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RESEARCH ARTICLE :

Study of soil physical and Microbialproperties of soil as influenced by weed management in maize (*Zea mays* L.)

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SUMMARY : A field investigation was conducted at BAU experimental Farm, Ranchi during *Kharif* season 2015 on sandy clay loam soil. The experiment was laid out in a RBD with 13 treatments: atrazine 0.5 + pendimethalin 0.5 kg/ha PE, two hand weeding at 20 and 40 DAS, two mechanical weeding at 20 and 40 DAS, atrazine 1.0 kg/ha PE, pretilachlor 0.5 + metribuzin 0.175 kg/ha PE, metribuzin 0.35 kg/ha at 15 DAS, pendimethalin 1.0 kg/ha PE, atrazine 1.0 kg/ha at 15 DAS, metribuzin 0.35 kg/ha PE, pretilachlor 1.0 kg/ha PE, pretilachlor 1.0 kg/ha at 15 DAS, green manuring by *Sesbania* @ 80 kg/ha *fb* 2, 4-D 0.625 kg/ha at 30 DAS and weedy Check, replicated thrice.. Maize *var.*Suwan was sown (on 30-06-2015) with spacing of 70 x 20 cm, seed rate 20 kg/ha and RDF 120:60:40 kg/ha. Result revealed that soil physical propertiessuch as pH, organic carbon and EC observed non-significantly affected with different weed management practices but CO_2 was observed maximum with green manuring by *Sesbania* @ 80 kg/ha *fb* 2, 4-D 0.625 kg/ha at 30 DAS.Population of soil microbial biomass (fungi, bacteria and *Actinomycetes*) was at par with all the different weed management practices. Dehydrogenase activity (µg TPF g^{-1} soil day^{-1}) and azotobacter count observed significantly highest with the application of green manuring by *Sesbania* @ 80 kg/ha *fb* 2,4-D 0.625 kg/ha at 30 DAS (T_{10}).

KEY WORDS :
Dehydrogenase, Maize, Microbial population, Physical properties

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BACKGROUND AND OBJECTIVES

Maize (*Zea mays* L.) is one of the most versatile crops having wider adaptability under diverse soil and climatic conditions. Globally, maize is known as the "Queen of Cereals" because it has the highest genetic yield potential amongst the cereals owing to its better dry matter accumulation efficiency in a unit area.It is cultivated in an area of about 150 M ha in 160 countries in diverse soil types, climate, and management practices with wider plant biodiversity that contributes about 36% towards the global food grain production

(Anonymous, 2013a). It is the third most important crop of India after rice and wheat that occupies an area of about 8.67 M ha with an average productivity of about 2.57 t/ha compared to the world average productivity of about 4.94 t/ha (Anonymous, 2014). It is grown on an area of 1.86 m ha with an average productivity of 1.45 t/ha in Jharkhand (Anonymous, 2013 b). Weeds, being hardier in nature compete with maize plants for nutrients, water, sunlight and space during entire vegetative and early reproductive stages of maize. They transpire a lot of valuable conserved moisture and also absorb more nutrients than the crop. The extent of nutrient loss varies from 30-40% of the applied nutrient (Mundra *et al.*, 2003). Also, wider spacing and slow initial growth of maize favours the growth of weeds even before crop emergence. The presence of weeds reduces the photosynthetic efficiency, dry matter production, their distribution to economical parts and thereby reduces sink capacity of crop resulting in poor grain yield. In this way, ideal environmental conditions provided for optimal crop productivity are being exploited by the weeds associated in the crop. In India, the presence of weeds, in general reduces the maize yield by 27-60%, depending upon the growth and persistence of weed population in maize crop (Singh *et al*., 2015) and Verma *et al*. (2015). Manual weeding is exhaustive, lengthy and labourious. Availability of man power for manual weeding at critical period of maize growth is difficult owing to pre-occupied farm work in other crops like rice, pulses etc. For controlling weeds in maize crop, pre-emergence or early post-emergence application of atrazine depending upon the soil type has been recommended. Application of pendimethalin also has been recommended under maize + legume intercropping situations. These herbicides do not control hardy weed species like *Commelina benghalensis, Ageratum conyzoides* and *Brachiaria ramosa* as they appear late in the season. The infestation of these weeds is increasing day by day in the maize-growing areas of the state especially where the farmers are using atrazine year after year. So in order to widen the weed control spectrum, it is imperative to use combination of herbicides having different mode of action (Walia *et al.,* 2007, Rana *et al.,* 1998 and Kumar *et al.,* 2011). Herbicides are extraneous to soil component pools and are expected to affect the catalytic efficiency and behavior of soil enzymes (Sannino and Gianfreda, 2001), which contribute to the total biological activity of the soil-plant environment (Dick, 1997). The interaction between herbicides and soil micro-organisms may be of practical significance because of possible inhibition in microbial activities contributing to soil fertility. Various studies have revealed that the herbicides can cause qualitative and quantitative change in enzyme activity (Xia *et al*., 2012), however, most of the studies were focused on single application for a short period, which might be used to provide realistic evaluation of the effects of herbicides on soil micro-organism (Haney *et al.*, 2000). The objectives of this study were to examine the impact of weed management on weed dynamics and yield of maize (*Zea mays* L.).

RESOURCES AND METHODS

A field investigation was conducted at BAU experimental Farm, Ranchi during *Kharif* season 2015 on sandy clay loam soil with low organic carbon (4.25 g/kg), moderately acidic (pH 5.7) in nature, low available nitrogen (263.07 kg/ha), medium potassium (176.96 kg/ha) and high phosphorus (28.42 kg/ha). The experiment was laid out in a RBD with 13 treatments: atrazine 0.5 + pendimethalin 0.5 kg/ha PE, two hand weeding at 20 and 40 DAS, two mechanical weeding at 20 and 40 DAS, atrazine 1.0 kg/ha PE, pretilachlor 0.5 + metribuzin 0.175 kg/ha PE, metribuzin 0.35 kg/ha at 15 DAS, pendimethalin 1.0 kg/ha PE, atrazine 1.0 kg/ha at 15 DAS, metribuzin 0.35 kg/ha PE, pretilachlor 1.0 kg/ha PE, pretilachlor 1.0 kg/ha at 15 DAS, green manuring by *Sesbania* @ 80 kg/ha *fb* 2, 4-D 0.625 kg/ha at 30 DAS and weedy Check, replicated thrice. Maize var. Suwan was sown with spacing of 70 x 20 cm, seed rate 20 kg/ha and RDF 120:60:40 kg/ha. Soil pH was determined by glass electrode pH meter taking 1:2.5 soil watersuspensions after stirring it for 30 minutes as described by (Jackson, 1973).Electrical conductivity was determined by taking supernatant liquid of soil water suspension prepared for pH determination by using electrical conductivity meter (Black, 1965). Organic carbon was determined by Walkley and Black's rapid titration method (1934) as determined by Black (1965). CO_2evalutionwsa carried by using standard alkali trap method.Population of bacteria, *Actinomycetes* and fungi in soil were determined by adopting standard pour plate technique (using soil extract *Agar* media) for bacteria (SubbaRao, 2008), Kenknight and Munaier's media for *Actinomycetes* (SubbaRao, 2008 and Rose Bengal *Agar* medium for fungi (SubbaRao, 2008). Microbial population were counted with the help of a colony counter and expressed as colony forming unit (cfu) per gram of dry soil. Total microbial population was determined by summation of the bacteria, *Actinomycetes* and fungal population. The dehydrogenase activity in soil was determined byTTC (TriphenylTetrazolium Chloride) method. Azotobactorspp were isolated following Soil-Paste Plate method. Yield data was measured from the net plot area leaving border portion from each side of the plot.The other package of practices used recommended for raising the crop. Statistical analysis and interpretation of results were done by calculating values of C.D. (critical difference) at 5% level of probability through analysis of variance technique as described by Gomez and Gomez (2003).

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Effect on physical properties of soil :

Physical properties of soil is carried out and presented in Table 1. Soil pH was affected by different weed management practices. Highest pH was found in the treatment of T_7 (pretilachlor 1.0 kg/ha at 15 DAS) and lowest pH was found in the treatment of T_1**(**pretilachlor1.0 kg/ha PE). Organic carbon percentage found non-significantly affected with different weed management practices and maximum value of organic carbon of soil 0.46 % obtained with the application of green manuring by *Sesbania* @ 80 kg/ha *fb* 2,4-D 0.625 kg/ha at 30 DAS (T_{10}) which was at par with rest of all other treatments.The highest soil EC was found in the treatment of T_6 (atrazine 0.5 + pendimethalin 0.5 kg/ha PE) and T_8(metribuzin 0.35 kg/ha at 15 DAS) and lowest EC was found in the treatment of T_4 (metribuzin 0.35 kg/ha PE). CO_2 evaluation are found significantly higher with the application of green manuring by *Sesbania* @ 80 kg/ha *fb* 2,4-D 0.625 kg/ha at 30 DAS (T_{10}), atrazine 1.0 kg/ha at 15 DAS (T_9)and weedy Check (T_{13}) and at par with the pretilachlor 0.5 + metribuzin 0.175 kg/ha PE (T_5), metribuzin 0.35 kg/ha at 15 DAS (T_8),atrazine 1.0 kg/ha PE (T_2) and atrazine 0.5 + pendimethalin 0.5 kg/ha PE (T_6) as compare to rest of the treatments.Similar findings were observed by Barla *et al.* (2016).

Effect on soil microbial population :

Population of soil microbial biomass (fungi, bacteria and *Actinomycetes*) was not affected by different weed management practices. However, maximum population of fungi (44 x 10^4cfu/g of soil) was observed in two hand weedings at 20 and 40 DAS (T_{12}) and it was more than initial value (43 x 10^4cfu/g of soil). But, the population of

Table 1 : Effect of different weed management practices on physical properties of soil in maize (*var.* Suwan) during *Kharif*, 2015

Treatments		pH	Organic carbon	EC	CO_2
T_1	Pretilachlor 1.0 kg PE	5.51	0.40	0.157	5.50
T_2	Atrazine 1.0 kg PE	5.72	0.43	0.157	8.61
T_3	Pendimethalin 1.0 kg PE	5.63	0.37	0.168	5.04
T_4	Metribuzin 0.35 kg PE	5.53	0.41	0.129	5.50
T_5	Pretilachlor + Metribuzine 0.5 + 0.175 kg PE	5.62	0.44	0.179	9.08
T_6	Atrazin + Pendimethalin 0.5 + 0.5 kg PE	5.68	0.43	0.184	8.56
T_7	Pretilachlor 1.0 kg at 15 DAS	5.79	0.42	0.168	6.00
T_8	Metribuzin 0.35 kg at 15 DAS	5.76	0.43	0.184	8.62
T_9	Atrazine 1.0 kg at 15 DAS	5.61	0.44	0.130	9.17
T_{10}	Green manuringfb 2, 4-D 0.625 kg at 30 DAS	5.74	0.46	0.135	9.17
T_{11}	Mechanical weeding at 20 and 40 DAS	5.61	0.37	0.155	5.04
T_{12}	Hand weeding at 20 and 40 DAS	5.61	0.43	0.138	8.25
T_{13}	Weedy Check	5.73	0.45	0.173	9.17
S.E. ±		0.08	0.12	0.004	0.38
C.D. (P=0.05)		NS	NS	NS	1.11
CV%		2.54	4.69	4.42	8.76

NS=Non-significant

bacteria (55 x 10^5/g of soil) was similar to initial value (55 x 10^5/g of soil) and in case of *Actinomycetes*, the population (22 x 10^6/g of soil) was more under green manuring by *Sesbania* @ 80 kg/ha *fb* 2, 4-D 0.625 kg/ha at 30 DAS (T_{10}) than initial value (18 x 10^6/g of soil). Dehydrogenase activity (μg TPF g^{-1} soil day^{-1})in soil was significantly higher with application of green manuring by *Sesbania* @ 80 kg/ha *fb* 2,4-D 0.625kg/ha at 30 DAS (T_{10}) and weedy Check (T_{13}) being at par with atrazine 1.0 kg/ha at 15 DAS (T_9)atrazine 1.0 kg/ha PE (T_2), pretilachlor 0.5 + metribuzin 0.175 kg/ha PE (T_5), atrazine 0.5 + pendimethalin 0.5 kg/ha PE (T_6) and metribuzin 0.35 kg/ha at 15 DAS (T_8) as compared to rest of the other treatments.

Azotobacter count observed significantly highest with the application of green manuring by *Sesbania* @

Table 2: Effect of different weed management practices on microbial population in maize (*var.* Suwan) during *Kharif*, 2015

Treatments		Fungal x 10^4 (cfu/g of soil)	Bacteria (x 10^5/g of soil)	*Actinomycetes* (x 10^6/g of soil)	Dehydrogenase (μg TPF g^{-1} soil day^{-1})	Azotobacter count
T_1	Pretilachlor 1.0 kg/ha PE	39	51	4.26	2.33	19
T_2	Atrazine 1.0 kg/ha PE	41	49	5.82	3.00	19
T_3	Pendimethalin 1.0 kg/ha PE	39	52	4.26	2.33	21
T_4	Metribuzin 0.35 kg/ha PE	39	52	4.37	2.33	20
T_5	Pretilachlor 0.5 + metribuzin 0.175 kg/ha PE	40	51	6.22	3.00	20
T_6	Atrazine 0.5 + pendimethalin 0.5 kg/ha PE	39	51	5.27	3.00	21
T_7	Pretilachlor 1.0 kg/ha at 15 DAS	39	50	4.45	2.33	20
T_8	Metribuzin 0.35 kg/ha at 15 DAS	39	48	5.91	3.00	18
T_9	Atrazine 1.0 kg/ha at 15 DAS	40	50	6.23	3.33	18
T_{10}	Green manuringfb 2, 4-D 0.625 kg/ha at 30 DAS	43	55	6.30	3.67	22
T_{11}	Mechanical weeding at 20 and 40 DAS	41	53	3.87	2.00	19
T_{12}	Hand weeding at 20 and 40 DAS	44	54	4.81	2.67	20
T_{13}	Weedy check	43	54	7.08	3.67	21
	Initial population	43	55	18	-	-
S.E.±		1.89	2.27	1.13	0.27	0.38
C.D. (P=0.05)		NS	NS	NS	0.80	1.10
CV%		8.10	7.63	9.90	8.92	23.12

NS=Non-significant

Table 3 : Yields (kg/ha) as influenced by different weed management practices in maize

Treatments		Grain yield (kg/ha)	Stover yield (kg/ha)	Stone yield (kg/ha)
T_1	Pretilachlor 1.0 kg/ha PE	3623	7228	1430
T_2	Atrazine 1.0 kg/ha PE	4288	9070	1533
T_3	Pendimethalin 1.0 kg/ha PE	3821	7228	1498
T_4	Metribuzin 0.35 kg/ha PE	3638	7795	1441
T_5	Pretilachlor 0.5 + metribuzin 0.175 kg/ha PE	4260	8645	1527
T_6	Atrazine 0.5 + pendimethalin 0.5 kg/ha PE	5095	11054	1742
T_7	Pretilachlor 1.0 kg/ha at 15 DAS	3565	6086	1417
T_8	Metribuzin 0.35 kg/ha at 15 DAS	3876	8503	1523
T_9	Atrazine 1.0 kg/ha at 15 DAS	3663	8362	1462
T_{10}	Green manuringfb 2, 4-D 0.625 kg/ha at 30 DAS	3393	5803	1416
T_{11}	Mechanical weeding at 20 and 40 DAS	4445	10062	1575
T_{12}	Hand weeding at 20 and 40 DAS	4608	10204	1693
T_{13}	Weedy check	2843	5003	1299
S.E. ±		399.86	864.31	70.09
C.D. (P=0.05)		1166.98	2522.48	204.57
CV%		17.61	18.53	8.08

80 kg/ha *fb* 2,4-D 0.625 kg/ha at 30 DAS (T_{10}) and being at par with pendimethalin 1.0 kg/ha PE (T_3), atrazine 0.5 + pendimethalin 0.5 kg/ha PE (T_6) and two hand weeding at 20 and 40 DAS (T_{12}) as compared to rest of the all other treatments. Similar findings were observed by Barla *et al*. (2016). De Roy *et al*. (2006). Shukla and Mishra (1997) observed growth of different microbial activity and concluded reduction due to application of different herbicides.

Effect on yields :

Grain, stover and stone yield of maize as influenced by different weed management practices are presented in (Table 3). Grain, stover and stone yield increased with application of atrazine 0.5 + pendimethalin 0.5 kg/ha PE (T_6) in comparison to weedy check to the tune of 79.21, 120.95 and 34.10%, respectively. Application of atrazine 0.5 + pendimethalin 0.5 kg/ha PE (T_6) recorded significantly higher grain yield (5095 kg/ha) being at par with two hand weedings at 20 and 40 DAS (T_{12}), two mechanical weedings at 20 and 40 DAS (T_{11}), atrazine 1.0 kg/ha PE (T_2) and pretilachlor 0.5 + metribuzin 0.175 kg/ha PE (T_5). Weedy check produced significantly lowest grain yield (2843 kg/ha).Application of atrazine 0.5 + pendimethalin 0.5 kg/ha PE (T_6) recorded significantly higher stover yield (11054 kg/ha) being at par with two hand weedings at 20 and 40 DAS (T_{12}), two mechanical weedings at 20 and 40 DAS (T_{11}), atrazine 1.0 kg/ha PE (T_2) and pretilachlor 0.5 + metribuzin 0.175 kg/ha PE (T_5). Weedy check produced significantly lowest stover yield (5003 kg/ha).Application of atrazine 0.5 + pendimethalin 0.5 kg/ha PE (T_6) recorded significantly higher stone yield (1742kg/ha) being at par with two hand weedings at 20 and 40 DAS (T_{12}) and two mechanical weedings at 20 and 40 DAS (T_{11}). Weedy check produced significantly lowest stone yield (1299 kg/ha)were reported by Hatti *et al*. (2014) and Barla *et al*. (2016).

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