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EFFECT OF NEW HERBICIDE MOLECULES ON YIELD, SOIL MICROBIAL BIOMASS AND THEIR PHYTOTOXICITY ON MAIZE (*ZEA MAYS* L.) UNDER IRRIGATED CONDITIONS

VEERESH HATTI[1]*, M. T. SANJAY[2], T. V. RAMACHANDRA PRASAD[2], K. N. KALYANA MURTHY[1], BASAVARAJ KUMBAR[1] AND M. K. SHRUTHI[1]

[1]Department of Agronomy,
University of Agricultural Sciences, GKVK, Bangalore - 560 065, INDIA
[2]AICRP on Weed Control, MRS, Hebbal, Bangalore - 560 024, INDIA
e-mail: veereshshatti@gmail.com

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***Corresponding author**

ABSTRACT

A field experiment was carried out during *kharif* 2012 at Main Research Station, University of Agricultural Sciences, Hebbal, Bangalore, Karnataka to evaluate the effect of new herbicide molecules on yield, soil microbial biomass and their phytotoxicity on maize in sandy loam soil under irrigated conditions. The experiment was laid out in RCBD with fourteen treatments replicated thrice. The treatments were pre and post-emergence herbicides (atrazine, oxyflurofen, pendimethalin and topramezone, 2, 4-D, tembotrione, respectively) and their combinations (topramezone + atrazine with and without adjuvant) which were compared with farmer's practices of intercultivation and hand weeding as well as weedy check. Significantly higher kernel yield was observed in pre-emergence application of oxyflurofen 23.5 EC – 200 g a. i. ha^{-1} at 3 DAS followed by post-emergence application of 2, 4-D Na salt 80 WP - 500 g a. i. ha^{-1} at 30 DAS (6107 kg ha^{-1}) when compared to farmer's practice of two inter cultivations (5418 kg ha^{-1}), two hand weeding (6081 kg ha^{-1}) and weedy check (2157 kg ha^{-1}). And the soil microbial biomass in herbicide treated treatments was significantly reduced at 25 DAS in comparison to sowing. However at harvest the soil microbial biomass was recovered due to degradation of herbicide. All these herbicides were not having any phytotoxic effect on the crop

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals in the world agricultural economy both as a food and fodder crop. Maize kernels are used for human consumption, feed for poultry and livestock, extraction of edible oil and also for starch and glucose industry. The critical stage of crop weed competition in maize crop is from 30 to 45 days from sowing (Kamble *et al.,* 2005). Controlling of weeds in maize in the critical period presumes most importance for realizing higher yield. Because weeds emerge fast and grow rapidly competing with the crop severely for growth resources *viz.*, nutrients, moisture, sunlight and space during entire vegetative and early reproductive stages of maize. They also transpire lot of valuable conserved moisture and absorb large quantities of nutrients from the soil. Further, wide spacing in maize allows faster growth of variety of weed species which reduces the photosynthetic efficiency, dry matter production and distribution to economical parts and there by reduces sink capacity of crop resulting in poor kernel yield (Vaid *et al.*, 2010). Thus, the extent of reduction in kernel yield of maize has been reported to be in the range of 33 to 50 per cent depending on the intensity and persistence of weed density in standing crop (Sharma *et al.*, 2000). Labour component in agriculture is becoming scarce, not available at time and prohibitive cost (Dalal and Nandkar, 2010). Under these situations use of herbicides to manage weeds forms an excellent alternative to manual weeding. Under these circumstances, a field experiment was conducted during *kharif* 2012 to study the effect of some new herbicide molecules on maize kernel yield, soil microbial biomass and their phytotoxicity on maize.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2012 at Main Research Station (12°58' N latitude, 77°35' E longitude at 930 meters above mean sea level), University of Agricultural Sciences, Hebbal, Bangalore, Karnataka to evaluate the effect of new herbicide molecules on yield, soil microbial biomass and their phytotoxic effect on maize under irrigated conditions. The soil type of the experimental site was sandy loam with a pH-6.7, available nitrogen-240.4 kg ha^{-1}, available phosphorus-32.4 kg ha^{-1}, available potassium-182.0 kg ha^{-1} and organic carbon content of 0.59%. The experiment was laid out in RCBD design with fourteen treatments replicated thrice *viz.*, T_1: topramezone 33.6 SC at 16.8 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1}, T_2: topramezone 33.6 SC at 21.0 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1}, T_3: topramezone 33.6 SC at 25.2 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1}, T_4: topramezone 33.6 SC at 16.8 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1} + MSO adjuvant at 2 ml lit^{-1}, T_5: topramezone 33.6 SC at 21.0 g a. i. ha^{-1} + atrazine 50

WP at 250 g a. i. ha^{-1} + MSO adjuvant at 2 ml lit^{-1}, T_6: topramezone 33.6 SC at 25.2 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1} + MSO adjuvant at 2 ml lit^{-1}, T_7: topramezone 33.6 SC at 25.2 g a. i. ha^{-1} (T_1 to T_7 are sprayed as early post-emergence at 15 DAS), T_8: atrazine 50 WP at 1000 g a. i. ha^{-1} (pre-emergence at 3 DAS), T_9: oxyflurofen 23.5 EC at 200 g a. i. ha^{-1} (pre-emergence at 3 DAS) + 2, 4-D Na 80 WP at 500 g a. i. ha^{-1} (post-emergence at 30 DAS), T_{10}: pendimethalin 30 EC at 750 g a. i. ha^{-1} (pre-emergence at 3 DAS) + 2, 4-D Na 80 WP at 500 g a. i. ha^{-1} (post-emergence at 30 DAS), T_{11}: tembotrione 42 SC at 105 g a. i. ha^{-1} + isoxadifen-ethyl 21 SC at 52 g a. i. ha^{-1} + stefes mero adjuvant at 2.5 ml lit^{-1} (post-emergence at 15 DAS), T_{12}: two intercultivations (20 and 40 DAS), T_{13}: two hand weedings (20 and 40 DAS) and T_{14}: weedy check. Bold and healthy certified seeds of maize hybrid Nityashree (NAH 2049) were sown by dibbling at a spacing of 60 x 30 with the seed rate of 15 kg ha^{-1} on 10th May, 2012. Recommended dose of FYM at 10 t ha^{-1} three weeks before sowing and $ZnSO_4$ at 10 kg ha^{-1} at the time of sowing and inorganic fertilizers (150: 75: 40 kg N, P_2O_5 and K_2O ha^{-1}) were applied to maize. Pre-emergence herbicides were applied by using knapsack sprayer fitted with Aspee WFN 78 nozzle with a spray volume of 750 liters ha^{-1}. At the time of herbicide application, adequate soil moisture was maintained with fewer clods. Post-emergence herbicides were applied by using knapsack sprayer fitted with Aspee WFN 40 nozzle by using 375 liters of spray volume ha^{-1}. The post-emergence herbicides were sprayed when the weeds were in active stage without being wilted to ensure good action by the herbicides. The soil microbial biomass was estimated by fumigation and extraction method as proposed by Carter (1991) and expressed as μg of soil microbial biomass per g of soil. Visual observations were recorded at 7, 14 and 28 days after spraying of herbicides to know the extent of toxicity caused by herbicides on crop by using phytotoxicity rating zero (no toxicity) to ten (100% toxicity) scale (Anon., 1981). The phytotoxicity rating was recorded on symptoms - epinasty, hyponasty, necrosis, wilting, vein clearing and stunted growth.

The experimental data on soil microbial biomass, yield and yield parameters were subjected to analysis by using Fisher's method of "Analysis of Variance" (ANOVA) as outlined by Panse and Sukhatme (1954). The levels of significance used in "F" and "t" test was at P = 0.05.

RESULTS AND DISCUSSION

Oxyflurofen–200 g a. i. ha^{-1} + 2, 4-D– 500 g a. i. ha^{-1} recorded significantly higher kernel weight per cob, kernel and stover yield which was found on par with hand weeding (20 and 40 DAS), topramezone - 25.2 g a. i. ha^{-1} + atrazine–250 g a. i. ha^{-1} with and without adjuvants, tembotrione-105 g a. i. ha^{-1} + isoxadifen-ethyl– 52 g a. i. ha^{-1} + adjuvant and pendimethalin–750 g a. i. ha^{-1} + 2, 4-D– 500 g a. i. ha^{-1} (Table 1). Significantly lowest kernel and stover yield was observed in weedy check (2157 kg ha^{-1}) because of severe weed competition exerted by weeds for space, light, moisture and nutrients throughout the crop growth period. These results were in agreement with Janjic *et al*. (1983) and Khan *et al*. (2002). Similarly, topramezone-25.2 g a. i. ha^{-1} + atrazine-250 g a. i. ha^{-1} with and without adjuvants, oxyflurofen– 200 g a. i. ha^{-1} + 2, 4-D-500 g a. i. ha^{-1}, topramezone-21.0 g a. i. ha^{-1} + atrazine-250 g a. i. ha^{-1} with and without adjuvants, tembotrione- 105 g a. i.

Table 1: Table 1: Kernel weight per cob (g), kernel yield (kg ha^{-1}), stover yield (kg ha^{-1}) and B:C ratio in maize as influenced by weed management practices

Weed management practices	Kernel weight per cob (g)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})	B:C ratio
T_1: Topramezone 33.6 SC at 16.8 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1}	99.2	4894	6320	2.85
T_2: Topramezone 33.6 SC at 21.0 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1}	108.5	5312	6955	3.09
T_3: Topramezone 33.6 SC at 25.2 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1}	120.6	5704	7245	3.29
T_4: Topramezone 33.6 SC at 16.8 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1} + MSO adjuvant at 2 ml lit^{-1}	94.6	4630	6254	2.71
T_5: Topramezone 33.6 SC at 21.0 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1} + MSO adjuvant at 2 ml lit^{-1}	109.1	5360	6995	3.11
T_6: Topramezone 33.6 SC at 25.2 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1} + MSO adjuvant at 2 ml lit^{-1}	118	5864	7395	3.38
T_7: Topramezone 33.6 SC at 25.2 g a. i. ha^{-1}	67.3	2976	4705	1.77
T_8 :Atrazine 50 WP at 1000 g a. i. ha^{-1}	95.9	4638	6286	2.71
T_9: Oxyflurofen 23.5 EC at 200 g a. i. ha^{-1} + 2,4-D Na 80 WP at 500 g a. i. ha^{-1}	128.1	6107	7615	3.35
T_{10}: Pendimethalin 30 EC at 750 g a. i. ha^{-1} + 2,4-D Na 80 WP At 500 g a. i. ha^{-1}	111.9	5469	6985	2.7
T_{11}: Tembotrione 42 SC at 105 g a. i. ha^{-1} + isoxadifen-ethyl 21 SC at 52 g a. i. ha^{-1} + stefes mero adjuvant at 2.5 ml lit^{-1}	113.9	5593	7109	3.05
T_{12}: Two intercultivations at 20 and 40 DAS	111.1	5418	6838	2.97
T_{13}: Two hand weedings at 20 and 40 DAS	121.9	6081	7602	3
T_{14}: Weedy check	51.3	2157	3866	1.35
S.Em +	6	235.9	486.9	NA
C. D. at 5%	17.4	685.9	1415.6	

DAS-Days after sowing, NA-Not analyzed, B:C-Benefit:Cost

Table 2: Soil microbial biomass (μg g^{-1} soil) in maize crop as influenced by weed management practices

Weed management practices	Soil microbial biomass (μg g^{-1} soil)		
	Sowing	25 DAS	Harvest
T_1: Topramezone 33.6 SC at 16.8 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1}	492.9	107.7	343.6
T_2: Topramezone 33.6 SC at 21.0 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1}	482.7	109.3	345.2
T_3: Topramezone 33.6 SC at 25.2 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1}	492	121.1	357
T_4: Topramezone 33.6 SC at 16.8 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1} + MSO adjuvant at 2 ml lit^{-1}	463.1	104.2	251.4
T_5: Topramezone 33.6 SC at 21.0 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1} + MSO adjuvant at 2 ml lit^{-1}	470.3	176.9	412.8
T_6: Topramezone 33.6 SC at 25.2 g a. i. ha^{-1} + atrazine 50 WP at 250 g a. i. ha^{-1} + MSO adjuvant at 2 ml lit^{-1}	482.7	105.5	341.4
T_7: Topramezone 33.6 SC at 25.2 g a. i. ha^{-1}	489.8	158.3	394.2
T_8 :Atrazine 50 WP at 1000 g a. i. ha^{-1}	488.6	97.8	333.7
T_9: Oxyflurofen 23.5 EC at 200 g a. i. ha^{-1} + 2,4-D Na 80 WP at 500 g a. i. ha^{-1}	489.5	90	326
T_{10}: Pendimethalin 30 EC at 750 g a. i. ha^{-1} + 2,4-D Na 80 WP At 500 g a. i. ha^{-1}	479.6	143.4	379.3
T_{11}: Tembotrione 42 SC at 105 g a. i. ha^{-1} + isoxadifen-ethyl 21 SC at 52 g a. i. ha^{-1} + stefes mero adjuvant at 2.5 ml lit^{-1}	492	111.7	347.6
T_{12}: Two intercultivations at 20 and 40 DAS	494.2	149	384.9
T_{13}: Two hand weedings at 20 and 40 DAS	467.8	175.4	411.3
T_{14}: Weedy check	485.8	198.7	434.6
S.Em+	NS	6.6	19
C. D. at 5%		19.1	55.4

DAS-Days after sowing, NS-Non significant

ha^{-1} + isoxadifen-ethyl- 52 g a. i. ha^{-1} with adjuvant and hand weeding (20 and 40 DAS) have recorded higher B:C ratio due to higher maize yield in these treatments and lower was found in weedy check.

At sowing, there was no significant difference in soil microbial biomass in different treatments (Table 2). At 25 DAS, the soil microbial biomass was significantly affected by different weed management practices, *i. e.,* significantly lowest soil microbial biomass was observed in pre-emergence application of oxyflurofen-200 g a. i. ha^{-1} + 2, 4-D-500 g a. i. ha^{-1} which was on par with atrazine-1000 g a. i. ha^{-1}, topramezone-16.8 g a. i. ha^{-1} + atrazine - 250 g a. i. ha^{-1} with and without adjuvant and topramezone - 25.2 g a. i. ha^{-1} + atrazine - 250 g a. i. ha^{-1} with adjuvant as compared to other treatments. Whereas significantly higher soil microbial biomass carbon was recorded in weedy check. These findings are in agreement with Rodriguez *et al*. (2004). At harvest, soil microbial biomass carbon was increased in herbicide treatments as compared to 25 DAS owing to the use of herbicides as source of carbon by the microbes as reported by Mandelbaum *et al*. (1993) and Jose Moreno *et al*. (2007). This might be due to the reduction in harmful effects of herbicide at later stages of crop growth by microbial degradation as quoted by Shukla (1997). But, comparatively lower microbial biomass was observed in topramezone - 16.8 g a. i. ha^{-1} + atrazine- 250 g a. i. ha^{-1} with adjuvants as compared to other herbicide treatments. Significantly highest soil microbial biomass was recorded in weedy check, topramezone - 21.0 g a. i. ha^{-1} + atrazine - 250 g a. i. ha^{-1} with adjuvant, hand weeding (20 and 40 DAS), topramezone - 25.2 g a. i. ha^{-1}, intercultural operations (20 and 40 DAS) and pendimethalin -750 g a. i. ha^{-1} + 2, 4-D - 500 g a. i. ha^{-1}. similar results were also reported by Singh and Singh (2009).

All the herbicides used in the present investigation did not caused any phytotoxic effect on maize in terms of epinasty, hyponasty, necrotic symptoms, stunted growth and wilting at 7, 14 and 28 days after spraying because of the selective nature of these herbicides to maize.

Pre-emergence application of oxyflurofen 23.5 EC-200 g a. i. ha^{-1} at 3 DAS followed by post-emergence application of 2, 4-D Na salt 80 WP – 500 g a. i. ha^{-1} at 30 DAS which was on par with hand weeding (20 and 40 DAS) is the most efficient weed management practice for obtaining higher productivity. Combination of pre and post-emergence herbicides like oxyflurofen, pendimethalin with 2, 4-D Na, topramezone with atrazine can be used for profitable maize cultivation under present labour constraint conditions.

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