et al.* [28] and Chikoye., *et al.* (2005) who reported decreased weed dry weight in weed control and maximum in check.

Conclusion

Spring maize can be successfully grown under no till system provided the insure irrigation facilities in the humid sub tropics. Significant maize yield was lost even in Spring season. Though none of weed management practices completely eliminated weeds, black polythene mulching resulted in best grain yield. Besides the environmental protection, cowpea co-culture treatments yielded almost similar grain yield as compared with common herbicidal weed management practices.

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Volume 2 Issue 9 September 2018