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RESEARCH NOTE

Pre- and post-emergence herbicidal impact on nodulation of soybean crop and soil biological indicators

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ABSTRACT

A field trial to investigate the effect of pre- and post-emergence herbicides on soil biological indicators in soybean was conducted at AICRP-Weed Management farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2021. The experiment was laid out in a randomized block design with three replications and twelve treatments. Wheat straw applied as mulching 5 t/ha on the soil recorded significantly higher dehydrogenase activity, CO_2 evolution, soil microbial biomass carbon, microbial count (bacteria, fungi and actinomycetes) and maximum root nodulation. Among chemical weed control, higher soil microbial biomass carbon was recorded in diclosulam 84% WDG 0.026 kg/ha as pre-emergence whereas in post-emergence herbicides, it was higher with quizalofop-ethyl 10% EC + chlorimuron-ethyl 25% WP 0.037+0.009 + 0.2% surfactant. Results revealed that mulching may have very good effect facilitating the degradation of herbicides also not only maintaining but increasing the microbial biomass carbon. Higher dehydrogenase activity was observed in mulching with wheat straw 5 t/ha and farmer's practice at flowering stage due to higher substrate availability. In herbicidal application treatments, suppression of dehydrogenase activity was observed, which might be due to the lethal action of herbicides on soil microorganisms,

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Soil enzymes are a group of enzymes commonly found in soil and play vital role in maintaining soil ecology, physical and chemical properties, soil fertility and soil health. These enzymes form key biochemical functions in organic matter decomposition in the soil system (Sinsabaugh *et al.* 1991). They are important in catalysing many vital reactions required for the life processes of micro-organisms in soils, stabilization of soil structure, decomposition of organic wastes, organic matter formation and nutrient cycling hence playing an important role in agriculture (Dick *et al.* 1994 and Dick 1997). The enzyme levels in soil systems vary in quantity, mainly because each soil type has different amounts of organic matter, composition, activity of its living organisms and intensity of biological processes. In practice, biochemical reactions occur mainly through the catalytic contribution of enzymes and transformable substrates that serv as energy sources for microorganisms (Kiss *et al.* 1978).

A field investigation was carried out at AICRP - Weed management farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2021 to study the effect of different weed management practices on soil biological indicators. The soil texture of the experimental field was clayey, with slightly alkaline pH (7.80), moderate organic carbon status (0.46%), low nitrogen content (178 kg/ha), medium available phosphorus content (17.05 kg/ha) and high potassium status (384 kg/ha). Soybean cv *PDKV Yellow Gold* was sown on 18th June 2021 on Broad Bed Furrow (BBF) with 45 x 5 cm spacing and 30:60:30 NPK kg/ha and was harvested on 7th October 2021. Total rainfall received during the crop growth period was 850 mm. The experiment was set up in a randomized block design with three replications and 12 treatments. The treatments comprised of flumioxazin 50% SC 0.125 kg/ha, diclosulam 84% WDG 0.026 kg/ha, pendimethalin 38.7% CS 0.677 kg/ha, pendimethalin 30% + imazethapyr 2% EC 0.960 kg/ha (ready mix), sulfentrazone 28% + clomazone 30% WP 0.725 kg/ha (ready mix), pendimethalin 30% EC + diclosulam 84% WDG 0.750 + 0.0252 kg/ha (tank mix), sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC 0.245 kg/ha POE (ready mix) at 20 DAS, quizalofop-ethyl 10% EC + chlorimuron-ethyl 25% WP 0.037+0.009 + 0.2% surfactant kg/ha POE (ready mix) at 20 DAS, fomesafen 12% + quizalofop-ethyl 3% SC 0.225 kg/ha PoE (ready mix) at 20 DAS,

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mulching (wheat straw) 5 t/ha, farmer's practice (2 HW at 15 and 30 DAS and one hoeing at 20 DAS) and weedy check. All pre-emergence herbicides were applied on the same day after sowing and post-emergence herbicides were applied at 2-3 leaf stage (25 DAS). Dehydrogenase activity in the soil samples was determined at flowering stage of soybean following procedure as described by Casida *et al.* (1964). CO_2 evolution in the soil sample was determined by Anderson (1982). Soil samples were stored at (28±2) ºC for a week to stabilize respiration, subsequently used for further analysis. Microbial biomass-C (MB-C) in herbicide treated as well as control soil sample was determined by fumigation extraction method (Vance *et al.* 1987) through back titration against 0.04 N (NH) Fe (SO_2). 6HO using ferroin indicator. Soil samples were collected from the rhizosphere of soybean after the next day of application of herbicide. The count of total bacteria, fungi and actinomycetes in fresh rhizosphere soil samples was carried out by following serial dilution plate count technique as described by Pahwa and Prakash (1996). Nodule count was recorded from the five randomly selected plants at 20 and 40 DAS, nodules were separated from the root and oven dried at 65ºC to determine their dry weight.

Dehydrogenase activity

Higher dehydrogenase activity was observed in cultural practices *i.e.* mulching with wheat straw 5 t/ha and farmer's practice at flowering stage due to higher substrate availability. Among herbicide treated plots, application of diclosulam 84% WDG 0.026 kg/ha as pre-emergence recorded higher dehydrogenase activity whereas among post-emergence application, quizalofop-ethyl 10% EC + chlorimuron-ethyl 25% WP 0.037+0.009 + 0.2% surfactant kg/ha registered higher DHA. In herbicidal application treatments, suppression of dehydrogenase activity was observed, which might be due to the lethal action of herbicides on soil microorganisms, which in turn affect the enzymatic chemical process as well as toxicity of the metabolites produced from herbicides. This result corroborates with the findings of Jyot *et al.* (2015), Sabale *et al.* (2015), Lal *et al.* (2017), Sinchana and Sheeja (2020).

Carbon-dioxide evolution

Higher carbon-dioxide evolution at flowering stage was recorded with mulching with wheat straw 5 t/ha and farmer's practice. Among pre-emergence herbicides, it was higher in diclosulam 84% WDG 0.026 kg/ha whereas, and in post-emergence herbicides applications it was observed in quizalofop-ethyl 10% EC + chlorimuron-ethyl 25% WP 0.037+0.009 + 0.2% surfactant kg/ha. Similar results were reported by Jyot *et al.* (2015), Sabale *et al.* (2015) and Lal *et al.* (2017).

Soil microbial biomass carbon

Soil microbial biomass carbon is considered to be one of the most responsible parameters for regulating nutrient cycling. Higher soil microbial biomass carbon was recorded in mulching with wheat straw 5 t/ha. Among chemical weed control, higher soil microbial biomass carbon was recorded in diclosulam 84% WDG 0.026 kg/ha as pre-emergence whereas in post-emergence herbicides, it was higher with quizalofop-ethyl 10% EC + chlorimuron-ethyl 25% WP 0.037+0.009 + 0.2% surfactant. Results revealed that mulching may have very good effect facilitating the degradation of herbicides also not only maintaining but increasing the microbial biomass carbon. Similar results are in accordance with Singh *et al.* (2014) and Mahapatra *et al.* (2021).

Microbial count

Higher count of all soil microflora was recorded in mulching with wheat straw 5 t/ha which was followed by farmers practice hand weeding at 15 and 30 DAS and hoeing 20 DAS (**Table 1**). Whereas, among pre-emergence herbicides application, diclosulam 84% WDG 0.026 kg/ha recorded highest bacterial count and in post-emergence herbicides treatments, quizalofop-ethyl 10% EC + chlorimuron-ethyl 25% WP 0.037+0.009. It might be due to the degradation of herbicides served as carbon source for growth of microbes. The microbial population started to regain after the weeds were killed by the herbicides and got mixed in the soil during this period and these might have served to increase the nutrients. There is temporary suppression in population of beneficial microorganisms, but with passage of time the population again recovered in this biological soil environment. It was in conformity with Ghosh *et al.* (2012), Sebiomo *et al.* (2011) and Trimurtulu *et al.* (2015)

Number of root nodules

All the weed control treatments significantly influenced the number of root nodules/plant at 20 and 40 DAS. Maximum number of root nodules was recorded in mulching with wheat straw 5 t/ha which was closely followed by farmer's practice. Among the weed control treatments mulching with wheat straw recorded higher number of nodules per plant

Table 1. Soil biological indicators as influenced by different weed management practices

Treatment	DHA (µg TPF g^{-1} $24hr^{-1}$)	CO_2 evolution (mg 100^{-g} soil)	SMBC (µg/g soil)	Microbial count		
				Bacterial (cfu g^{-1} soil×10^7)	Fungal (cfu g^{-1} soil ×10^4)	Actinomycetes (cfu g^{-1} soil ×10^6)
Flumioxazin 0.125 kg/ha	22.47	23.83	187.84	14.97	17.09	10.92
Diclosulam 0.026 kg/ha	24.10	26.70	193.85	15.80	17.42	11.67
Pendimethalin 0.677 kg/ha	21.66	22.73	184.80	12.97	15.62	10.65
Pendimethalin + imazethapyr 0.960 kg/ha (ready mix)	22.68	25.67	190.22	15.30	17.22	11.36
Sulfentrazone + clomazone 0.725 kg/ha (ready mix)	23.49	26.40	191.36	15.67	17.33	11.59
Pendimethalin + diclosulam 0.750 + 0.0252 kg/ha (tank mix)	22.06	23.47	186.60	14.97	16.76	10.84
Sodium acifluorfen + clodinafop-propargyl 0.245 kg/ha PoE (ready mix)	25.03	26.71	194.31	15.90	17.76	11.87
Quizalofop-ethyl + chlorimuron-ethyl 0.037+0.009 + 0.2% surfactant kg/ha PoE (ready mix)	26.04	27.87	199.29	16.7	18.09	12.81
Fomesafen + quizalofop-ethyl 0.225 kg/ha PoE (ready mix)	25.22	27.77	198.06	15.95	18.00	12.04
Mulching (wheat straw) 5 t/ha	29.11	30.07	207.85	20.80	21.1	15.51
Farmer's practice (2 HW at 15 & 30 DAS and one hoeing 20 DAS)	27.73	28.60	204.11	17.23	18.26	13.26
Weedy check	26.91	28	200.57	16.88	18.23	12.97
LSD (p=0.05)	4.39	4.45	13.33	1.73	1.45	1.26

Table 2. Root nodules/plant (mg) as influenced by different weed management practices

Treatment	No. of root nodules		Dry wt. of root nodules (mg)	
	20 DAS	40 DAS	20 DAS	40 DAS
Flumioxazin 0.125 kg/ha	7.23	17.57	34.85	65.75
Diclosulam 0.026 kg/ha	7.80	18.32	38.80	70.65
Pendimethalin 0.677 kg/ha	7.30	17.64	36.10	68.45
Pendimethalin + imazethapyr 0.960 kg/ha (ready mix)	7.20	17.30	34.35	69.18
Sulfentrazone + clomazone 0.725 kg/ha (ready mix)	6.96	17.23	31.92	63.98
Pendimethalin + diclosulam 0.750 + 0.0252 kg/ha (tank mix)	7.27	17.07	35.15	67.88
Sodium acifluorfen + clodinafop-propargyl 0.245 kg/ha PoE (ready mix)	7.70	18.64	36.41	67.79
Quizalofop-ethyl + chlorimuron-ethyl 0.037+0.009 + 0.2% surfactant kg/ha PoE (ready mix)	7.73	17.47	39.29	66.28
Fomesafen + quizalofop-ethyl 0.225 kg/ha PoE (ready mix)	7.66	17.31	36.52	67.42
Mulching (wheat straw) 5 t/ha	8.45	18.93	39.52	72.42
Farmer's practice (2 HW at 15 & 30 DAS and one hoeing 20 DAS)	8.07	18.29	38.22	72.36
Weedy check	6.96	16.39	29.49	60.22
LSD (p=0.05)	0.98	1.68	6.40	8.54

than farmer's practice due to soil disturbances which might had affected the root growth and consequently poor nodulation (**Table 2**). Increase in number of effective nodules per plant in these treatments mainly attributed to complete or partial removal of weed competition in terms of allelopathic effect. A marginal effect of herbicides on number of root nodules owing to the limited infection sites on soybean roots to initiate the nodulation. However, mulching with wheat straw 5 t/ha showed significant improvement in dry weight of root nodules over weedy check but was statistically at par with remaining treatment except sulfentrazone 28% + clomazone 30% WP 0.725 kg/ha (ready mix). Antagonistic effect of herbicidal treatment on number and dry weight of nodules/plant might due to either phytotoxic effect on crop plants or adverse effect on nodule forming rhizobia. The increased in the nodule dry weight significantly possibly due to stimulatory effect of these chemicals on synthesis of nodular tissue. These results are in accordance with the results reported by Billore *et al.* (2001), Jha (2014), Singh *et al.* (2015), Deepa *et al.* (2017) and Singh *et al.* (2019).

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