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Integrated weed management in maize under different tillage regimes

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Abstract

To explore the utilization of allelopathic plants (*Sorghum bicolor*, Sunflower and *Parthenium*) surface mulches and water extracts combined with reduce dose of herbicide under different tillage regimes (minimum, conventional and deep tillage) as an effective, economical and ecofriendly weed management tool in spring maize, field experiments were carried out during 2014 and repeated in 2015 at Agriculture Research Station Swabi, Pakistan. The experiments were laid out in RCBD with split plot arrangements and replicated thrice. 3 Tillage regimes were assigned to Main plots, while 12 weed control measures were assigned to sub plots. Maize hybrid 'Pioneer 3025' was sown by maintaining plant-plant distance of 15 cm and row-row distance of 75 cm. Data were recorded on weed density 30 DAS, Plant height kernel yield. The data showed that Tillage and all allelopathic extracts and mulch treatments had significant effect ($P \leq 0.05$) on weed density 30 DAS, plant height and Kernel yield Among the Tillage x weed management interactions Mulch treatments under conventional tillage were superior than aqueous extracts and recommended at razine application, which encourages the exploitation of alleopathic plants as surface mulches for sustainable wee d management in maize. Hence it is concluded that allelopathic plants surface mulches could reduce weed density which ultimately increased the 1000 kernel weight.

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Introduction

In Pakistan, maize was grown on an area of 1.168 million ha with a total production of 3.31 million tons giving an average yield of 4.23 t ha^{-1}. This is very low as compared to the advanced maize producing countries of the world. For the low production of maize crop certain factors are involved but weed infestation is ranked as the prime enemy which reduces the crop yield ranging from 24-83 % (Ashiq *et al.* 2003; Dogan *et al.* 2004, Usman *et al.* 2001). Maize being a rainy season and widely spaced crop gets infested with a variety of weeds and subjected to heavy weed infestation which results in huge losses to quality and quantity of crops through allelopathy and direct competition with crop (Gupta, 2004). Important yield reducing spring weeds of maize in Pakistan are *Cyprus rotandus* L., (purple nutsedge vern. deela), *Cynodon dactylon* (L.) Pers. (bermuda grassvern. khabal), *Trianthema partulicastrum* L. (horsepurs lanevern. It-sit), *Dactylocteniumae gyptium* L., (Egyptian crowfoot grass vern. Madhana grass) and *Echinochloa cruss-galli* L. (barnyard grass vern. sawakh) (Tahir *et al.*, 2009). Presence of these weeds decreases the yield of spring planted maize depending on the location; weed species, weed density, crop population and the available resources. Weeds are however, the most resilient and persistent pest (Beckett *et al.*, 1988), as annual losses in crop yield and quality due to weeds are greater than those due to cumulative loss due insects and diseases (Hassan and Marwat, 2001; Khan *et al.*, 2008). Control of weeds from the field of maize is therefore, very essential for obtaining a good crop harvest.

Weeds can be controlled effectively using herbicides with a resultant increase in crop yield (Santos, 2009). butnon-judicious use of herbicides can create environmental and health related problems (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 designed which should be integration of weed control methods for sustainable agriculture.

Several allelopathic plants have been reported for weed management through the inhibitory effect on weeds. Allelopathy a new approach to be used as alternative to synthetic herbicides for the weed management as a source of bio-herbicides. Several allelopathic plants such as *Sorghum bicolor* (L.) Conard Moench. (Cheema *et al.*, 2003a; Weston and Duke, 2003), *Halianthus annuus* L. (Leather, 1987; Batish *et al.* 2002) and *Parthenium hysterophorus* L. (Belz *et al.*, (2007) are inhibitory as well as stimulatory to weeds at low doses. Research efforts have made it possible to use the allelopathic plants for quality production of crops and to reduce the use of synthetic pesticides to contribute for maintaining sustainable agriculture (An *et al.* 2005). Tillage is also considered an effective farm activity for the purpose of developing a desired soil structure (Arif *et al.*, 2007). It constitutes a fundamental component in the weed management strategies. It not only kills weeds, but also disturbs the soil (Mohler and Galford, 1997). Individually the effect of allelopathy and tillage has been well reported however the interaction of both has been studied very rarely. Keeping in view the importance of tillage as a fundamental component in the weed management strategies and unlimited opportunities that allelopathy provides and the recognized importance of allelochemicals in weed management, present investigations were designed with the objective to evaluate the integrated effect of tillage and allelopathy on Weed density and 1000kernel weight of maize.

Materials and methods

Site and Treatments

To evaluate the effect of various allelopathic treatments under different tillage regimes on weed density, plant height and kernel yield of maize, experiments were conducted during spring 2014 and 2015 at Agricultural Research Station, Swabi, Pakistan. Maize hybrid 'Pioneer 3025' was used as the test species. The experiments comprised were laid out in Randomized Complete Block design with a split plot arrangement.

Main plots: Tillage systems = 3

MT = Minimum tillage (rotavator + planking)

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

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

Sub plots: Treatments=12

T1= *Sorghum* + Sunflower (WEs) @ 15 L each + atrazine @ 0.125 kg a.i /ha

(Pre emergence)

T2= *Sorghum* + *Parthenium* (WEs) @ 15 L each + atrazine @ 0.125 kg a.i /ha (Pre emergence)

T3= Sunflower + *Parthenium* (WEs) @ 15 L each + atrazine @ 0.125 kg a.i /ha (Pre emergence)

T4= *Sorghum* + Sunflower + *Parthenium* (WEs) @ 15 L each + atrazine @ 0.125 kg a.i /ha (Pre-emergence)

T5= *Sorghum* + Sunflower (SMs) each @ 6 Mg/ha (3-4 leave stage of maize)

T6= *Sorghum* + *Parthenium* (SMs) each @ 6 Mg/ha (3-4 leave stage of maize)

T7=Sunflower + *Parthenium* (SMs) each @ 6 Mg/ha (3-4 leave stage of maize)

T8=Sorghum + Sunflower + *Parthenium* (SMs) each @ 4 Mg/ha (3-4 leave stage of maize)

T9= Atrazine @ 0.125 kg a.i/ha (Pre emergence)

T10= Atrazine @ 0.50 kg a.i/ha (Pre emergence)

T11= Hand weeding after 15-20 days (once)

T12= Weedy check (comparison)

Extract treatments and herbicides treatment were applied as pre emergence after sowing while mulches were applied on the surface after the crop establishment to 3-4 leaves stage. Hand weeding was done after 15-20 days of emergence of crop. Weedy Check Comparison was included for comparison. Plant-Plant distance of 15 cm and row-row distance of 75 were maintained in each plot having net size of 3 x 2 m^2. All the agronomic practices were kept constant for all the treatments.

Collection of Allelopathic Plants

All the allelopathic plants, both crop and weeds, were collected from the farmers' fields in District Swabi. All the plant samples were washed to remove dust and other particles and then 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.

Extracts Preparation

Oven dried powders of allelopathic plants were soaked in water in1:10 (w/v) for 48 hours. Finally extracts were filtered through muslin cloth to obtain respective water extracts (Cheema and Khaliq, 2000). One-quarter dose (0.125 kg a.i/ha) of atrazine was tank mixed with each extract.

Mulch Preparation

Surface mulching were prepared by obtaining the whole plants 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 rain water. The chaffed herbages were mixed in different combinations according to treatments and applied as surface application in respective plots after 15-20 days after crop emergence.

Data Recording on Parameters Studied

During the course of experimentation, the data were recorded on the following traits:

Weed density (m^{-2}) 30 days after sowing (DAS)

Weed density data was recorded 30 and 60 days after sowing. Each time quadrate having size 33x33 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}

Plant height (cm)

Plant height data was recorded at the time of maturity. Ten Plants were randomly selected and plant height was measured from the base to the top of the plant, and was averaged and recorded for each treatment.

1000 Kernel weight (g)

1000 kernel weight is a function of grain size and density and was recorded in grams/1000 kernels. Representative sample (50 gm) of each treatment was taken and thousand kernel weights recorded by counting and weighting clean, unbroken and sound grains. The test weight in kg/hectoliter of each treatment was determined according to method 55-10 of AACC (2000).

Statistical Analysis

The data recorded were analyzed statistically year-wise as well as 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, 1980). The statistical Software Statistic 8.1 was used for the analysis of the data.

Results and discussion

Total weed density (m²) 30 DAS

Data regarding total weed density (m²) 30 DAS are presented in (Table 1.1). Analysis of the data indicated that total weed density was significantly influenced by tillage systems and application of different weed control practices. Interaction between tillage and weed control practices was found significant. Year as source of variance was also found significant. Total weed density 30 DAS was higher (166.85) during 1st year of the study as compared to 2nd year (157.55). Among the various tillage regimes highest total weed density (167.78) was recorded in reduced tillage followed by deep tillage with (160.15), while the lowest total weed density (158.67) was recorded in conventional tillage. All the tillage regimes had significant effect on total weed density 30 DAS in maize. It 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. These results are also in agreement with the findings of Khattak & Khan (2005) who stated that with the increasing frequency of tillage, density of weed species was reduced due to the destructions of annual and perennial germinated weeds in the soil. Major weeds infested the experimental field were *Cyperus rotundus*, *Cynodon dactylon* and *Digitaria sanguinalis*. These results suggested that perennial as well as annual weeds could be suppressed by deep and conventional tillage effectively as compare to minimum tillage.

Pooled data of two years indicated that total weed density ranged from 81.33-325.33 as affected by various weed control methods. The highest total weeds density 30 DAS (325.33) was recorded in control (weedy check) treatment followed by herbicide (1/4th dose of atrazine) treatment with (307.72), while the minimum weed density 30 DAS (81.30) was recorded in *Sorghum* + Sunflower + *Parthenium* (SMs) treatment. Among water extract and surface mulches total weed density was lower in mulches as compared to water extracts; however comparative effect of surface mulches to inhibit the total weed density was less than recommended herbicide (labelled dose of atrazine) treatment. Possible reason for less effect of water extracts than recommended herbicide could be several abiotic and biotic factors (temprature, light and soil condition etc). Although allelopathy is considered as a genetically influenced factor (Duke, 1985), but while moving or leaching in the soil, the activity of allelochemicals may influenced due to soil physicochemical, biological properties, while the dominant effect of surface mulches against densities of weeds could be partially attributed due to the reported allelochemicals 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. (Bu *et al*. 2002) reported that soil surface mulches of allelopathic plants increase water holding capacity, increase status of nutrients in the soil and at the same time retard the growth and development of weeds. Reduce dose of atrazine showed stimulatory effect on germination of total weed density and thus contributed toward highest weed density next to control.

Table 1.1. Effect of integrated weed management under different tillage regimes on weed density, plant height and 1000 kernel weight in maize.

		Total weed density (m2) 30 DAS			Plant height (cm)			1000 Kernel weight		
Tillage regimes	Tillage codes	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Minimum tillage	Til 1	176.11 a	159.44 a	167.80 A	152 c	173.28 b	163 C	250 ab	270.78 b	260 B
Conventional tillage	Til 2	161.78 b	155.56 c	158.70 B	167 b	183.22 b	175 B	243 b	287.50 a	265 AB
Deep tillage	Til 3	162.67 b	157.64 b	160.20 B	191 a	201.36 a	196 A	262 a	282.89 a	273 A
	LSD (5%)	0.97	1.02	2.09	9.71	14.67	7.3	18.94	8.66	8.65
Weed control treatments										
Sorg + SF + 1/4 atrazine (WEs)	T1	182.56 d	160.89 e	171.70 E	174 ac	188 ac	181 AD	250 df	264 ef	257 D
Sorg + Par + 1/4 atrazine (WEs)	T2	181.11 d	180.78 d	180.90 D	174 ac	189 ac	182 AD	257 be	282 cd	270 C
SF + Par + 1/4 atrazine (WEs)	T3	189.67 c	188.44 c	189.10 C	165 d	181 c	173 E	243 ef	273 de	258 D
Sorg + SF+ Par+ 1/4 atrazine (WEs)	T4	168.11 e	145.89 f	157.00 F	168 bd	185 bc	177 CE	260 bd	286 c	273 C
Sorg + SF (S.Ms)	T5	112.89 h	100.67 h	106.8 I	168 bd	181 c	174 DE	263 bd	285 c	274 C
Sorg + Par (S.Ms)	T6	121.56 f	69.67 i	109.10 H	183 a	194 ac	188 A	253 ce	283 cd	268 C
SF + Par (S.Ms)	T7	97.44 j	89.67 j	93.60 J	177 ab	196 ab	187 AB	269 b	314 ab	291 AB
Sorg + SF+ Par (S.Ms)	T8	84.56 k	78.11 k	81.30 K	183 a	196 ab	189 A	286 a	316 a	301 A
1/4 dose of atrazine	T9	330.56 a	284.89 b	307.70 B	167 cd	181 c	174 DE	237 fg	254 f	246 E
Full dose of atrazine	T10	115.78 g	100.22 h	108.00 HI	169 bd	200 a	185 AC	269 bc	304 b	286 B
Hand weeding	T11	109.11 i	122.56 g	115.80 G	169 bd	188 ac	178 BE	226 g	276 cd	250 DE
Control	T12	308.89 b	341.78 a	325.30 A	143 e	153 d	148 F	209 h	228 g	218. F
	LSD (5%)	2.08	2.33	1.43	9.38	14.56	8.58	15.65	11.32	9.567
Means		167 A	155 B	162	170 B	186 A		252 B	280 A	
Interaction (Tillage x treatments)		0.00	0.00	0.00	0.01	NS	0	NS	0	0

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.

T1= *Sorghum* + Sunflower (WEs) @ 15 L each + atrazine @ 0.125 kg a.i /ha (Pre Emergece), T2= *Sorghum* + *Parthenium* (WEs) @ 15 L each + atrazine @ 0.125 kg a.i /ha (Pre Emergence), T3= Sunflower + *Parthenium* (WEs) @ 15 L each + atrazine @ 0.125 kg a.i /ha (Pre Emergence), T4= *Sorghum* + Sunflower + *Parthenium* (WEs) @ 15 L each + atrazine @ 0.125 kg a.i /ha (Pre-Emergence), T5= *Sorghum* + Sunflower (SMs) each @ 6 Mg/ha (3-4 leave stage of maize), T6= *Sorghum* + *Parthenium* (SMs) each @ 6 Mg/ha (3-4 leave stage of maize), T7= Sunflower + *Parthenium* (SMs) each @ 6 Mg/ha (3-4 leave stage of maize), T8= *Sorghum* + Sunflower + *Parthenium* (SMs) each @ 4 Mg/ha (3-4 leave stage of maize), T9= Atrazine @ 0.125 kg a.i/ha (Pre emergence) T10= Atrazine @ 0.50 kg a.i/ha (Pre emergence), T11= Hand weeding after 15-20 days (once), T12= Weedy check (comparison).

Plant height (cm)

Data regarding plant height (cm) is presented in (Table 1.1). Analysis of the data indicated that plant height (cm) had significantly influenced by various tillage regimes and application of different weed control practices. Interaction between tillage and weed control practices was also found significant. Year as source of variance had also significant effect over the plant height (cm). Combined analysis of two years revealed that higher plants (195.93 cm) were recorded in deep tillage followed by conventional tillage with (175.22 cm), while minimum height of plants (162.87 cm) was recorded in reduce tillage. All the tillage regimes showed significant results for the plant height of maize. It could be attributed to the fact that deep tillage can reduced the soil bulk density and improve soil aeration which could allow the plant to utilized all the available nutrients from the root zone during the initial growth stage (Mock and Erbch, 1977; Pathak *et al.*, 2004 and Tomar *et al.*, 2005).

Our results for tillage are in line with Smith *et al* (1987), and Cassel *et al* (1995) who reported that plant shoot development are dependent on root development and by increasing the depth of tillage plant vegetative growth are increased.

Pooled data of two years indicated that plant height ranged from (148.17-189.28 cm) as affected by various weed control methods. The highest plant height (189.28 cm) was recorded in *Sorghum* + Sunflower + *Parthenium* (SMs) treatment which were statistically at far with sorgham + parthenium (SMs) treatment. Lower plant height 148.17 cm) was recorded in control (weedy check) treatment. Comparative inhibitory effect of water extracts on weed control was lower than mulches; however mulches performance as compared to synthetic herbicide was approximately equal. These reductions in weed densities could be the possible reason due to which maize crop got a chance to grow well with minimum competition of weeds. These results are in close similarity to the findings of Irshad and Cheema, (2004) who reported that improvement in height of wheat crop, growth and its yield parameters were due to the better weed control, which ultimately enabled the crop plants to utilize the available resources in better way without interference.

1000 Grain weight (g)

Data regarding 1000 grain weight (g) is presented in (Table 1.1). Analysis of the data indicated that 1000 grain weight (g) had significantly influenced by various tillage regimes and application of different weed control practices. Interaction between tillage and weed control practices was found significant. Year as a source of variation was also found significant effect over 1000 Grain weight (g). Recorded 1000 grain weight (280.39 g) in 2nd year of the study was higher than (251.79 g) than in 1st year. Combined analysis of both the years revealed that maximum 1000 grain weight (272.81 g) was recorded in deep tillage followed by conventional tillage with (265.28 g), while the minimum 1000 grain weight (260.18 g) was recorded in minimum tillage. All the tillage regimes had significant effect on 1000 grain weight of maize.

It may possibly due to the softening of the seed bed for vigorous plant germination and increased nutrient availability in depth tilled soil (Ali *et al.*, 2012b). Our results are consistent with the results of Diaz-Zorita (2000), Khan *et al.* (2007) and Wasaya *et al.* (2011) who reported increased 1000-grain weight in deep tilled soils. Similarly, Khan *et al.* (2007) reported that significantly higher 1000-grain was obtained when maize was grown under deep tillage.

Analysis of pooled data indicated that 1000 grain weight ranged from (218.28-300.61 g) as affected by various weed control methods. The data for maximum 1000 grain weight (300.61 g) was recorded in *Sorghum* + Sunflower + *Parthenium* (SMs) treatment, while minimum 1000 grain weight (218.28 g) was recorded in control (weedy check) treatment. Havior weight of 1000 grain in *Sorghum* + Sunflower + *Parthenium* (SMs) could attributed to better weed control, narrowed maize-weed competition for nutrients and other growth factors and thus positively affected the grain development process, which could possibly due to the translocation of more photosynthetes towards grains. The suppressive effect of weed interference on 1000 grain weight in maize has already been reported by Malik and Shah (1993) and Ansar *et al.* (1996).

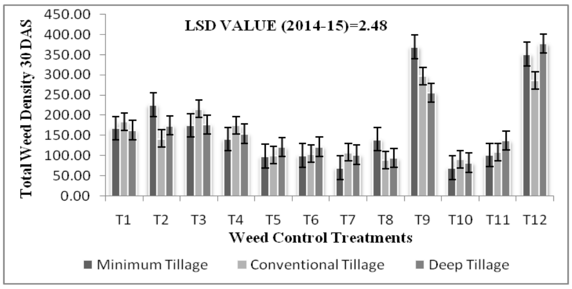

Fig. 1. Vertical bars show standard error of mean of three replicates.

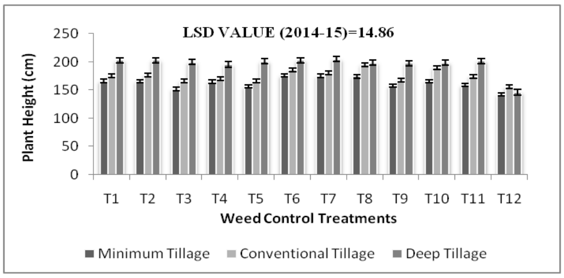

Fig. 2. Vertical bars show standard error of mean of three replicates.

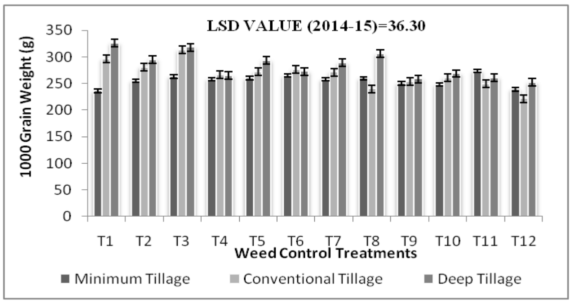

Fig. 3. Vertical bars show standard error of mean of three replicates.

Conclusions

From the current study it is concluded that the surface residues and water extracts combined with 0.125 kg a.i/ha of atrazine could reduce weed density ranged from 38-65 %. According to our hypothesis that allelopathic plants can be used for eco-friendly weed management and could be recommended as an alternative to synthetic herbicide has been found true. Furthermore, the surface mulches application of such plant species could reduce our reliance on synthetic herbicide which ultimately attributing toward the sustainable weed management strategies. Hence, the findings of this study suggests that Allelopathic plants viz sorghum bicolor, Sunflower and *Parthenium* residues may be used as a surface mulches (SMs) under conventional tillage system to reduce the weeds, and increase the 1000 kernel weight.

Recommendation

Keeping in view the importance of sustainable weed management, it is recommended to integrate *Sorghum bicolor*, Sunflower and *Parthenium* as surface mulches under conventional tillage to reduce the weed density, increase the 1000 kernel weight.

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