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Response of Weed Management Practices on Yield Loss, Soil Enzyme Activity and Microbial Populations in Maize (*Zea mays* L.)

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ABSTRACT

Background: Maize popularly known as “Queen of cereals”. Weeds resulted in the highest crop loss (33%), followed by pathogens (26%), insects (20%), storage pests (7%), rodents (6%) and others (8%) in India. Application of herbicides will affect various soil microbial processes and enzymatic activities in the soil, whose activity is very important for maintaining the soil fertility.

Methods: The present field experiment was conducted during *Rabi*, 2017-18 and 2018-19 under irrigated conditions at wetland farm of S.V. Agricultural College, Tirupati Andhra Pradesh, with ten treatments and three replications in a randomized block design.

Result: Higher kernel and stover yield of maize was recorded with hand weeding twice at 15 and 30 DAS and the yield loss was comparatively lower with atrazine 1.0 kg ha^{-1}as PE *fb* topramezone 30 g ha^{-1}or tembotrione 120 g ha^{-1} as PoE or atrazine 1.0 kg ha^{-1}as PE *fb* HW at 30 DAS, while these were lowest with weedy check. Soil microbial count and enzyme activity was statistically comparable in all the pre followed by post emergence herbicide treatments.

Key words: Enzyme activity, Maize, Microbial population, Soil, Weed index, Yield.

INTRODUCTION

Maize (*Zea mays* L.) is the most versatile and emerging food crop of global importance. It is popularly known as “Queen of cereals” because of its high genetic yield potential and its unmatchable suitability to diverse environmental conditions among the cereals. Maize is the third most important food grain crop in India after rice and wheat. Weeds resulted in the highest crop loss (33%), followed by pathogens (26%), insects (20%), storage pests (7%), rodents (6%) and others (8%) in India (Yaduraju and Mishra, 2018). Heavy infestation of weeds and shortage of labour for weeding in time are the two foremost constraints to enhance the productivity of maize. Conventional methods of weed control are slow, laborious and sometimes uneconomical. Usage of pre-emergence herbicides assumes greater importance in view of their effectiveness from the beginning of crop growth. Early post emergence or sequential use of pre *fb* post emergence herbicides may help in tackling the problem of weeds at later stages of crop growth (Devi and Venkateswarlu, 2017). Application of herbicides will affect various soil microbial processes and enzymatic activities in the soil, whose activity is very important for maintaining the soil fertility. Biological properties are critically important to the ecosystem functioning since they are involved in soil organic matter decomposition, nutrient cycling and degradation of pesticides, such as herbicides. Soil microbial biomass represents the active part of soil organic matter and is involved in several functions in soil, presenting a rapid turnover of soil C, N and P, while enzymes are a suitable indicator of the catabolic activity of soil microorganism (Sanjay and Divya, 2016). Keeping the above facts in view, an investigation was carried out to study the effectiveness of pre emergence, early post emergence and sequential application (single or in combination) of herbicides for broad spectrum weed control, increased yields and to detect the quantity of microbial population and enzyme activity in soil at harvest of maize.

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MATERIALS AND METHODS

The present field experiment was conducted during *Rabi,* 2017-18 and 2018-19 at S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University Andhra Pradesh, which is geographically situated at 13.6°N latitude and 79.3°E longitude, at an altitude of 182.9 m above the mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh. The experiment was laid out in a randomized block design with three replications and ten weed management practices *viz.,* atrazine 1.0 kg ha^{-1} as pre emergence (PE) *fb* one HW at 30 DAS (T_1), atrazine 1.0 kg. ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as post emergence (PoE) (T_2), atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE (T_3), atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE (T_4), atrazine 1.0 kg ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE (T_5), atrazine @ 1.0 kg ha^{-1} as PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE (T_6), atrazine @ 1.0 kg. ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE (T_7), atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g+2,4-D amine salt 290 g ha^{-1} as PoE (T_8), hand weeding twice at 15 and 30 DAS (T_9) and weedy check (T_{10}). A total rainfall of 43.3 mm was received in 2 rainy days as against the decennial average rainfall of 246.3 mm in 9.2 rainy days during *Rabi,* 2017-18 and in *Rabi,* 2018-19 a total rainfall of 128.2 mm was received in 8 rainy days as against the decennial average rainfall of 254.7 mm received in 10.5 rainy days. The soil of the experimental site was sandy clay loam in texture, neutral in soil reaction and moderately fertile being low in organic carbon (0.25%) and available nitrogen (174 kg ha^{-1}), medium in available phosphorus (20.5 kg ha^{-1}) and potassium (186 kg ha^{-1}). Maize hybrid *'DHM-117'* was sown at a spacing of 60 cm×20 cm with a gross plot size of 5.4 m×4. 6 m. Recommended dose of 240 kg N, 80 kg P and 80 kg K ha^{-1} was supplied through urea, single super phosphate and muriate of potash to all the plots uniformly. Pre emergence herbicide was applied within 24 hours after sowing and early post-emergence herbicides were applied at 2-3 leaf stage of weeds in maize. Weed population was counted with the help of 0.5 × 0.5 m quadrant thrown randomly at two places in each plot and converted to population or density m^{-2}. While recording weed population the biomass was harvested from each quadrant. Microbial mass in the soil was normally expressed in colony forming units per gram of soil (CFU g^{-1} of soil). The viable count for bacteria, fungi and actinomycetes was done on Nutrient agar (NA), Potato dextrose agar (PDA) and Actinomycetes isolate agar (AIA) media, respectively (Jones and Mollison).

The viable count of soil microbes was enumerated by following formula:

Colony forming units per ml of sample =

$$\frac{\text{Number of colonies}}{\text{Quanity of simple}} \times \text{Dilution factor}$$

The enzyme activity was estimated in the experimental soil collected at 0-15 cm depth from different treatments at harvest of maize as described by Klein *et al.* (1971) and soil phosphatase activity was assayed by the method of Tabatabai and Bremner (1969). Data recorded on maize during the course of investigation was statistically analyzed following the analysis of variance for randomized block design as suggested by Panse and Sukhatme (1985).

Weed index was computed by using the following formula.

$$\text{WI (\%)} = \frac{X-Y}{X} \times 100$$

Where,

X = Yield from two hand weedings treatment (kg ha^{-1}).

Y = Yield from the treatment for which WI has to be worked out (kg ha^{-1}).

RESULTS AND DISCUSSION

Enzyme activity in soil at harvest of maize as influenced by weed management practices

Acid phosphatase activity

Weed control practices imposed in maize have exerted significant influence on acid phosphatase activity at harvest of maize, during both the years of study as indicated in Table 1. In the pooled mean atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE recorded higher acid phosphatase activity in the soil at harvest of corn, which was however, statistically comparable with atrazine 1.0 kg ha^{-1} as pre emergence (PE) *fb* 2,4-D amine salt 580 g ha^{-1} as post emergence (PoE), atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g + 2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE in the order of descent. Atrazine 1.0 kg ha^{-1} as PE *fb* one hand weeding (HW) at 30 DAS was at par with HW twice at 15 and 30 DAS and both were in turn at par with weedy check.

Alkaline phosphatase activity

Alkaline phosphatase activity at harvest of corn was lower with weedy check which was in statistical parity with atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS and HW twice at 15 and 30 DAS in the pooled mean (Table 1).

Atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE recorded higher alkaline phosphatase activity, which was in parity with atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 60 g + 2,4-D amine salt 290 g ha^{-1} as PoE and the above treatments were at par among themselves in the sequence of descent.

Urease activity

In the pooled mean urease activity (Table 1) was higher with atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as

Table 1: Enzyme activity in the soil at harvest of maize as influenced by different weed management practices.

Treatments	Acid phosphatase activity (µg *pnp* g^{-1} h^{-1})			Alkaline phosphatase activity (µg pnp g^{-1} h^{-1})			Urease activity (µg NH_4^+ g^{-1} h^{-1})			Dehydrogenase activity (µg TPF g^{-1} h^{-1})		
	17-18	18-19	Mean	17-18	18-19	Mean	17-18	18-19	Mean	17-18	18-19	Mean
T_1: Atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS	14.5	14.5	14.5	10.2	10.1	10.1	100	80	90	83	95	89
T_2: Atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE	19.6	17.7	18.6	11.8	13.4	12.6	121	110	116	97	112	104
T_3: Atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g. ha^{-1} as PoE	19.2	17.3	18.2	12.7	13.1	12.9	120	106	113	96	114	105
T_4: Atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE	18.7	18.0	18.3	12.2	12.8	12.5	118	111	114	98	117	107
T_5: Atrazine 1.0 kg. ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE	19.4	17.8	18.6	12.4	13.1	12.7	121	107	114	97	118	107
T_6: Atrazine 1.0 kg ha^{-1} PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE	19.2	17.5	18.4	12.0	12.7	12.3	119	105	112	96	116	106
T_7: Atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE	18.8	17.5	18.2	12.5	13.1	12.8	122	106	114	95	118	107
T_8: Atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g+2,4-D amine salt 290 g ha^{-1} as PoE	19.6	17.4	18.5	11.9	13.3	12.6	121	111	116	95	115	105
T_9: Hand weeding twice at 15 and 30 DAS	15.2	13.5	14.4	10.3	10.1	10.2	103	75	89	78	91	84
T_{10}: Weedy check	14.8	13.7	14.3	10.0	10.3	10.1	105	83	94	79	93	86
SEm ±	0.56	0.50		0.44	0.42		3.8	2.9		2.8	3.2	
CD (P = 0.05)	1.7	1.5		1.3	1.3		12	9		9	10	

PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE and atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE and in the order of descent, Whereas lowest urease activity was recorded with HW twice at 15 and 30 DAS, which was however comparable with atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS and weedy check.

Dehydrogenase activity

Dehydrogenase activity was higher with atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE, which was however comparable with atrazine 1.0 kg ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g+2,4-D amine salt 290 g ha^{-1} as PoE and atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE, in the order of descent without statistical disparity among them in the pooled mean. Whereas lowest dehydrogenase activity was recorded with HW twice at 15 and 30 DAS, which was however comparable with weedy check and atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS.

Pre emergence followed by recommended dose of post emergence application or tank mix application of half of the recommended doses of post emergence herbicides resulted in significantly higher enzyme activity *i.e.* soil phosphatase, urease and dehydrogenase activity compared to hand weeding twice, pre emergence application of atrazine 1.0 kg ha^{-1} and weedy check. Harmful effect of these herbicides might have been reduced by microbial degradation at later stages of crop growth particularly at the time of harvest (Aruna *et al.,* 2018).

Total microbial population in the soil

Total microbial population in the soil at harvest of maize as influenced by different weed management practices were depicted in Table 2.

Bacterial population

Initial bacterial population in soil before sowing of maize was 21.2 and 20.4 (× 10^{6} CFU g^{-1} of soil) and initial fungi population in the soil before sowing of maize was 7.5 and 7.4 (× 10^{4} CFU g^{-1} of soil) during both the years of experimentation.

Bacterial population at harvest of maize was higher with atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg

Table 2: Microbial count in the soil at harvest of maize as influenced by different weed management practices.

Treatments	Total bacterial population (× 10^{6} CFU g^{-1} soil)			Total fungal population (× 10^{4} CFU g^{-1} soil)			Total actinomycetal population (× 10^{5} CFU g^{-1} soil)		
	17-18	18-19	Mean	17-18	18-19	Mean	17-18	18-19	Mean
T_1: Atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS	17.3	18.4	17.7	8.3	8.3	8.3	21.0	19.2	20.1
T_2: Atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE	25.7	25.4	25.6	10.3	10.3	10.3	26.3	24.0	25.2
T_3: Atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g. ha^{-1} as PoE	25.0	25.8	25.4	10.4	11.2	10.8	25.7	24.2	24.9
T_4: Atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE	25.1	24.5	24.8	10.2	10.3	10.3	25.3	25.3	25.3
T_5: Atrazine 1.0 kg. ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE	25.3	25.0	25.2	10.3	10.7	10.5	26.0	25.7	25.9
T_6: Atrazine 1.0 kg ha^{-1} PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE	25.0	24.8	24.9	10.0	10.5	10.3	26.7	24.3	25.5
T_7: Atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE	25.1	24.6	24.9	10.7	10.3	10.4	26.3	24.3	25.3
T_8: Atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g+2,4-D amine salt 290 g ha^{-1} as PoE	24.7	25.5	25.1	10.3	11.3	10.8	26.0	24.7	25.3
T_9: Hand weeding twice at 15 and 30 DAS	18.7	19.3	19.0	8.5	8.7	8.6	22.3	19.3	20.8
T_{10}: Weedy check	18.3	18.1	18.4	8.7	8.9	8.8	21.3	19.0	20.2
SEm ±	0.89	0.76		0.43	0.41		0.82	0.69	
CD (P=0.05)	2.7	2.3		1.3	1.2		2.5	2.1	

ha^{-1} as PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE and atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE without significant disparity among them in the order of descent in the pooled mean.

Fungal population

Initial fungi population in the soil before sowing of maize was 7.5 and 7.4 (× 10^4 CFU g^{-1} of soil) during first and second year of experimentation respectively. Fungi population was higher with atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2, 4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE and atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE in the order of descent without significant disparity among them. Lower fungal count was recorded with atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS, which was in parity with HW twice at 15 and 30 DAS and weedy check during both the years of investigation and in the pooled mean.

Actinomycetal population

Initial actinomycetes population in soil before sowing of maize was 25.6 and 25.8 (× 10^5 CFU g^{-1} of soil) during both the years of experimentation. Atrazine 1.0 kg ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g + 2,4-D amine salt 290 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE, atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE and atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE were comparable among themselves in the pooled analysis values. Actinomycetes population at harvest of maize was lower with atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS during, 2018 and with weedy check during, 2019 and both were in parity with HW twice at 15 and 30 DAS during the two years of study and in the pooled mean.

Total microbial population was higher with application of pre emergence herbicides followed by recommended dose of post emergence herbicides or tank mix application of half of the recommended doses of post emergence herbicides (Simerjeet *et al*., 2014). This might be due to the fact that applied herbicides themselves might serve as source of carbon to microbes and It could be further inferred that the microbial population started to regain after the weeds were also killed by the herbicides and got mixed in the soil during this period and these might have served to increase the nutrients which inturn increased microbial multiplication on increased supply of nutrients. Similar results of increased

Table 3: Weed index, kernel and stover yield of maize as influenced by different weed management practices.

Treatments	Weed Index (%)			Kernel yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	17-18	18-19	Pooled	17-18	18-19	Pooled	17-18	18-19	Pooled
T_1: Atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS	11.5 (4.2)	10.3 (3.2)	10.4 (3.7)	8161	7403	7782	10617	9987	10302
T_2: Atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE	10.1 (3.1)	9.9 (3.0)	9.5 (3.0)	8253	7421	7527	10717	10007	10362
T_3: Atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g. ha^{-1} as PoE	6.8 (1.5)	7.5 (1.7)	7.5 (1.7)	8389	7518	7853	10738	10154	10446
T_4: Atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 67.5 g ha^{-1} as PoE	39.2 (39.9)	39.3 (40.2)	39.3 (40.1)	5116	4575	4846	7612	6902	7257
T_5: Atrazine 1.0 kg. ha^{-1} as PE *fb* 2,4-D amine salt 580 g ha^{-1} as PoE	41.1 (43.3)	40.0 (41.4)	40.6 (42.3)	4836	4482	4659	7571	6885	7228
T_6: Atrazine 1.0 kg ha^{-1} PE *fb* tembotrione 60 g+2,4-D amine salt 290 g ha^{-1} as PoE	27.2 (21.0)	29.4 (24.3)	28.3 (22.7)	6730	5787	6259	9008	8247	8628
T_7: Atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 15 g+2,4-D amine salt 290 g ha^{-1} as PoE	25.3 (18.5)	28.3 (22.6)	26.9 (20.5)	6941	5922	6432	9099	8153	8626
T_8: Atrazine 1.0 kg ha^{-1} as PE *fb* halosulfuron methyl 34 g+2,4-D amine salt 290 g ha^{-1} as PoE	49.3 (57.5)	50.4 (59.3)	49.8 (58.4)	3620	3116	3368	5391	5458	5425
T_9: Hand weeding twice at 15 and 30 DAS	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	8518	7650	8084	10861	10304	10582
T_{10}: Weedy check	58.8 (73.2)	59.0 (73.5)	58.9 (73.4)	2280	2025	2153	3940	3934	3937
SEm ±	1.29	1.22	1.30	189.0	179.2	145.1	370.4	342.3	176.4
LSD (p= 0.05)	3.9	3.7	3.9	566	537	434	1110	1025	528

*Data in parentheses are original values, which were subjected to angular transformation and analysed statistically.

total microbial population at harvest were observed by Veeresh *et al.* (2014).

Maize yield loss, kernel and stover yield

Among the different herbicides tried highest kernel and stover yield of maize (Table 3) was registered with atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE, which was at par with atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE and atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS, without significant disparity among them. Lower yield loss in the above might be due to effective control of weeds at all the stages of crop growth by sequential use of pre and post emergence herbicides. Similar results of lower yield loss with atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE was reported by Rao *et al.* (2016). Highest kernel and stover yield might be due to reduced competition between the crop and weeds for the existing resources throughout the crop growing period enabling the crop for maximum utilisation of nutrients, moisture, light and space, which enhanced the vegetative and reproductive potential of the crop that reflected in the form of higher kernel yield of maize. The results corroborate with the findings of Parameswari *et al.* (2017).

The lowest kernel yield of maize was resulted with weedy check. This was mainly due to greater competition for the growth resources among the crop and weeds as evident by the lowest crop stature, yield attributes and finally kernel yield of maize (Bahirgul and Ramesh, 2019).

CONCLUCION

In conclusion, the present study has revealed that application of recommended dose of herbicides did not effect the soil microbial population and enzyme activity at the time of harvest. and so it can be inferred that application of recommended dose of herbicides to control weeds may not harm the environment. Highest kernel and stover yield of maize was registered with atrazine 1.0 kg ha^{-1} as PE *fb* topramezone 30 g ha^{-1} as PoE, which was at par with atrazine 1.0 kg ha^{-1} as PE *fb* tembotrione 120 g ha^{-1} as PoE and atrazine 1.0 kg ha^{-1} as PE *fb* one HW at 30 DAS.

Conflict of interest: None.

REFERENCES

Aruna, K.J., Rao, P.C., Madhavi, M. and Padmaja, G. (2018). Effect of herbicides on the activity of soil enzyme urease in maize crop. Indian Journal of Agricultural Research. 52(3): 300-304.

Bahirgul, S. and Ramesh, B. (2019). Influence of early post emergence herbicide mixtures on weed control and grain yield of maize (*Zea mays* L.). Acta Scientific agriculture. 3(5): 26-28.

Devi, B.R. and Venkateswarlu, B. (2017). Weed dynamics and yield of baby corn as influenced by nitrogen levels and weed control practices. Research Journal of Agricultural Sciences. 8(6): 1440-1445.

Jones, P.C.T. and Mollison, J.E. (1947). A Technique for the Quantitative Estimation of Soil Micro-organisms. Journal of General Microbiology. 2(1): 54-69.

Klein, K.R., Steinberg, B., Fiethen, P. and Overath. (1971). Fatty acid degradation in *Escherichia coli*. An inducible system for the uptake of fatty acids and further characterization of old mutants. European Journal of Bio Chemistry. 19: 442-450.

Panse, V.G. and Sukhatme, P.V. (1985). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi. 100-174.

Parameswari, Y.S., Srinivas, A. and Ram Prakash, T. (2017). Productivity and economics of Rice (*Oryza sativa*)- zero till maize (*Zea mays*) as affected by rice establishment methods and weed management practices. International Journal of Current Microbiology and Applied Sciences. 6(10): 945-952.

Rao, C.H.R., Prasad, P.V.N. and Venkateswarlu, B. (2016). Assesment of different herbicides on yield and economics of *kharif* maize (*Zea mays* L.). Int. j. Agric. Sci. Res. 6(6): 409-414.

Sanjay, A. and Divya, S. (2016). Pesticides effect on soil microbial ecology and enzyme activity- An overview. Journal of Applied and Natural Sciences. 8(2): 1126 - 1132.

Simerjeet, K., Surjit, S. and Phutela R.P. (2014). Effect of herbicides on soil microorganisms in direct-seeded rice. Indian Journal of Weed Science. 46(3): 229-233.

Tabatabai, M.A. and Bremner, J.M. (1969). Use of *p*-nitrophenyl phosphate for assay of soil phosphatase activity. Soil Biology and Biochemistry. 1(4): 301-307.

Veeresh, H., Sanjay, M.T., Prasad, T.V.R., Murthy, K.N.K., Basavaraj, K. and Shruthi, M.K. (2014). Effect of new herbicide molecules on yield, soil microbial biomass and their phytotoxicity on maize (*Zea Mays* L.) under irrigated conditions. The Bio scan. 9(3): 1127-1130.

Yaduraju, N.T. and Mishra, J.S. (2018). Smart weed management: A small step towards doubling farmers income. Indian Journal of Weed Science. 50(1): 1-5.