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EFFECT OF POST EMERGENCE OF HERBICIDES ON WEEDS, NODULATION, SOIL PROPERTIES AND YIELD ATTRIBUTES OF BLACK GRAM [*VIGNA MUNGO* (L.)] HEPPER

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ABSTRACT

A field experiment was conducted at Shamli during kharif 2007 to examine the effect of herbicides in black gram on productivity weed infestation and soil health. Treatment consisting of clodinafop-propargyl 8% EC at 80, 100 and 150 g a. i. ha^{-1}, Na- acifluorfen 20% SL of 150 and 200 g a. i. ha^{-1}, combination of clodinafop- propargyl 8% EC + Na-acifluoren 16.5% SL at 80+ 150, 100 + 200 and 150 + 300 g ha^{-1},imazethapyr10% SL at 100 g a. i. ha^{-1}, weed free and weedy check were tested in RBD with 3 replications. The black gram variety used for the study was PDU-1. Treatment of weed free check was found best by recording highest nodulation, yield and yield attributes, N uptake and soil parameters. It was significantly superior with imazethapyr 10% SL @ 100 g a. i. ha^{-1}, the treatment that showed highest nodule and plant dry weight, weed control efficiency, grain yield (1168 kg ha^{-1}), straw yield (1498kg ha^{-1}) N uptake (80.5kg ha^{-1} in grain and 25.1kg ha^{-1}in straw) soil organic carbon, available N, P, K, microbial counts and dehydrogenase activity among different herbicides treatments. Clodinafop- propargyl 8% EC +Na- acifluorfen 16.5% SL was also found effective in weed control with 100 +200 g a. i. ha^{-1}. It was comparable to imazethapyr 10% SL @ 100 g a. i. ha^{-1} in weed index, weed control efficiency, nodule dry weight, grain and straw yield, N uptake, soil organic C, available N and K, microbial counts and dehydrogenase activity. The highest net return of Rs. 43520 ha^{-1} was obtained with weed free check, which was at par with imazethapyr 10% S @100 g a.i. ha^{-1} and cladinafop-propargyl 8% EC + Na- acifluorfen 16.5% SL @ 100 + 200 g a. i. ha^{-1}.

Key words : Black gram, Herbicide, Nodulation, Nutrient uptake, Soil properties, Yield.

INTRODUCTION

Black gram [*Vigna mungo* (L.)] Hepper is an important pulse crop of India containing 26% protein. Being N_2-fixing crop it provides good returns to farmers even with low level of farm input. Black gram is usually accompanied by luxuriant weed growth during the kharif (rainy) season owing to abundant rain fall received during monsoon leading to crop loses. The crop is not very good competitor against weed and therefore, weed control initiatives are essential to ensure proper crop growth, particularly in the early growth period. Depending on the nature, density and period of occurrence weeds can cause loses of grain yield of black gram varying from 41.6 to 64.1% (Chand *et al*., 2004; Rathi *et al*., 2004). The critical period of crop weed competition in black gram usually

falls between 15 and 45 days after sowing. The uncontrolled weeds at critical period of crop weed competition will reduce the yield of black gram by 38 to 65% depending upon type and intensity of weed infestation. Hand weeding through hoeing is a common practice of weed control in black gram, however, non-availability of labour or continuous rains often prevents timely weed control by such practices. Under such situations application of herbicides offer an alternate and equally effective method of weed control. Post emergence herbicides provide the farmers to have a wide choice of application time from 10 to 20 DAS. Few post emergence herbicides such as imazethapyr, Na-aciflourfen etc. are found to control both the broad leaved and grassy weed and mixed application of these herbicides is usually recommended for effective weed control in black gram. The applied herbicides either on soil surface or foliage undergoes to various fates in soil such as adsorption on soil particles, leaching to deeper layers and decomposition by soil microorganisms depending upon their chemical nature. These herbicides thus have a definite influence on soil and may alter soil physicochemical and biological properties, in turn affecting the nodulation of black gram. Keeping these aspects present study was carried out to examine the effect of post emergence herbicides in black gram on nodulation, dry matter yield, soil chemical and biological properties and yield attributes.

MATERIALS AND METHODS

Field experiment was conducted at Shamli, India (29.45^0 N,77.31^0 E, 248 m above mean sea level) during kharif season of 2007 in sandy loam soil having pH 8.02,E.C. 1.1ds m^{-1}, CEC 14 [cmol (P^+) kg^{-1}], organic carbon 0.63% and 288, 24.6 and 208 kg ha^{-1} of available N,P and K respectively. Eleven weed control treatments (as per detail in table 1were laid out in plots of 3.0 m X 5.0 m with 3 replications in Randomized Block Design

Black gram variety PDU-1 was sown @ 16 kg ha^{-1} rate in 30 cm apart in furrows. The crop was uniformly fertilised with basal application of 20 kg nitrogen ha^{-1} (urea), 40 kg P_2O_5 ha^{-1} (single super phosphate) and 40 kg K_2O ha^{-1} (muriate of potash) and standard package of practices were adopted.

Five plants from the each plot were randomly uprooted along with a soil core at 50 days after sowing (DAS). Roots were washed to remove the adhering soil and nodules were removed from roots for counting. Dry weight of nodules and plants were determined after drying to constant weight. The weed parameters were recorded at 30 DAS. Grain and straw yields were recorded at final harvest. N and P content in grain and straw samples were determined following methods as described by Page (1982) and N and P uptake were computed.

Soil samples of 0-15 cm depth were collected, in duplicate, from individual crop at 15 day after herbicide (DAH) application and after crop harvesting. One soil sample of each plot was air- dried, processed to pass through 2mm sieve and analysed for available N (0.32% alkaline $KMnO_4$ oxidizable) and available P (0.5 M $NaHCO_3$ extractable) following the methods described by Page (1982). Another soil sample was stored at low temperature in deep freezer and used for estimation of different soil biological properties. The population of bacteria, fungi and actinomycetes in soil was determined by serial dilution pour plate method as described by Wollum (1982) using Thornton's medium for bacteria, Ken Knight and Munaier's medium for actinomycetes and Martin's Rose-Bengal streptomycin agar medium for fungi. Soil dehydrogenase activity was estimated by reduction of 2,3,5 triphenyl tetrazolium chloride to triphenyl formazan (TPF) by the method of Tabatabai (1994). The treatments were compared using the F-test by calculating the critical differenceat 5% level of significance.

RESULTS AND DISCUSSION

Nodulation

The applied herbicides did not show adverse effects on the number and dry weight of nodules at 50 DAS reported by Kishinevsky *et al* (1998) in peanut (table 2). Moreover, combined application of clodinafop-propargyl 8% EC + Na-acifluorfen 16.5% SL at different rates, Na-acifluorfen 20% SL @ 150 g a.i. ha^{-1} and imazethapyr 10% SL @ 100 g a.i.ha^{-1} indicated slight improvement in nodule number and significant increase in nodule dry weight as compared to control. Maximum nodule number and nodule dry weight was recorded with weed free check treatment, being significantly more of 70.7 and 38.8% over control. A marginal effect of herbicides on nodule number may be because of limited infection sites on black gram roots to initiate the nodulation, however, combined use of cladinafop-propargyl 8% EC + Na-acifluorfen 16.55 SL at different doses and imazethapyr 10% SL @ 100 g a.i. ha^{-1} increased the nodule dry weight significantly possibly due to stimulatory effect of these chemicals on synthesis of nodular tissue (Billore *et al*., 2001).

Plant dry matter

Weed free check produced significantly higher plant dry weight of 9.97 g $plant^{-1}$ over untreated control and was significantly higher with imazethapyr 10% SL @ 100 g a.i. ha^{-1}, which recorded the 8.45 g $plant^{-1}$ plant dry

Table 1: Weed control treatments and schedule time of herbicide application.

S.No.	Treatments	Dose (g a.i.ha^{-1})	Application time (days after sowing)
1.	Clodinafop-propargyl 8% EC	80	15-20
2.	Clodinafop-propargyl 8% EC	100	15-20
3.	Cladinafop-propargyl 8% EC	150	15-20
4.	Cladinafop-propargyl 8% EC +Na-acifluorfen 16.5% SL	80 +150	15-20
5.	Cladinafop-propargyl 8% EC +Na-acifluorfen 16.5% SL	100 +200	15-20
6.	Cladinafop-propargyl 8% EC +Na acifluorfen 16.5% SL	150 +300	15-20
7.	Na-acifluorfen 20% SL	150	15-20
8.	Na-acifluorfen 20% SL	200	15-20
9.	Imazethapyr 10% SL	100	7-12
10.	Weed free check	-	-
11.	Control (untreated)	-	-

Table 2 : Effect of herbicides application on nodulation and plant dry weight at 50 DAS in black gram.

Treatments	Nodule number plant^{-1}	Nodule dry weight (mg plant^{-1})	Plant dry weight (g plant^{-1})
Clodinofop-propargyl 8% EC @ 80 g a.i. ha^{-1}	27.6	26.9	6.15
Clodinafop-propargyl 8% EC @ 100 g a.i. ha^{-1}	30.3	28.2	6.51
Clodinafop-propargyl 8% EC @ 160 g a.i. ha^{-1}	33.5	31.8	7.82
Clodinafop-propargyl 8% EC + Na-acifluorfen @16.5 SL @ 80 + 165 g a.i. ha^{-1}	24.5	24.9	7.21
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 100 + 206.2 g a.i. ha^{-1}	27.8	27.9	7.98
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 160 + 330 g a.i. ha^{-1}	29.3	29.1	8.31
Na-acifluorfen 20% SL @ 165 g a.i. ha^{-1}	30.2	28.5	6.63
Na-acifluorfen 20% SL @ 206.5 g a.i. ha^{-1}	27.6	28.7	6.21
Imazetharpyr 10% SL @ 100 g a.i.ha^{-1}	29.1	35.9	8.45
Weed free check	37.4	37.9	9.97
Weedy check (untreated)	21.9	27.3	5.61
C.D. (P=0.05)	3.5	3.0	1.09

weight (table 2). All the used herbicides except clodinafop-propargyl 8% EC@80 g and 100 g a.i. ha^{-1}, recorded significant increases in plant dry weight ranging from 9.6% with clodinafop-propargyl 8% EC @80g a.i. ha^{-1} to50.62% with imazethapyr 10% SL @100 g a.i. ha^{-1} over control (untreated). Na-acifluorfen 20% SL @ 150g a.i.ha^{-1} alone gave significantly more plant dry weight of 18.1% over control and was slightly better than its 200 g a.i. ha^{-1} dose. Combined use of cladinafop-propargyl 8% EC @ 80 g a.i. ha^{-1} to 50.62 + Na-acifluorfen 16.5% SL @100 +200 g a. i. ha^{-1} by recording significantly more plant dry weight was also better than their 80 + 150 g a.i. and 150 + 300 g a.i. ha^{-1} doses. Such beneficial effects of herbicides in plant dry weight may be due to effective weed control and minimising the crop weed competition resulting in better plant growth as also reported by Chandel and Sexena (2001) in soybean. Further, the increase in plant dry matter with treatments of herbicides may also be due to better nodulation and N_2-fixation.

Weed infestation

The different herbicides significantly reduced the weed population from 19.1 to 87.4% and weed dry matter from 32.9 to 92.6% as compared to control at 30 DAS (table 3). The highest reduction in weed population and weed dry matter was noted with imazethapyr 10% SL @ 100 g a.i. ha^{-1} registering maximum weed control efficiency of

92.6% and minimum weed index of 2.91%. Such variable effects of weedicides on weeds in black gram have also been reported by Rathi *et al*. (2004). The different doses of the used chemical gave variable effects on weed counts, weed dry matter and weed control efficiency. Clodinafop-propargyl 8% EC @ 80 g a.i. ha^{-1} reduced the weed counts by 19.5% and weed dry matter by 35.1%over control and was at par with its higher doses. The combined used of clodinafop-propargyl 8% EC with Na-acifluorfen 16.5% SL @ 160 + 300 g a.i. ha^{-1} was found superior to its other doses of 80 + 150 g a.i. and 100 + 200 g a.i. ha^{-1} in weed control efficiency. It was at par with imazethapyr 10% SL @ 100 g a.i. ha^{-1} in weed control efficiency and weed index. Such variations in the efficiency of different herbicides were because of their chemical structure and mode of action, and have been reported elsewhere (Chand *et al*., 2004).

Field and yield attributes

Treatment of control resulted in the lowest grain and straw yields, pods $plant^{-1}$, grains pod^{-1} and 1000-grain weight due to heavy infestation of weeds (table 4). Reduction in yield and yield attributes was mainly due to high plant-weed competition for light, space, moisture and nutrients. The different weed control treatment produced significantly more grain yield than control. The highest grain and straw yield recorded with free check, where yield attributes were also higher. Among different herbicides, imazethapyr 10% SL @ 100 g a.i. ha^{-1} gave the highest grain and straw yields due to better yield attributes. Clodinafop-propargyl 8% EC @ 80 g a.i. ha^{-1} gave significantly more grain yield of 73.5% over control and was at par to its 100 and 150 g a.i. doses. Combined use of clodinafop- propargyl 8% EC + Na- acifluorfen 16.5% SL @ 80 +150 g a.i. ha^{-1} and 100 + 200 g a.i. ha^{-1} were also statistically similar in black gram yield and yield attributes. However, their doses 150 + 300 g a.i. ha^{-1} showed significant reduction in grain and straw yield as compared to their doses of 100 + 200 g a.i. ha^{-1}. Sodium acifluorfen 20% SL @ 150 g a.i. ha^{-1} also produced significantly more yield and yield attributes over the control.

Nitrogen uptake

The applied herbicides improved N uptake by soybean through minimum weed-crop competition, allowing better growth environment and availability of nutrients to the crop (table 4). Clodinafop-propargyl 8% @ g a.i. ha^{-1} gave significant increase of 90.3 and 120% in N uptake by grain and straw, respectively over control (untreated). Combined use of this dose of clodinafop-propargyl was comparable to its 100 and 150 g a.i. doses. Similarly, Na-acifluorfen 20% SL @ 150 g a.i. ha^{-1} gave better N uptake and content by straw over its 200 g a.i. ha^{-1} dose. The highest N uptake was recorded with imazethpyr 10% SL @ 100 g a.i. ha^{-1}. This may be because of most effective

Table 3 : Effect of herbicides application on number and dry weight of weeds, weed index and control efficiency at 40 DAS in black gram.

Treatments	No. of weeds m^{-2}		Weed dry weight (g m^{-2})	Weed index (%)	Weed control efficiency (%)
	Pre treatment	50 DAS			
Clodinafop-propargyl 8% EC @ 80 g a.i. ha^{-1}	321.0	231.0	179.5	52.53	35.1
Clodinafop-propargyl 8% EC @ 100 g a.i. ha^{-1}	317.0	332.0	179.8	54.53	35.0
Clodinafop-propargyl 8% EC @ 160 g a.i. ha^{-1}	319.0	209.0	185.6	51.70	32.9
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 80 + 165 g a.i. ha^{-1}	316.0	79.0	38.6	8.73	86.1
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 100 + 206.5 g .i. ha^{-1}	325.0	60.0	28.0	4.90	89.9
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 160 + 330 g a.i. ha^{-1}	314.0	41.0	22.8	12.14	91.8
Na-acifluorfen 20% SL @ 165 g a.i. ha^{-1}	332.0	134.0	139.0	16.79	49.8
Na-acifluorfen 20% SL @ 206.2 g a.i. ha^{-1}	308.0	313.0	125.4	37.74	54.7
Imazethapyr 10% SL @ 100 g a.i. ha^{-1}	274.0	36.0	20.5	2.91	92.7
Weed free check	0.0	0.0	0.0	-	100.0
Weedy check (untreated)	323.0	287.0	276.8	74.31	-
C.D. (P=0.05)	7.50	7.52	7.14	2.03	2.58

Table 4 : Effect of herbicides application on yields and yield attributes of black gram.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Pods Plant^{-1}	Grain Plant^{-1}	1000 grain Wt (g)	N uptake (kg ha^{-1})	
						Grain	Straw
Clodinafop-propargyl 8% EC @ 80 g a.i. ha^{-1}	571	799	38.0	2.7	32	35.6	11.7
Clodinafop-propargyl 8% EC @ 100 g a.i. ha^{-1}	547	770	37.8	2.7	33.6	32.5	11.1
Clodinafop-propargyl 8% EC @ 150 g a.i. ha^{-1}	581	801	36.6	2.7	33.8	33.7	11.6
Clodinafop-propargyl 8% EC +Na-acifluorfen 16.5 SL @ 80 +150 g a.i. ha^{-1}	1098	1494	57.2	3.8	51.4	73.6	23.7
Clodinafop-propargyl 8% EC +Na-acifluorfen 16.5 SL@100 + 200 g a.i. ha^{-1}	1144	1498	57.8	4.0	52.2	77.8	24.7
Clodinafop-propargyl 8% EC+ Na-acifluorfen SL @ 150+300 g a.i. ha^{-1}	1057	1290	46.6	3.0	34.5	70.5	19.9
Na-acifluorfen 20% SL @ 165 g a.i. ha^{-1}	1001	1298	50.9	3.2	48.0	65.4	19.4
Na-acifluorfen 20% SL@206.2 g a.i. ha^{-1}	794	1032	47.6	2.8	34.6	51.9	15.4
Imazethapyr 10% SL@ 100 g a.i. ha^{-1}	1168	1498	58.0	4.2	56.0	80.5	25.1
Weedy free check	1203	1502	59.6	4.4	58.8	83.5	26.7
Control (untreated)	309	414	21.0	2.2	27.8	18.7	5.3
C. D. (P=0.05)	265	325	10.4	NS	1.8	17.9	5.5

Table 5 : Effect of herbicides application on economics of black gram crop.

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Clodinafop-propargyl 8% EC @ 80 g a. i. ha^{-1}	12040	31820	19780	1.64
Clodinafop-propargyl 8% EC @ 100 g a.i. ha^{-1}	12860	31700	18840	1.46
Clodinafop-propargyl 8% EC @ 160 g a.i. ha^{-1}	12940	32680	19740	1.52
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 80 + 165 g a.i. ha^{-1}	12900	54020	41120	3.18
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @100 + 206.2 g a.i. ha^{-1}	13280	56780	43500	3.27
Clodinafop-propargyl 8% EC + Na- acifluorfen 16.5 SL @ 160 +330 g a.i. ha^{-1}	14116	47406	32290	2.35
Na-acifluorfen 20% SL @ 165 g a.i. ha^{-1}	12833	35915	23082	1.79
Na-acifluorfen 20% SL @ 206.2 g a.i. ha^{-1}	13430	53480	22050	1.64
Imazethapyr 10% SL @ 100 g a.i. ha^{-1}	13280	57400	41120	3.09
Weed free check	16040	59560	43520	2.71
Weedy check	11040	20517	9477	0.85
C.D. (P=0.05)	-	1040	946	-

weed control by this treatment allowing better crop growth and availability of nutrients to black gram, as reported earlier by Jayakumar *et al*. (1989) in case of soybean.

Economics

The highest return of Rs. 43520 ha^{-1} was obtained with weed free check, which was at par with Clodinafop-propargyl 8% EC + Na- acifluorfen 16.5% SL @ 100 + 200 g a.i. ha^{-1} (Rs. 43500 ha^{-1}) (table 5). The treatments of weed free check, imazethapyr 10% SL @ 100 g a.i. ha^{-1} and clodinafop-propargyl 8% EC +Na- acifluorfen 16.5% SL @ 100 + 200 g a.i. ha^{-1} also showed statistically comparable gross of Rs. 43520, 41120 and Rs. 43500 ha^{-1}, respectively. Control treatment gave minimum and significantly less return than all treatments. The higher net return with imazethapyr 10% SL @ 100 g a.i. ha^{-1} and Clodinafop- propargyl 8% EC + Na-acifluorfen 16.5% SL is attributed to their better weed control efficiency and more grain yield. The B : C ratio was highest with Clodinafop- propargyl 8% EC + Na-acifluorfen 16.5% SL @ 100 +1200 g a.i. ha^{-1} (3.27) followed by its its 80 + 150 g a.i. ha^{-1} doses (3.18).

Soil properties

Organic carbon : Organic C in soil was more after crop harvesting than at 15 days after herbicides (DAH) application (table 6). Clodinafop-propargyl 8% EC at all doses was statistically comparable to control check in soil organic C at both 15 DHA and crop harvesting. Clodinafop-propargyl 8% EC + Na- acifluorfen 16.5% SL @ 80 + 150 g a.i. ha^{-1} gave significant increase in soil organic C of 5.8% over control at both the stages. The increased doses of clodinafop-propargyl 8% EC + Na-acifluorfen 16.5% SL did not further improve the soil organic C. weed free check gave highest and significantly more soil organic C of 19.6 and 23.5% over untreated at harvest and was followed by imazethapyr 10% SL @ 100 g a.i. ha^{-1}. Such variable effects of herbicides on organic C could be ascribed to variation in plant growth and addition of bio-mass to soil through rhizodeposition, leaf fall etc. Similar increase in soil organic C through inclusion of legumes has also been reported by Singh *et al*. (1996).

Available N, P and K : Clodinafop- propargyl 8% EC + Na-acifluorfen 16.5% SL @ 80 + 150 g a.i. ha^{-1} recorded the highest available N among different herbicides treatment registering significant increase of 70.6% over control at 15 DAH (table 5). The minimum available N in soil was noted with weedy check and highest with weed free check. The different doses of clodinafop-propargyl 8% EC alone and in combination of Na-acifluorfen 16.5% SL was statistically comparable to soil available N at both amount at crop harvest. Chantana *et al*. (1999) reported that herbicides application did not have adverse effect on nitrogenase activity and N_2- fixation of soybean. The energy source of N_2 fixation in plant photosynthate and hence N_2-fixation has direct correlation with crop health. The different herbicides improved the crop growth as evident by the plant dry matter. This improvement in crop growth probably supplied increase/ adequate amount of C substrate for N_2-fixation resulting in higher N_2 fixation and residual N in soil.

The applied herbicides also influenced the available P and K in soil significantly at harvest. Control untreated recorded the least and weed free check resulted in highest values of available P and K in soil at both the intervals. Among different herbicides, the highest available P and K in soil was noted with imazethapyr 10% SL @ 100 g a.i. ha^{-1} followed clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 100+200 g a.i. ha^{-1} at 15 DAH, recorded significantly lower values of soil available P as compared to weed free check. Similar trend was noted in soil available K and all the herbicides, except imazethapyr 10% SL @ 100g a.i. ha^{-1} recorded significantly low available K content in the soil after 15 DAH. This could be attributed to differences in weed control efficiency of the used herbicides allowing variations in crop growth and uptake of these nutrients by weeds flora and crop.

Soil biological properties : Applied herbicides did not show adverse effects on microbial counts and dehydrogenase enzyme activity in soil as compared to weedy check at 15 DAH and harvesting (table 7). Weed free check gave the maximum and significantly higher microbial population and dehydrogenase activity than the control at both the intervals. Clodinafop-propargyl 8% EC @ 80 g a.i. ha^{-1} recorded almost similar microbial population but significantly higher dehydrogenase activity than the control at 15 DAH and harvesting. Increasing dose of this herbicide did not favour the population of bacteria, actinomycetes and dehydrogenase activity, however, its 150 g a.i. dose gave the more fungal counts than 80 g a.i. ha^{-1} dose. Combined application of clodinafop-propargyl 8% EC + Na-acifluorfen 16.5% SL @ 100 + 200 g a.i. ha^{-1} gave higher microbial population and dehydrogenase activity over its 80 + 150 and 160 + 300 g a.i. doses at both the intervals. Application of Na-acifluorfen 20% SL @ 150 g a.i. ha^{-1} also gave significantly higher microbial counts and dehydrogenase activity at 15 DAH and harvesting over untreated. Among different herbicides, imazethapyr 10% SL @ 100 g a.i. ha^{-1} gave the highest microbial population and dehydrogenase activity at both the intervals. The

Table 6 : Effect of herbicides application on organic carbon (%) and available NPK (kg ha^{-1}) in soil after black gram.

Treatments	Organic carbon		Available N		Available P		Available K	
	15 DAH	Harvest	15 DAH	Harvest	15 DAH	Harvest	15 DAH	Harvest
Clodinafop-propargyl 8% EC @ 80 g a.i. ha^{-1}	0.50	0.51	17.63	15.53	15.36	13.36	126.5	125.4
Clodinafop-propargyl 8% EC @ 100 g a.i. ha^{-1}	0.51	0.52	16.44	14.44	14.44	12.40	118.0	116.0
Clodinafop-propargyl 8%EC @ 160 g a. i. ha^{-1}	0.51	0.51	16.41	14.41	14.14	12.14	120.1	118.0
Clodinafop- propargyl 8% EC + Na-acifluorfen 16.5 SL @ 80 +165 g a.i. ha^{-1}	0.55	0.55	21.48	19.44	19.84	17.84	126.5	125.2
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 100 + 206.2 g a.i. ha^{-1}	0.56	0.56	24.64	21.84	22.64	20.46	138.1	131.7
Clodinafop- propargyl 8% EC + Na-acifluorfen 16.5 SL @ 160 + 330 g a.i. ha^{-1}	0.56	0.57	22.62	20.52	20.26	19.26	126.1	123.7
Na-acifluorfen 20% SL @ 165 g a.i. ha^{-1}	0.52	0.52	21.72	18.72	19.72	17.92	124.3	121.7
Na-acifluorfen 20% SL @ 206.2 g a.i. ha^{-1}	0.50	0.51	20.56	18.36	18.65	16.56	124.7	122.3
Imazethapyr 10% SL @ 100 g a.i. ha^{-1}	0.56	0.57	24.73	22.23	22.31	20.31	138.3	126.1
Weed free check	0.61	0.63	29.92	27.52	27.29	25.19	140.4	136.1
Weedy check	0.51	0.51	14.44	12.24	12.04	10.14	110.3	108.2
C.D. (P=0.05)	0.03	0.02	0.35	0.35	0.19	0.17	7.19	5.85

DAH = Days after herbicides application.

Table 7 : Effect of herbicides application in black gram on microbial counts (Log_{10} cfu g^{-1} soil) and dehydrogenase activity (µ TPF g^{-1}).

Treatments	Bacteria		Fungi		Actinomycetes		Dehydrogenase activity	
	15 DAH	Harvest	15 DAH	Harvest	15 DAH	Harvest	15 DAH	Harvest
Clodinafop-propargyl 8% EC @ 80 g ai ha^{-1}	6.94	7.22	3.36	3.42	5.31	5.39	92.17	103.98
Clodinafop-propargyl 8% EC @ 100 g ai ha^{-1}	7.00	7.16	3.31	3.37	5.26	5.34	90.21	100.01
Clodinafop-propargyl 8% EC @ 160 g ai ha^{-1}	6.94	7.14	3.40	3.45	5.18	5.30	89.90	96.65
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 80 + 165 g ai ha^{-1}	6.98	7.13	3.47	3.58	5.36	5.48	141.66	147.96
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 100 + 206.2 g ai ha^{-1}	7.18	7.83	3.54	3.60	5.42	5.53	142.39	153.28
Clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 @ 160 +330 g ai. ha^{-1}	6.91	7.14	3.50	3.52	5.29	5.39	136.00	142.32
Na-acifluorfen 20% SL @ 165 g ai ha^{-1}	6.93	7.04	3.47	3.55	5.35	5.42	132.51	136.60
Na-acifluorfen 20% SL @206.2 g ai ha^{-1}	6.92	7.13	3.45	3.54	5.26	5.35	122.84	131.92
Imazethapyr 10% SL @ 100 g ai ha^{-1}	7.23	7.26	3.65	3.68	5.58	5.66	156.24	163.62
Weed free check	7.31	7.37	3.70	3.73	5.67	5.74	178.80	182.98
Weedy check (untreated)	7.03	7.07	3.19	3.24	5.17	5.33	70.13	83.14
C.D. (P=0.05)	0.01	0.01	0.01	0.01	0.01	0.01	9.89	6.75

results suggested that used herbicides had variable stimulatory effect on the microbial population and dehydrogenase activity. It may be due to utilization of herbicides as a nutrient source by soil microbes as reported by Ramesh *et al*. (2000) in soybean. It may also be due to better crop growth under weed control treatments, which provided more carbon and energy substrates to the microbes released in the form of root exudates and addition of organic matter because of greater crop biomass and root growth.

The study suggested that clodinafop-propargyl 8% EC + Na-acifluorfen 16.5% SL @ 100 + 200 g a.i. ha^{-1} is most suitable post emergence herbicide for weed control in black gram in the region producing grain yield and net return comparable to weed free check and highest B : C ratio. The mixtre of clodinafop-propargyl 8% EC + Na-acifluorfen 16.5 SL @ 80 + 150 g a.i. ha^{-1} showed net return statistically comparable to imazethapyr 10% SL @ 100 g a.i. ha^{-1} and weed free check treatment.

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