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Impact of integrated weed management in maize on weed density, biological yield and soil physicochemical properties

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Abstract

To evaluate the impact of integrated weed management in maize on weed density 60 DAS (m^2), biological yield (Kg ha^{-1}) and soil physicochemical properties, fieldexperiments were performed at Agriculture Research Station Swabi, KPK Pakistan during spring 2014 and 2015 on silt loam soil using randomized complete block design (RCBD) with split plot arrangement. Three kind of tillage regimes (minimum, conventional and deep tillage) were used in main plots. Allelopathic plant residues (*S. bicolor, H. annuus and P. hysterophorus)* were surface mulched and their water extracts were integrated with 0.125 kg a.i. ha^{-1} (1/4th dose) of atrazine. Maize hybrid "Pioneer 3025" was sown by maintaining plant-plant distance of 15 cm and row-row distance of 75 cm. Data for weed density 60 DAS, Biological yield, soil N, P, K, pH, EC and organic matters was recorded. Result showed that tillage and other weed control treatments (water extracts and surface mulches) had significant effect on weed density 60 DAS, biological yield, soil organic matters. Results of the current study suggested that *S.bicolor+H.annuus* + *P.hysterophorus* (SM) each @ 4 Mg/ha under conventional tillage regime reduced weed density 60 DAS, increased biological yield Kg ha^{-1} of maize crop and soil organic matters. However, further studies are suggested to confirm our results under field condition.

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Introduction

Maize (*Zea mays* L.) belongs to family Poaceae. It is an important spring as well as summer crop in KPK (Pakistan). It is the third most important cereal crop after wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) in Pakistan. Overall maize crop contributes 10 percent of all agricultural production and 15 percent of agricultural employment in Pakistan (Khaliq *et al.*, 2004). In Pakistan maize is cultivated on an area of 1.19 million hectares and has average annual production of 5.27 million tones (Govt of Pakistan, 2016-17). Current average maize yield in Pakistan is very low as compared to the world's potential yield (12 ton ha^{-1}).Weed infestation is the most important and limiting factor, which caused yield reduction ranged from 24-83 %(Dogan, 2004; Usman *et al.* 2001).Weeds are the most ever-present class of pests that interfere with crop plants through allelopathy and competition for moisture, solar radiation, gases and space resulting in direct loss to quantity and quality of the produce (Gupta, 2004). Weeds are usually controlled through commercial herbicides; however, the non-judicious use of herbicides can create many environmental and health related problems everywhere in addition to resistance development in weeds (Jabran*et al.*, 2008). Hand weeding is labor intensive, time consuming and getting expensive. This is not practicable for large areas. Cultural methods are environment friendly, but very slow. Therefore, the scientists realized the need of an alternative to herbicide should be to design for sustainable weed management by the use these of allelopathic plants and weeds for quality production of crops and to reduce the use of synthetic herbicides to contribute for maintaining sustainable agriculture (An *et al.*, 2005). Several allelopathic plant species have been reported for weed management in cereal crops through the inhibitory effect weed species. Allelopathy is a new approach to be used as an alternative to synthetic herbicides for the weed management as a source of bio herbicides. Several allelopathic plant species such as *Sorghum bicolor* (L.) Conard Moench. (Cheema and Khaliq, 2003; Weston and Duke, 2003), *Halianthusannuus*L. (Leather, 1987; Batish*et al.,* 2002) and *Parthenium hysterophorus*L. (Hassan *et al.,* 2018, Belz*et al.,* 2007, Belz, 2016) are inhibitory as well as stimulatory to weeds at low doses due to hormesis. Mulches interfere the germination of weed seeds and thus retard the growth and development of weeds through the release of allelochemicals (Bilalis*et al.*, 2003). The physical existence of mulches on soil surface may be attributed toward selective weed control through the release of allelochemicals from the mulch residues (Weston, 1996).

Tillage is considered an important and effective farm activity for the improvement of soil tilth and soil physical condition (Khan *et al.*, 2010). Tillage practices improve nutrient use efficiency of crops which ultimately leads to good crop yield (Bahadar*et al.*, 2007). It also has a positive impact on soil organic matter contents (Tian *et al.*, 2016) and could increase soil aeration which helps in decomposition of organic residues, organic nitrogen, mineralization and availability of nitrogen to plants for use (Dinnes*et al.*, 2002). Keeping in view the importance of allelochemicals being an effective and ecofriendly alternative to synthetic herbicides and Tillage as an important farm activity, the present study was designed to evaluate the impact of integrated weed management strategies on weed control, biological yield of maize and the effect of allelochemicals and tillage practices on soil physicochemical properties.

Materials and methods

Experimental site and details

Field experimentswere conducted at Agriculture Research Station Swabi, Khyber Pakhtunkhawa, Pakistan in (March-June) 2014 and repeated in same season during 2015. Maize hybrid "Pioneer 3025" was selected as the test crop. Sorghum (*Sorghum bicolor*L.*),* sunflower *(Helianthus annuus*L.), and parthenium (*Parthenium hysterophorus*L.*)* residues in mutual combination were used for surface mulches, whereas, their water extracts combination was integrated with atrazine @ 0.125 kg a.i ha^{-1} for foliar application. Recommended dose of atrazine @ 0.50 kg a.i ha^{-1}, 1/4th dose of atrazine (0.125 kg a.i ha^{-1}), hand weeding and weedy check were also included in treatments. The experiments were laid out in randomized complete block design (RCBD) with split plot arrangement having three main plots assigned to 3 different tillage regimes along with *Z.mays* crop and 12 sub plots were allotted to different weed control measures having net plot size of 3m × 2m. Recommended seed rate of 25 kg ha^{-1}; row to row distance of 75 cm and plant to plant distance of 15 cm were maintained.

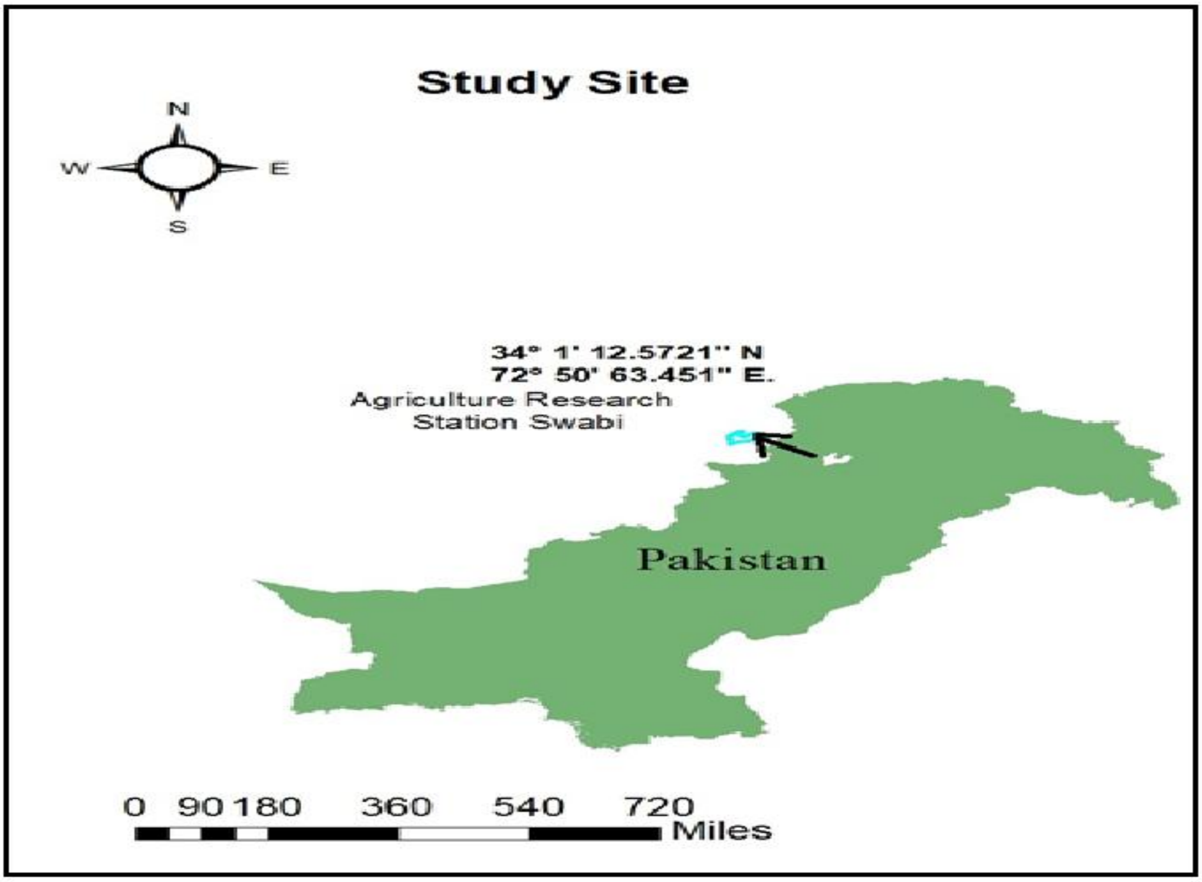

Fig. 1.

The soil was silty loam with 15.13, 60.63, 21.8, 0.71, 0.028 % of clay, silt, sand, organic matter and Nitrogen respectively. Phosphorus, and potassium contents were 4.17 and 105 (mg kg^{-1} soil) with 0.06 (d Sm^{-1}) and pH of 7.67 respectively. The fertilizer @ 150 kg nitrogen + 100 kg phosphorous (P_2O_5) ha^{-1} was applied in the form of urea and diamonium phosphate (DAP), respectively.

Factor (A) Main plots: Tillage systems = 3

MT = Minimum tillage (rotavator + planking)

CT= Conventional tillage {tine plough (twice) + planking}

DT = Deep tillage (chisel plough + tine plough + planking)

Factor (B) Sub plots: Treatments=12

T1=*S.bicolor*+*H.annuus* (WE) @ 15L each + atrazine @ 0.125 kg a.i ha^{-1} (Pre emergece)

T2=*S.bicolor*+*P.hysterophorus* (WE) @ 15L each + atrazine @ 0.125 kg a.i ha^{-1} (Pre emergence)

T3=*H.annuus*+*P.hysterophorus* (WE) @ 15L each + atrazine @ 0.125 kg a.i ha^{-1} (Pre emergence)

T4=*S.bicolor*+*H.annuus*+*P.hysterophorus* (WE) @ 15L each + atrazine @ 0.125 kg a.i ha^{-1} (Pre-emergence)

T5=*S.bicolor* + *H.annuus* (SM) each @ 6 Mg ha^{-1} (3-4 leave stage of *Z.mays*)

T6=*S.bicolor* + *P.hysterophorus* (SM) each @ 6 Mg ha^{-1} (3-4 leave stage of *Z.mays*)

T7=*H.annuus* + *P.hysterophorus* (SM) each @ 6 Mg ha^{-1} (3-4 leave stage of *Z.mays*).

T8=*S.bicolor*+*H.annuus* + *P.hysterophorus* (SM) each @ 6 Mg ha^{-1} (3-4 leave stage of *Z.mays*)
T9=Atrazine @ 0.125 kg a.i ha^{-1} (Pre emergence)
T10=Atrazine @ 0.50 kg a.i ha^{-1} (Pre emergence)
T11=Hand weeding after 15-20 days (once)
T12=Weedy check (comparison).

Collection of allelopathic plants
Fresh plants of sorghum, sunflower and parthenium were collected from farmer's field in district Swabi. All plant samples were washed to remove dust and other particles and were chopped by electric cutter into 3-4 pieces and dried in oven (Kenton; KH-120AS) for 72 hours at 65°C and were ground with the help of electrical grinder.

Preparation of extracts
Oven dried powder of allelopathic plants were soaked in water 1:10 (w/v) for 48 hours. Finally, extracts were filtered through Muslim cloth to obtain respective water extracts (Cheema and Khaliq, 2000).

Quarter dose (0.125 Kg.a.i ha^{-1}) of atrazine was tank mixed with each extract.

Preparation of surface mulches
Surface mulches were prepared by obtaining the whole plant species of Sorghum, Sunflower and Parthenium by harvesting at maturity, dried, chaffed with electric cutter into 3-4 cm pieces and stored under cover to avoid possible leaching by rainwater.

The chaffed mulches were integrated in different combinations according to treatments and applied as surface application in respective plots 15-20 days after crop emergence.

Recorded parameters
Weed density (m^2): Data was recorded 60 days after sowing. Each time quadrate having size 33×33 cm was placed randomly three times in each treatment.

The weeds were counted and identified to determine the weed density. Average was calculated and then subsequently was converted into m^{-2}.

Biological yield (Kg ha^{-1}): Biological yield included grain, stoverand pith yield. Crop from each treatment was manually harvested, dried in sun and the weighted to obtain biological yield Kg ha^{-1}). Soil pH: The pH was recorded by pH meter (3510 JENWAY) with glass electrode after standardizing the meter with buffer of 9.5 and 4.0 pH as standards (McLean, 1982). Electrical conductivity (d Sm^{-1}): A 10-gm soil sample in shaking bottle was mixed with 50 ml water (1:5) and shacked for 30-60 mints and allowed overnight in order to settle the soil particles. The conductivity cell was filled with soil extract and EC was measured.

Soil Organic matter (%): Procedure described by Walkely and Black was followed with all protocols (Jackson, 1962).

Total nitrogen (%): Nitrogen was determined by Gunning & Hibbard's method of sulphuric acid digestion and distillation of ammonium into 4% boric acid by macro distillation apparatus (Jackson, 1962).

Available phosphorus (mg kg^{-1} soil): Available phosphorus was calculated by method described by (Olsen and Sommers, 1982).

Extractable potassium (mg kg^{-1} soil): Available K was determined by Sherwood 410 flame photometer (Carson, 1980).

Statistical analysis
The data recorded were analyzed statistically combined over years using analysis of variance techniques appropriate for Randomized Complete Block Design (RCBD) with Split plot arrangements. Means were compered using LSD test at 0.05 of probability, when the F values were significant (Steel and Torrie, 1997). The statistical software Statistic 8.1 was used for the analysis of the data.

Results and discussion

Weed density 60 DAS (m^2)
Statistical analysis of the data revealed that weed density 60 DAS was significantly influenced by

Tillage, WC treatments and interaction between Tillage x WC treatments (Table 2). Among different tillage regimes minimum weed density 60 DAS (158.93) was recorded in deep tillage, whereas the maximum value (195.22) was recorded in minimum tillage. Maximum weed density 60DAS could be due to the fact that in minimum tillage the soil was not disturbed to the greater extent as compared to conventional tillage (CT) and deep tillage (DT) practices. Thus, the weeds seed bank was encouraged to germinate in minimum tillage. Our results are in line with the findings of Cardina*et al.*, (1991) who concluded that density of weed species could be increased in minimum tillage.

Table 1. List of allelochemical previously identified for weed management.

Plant species	Allelochemicals	References
Sorghum bicolor (L.)	p-coumaric acid, benzoic acid, chlorogenic acid	Guenzi and McCalla (1966)
	Ferulic acid, p-hydroxybenzoic acid, gallic acid,	Cheema (1988)
	caffeic acids, Sorgoleone	Nimbal*et al.* (1996)
Helianthus annuus (L.)	chlorogenic acid, isochlorogenic acid,	Wilson and Rice (1968)
	α-naphthol, scopolin, annuionones.	Macias *et al.*(1998)
		Anjum and Bajwa (2005)
Parthenium hysterophorus (L.)	caffeic acid, p-coumaric acid, anisic acid,	Tower *et al.* (1977)
	Ferulic acid, p-hydroxybenzoic acid, vanillic acid	Herz*et al.* (1962),
	Parthenin, coronopilin and damsin	Rodriguez *et al.* (1971)
		picman*et al.* (1980)

Our findings are also in similar directions to that of Khattakand Khan (2005) who reported that with increased tillage frequency, density of weed species were reduced significantly due to destructions of annual and perennial germinated weeds in the soil.

Major weeds infested the experimental site were *Cynodondactylon, Digitariasanguinalis, Cyprus rotendus, Trianthemaportulacastrum and Cynodondactylon*. These findings suggested that perennial as well as annual weeds could be suppressed by deep tillage followed by conventional tillage effectively as compared to minimum tillage.

Pooled data of two years indicated that weed density 60 DAS ranged from (101.39-324.39) as affected by weed control treatments. Maximum weeds density 60 DAS (324.39) was recorded in control (weedy check) treatment followed by atrazine @ 0.125 kg a.i ha^{-1} treatment with (240.72). It is noticed that in atrazine @ 0.125 kg a.i ha^{-1}treatment the germination of weed seeds were stimulated. The stimulation of weeds at lower doses was earlier reported by Rashid *et al.*, 2008. Minimum weed density (101.39) was recorded in *S.bicolor* + *H.annuus* + *P.hysterophorus* (SM) treatment. Dominant effect of surface mulches against densities of weeds could be partially attributed due to the reported allelochemicals (Table 1) in these allelopathic crops/weed and partially could be due to the physical coverage of mulches on surface, which may reduce the penetration of sunlight required for the photosynthesis.

These results are in similar line of observation found by (Erenstien, 2002) who reported that surface mulches reduced the weed density and growth of weeds by smothering or through allelopathy, similarity of our results were found in work done by (Kamara *et al.* 2002) who reported that implementation of surface mulches in crop for weed management reduce the penetration of light for weeds and thus effect the photosynthetic process in weeds.

Table 2. Impact of integrated weed management on weed density 60 DAS (m²), biological yield (kg ha⁻¹) of maize, and soil physicochemical properties.

Tillage regimes	WD 60 DAS	Biological yield t ha-1	N (%)	P (mg kg-1)	K mg kg-1)	EC (dsm-1)	pH	SOM (%)
RT	195.22 a	14735 b	0.03	4.47	109	0.9136	7.653	0.82 a
CT	169.54 b	14931 b	0.029	4.45	111	0.9139	7.658	0.73 b
DT	158.93 c	16993 a	0.03	4.44	111	0.914	7.656	0.72 b
LSD (0.05)	1.4	1232.1	NS	NS	NS	NS	NS	0.032
Weed control treatments								
T1	205.17 d	15617 bc	0.0284 c	4.34 fg	113 ab	0.902 e	7.651 d	0.71 ce
T2	215.89 c	15863 bc	0.0289 bc	4.35 fg	112 ac	0.906 e	7.671 b	0.72 cd
T3	207.56 d	15924 bc	0.0276 c	4.41 ef	110 bc	0.910 b	7.623 f	0.71 ce
T4	143.17 f	16370 b	0.0269 c	4.45 de	108 cd	0.928 a	7.642 de	0.73 c
T5	117.39 h	16188 bc	0.0345 a	4.51 ad	112 ac	0.918 c	7.612 f	0.88 a
T6	117.22 h	18293 a	0.0307 b	4.55 ab	113 ab	0.923 b	7.660 b	0.86 ab
T7	107.17 i	16225 bc	0.0341 a	4.48 be	115 a	0.919 b	7.643 e	0.84 b
T8	101.39 j	17774 a	0.0339 a	4.56 a	116 a	0.927 a	7.644 d	0.84 b
T9	240.72 b	14464 d	0.0278 c	4.53 ac	109 bc	0.919 b	7.660 b	0.70 df
T10	177.72 e	15383 c	0.0269 c	4.51 ad	110 bc	0.907 de	7.659 c	0.69 ef
T11	137.00 g	15358 c	0.0306 b	4.47 ce	108 cd	0.912 cd	7.646 de	0.73 c
T12	324.39 a	10178 e	0.0283 c	4.32 g	105 d	0.894 f	7.680 a	0.68 f
LSD (0.05)	2.96	875.3	0.002	0.0755	4.53	0.005	0.0076	0.024
Interaction (Till x WC treats)	*	*	NS	NS	NS	NS	NS	*

For each effect, values with same letter(s) in a column do not differ from one another at p = 0.05 according to LSD test.

Fig. 2 showsthat among the interaction (tillage x weed control treatments), minimum weed density 60 DAS (87.13) was recorded in *S.bicolor+H.annuus + P.hysterophorus*(SM) treatment under conventional tillage regime, whereas the minimum (374.67) was recorded in weedy check under minimum tillage regimes. Hence based on our findings it is suggested that *S.bicolor+H.annuus + P.hysterophorus*(SM) treatment under conventional tillage regime could be used an alternative option in replacing atrazine for weed management in spring planted maize under the agro climatic condition of District Swabi.

Biological Yield (kg ha⁻¹)

Statistical analysis of the data revealed that Biological yield was significantly influenced by Tillage, WC treatments and interaction between (Tillage × WC treatments)(Table 2). Among the different tillage regimes, maximum value of biological yield (16993) was recorded in deep tillage wherein minimum value (14735) was observed in minimum tillage which was statistically similar to that of (14931) recorded in conventional tillage. The higher biological yield could be attributed to reduced bulk density of soil in deep tillage which provides favorable condition for root growth and rich nutrient uptake. Our results areconsistent with the observations of DiazZortia (2000), and Memon*et al.* (2012), who observed that biological yield of maize increased with increasing tillage intensity. But on other hand Malhi and Lemle., (2007) reported that biological yield was higher in no tilled soil than that in tilled ones.

Data recorded for weed control treatments showed that maximum Biological yield (18293) was noted in *S.bicolor + P.hysterophorus* (SM) and was statistically similar to that of (17774) recorded in *S.bicolor* + *H.annuus* + *P.hysterophorus* (SM). Minimum value (10178) was observed for weedy check treatment. The performance of atrazine@ 0.50 kg a.i ha^{-1}(commercial herbicide) was comparatively lower than the application of S.bicolor + *H.annuus* + *P.hysterophorus* (SM) treatment. These interesting findings of surface mulches could be attributed due to the fact that in surface mulches weed crop competition was less due to physical coverage and effect of allelochemical released from these mulches.

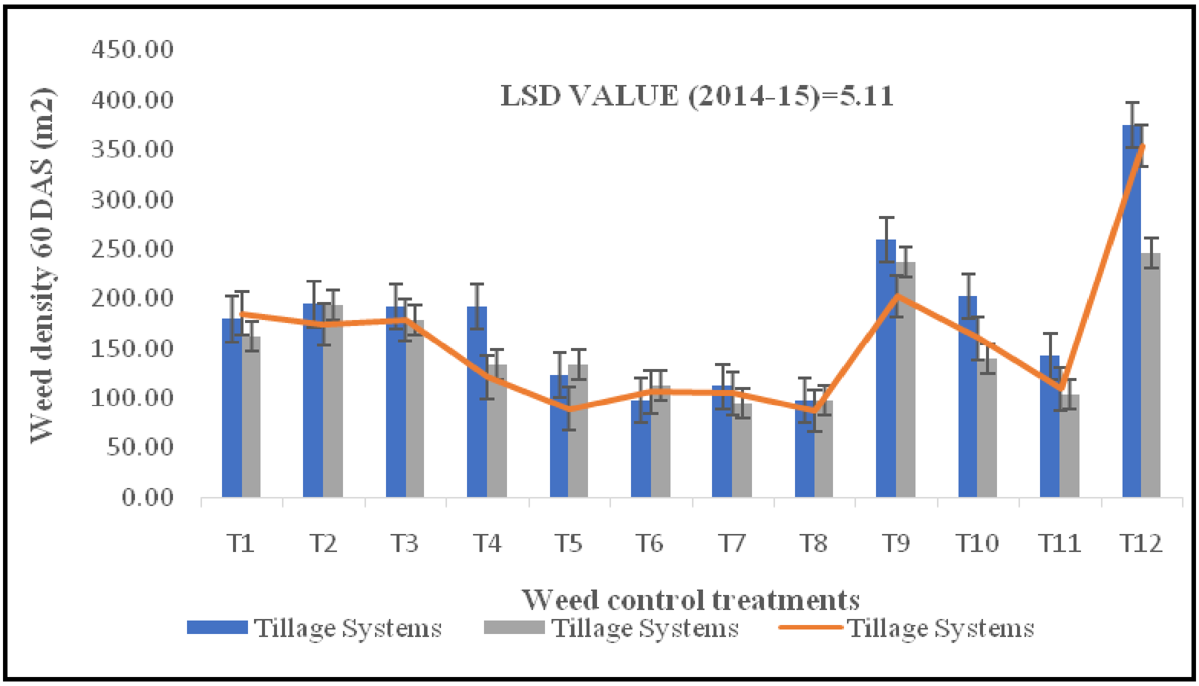

Fig. 2. Interaction between tillage and weed control treatments on Weed density 60 DAS (m^2) in spring planted maize during 2014 and 2015.Vertical bars show standard error of mean of three replicates.

Main concern of this study was to evaluate the interaction effect of tillage and WC treatments. Fig. 3 shows that maximum biological yield (18120) was recorded in *S.bicolor* + *H.annuus* + *P.hysterophorus* (SM) treatment under conventional tillage regime, whereas the minimum (9088) was recorded in weedy check treatment under deep tillage regime.

Logically maximum biological yield could be due to effective weed control in the same treatment which allow maize crop to utilized available nutrients and water from the soil.

Based on these findings it could be suggested that *S.bicolor* + *H.annuus* + *P.hysterophorus*(SM) treatment under conventional tillage regime could produce maximum biological yield and hence atrazine (commercial) herbicide could be replaced with it for effective and ecofriendly technique.

Total Nitrogen (%)

Statistical analysis of the data revealed that Total nitrogen was significantly influenced by weed control treatments, whereas the effect of tillage and interaction (Tillage x WC treatments) were found non-significant (Table 2). Among various weed control treatments, maximum value for total Nitrogen (0.0345 %) was recorded in *S.bicolor* + *H.annuus* (SM) treatment, which was statistically similar to those of (0.0341) and (0.0339) in *H.annuus* + *P.hysterophorus* (SM) and *S.bicolor* + *H.annuus* + *P.hysterophorus* (SM) treatments respectively.Our results for total Nitrogen are confirmatory to the previous results obtained by Batish*et al* (2002).

He reported that plant residues of parthenium were applied on the surface of soil which decreased the soil pH and increased total nitrogen (%) in soil.

Available Phosphorus (mg kg⁻¹)

Analysis of the data showed that available Phosphorus was significantly influenced by weed control treatments (Table 2). Tillage and interaction (Tillage x weed control treatments) effects were found non-significant for available Phosphorus. Among weed control treatments maximum available Phosphorus (4.56 %) was recorded in *S.bicolor* + *H.annuus* + *P.hysterophorus* (SM) treatment, whereas the minimum value (4.32) was recorded in weedy check treatment. These results are in agreement with Agbede and Ojeniyi (2009) who stated that in zero tillage and mulched plots, available phosphorus was higher compared to minimum and conventional tillage and unmulched plots.

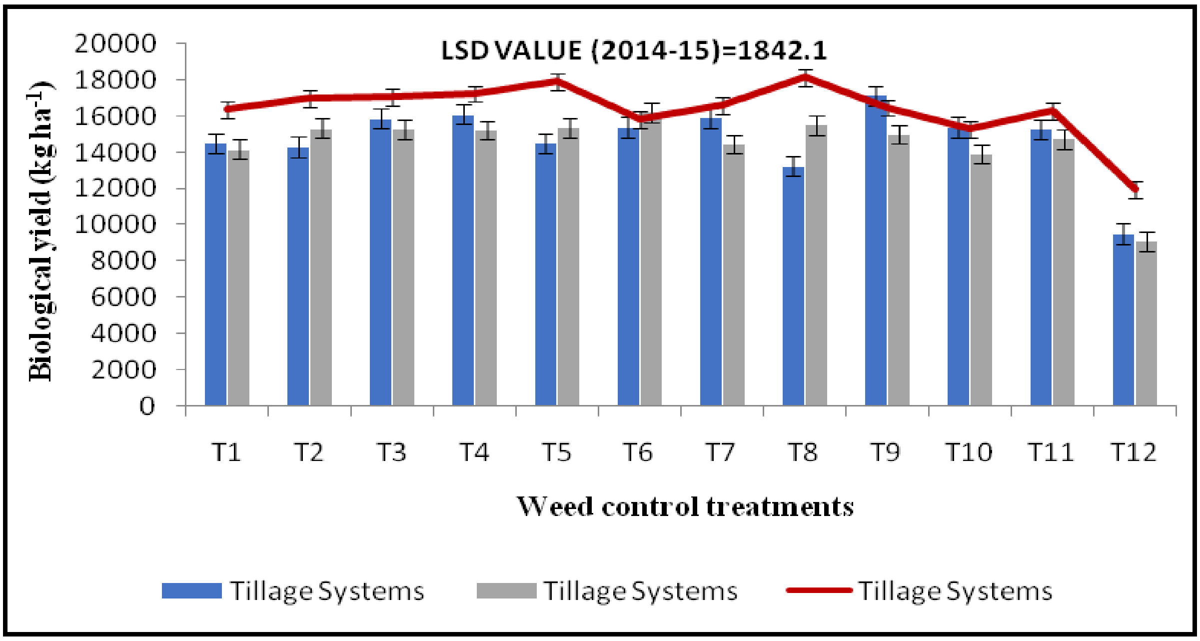

Fig. 3. Interaction between tillage and weed control treatments on Biological yield (kg ha^{-1}) in spring planted maize during 2014 and 2015. Vertical bars show standard error of mean of three replicates.

Extractable potassium (mg kg⁻¹)

Statistical analysis of the data revealed that extractable potassium was significantly influenced by weed control treatments, whereas tillage and interaction (tillage x weed control treatments) were found non-significant (Table 2).

Among the WC treatment maximum value for extractable potassium (116) was recorded in *S.bicolor* + *H.annuus* + *P.hysterophorus* (SM) treatment, which was statistically similar to that of (115) recorded in *H.annuus* + *P.hysterophorus* (SM) treatment. Minimum extractable potassium (105) was recorded in weedy check treatment. These results are in agreement with Agbede and Ojeniyi (2009) who stated that in zero tillage and mulched plots, available potassium was higher compared to minimum and conventional tillage and un-mulched plots.

Soil pH

Statistical analysis of the data indicated that WC treatments effect was found significant for soil ph (Table 2). Tillage and Interaction between (Tillage x WC treatment) were non-significanteffect. Analysis of pooled data indicated that soil pH ranged from (7.612-7.680) as affected by various weed control treatments. Maximum soil pH (7.680) was recorded in control (weedy check) treatment and minimum soil pH (7.612) was recorded in *S.bicolor* + *H.annuus* (SM) treatment. Similar results were found by Billeaud and Zajjcek (1989) who reported that mulches decreased soil pH and this is proportional to the depth of these mulches.Ossom and Matsenjwa (2007) reported significant effect of mulches on soil pH.However, our findingsare against the result found by Tukey and Schoff (1963) who found that mulching had no consistent effect on soil pH.

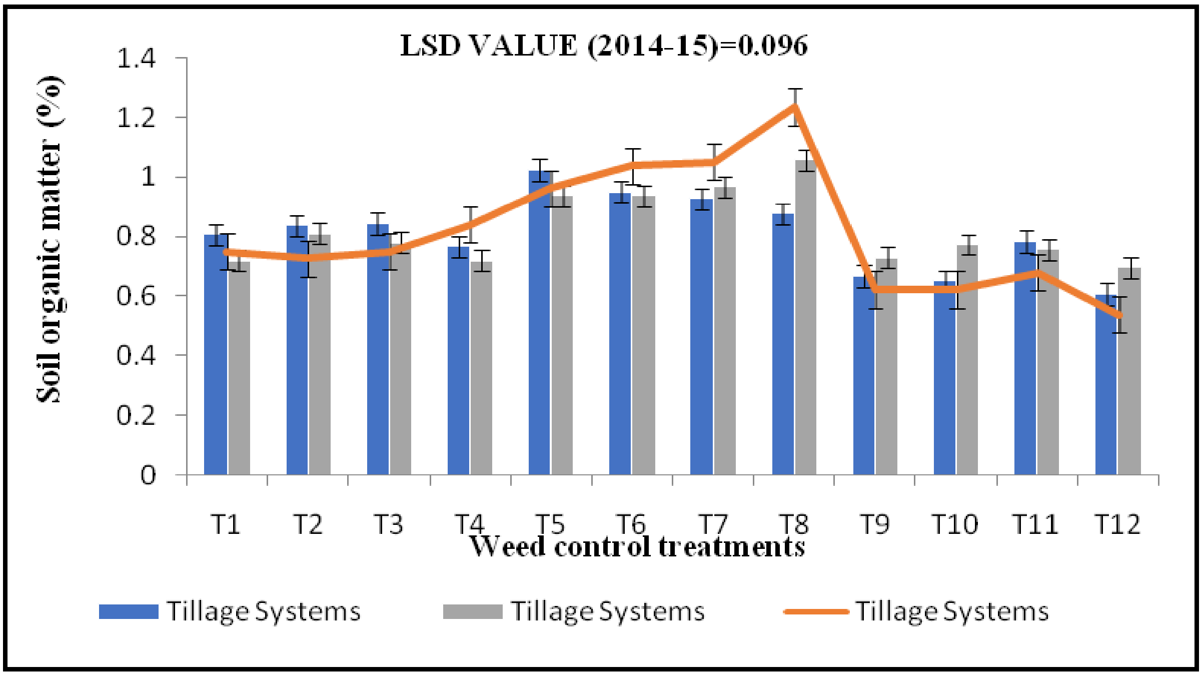

Fig. 4. Interaction between tillage and weed control treatments on Weed density 60 DAS (m^2) in spring planted maize during 2014 and 2015. Vertical bars show standard error of mean of three replicates.

Soil electric conductivity (10-3) (dsm^{-1})

Statistical analysis of the data indicated that soil EC was significantly influenced by WC treatments (Table 2). Whereas Tillage and interaction (Tillage c WC treatments) had no significant effect on soil EC. Maximum value (0.928) was observed in *S.bicolor+H.annuus+P.hysterophorus* (WE) @ 15L each + atrazine @ 0.125 kg a.i ha^{-1}which was statistically similar to that of (0.927) recorded in *S.bicolor+H.annuus + P.hysterophorus* (SM) each @ 4 $Mgha^{-1}$. Minimum EC (0.894) was recorded in weedy check plot. Our result in close similarity to Chudary*et al.* (2004) who reported similar findings that using mulch Ec decreased 53% as compare to control.

Soil organic matters (%)

Statistical analysis of the data revealed that soil organic matters were significantly influenced by tillage, weed control treatments and interaction between different tillage regimes x weed control treatments (Table 2). Among the tillage regimes, mean maximum soil organic matters (0.823 %) was recorded in Minimum tillage while the mean minimum organic matters (0.72%) was recorded in deep tillage which was statistically at par with (0.73 %) recorded in conventional tillage regime. Our data are confirmatory to the previous work of Doran, 1987; Wander *et al.*, 1998 ;) who reported that concentration of soil organic matter decreased rapidly with increasing soil depth. Similarly, Kristensen *et al.*, 2000 and Denef*et al.*, 2004) reported that carbon and nitrogen stock (organic matter) in the surface 0-5 cm soil layer are generally significantly larger in no till than conventional tillage.

Whereas, among weed control treatments maximum soil organic matters (0.88 %) was recorded in *S.bicolor + H.annuus* (SM) treatment whereas, the minimum (0.68 %) was recorded in weedy check treatment. Organic matter (%) were higher in all mulch treated plots due to decomposition of microorganism through allelochemicals as compared to control (weedy check) treatment. Our results are in agreement with Yang *et al.* (2006) who observed higher organic matters in mulch treated plots.

Fig. 4 shows that among the interaction between (Tillage x weed control treatments), maximum organic matters (1.23 %) was recorded in *S.bicolor+H.annuus + P.hysterophorus* (SM) each @ 4 $Mgha^{-1}$ under conventional tillage regime. Whereas the minimum soil organic matters (0.538 %) was recorded in weedy check under conventional tillage.

Conclusion

From the current studies, it is concludedthat integration of *S.bicolor* + *H.annuus* + *P.hysterophorus* (SM) each @ 4 Mg ha^{-1}under conventional tillage may reduce weed density 60 DAS, increased biological yield of maize and soil organic matter contents. Comparatively the performance of atrazine (commercial herbicide) was less than *S.bicolor* + *H.annuus* + *P.hysterophorus* (SM) each @ 4 Mg ha^{-1} under conventional tillage regime, which is an important milestone toward sustainable weed management approach. However, further studies are required to confirm our findings for the effect of the same surface mulches integration under conventional tillage regime in different Agro climatic conditions.

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