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Comparison of Straw Mulching and Herbicide Levels for Control of Various Weed Species in Maize (*Zea mays* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Weed management in maize is one of biggest concerns for growers. To reduce dependence on chemicals and chances of herbicide resistant weeds, and to improve soil status, thus straw mulching was added as cultural component with chemicals for improving weed management in maize. Field experiments were conducted at two locations (Punjab Agricultural University, Ludhiana, and Regional Research Station, Gurdaspur) during *kharif* season to find out the influence of different paddy straw mulch and herbicides for control of various weeds species in maize. The results showed that application of paddy straw mulch 6.25 t/ha effectively controlled *Eleusine indica, Cynodon dactylon, Commelina benghalensis, Eragrostis tenella, Digitaria sanguinalis*, *Echinochloa colona*, *Trianthema portulacastrum, Portulaca oleracea, Phyllanthus niruri, Euphorbia hirta, Conyza stricta* and *Cyperus compressus* over no mulching. In addition to above weed

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species, paddy straw mulch 9.0 t/ha also effectively reduced density of *Dactyloctenium aegyptium, Acrachne racemosa, Digera arvensis, Mollugo nudicaulis, Alternanthera philoxeroides, Amaranthus viridis* and *Veronica agrestis* and *Cyperus rotundus* as compared to 6.25 t/ha and no mulch treatment. Atrazine pre emergence at 1.0 kg/ha controlled *Eleusine indica, Echinochloa crusgalli, Eragrostis tenella, Digitaria sanguinalis, Echinochloa colona*, *Trianthema portulacastrum*, *Mollugo nudicaulis*, *Alternanthera philoxeroides, Digera arvensis*, *Amaranthus viridis* and *Cyperus compressus* compared to its lower dose (0.8 kg/ha) and control at all stages. Post emergence application of tembotrione reduced the density of all weed species compared to atrazine and unweeded control.

Keywords: Atrazine; maize; straw mulch; species-wise density; tembotrione.

1. INTRODUCTION

Maize being a C_4 plant is one of the most important cereal crop grown under diverse soil and climatic conditions. In India, maize-wheat is a major cropping system adopted on a large scale in Indo-gangetic plains of the country. The low productivity in maize may be due to many limiting factors of which poor weed management poses severe threat to crop productivity. Weeds are the plants which do more harm than benefits. Weeds are plants that are considered undesirable because they negatively impact the quality and quantity of agricultural output. They also reduce the efficient use of resources by crop plants. Controlling weeds in maize cultivation is a significant obstacle, since they can reduce grain yield by up to 86% [1]. According to Zimdahl [2], weed infestation resulted in a 10% decrease in agricultural production worldwide, primarily due to their competitive nature, despite efforts to manage them in most agricultural systems. Weeds cause a reduction of up to 40 percent in global maize yield [3]. Uncontrolled proliferation of weeds in maize leads to significant reductions in crop output, potentially reaching as high as 100% [4]. Maize crops might experience significant reductions in output, perhaps reaching up to 52 percent, as a result of a severe infestation caused by greater row spacing [5]. Magnitude of crop losses caused by weeds varies depending on the specific weed species present [6]. The predominant weed species associated in maize are *Dactyloctenium aegyptium, Eleusine indica, Cynodon dactylon, Echinochloa colona, Brachiaria reptans, Digitaria sanguinalis, Sorghum halepense, Panicum* spp., *Digitaria ciliaris, Leptochloa chinensis* and *Commelina benghalensis* as grasses, *Ageratum conyzoides, Oxalis latifolia, Celosia argentea, Cleome viscosa, Sida acuta, Portulaca oleracea, Phyllanthus niruri, Amaranthus viridis, Tridax procumbens, Ipomoea pestigridis, Parthenium hysterophorus* and *Euphorbia hirta* as broadleaf weeds and *Cyperus rotundus* as sedges.

The presence of weed species is influenced by many factors such as location, climate, agronomic practices, crop sequence, weed control strategies, and the existing soil weed seed bank [7-9]. Weed plants possess a multitude of development traits and adaptations that allow them to effectively exploit a wide range of ecological niches. Some weeds have developed advantageous traits such as synchronised germination, being shaded by the crop during establishment, rapid response to moisture, ability to adapt to harsh soil and climate situations, herbicide resistance, morphological similarities to crops, and easy contamination with crop seeds. As a result, these weeds are commonly found in association with specific crops. Weed flora alters with location, for instance, *Cyperus rotundus* and *Trianthema portulacastrum* were dominant weed species in spring maize at Hisar. The study conducted by Pandey et al. [10] found that *Cyperus rotundus* was the most prevalent sedge in maize at Uttaranchal. The yield losses in maize due to weeds vary from location to location owing to differences in management practices, climate, and other factors. The efficacy of maize cultivation relies on the management of weeds through the application of herbicides. Nevertheless, herbicides should not be regarded as a substitute for other methods of weed control, but rather as a complement to existing methods. Research conducted by Bhatt and Khera [11], Sarkar and Singh [12], Anikwe et al. [13], and Glab and Kulig [14] has demonstrated the effectiveness of mulch in suppressing weed growth in maize. Straw mulching in combination with weed control by using herbicides has the potential to manage diverse weed population. The utilisation of both chemical and non-chemical methods, such as mulch, is more effective in managing weeds in maize compared to relying solely on one method. This research study was conducted to generate valuable information for controlling different weed species in maize with various straw mulch levels and herbicides dose.

2. MATERIALS AND METHODS

Field investigations were done at two locations during the kharif season of 2017 as a multi-location trial. The trial took place at the Research Farm of Punjab Agricultural University in Ludhiana, Punjab, India, and the Research Farm of Regional Research Station in Gurdaspur, Punjab, India. The soil at the Ludhiana site had a pH level of 7.5, consisting of 81.50% sand, 10.80% silt, and 7.70% clay. It also had available nitrogen (N), phosphorus (P), and potassium (K) levels of 138.1, 17.2, and 179.1 kg/ha, respectively. On the other hand, the soil at the Gurdaspur site had a pH level of 7.4, with 61.11% sand, 12.98% silt, and 25.91% clay. Its available N, P, and K levels were 136.6, 18.9, and 195.3 kg/ha. The study consisted of three straw mulch treatments: no mulch, paddy straw mulch 6.25 t/ha, paddy straw mulch 9.0 t/ha and six weed control treatments: atrazine 1.0 kg/ha pre-emergence, atrazine 0.8 kg/ha pre-emergence, tembotrione 0.110 kg/ha at 20 DAS, tembotrione 0.088 kg/ha at 20 DAS, weed free and unweeded check. The experiment was laid out in a factorial randomized block design with three replications at both locations. Maize hybrid (PMH 1) was planted on 22 June, 2017 at Ludhiana whereas at Gurdaspur it was sown on 6th June, 2017 using seed rate of 20 kg/ha. Paddy straw mulch (PSM) was applied immediately after the emergence of maize seedlings in between the lines as per the treatments. To manage weed growth, Atrataf 50 WP (atrazine) were used as a pre-emergence treatment within 2 DAS, while Laudis 420 SC (tembotrione) with an activator were used as a post-emergence treatment at 20 days after sowing (DAS) at a rate of 1000 ml/ha. The herbicides were applied using knapsack sprayer that delivered 500 l/ha spray solution for PRE herbicide though flood jet nozzle and 375 l/ha for POST herbicide through a flat fan nozzle. The efficacy of various straw mulch and herbicide levels was evaluated at 20 DAS and at harvest. Two quadrates of 50 cm×50 cm were randomly placed in each plot during each sampling time to determine the density of different weed species. Weed count was recorded species-wise and expressed in number per square meter. Data were analyzed using GLM procedure in SAS 9.3 [15] to evaluate differences between treatments. The treatments means were made at P≤0.05 by using Duncun's Multiple Range Test (DMRT). Weed density was square root transformated ($\sqrt{x+1}$) before performing ANOVA because of high variance. The square root transformed and original values are presented for clear presentation of weed data.

3. RESULTS AND DISCUSSION

3.1 Species-wise Weed Density at 20 Days after Sowing

The data on species wise density of different weeds were recorded at 20 days after sowing (DAS) at both the locations and are presented in Tables 1 and 2. The study showed that at 20 DAS, major weed species observed at Ludhiana site were *Dactyloctenium aegyptium, Eleusine indica* and *Commelina benghalensis* among grasses, *Trianthema portulacastrum, Portulaca oleracea* and *Digera arvensis* among broadleaf weeds and *Cyperus rotundus* and *Cyperus compressus* were recorded as sedges whereas, at Gurdaspur, *Dactyloctenium aegyptium* and *Cynodon dactylon* as grasses, *Trianthema portulacastrum, Digera arvensis, Alternanthera philoxeroides* and *Amaranthus viridis* were among broadleaf weeds and only *Cyperus rotundus* was recorded as sedges. *Eleusine indica, Commelina benghalensis* and *Euphorbia hirta* were also present at lower densities at Gurdaspur. Diversity in weed flora at different locations was also observed by Ndam et al. [16]. Pandey et al. [10] reported that *Cyperus rotundus* was the most dominant weed among sedges in maize fields.

It was observed that 9.0 t/ha mulch application recorded minimum density of *D. aegyptium, C. benghalensis, D. arvensis, C. rotundus* and *C. compressus* at Ludhiana and *D. aegyptium, D. arvensis, A. philoxeroides, A. viridis* and *C. rotundus* at Gurdaspur in comparison to 6.25 t/ha and no mulch. In continuation, application of both 6.25 t/ha and 9.0 t/ha mulch recorded statistically similar and lower density of *E. indica, T. portulacastrum* and *P. oleracea* at Ludhiana and *C. dactylon* and *T. portulacastrum* at Gurdaspur as compared to no mulching.

Among weed control treatments, minimum density of all weeds was recorded under weed free treatment whereas maximum density was observed under unweeded check. From the herbicides, atrazine 1.0 kg/ha resulted in

Table 1. The impact of straw mulch and herbicides on species-wise weed density (number per square m) at 20 DAS in maize field trials at Ludhiana, Punjab

Treatment	Grasses			BLWs*			Sedges	
	D. aegyptium	***E. indica***	***C. benghalensis***	***T. portulacastrum***	***P. oleracea***	***D. arvensis***	***C. rotundus***	***C. compressus***
Straw mulch								
No mulch	12.05(185)c	3.57(18)b	2.83 (8)c	2.02(4)b	1.50(2)b	2.96(9)c	4.66(24)c	11.51(167)c
PSM 6.25 t/ha	4.50(26)b	1.00(0)a	2.08 (4)b	1.00(0)a	1.00(0)a	2.05(4)b	3.90(18)b	5.86(46)b
PSM 9.0 t/ha	3.29(13)a	1.00(0)a	1.54 (2)a	1.00(0)a	1.00(0)a	1.69(2)a	3.54(15)a	4.34(25)a
Weed control								
Atrazine 1.0kg/ha	3.11(18)b	1.00(0)a	1.66 (3)b	1.00(0)a	1.00(0)a	1.41(1)b	1.86(4)b	2.93(15)b
Atrazine 0.8kg/ha	6.64(53)c	1.14 (0.4)a	2.32 (5)c	1.00(0)a	1.00(0)a	1.99(4)b	5.30(28)c	7.32(64)c
Tembotrione 0.110 kg/ha	9.66 (126)d	2.66(12)b	2.50(6)cd	1.75(3)b	1.30(1)b	2.99(8)c	5.19(26)c	10.83(134)d
Tembotrione 0.088 kg/ha	9.64 (125)d	2.68(12)b	2.68(7)cd	1.66(2)b	1.41(1)b	2.98(8)c	5.40(29)c	10.69(131)d
Weed free	1.00(0)a	1.00(0)a	1.00 (0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00 (0)a
Unweeded check	9.64 (126)d	2.66(12)b	2.75(7)cd	1.67(3)b	1.29(1)b	3.03(9)c	5.44(29)c	10.64(131)d

- *Data were analyzed with square root transformation using the formula $\sqrt{x+1}$. Original density is in parentheses*
- *Variables with the same letters do not show significant variation at 5% DMRT level*
- *BLWs*; Broad Leaf Weeds, DAS; Days after sowing, PSM; Paddy straw mulch*

Table 2. The impact of straw mulch and herbicides on species-wise weed density (number per square m) at 20 DAS in maize field trials at Gurdaspur, Punjab

Treatment	Grasses			BLWs			Sedges
	D. aegyptium	***C. dactylon***	***T. portulacastrum***	***D. arvensis***	***A. philoxeroides***	***A. viridis***	***C. rotundus***
Straw mulch							
No mulch	3.49(15)c	2.26(5)b	1.96(4)b	1.72(2)c	2.35(5)c	1.92(4)c	13.40(212)c
PSM 6.25 t/ha	2.64(8)b	1.53(2)a	1.22(0.6)a	1.42(1)b	1.17(0.4)b	1.55(2)b	10.13(120)b
PSM 9.0 t/ha	1.85(3)a	1.43(1)a	1.17(0.4)a	1.17(0.4)a	1.00(0)a	1.31(1)a	9.18(99)a
Weed control							
Atrazine 1.0 kg/ha	1.72(3)b	1.71(3)a	1.00(0)a	1.00(0)a	1.20(0.6)b	1.00(0)a	10.62(116)b
Atrazine 0.8 kg/ha	1.91(4)c	2.13(4)a	1.00(0)a	1.17(0.4)b	1.58(2)c	1.00(0)a	13.77(191)c
Tembotrione 0.110 kg/ha	3.86(16)d	2.16(4)a	2.03(3.5)b	1.88(3)c	1.83(3)d	2.17(4)b	14.02(201)d
Tembotrione 0.088 kg/ha	4.02(18)d	2.18(4)a	2.02(3.4)b	1.89(3)c	1.84(3)d	2.10(3)b	13.98(200)d
Weed free	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0) a	1.00(0)a
Unweeded check	3.85(15)d	2.17(4)a	2.01(3.4)b	1.93(3)c	1.84(3)d	2.27(4)b	14.06(201)d

- *Data were analyzed with square root transformation using the formula* $\sqrt{x+1}$*. Original density is in parentheses*
- *Variables with the same letters do not show significant variation at 5% DMRT level*
- *BLWs*; Broad Leaf Weeds, DAS; Days after sowing, PSM; Paddy straw mulch*

Table 3. The impact of straw mulch and herbicides on species-wise weed density (number per square m) at harvest in maize in field trials conducted at Ludhiana, Punjab

Treatment	Grasses						BLWs*	Sedges	
	D. aegyptium	*E. indica*	*C. benghalensis*	*E. tenella*	*D. sanguinalis*	*E. colona*	*D. arvensis*	*C. rotundus*	*C. compressus*
Straw mulch									
No mulch	2.60(8)c	1.24 (0.7)b	2.88(9)c	2.20(5)c	1.40(2)c	1.25 (0.9)b	1.46(1)c	3.04(11)c	1.33(1)b
PSM 6.25 t/ha	2.18(5)b	1.08 (0.2)a	2.39(5)b	1.65(2)b	1.09 (0.2)b	1.00(0)a	1.24 (0.6)b	2.16(5)b	1.00(0)a
PSM 9.0 t/ha	1.81(3)a	1.00(0)a	1.90(3)a	1.40(1)a	1.00(0)a	1.00(0)a	1.00(0)a	1.76(3)a	1.00(0)a
Weed control									
Atrazine 1.0 kg/ha	2.64(6)b	1.00(0)a	2.53(6)c	1.56(2)a	1.00(0)a	1.00(0)a	1.23 (0.6)b	2.24(4)c	1.00(0)a
Atrazine 0.8 kg/ha	3.21(10)c	1.73 (0.4)b	3.08(9)d	2.16(6)b	1.00(0)a	1.00(0)a	1.38(1)c	2.97(8)d	1.00(0)a
Tembotrione 0.110 kg/ha	1.31 (0.9)a	1.00(0)a	2.14(4)b	1.27 (0.7)a	1.00(0)a	1.00(0)a	1.05 (0.1)a	1.77(2)b	1.00(0)a
Tembotrione 0.088 kg/ha	1.29 (0.9)a	1.00(0)a	2..06(4)b	1.27 (0.7)a	1.00(0)a	1.00(0)a	1.05 (0.1)a	1.65(2)b	1.00(0)a
Weed free	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a
Unweeded check	3.74(13)d	1.46(1)c	3.53 (12)e	2.84(8)c	1.98(4)b	1.50(2)b	1.70(2)d	4.31(20)e	1.67(3)b

- *Data were analyzed with square root transformation using the formula √x+1. Original density is in parentheses*
- *Variables with the same letters do not show significant variation at 5% DMRT level*
- *BLWs*; Broad Leaf Weeds, DAS; Days after sowing, PSM; Paddy straw mulch*

Table 4. The impact of straw mulch and herbicides on species-wise weed density (number per square m) at harvest in maize in field trials conducted at Gurdaspur, Punjab

Treatment	Grasses			BLWs*					Sedges
	D. aegyptium	***E. indica***	***C. dactylon***	***E. tenella***	***E. hirta***	***A. viridis***	***V. agrestis***	***C. stricta***	***C. rotundus***
Straw mulch									
No mulch	1.96(3)c	1.66(2)b	1.91(3)c	1.99(4)b	1.68(2)b	1.38 (1)c	2.56(7)c	1.69(2)b	4.75(26)c
PSM 6.25 t/ha	1.81(3)b	1.21 (0.6)a	1.55(2)b	1.35(1)a	1.38(1)a	1.09 (0.2)b	1.89(3)b	1.37(1)a	4.13(19)b
PSM 9.0 t/ha No mulch	1.27 (0.9)a	1.19 (0.6)a	1.27 (0.8)a	1.24 (0.8)a	1.30 (0.8)a	1.00 (0)a	1.45 (1)a	1.32 (0.9)a	3.34 (13)a
Weed control									
Atrazine 1.0 kg/ha	1.71 (2)c	1.25 (0.7)a	1.51 (2)b	1.22 (0.7)a	1.48 (1)b	1.00 (0)a	2.36 (5)b	1.61 (2)b	4.94 (24)c
Atrazine 0.8 kg/ha	1.80 (3)c	1.40 (1.3)b	1.77 (2)c	1.86 (3)b	1.65 (2)b	1.17 (0.4)b	2.67 (7)b	1.97 (3)c	5.50 (30)d
Tembotrione 0.110 kg/ha	1.47 (1)b	1.17 (0.4)a	1.38 (1)b	1.17 (0.4)a	1.00 (0)a	1.00 (0)a	1.41 (1)a	1.00 (0)a	3.39 (11)b
Tembotrione 0.088 kg/ha	1.54 (1.6)b	1.17 (0.4)a	1.41 (1)b	1.22 (0.7)a	1.27 (0.7)a	1.00 (0)a	1.13 (0.4)a	1.00 (0)a	3.5 (11)b
Weed free	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00(0)a	1.00 (0)a	1.00(0)a	1.00(0)a	1.00(0)a
Unweeded check	2.56(6)d	2.11(4)c	2.38(5)d	2.7 (8)c	2.32(5)c	1.76 (3)c	3.22(11)c	2.18(4)c	6.27(39)e

- *Data were analyzed with square root transformation using the formula $\sqrt{x+1}$. Original density is in parentheses*
- *Variables with the same letters do not show significant variation at 5% DMRT level*
- *BLWs*; Broad Leaf Weeds, DAS; Days after sowing, PSM; Paddy straw mulch*

significantly less density of *D. aegyptium, C. benghalensis, C. rotundus* and *C. compressus* at Ludhiana and *D. aegyptium, D. arvensis, A. philoxeroides* and *C. rotundus* at Gurdaspur in comparison to its lower dose, but the later one also significantly controlled the density of *D. aegyptium, D. arvensis* and *C. compressus* at Ludhiana and *D. aegyptium* and *D. arvensis* at Gurdaspur as compared to unweeded check. However, the density of *C. dactylon* at Gurdaspur was not significantly influenced by both doses of atrazine. The higher weed population was observed in both tembotrione treatments at 20 DAS because this herbicide was applied as post emergence after collection of weed data at 20 DAS. Thus the data showed that initial flush of *D. aegyptium, C. benghalensis, A. philoxeroides, C. rotundus* and *C. compressus* were controlled with atrazine 1.0 kg/ha within 2 days of sowing, whereas atrazine 0.8 kg/ha applied within 2 days of sowing effectively controlled *E. indica, T. portulacastrum, A.viridis, P. oleracea* and *D. arvensis*. Chopra and Angiras [17] also corroborated with the research findings on Atrazine as pre-emergence application.

3.2 Species-wise Weed Density at Harvest

Species-wise density of different weeds at harvest at Ludhiana and Gurdaspur are presented in Tables 3 and 4. The major weed species observed at harvest at Ludhiana site were *D. aegyptium, E. indica, C. benghalensis, E. tenella, D. sanguinalis* and *E. colona* among grasses, *D. arvensis* as broadleaf weed and *C. rotundus* and *C. compressus* were recorded as sedges whereas at Gurdaspur, *D. aegyptium, E. indica, C. dactylon* and *E. tenella* were the major grass weed species, *E. hirta, A.viridis, V. agrestis* and *C.stricta* were among broadleaf weeds and only *C. rotundus* was recorded as sedges.

The mulch application at 9.0 t/ha led to a considerably lower density of *D. aegyptium, C. benghalensis, E. tenella, D. sanguinalis, D. arvensis*, and *C. rotundus* compared to the treatments with 6.25 t/ha mulch and no mulch at Ludhiana. However, both the mulch treatments of 6.25 t/ha and 9.0 t/ha showed statistically similar and considerably decreased density of *E. indica, E. colona,* and *C. compressus* compared to the treatment without mulch. However, in Gurdaspur, applying mulch 9.0 t/ha recorded lowest density of *D. aegyptium, C. dactylon, A. viridis, V. agrestis,* and *C. rotundus* compared to treatments with 6.25 t/ha of mulch and no mulch. Likewise, both 6.25 t/ha and 9.0 t/ha mulch treatments were statistically similar and significantly better in controlling the density of *E. indica, E. tenella, E. hirta* and *C. stricta* as compared to no mulch treatment. Kumar and Angadi [18] reported that mulch is a good agronomic manipulation for weed management in maize. Uwah and Iwo [19] also observed that straw mulch recorded significantly less weed density in comparison to no mulch.

In case of herbicide treatments, application of tembotrione at 0.088 and 0.110 kg/ha resulted in significantly better control of *D. aegyptium, C. benghalensis, E. tenella, D. arvensis* and *C. rotundus* at Ludhiana. Similarly, in Gurdaspur, tembotrione at both doses provided better control of *D. aegyptium, E. hirta, V. agrestis, C. stricta*, and *C. rotundus* compared to atrazine at 0.8 and 1.0 kg/ha, and unweeded check. Whereas, application of tembotrione at both doses and atrazine at 1.0 kg/ha were statistically similar in reducing the density of *E. indica, E. tenella, D. sanguinalis, E. colona* and *C. compressus* at Ludhiana and *E. indica, C. dactylon, E. tenella* and *A. viridis* at Gurdaspur but were significantly better as compared to the atrazine at 0.8 kg/ha and unweeded check. Atrazine at both doses also recorded significantly better control of all the weed species as compared to unweeded check except *C. stricta* which was re- emerged and not controlled at harvest. The findings showed that tembotrione at 0.088 and 0.110 kg/ha shown greater efficacy in managing several weed species in maize, compared to atrazine 1.0 kg/ha and atrazine 0.8 kg/ha. Rana et al. [20] found that applying tembotrione after emergence efficiently suppressed the populations of *Echinochloa colona, Commelina benghalensis, Polygonum alatum*, and *Ageratum conyzoides*.

4. CONCLUSION

It is concluded that application of paddy straw mulch 6.25 t/ha effectively controlled *E. indica, C. dactylon, C. benghalensis, E. tenella, D. sanguinalis*, *E. colona*, *T. portulacastrum, P. oleracea, P. niruri, E. hirta, C. stricta* and *C. compressus* over no mulching. Furthermore, the application of paddy straw mulch at a rate of 9.0 t/ha resulted in a significant reduction in the population density of *D. aegyptium, A. racemosa, D. arvensis, M. nudicaulis, A. philoxeroides, A. viridis, V. agrestis*, and *C. rotundus* as compared to the application of 6.25 t/ha and no mulch. Post emergence application of tembotrione at 0.088

and 0.110 kg/ha significantly reduced the density of all weed species observed in research experiments as compared with using atrazine at 0.8 and 1.0 kg/ha and unweeded check.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bijanzadeh E, Hossein G. Effect of separate and combined treatments of herbicides on weed control and maize (*Zea mays* L.) yield. Weed Technology. 2006;20:640-645.
2. Zimdahl RL. Weed crop competition: A review. Oxford, UK, Blackwell Publishers. 2004;109-130
3. Oerke EC, Dehne HW. Safeguarding production losses in major crops and role of crop production. Crop Protection. 2004;23:275-285.
4. Sharma R. Integrated weed management in kharif maize. Intensive Agriculture; May-June: 6-9 2005.
5. Walia US, Brar LS, Singh B. Recommendations for weed control in field crops. Research Bulletin, Department of Agronomy, Agrometerology and Forestry, PAU Ludhiana. 2005;5.
6. Hirwe O, Kumar S, Sri K, Reddy P, Kumar N, Nandana S, Sharma S, Bhat S. Different weed management techniques in maize (*Zea mays*. L): A Review. International Journal of Plant and Soil Science. 2023;35:179-191.
7. Hargilas H. Effective weed management strategy for maize (*Zea mays*) under rainfed conditions of southern Rajasthan. Indian Journal of Agricultural Sciences. 2020;90:693-698.
8. Nayak A, Khanda CM, Das S, Mohanty SK, Sahoo BB, Nayak BS. Enhancing hybrid maize (Zea mays) productivity, profitability and energetics through tillage and weed-management practices in Eastern India. Indian Journal of Agronomy. 2022;67:152-157.
9. Singh VP, Paliwal A, Pratap T, Singh SP, Kumar A, Shyam R. Bio-efficacy of nicosulfuron against mixed weed flora in maize and its residual effect on succeeding crops. Indian Journal of Weed Science. 2022;54:251-256.
10. Pandey AK, Parkash V, Singh RD, Mani VP. Integrated weed management in maize (*Zea mays*). Indian Journal of Agronomy. 2001;46:260-265.
11. Bhatt R, and Khera KL. Effect of tillage and mode of straw mulch application on soil erosion in sub montaneous tract of Punjab, India. Soil and Tillage Research. 2006;88:107-115.
12. Sarkar S, Singh SR. Interactive effect of tillage depth and mulch on soil temperature, productivity and water use pattern of rainfed barley (*Hordium vulgare* L.). Soil and Tillage Research. 2007;92:79-86.
13. Anikwe MAN, Mbah CN, Ezeaku PI, Onyia VN. Tillage and plastic mulch effects on soil properties and growth and yield of cocoyam (*Colocasia esculenta*) on an ultisol in south eastern Nigeria. Soil and Tillage Research. 2007;93:264-273.
14. Glab T, Kulig B. Effect of mulch and tillage system on soil porosity under wheat (*Triticum aestivum*). Soil and Tillage Research. 2008;99:169-178.
15. SAS User’s Guide. SAS Institute, Cary, NC (USA).
16. Ndam LM, Enang JE, Mih AM, Egbe AE. Weed diversity in maize (*Zea mays* L.) fields in South Western Cameroon. International Journal of Current Microbiology and Applied Sciences. 2014;3:173-180.
17. Chopra P, Angiras NN. Influence of tillage and weed control methods on weeds, yield and yield attributes of maize (*Zea mays* L.). Indian Journal of Weed Science. 2008;40:47-50.
18. Kumar BRM, Angadi SS. Effect of tillage, mulch and weed management on performance of maize (*Zea mays*) in Karnataka. Indian Journal of Dryland Agriculture Research and Development. 2014;29:57-62.
19. Uwah DF, Iwo GA. Effectiveness of organic mulch on the productivity of maize (*Zea mays* L.) and weed growth. Journal of

Animal and Plant Sciences, 2011;21:525-530.

20. Rana SS, Badiyala D, Sharma N, Kumar R, Pathania P. Impact of tembotrione on weed growth, yield and economics of maize (*Zea mays* L.) under Mid Hill conditions of Himachal Pradesh. Pesticide Research Journal. 2017;29:27-34.

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