Original Research Article

Effect of chemical weed management practices on weed dynamics, soil microorganism and nutrient uptake in blackgram [*vigna mungo* (L.)]

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Abstract

An investigation was carried out at Zonal Agricultural Research Station, Kalaburagi, University of Agricultural Sciences, Raichur during *kharif* 2021-22 to study the effect of pre and post emergent application of weedicides on seed yield, weed dynamics, microbial population and nutrient uptake by weeds in blackgram. The results revealed that, significantly lower weed density (grassy weeds, sedges and broad leaf weeds (0.71) and weed dry weight (0.71) was observed with hand weeding at 25-30 DAS and intercultivation at 45 DAS (control) followed by sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS [grassy weeds (1.08, 1.26 and 1.83) sedges (1.03, 1.57 and 1.47) and broad leaf weeds (1.72, 2.06 and 2.11 at 25, 50 DAS and at harvest respectively]. Weed control efficiency was significantly higher with sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS (89.52, 90.31 and 91.17 at 25, 50 DAS and at harvest respectively) that was on par with hand weeding. Hand weeding at 25-30 DAS and intercultivation at 45 DAS recorded significantly higher population of bacteria, fungi and actinomycetes (13.82, 12.49 and 5.25 cfu x 10^{6} g-^{1} soil respectively). All chemical weedicides applied either pre-emergent or post-emergent significantly reduced population of total bacteria, fungi, actinomycetes. Significantly higher nutrient uptake by weeds was recorded with weedy check (71.03, 32.00 and 56.67 kg ha^{-1} nitrogen, phosphorus and potassium respectively). Where as, higher nutrient uptake by blackgram was with hand weeding at 25-30 DAS and intercultivation at 45 DAS (126.25, 28.20 and 109.30 kg ha^{-1} nitrogen, phosphorus and potassium respectively). After the harvest, soil available nutrients status was higher with hand weeding at 25-30 DAS and intercultivation at 45 DAS (141.38, 42.10 and 298.53 kg ha^{-1} nitrogen, phosphorus and potassium respectively) and significantly lower nutrients were observed with weedy check (122.93, 30.17 and 220.10 kg ha^{-1} nitrogen, phosphorus and potassium respectively).

Key words: *weedicide, yield, soil microbial population, weed control efficiency, nutrient uptake*

1. Introduction

Blackgram is third most important pulse crop grown under rainfed area, rice fallow and irrigated conditions during *kharif* as well as *summer* seasons. It is a self pollinated leguminous crop which contains 24 per cent protein, 60 per cent carbohydrate, 1.3 per cent fat, 3.2 percent minerals, 0.9 per cent fibre, 154 mg calcium, 385 mg phosphorus, 9.1 mg iron per 100 g and small amount of vitamin-B complex [1]. It is a highly prized pulse crop of leguminosae family and is widely cultivated in India and is popularly known as “Urad dal”. Blackgram plays an important role in human nutrition, soil fertility build up and in the economy of small and medium farmers due to less investment. The crop thrives well in a climate of 27-30°C temperature with moderate rainfall and loamy soil with high water holding capacity. India is the largest producer and consumer of pulses in the world. Blackgram contributes about 13 per cent of total pulse area and 10 per cent of total pulse production of our country. In India, this crop is cultivated over an area of about 46.5 lakh hectares with a production of 24.90 lakh tonnes and productivity of 536 kg ha^{-1} [2]. It is majorly grown in Madhya Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu, Karnataka and Uttar Pradesh states. In Karnataka, it is cultivated over an area of 0.93 lakh hectares with a production of 0.48 lakh tones and productivity of 514 kg ha^{-1} [3]. Major Blackgram growing areas are Kalaburagi, Bidar, Gadag, Yadgir, Raichur, Dharwad districts. The lower productivity of blackgram is mainly because of several biotic and abiotic factors. Among the biotic factors, heavy weed infestation and high incidence of insects and diseases are the major factors responsible for poor yield of blackgram. Heavy weed infestation is recognized as a major bottleneck in realizing the potential yield of blackgram especially in *Kharif* season. The crop has to compete for light, water, nutrient, and space with weeds during initial growth phases. The reports suggest that 30-50% losses in blackgram yield have been estimated [4] due to weed infestation. The weed causes maximum damage initially (25 to 35 days after sowing) and reduces the yield up to 43.2-64.1% [5]. The crop is not very good competitor against weeds [6] and therefore, weed control initiatives are essential to ensure proper growth of crop particularly in the early period growth. Being a rainy season crop, it is invaded by a large number of fast growing weeds. The critical period of crop weed competition in blackgram is during the first 25- 35 days after sowing. During this period, weeds grow quickly taking the advantage of its slow initial growth. Weeds smother the crop by competing for moisture, nutrients, light and space. They exploit the applied as well as the native nutrients. The problem is further aggravated under moisture stress conditions where, most of the

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available soil moisture in root zone is exhausted by fast growing weeds. Among the different methods of weed control, chemical method is becoming more popular among farmers due to non-availability of cheap labour. Blackgram is less competitive against many weeds during early stage of crop as most sensitive period of weed competition is between 25 to 30 days after sowing. Unchecked weeds have been reported to cause a considerable reduction in seed yield of blackgram, during summer blackgram could be 46-53% [7] whereas, in *kharif* blackgram the losses could be 43.2-64.1% [8]. Hand weeding is laborious, time consuming, costly and tedious. Many times labours are not available at the critical period of weed removal. Furthermore, weather conditions during *kharif* do not permit timely hand weeding due to wet field conditions. Use of herbicides offers an alternative for possible effective management of weeds. Soil microbes also play a vital role in maintaining the physical and chemical properties and various mechanisms in soil and thus, conserve soil ecology as well as soil health [9]. The presence of herbicide residues in soil could have direct impacts on soil microorganisms is matter of great concern. It has been reported that some microorganisms were able to degrade the herbicide, while some others were adversely affected depending on the application rates and the type of herbicide used [10]. Therefore, effects of herbicides on microbial growth, either stimulating or depressive, depend on the chemicals (type and concentration), microbial species and environmental conditions [11]. Microcosms containing soil microfauna of field communities offer higher resolution of ecotoxicological effects of chemicals in soil environments [12]. As the precise assessment of the potential non-target effects of herbicides on soil microorganisms in pulses field are of growing interest, therefore, soil microcosm can provide better understanding of possible response of soil microbes to herbicides. Weeds increase cost of cultivation and deplete the resource [13]. In order to achieve enhanced crop production and higher benefits from applied inputs, weeds must be kept under check by any of the safe and effective mean. Herbicide combinations are more effective weapons in tackling weed menace and thereby nutrient depletion by them than a single herbicide approach [14]. Therefore in the present study, the effect of various herbicides was compared with hand weeding and intercultivation for better weed management and yield of blackgram along with its effect on weed dynamics, soil microorganisms and nutrient uptake by weeds and the crop.

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2. Materials and Methods

A field experiment was conducted during *kharif* season 2021-22 at Zonal Agricultural Research Station, Kalaburagi, University of Agricultural sciences, Raichur (Karnataka). The soil of experimental site was medium black clay in texture having alkaline pH of 8.4, bulk density 1.33 g/cc and with organic carbon content 0.52%. The soil was medium in nitrogen (178 kg ha^{-1}), low in phosphorus (22 kg ha^{-1}) and medium in potassium (328 kg ha^{-1}) contents at the time of initiation of the experiment. The climate of the area was subtropical, received annual average rainfall of 720 mm and mean maximum and minimum temperature were 38.77°C and 17.76°C, respectively. The experiment involving nine treatments was laid out in randomized complete block design. The treatments comprised T1: weedy check, T2: hand weeding at 25-30 DAS and intercultivation at 45 DAS, T3: alachlor 50% EC @ 1.0 kg a.i. ha^{-1} as PE *fb* intercultivation at 30 DAS, T4: pendimethalin 38.7% CS @ 0.75 kg a.i. ha^{-1} as PE *fb* intercultivation at 30 DAS, T5: pendimethalin 30% EC + imazethapyr 2% EC @ 2 kg a.i. ha^{-1} as PE, T6: propaquizafop 10 EC @ 50 g a.i. ha^{-1} at 20-25 DAS, T7: propaquizafop 2.5% + imazethapyr 3.7% w/w @ 1.0 kg a.i. ha^{-1} at 20-25 DAS, T8: sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 1.0 kg a.i. ha^{-1} at 20-25 and T9: imazethapyr + imazamox @ 100 g a.i. ha^{-1} at 20-25 DAS. The blackgram variety 'DU-1' having duration of 70-75 days was sown with 30 cm spacing using seed rate of 15 kg ha^{-1}. Fertilizer dose of 40:20:20 kg ha^{-1} in the form of urea (87 kg ha^{-1}), single super phosphate (125 kg ha^{-1}) and muriate of potash (33 kg ha^{-1}) was applied to the soil at the time of sowing. A knapsack sprayer fitted with flat fan nozzle was used to apply the pre-emergent weedicide on the first day after sowing and post-emergent weedicide with a spray volume of 750 l ha^{-1} as per the treatments. Suitable plant protection chemicals were sprayed in all the plots to check the incidence of pests and diseases. In different plots weed management operation was done as per the treatments. Observations on different weed population (grasses, sedges and broad leaf weeds) were recorded at 25 and 50 DAS and at harvest. In each plot grasses, sedges and broad-leaves were counted from randomly selected places in each plot using 0.5 × 0.5 m quadrant (0.25 m^2). Weed count was expressed as number per m^{-2} and subjected to square-root transformation $(x+0.5)^{1/2}$ to normalize their distribution. Total weed density was obtained by adding all the grasses, sedges and broad leaf weeds. The weeds removed from the selected areas were dried at 70° C for 72 hours to obtain constant weight and the dry weight was expressed in g m^{-2}. Weed control efficiency (WCE) was calculated by using suitable formula [15].

$$\text{WCE (\%)} = \left(\frac{\text{WCC} - \text{WCT}}{\text{WCC}}\right) \times 100$$

Where, WCC = Dry weight of weeds in unweeded control plot (g)

WCT = Dry weight of weeds in treated plot (g)

Weed index represents actual measure of weeds present and was calculated by following suitable formula [16]

$$\text{Weed Index} = \left(\frac{X - Y}{X}\right) \times 100$$

Where, X = Seed yield in weed free check plot (kg ha^{-1})

Y= Seed yield in treated plot (kg ha^{-1})

Enumeration of microorganisms *viz*., bacteria, fungi and actinomycetes was done by the serial dilution agar plating method. A known amount (10 ml or 10 g) of soil is suspended or agitated in known volume of sterile water blank (90 ml to make the volume to 100 ml) to make a microbial suspension. Serial dilution 10^{-2}, 10^{-3}, .….10^{-7} are made by pipetting measured volumes (1.0 ml) into additional dilution blanks (having 99 ml). Finally, 1.0 ml aliquot of various dilutions are added to sterile petridishes (triplicate for each dilution) to which are added 15 ml of sterile, cool, molten (45^{o} C) media (Potato dextrose agar for fungi, Nutrient agar for bacteria, Glycerol yeast agar for actinomycetes). The dilutions 10^{-2} to 10^{-5} are selected for enumeration of fungi, 10^{-3} to 10^{-6} for actinomycetes and 10^{-4} to 10^{-7} for bacteria as relative to their proportion in soil. Upon solidification, plates are incubated in an inverted position for 5-7 days at 25^{o} C. The number of colonies appearing on dilution plates are counted, averaged and multiplied by the dilution factor to find the number of cells $spores^{-1}$ per gram of the sample [17] Nitrogen, phosphorus and potassium contents in plant samples and weeds at harvest were estimated by modified micro-kjeldhal method, Vanadomolybdate yellow colour method and flame photometric method, respectively [18]. Nutrient uptake was calculated by using the following formula

$$\text{Uptake of nutrients (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%) x Biomass (kg ha}^{-1}\text{)}}{100}$$

Soil samples were collected from 0-30 cm depth before and after harvest of the crop from each treatment in all the three replications. The soil samples were analysed for available nitrogen, available phosphorus and available potassium content. Statistical analysis of the data was done as per the Fisher's analysis of variance technique for the experimental designs as outlined by [19]. and treatment means were compared using least significant difference test at p=0.05 probability level using t-test.

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3. Results and Discussion

The most important grassy weeds observed in the experimental plot were *Cynodon dactylon, Panicum* spp., *Dactyloctenium aegyptium, Digitaria marginata* and *Erogrostis gangetica.* While common broad-leaved weeds observed were *Commelina benghalensis, Phyllanthus niruri*, *Tribulus terrestris*, *Abutilon indicum*, *Euphorbia hirta*, *Trichodesma* spp., *Portulaca oleracea*, *Tridax procumbens*, *Amaranthus viridis*, *Digeria arvensis*, and *Leucus aspera* and the common sedge observed was *Cyperus rotundus*.

3.1 Effect of treatments on weed density, weed dry weight and weed index.

Weed density, dry weight of weeds and weed index were significantly influenced by different weed management practices (Table 1 and 2). All the weed control treatments proved significantly superior over weedy check. Significantly lower grassy weeds, sedges and broad leaf weeds (0.71), weed dry weight (0.71 g plant^{-1}) were observed with T2 (hand weeding at 25-30 DAS and intercultivation at 45 DAS). Among the chemical weedicides treatment T8 (post emergent application of sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS) recorded significantly lower density of grassy weeds (1.08, 1.26 and 1.83), sedges (1.03, 1.57 and 1.47) and broad leaf weeds (1.72, 2.06 and 2.11 at 25, 50 and at harvest respectively) and weed dry weight (1.44, 1.53 and 1.57 at 25, 50 DAS and at harvest respectively). This was followed by propaquizafop 2.5% + imazethapyr 3.7% w/w @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS [20] and [21], The weedy check recorded significantly higher grassy weeds (2.89,4.04 and 4.45), sedges (2.35, 3.07 and 3.57) and broad leaf weeds (3.66, 3.85 and 4.08 at 25, 50 and at harvest respectively) and higher total weed dry weight (3.98, 4.42 and 4.83 at 25, 50 DAS and at harvest respectively). Weed index is a measure of weed density. Significantly lower weed index was recorded by T2 followed by T8 (6.56). Whereas, higher weed index was obtained with weedy check (52.61%) [20] and [21]. Effective control of weeds under weedicide applied could be assigned to the reason for superior weed indices.

3.2 Effect of treatments on seed yield of blackgram and weed control efficiency

Significantly higher seed yield (1139 kg ha^{-1}) of blackgram (Table 2) was obtained in T2 (hand weeding at 25-30 DAS and intercultivation at 45 DAS) followed by T8 sodium acifluorfen 16.5% + clodinafop propargyl 8% EC, as post emergent weedicide @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS (1059 kg ha^{-1}). The treatment T1 (weedy check) recorded significantly lower seed yield (540 kg ha^{-1}) among all the treatments. Weed control efficiency was significantly higher with T8 (89.52%, 90.31% and 91.17% at 25, 50 DAS and at harvest, respectively). This was followed by propaquizafop 2.5% + imazethapyr 3.7% w/w @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS (65.07%, 88.50% and 89.74% at 25 50 DAS and at harvest, respectively). Timely application ready-mix sodium acifluorfen 16.5% and clodinofop propargyl 8% EC with 1.0 kg ha^{-1} killed most weeds effectively in black gram. As the weedicides were very effective in controlling the weeds, that could have otherwise utilised all growth resources (water, nutrients, light and space) and reduced the blackgram yield [24], [25],[26], [27], and [28]. Clodinafop propargyl controls grassy weeds by inhibiting acetyl-CoA carboxylase while, Acifluorfen controls both grassy and broad leaves by inhibiting proto-porphyrinogen oxidase [29]

3.2 Effect of treatments on soil microorganisms (fungi, bacteria and actinomycetes)

The microbial population (bacteria, fungi and actinomycetes) before the initiation of trial was quiet uniform (Table 3) in the beginning whereas, at harvest the microbial count was significantly higher in hand weeding at 30 DAS and Intercultivation at 45 DAS at harvest (13.82, 12.49 and 4.73 (cfu X 10^{6} g^{-1} soil, respectively) followed by weedy check (12.27, 11.90 and 4.3 cfu X 10^{6} g^{-1} soil respectively). Further, it is to be noted that the microbial load was higher at the time of sowing and went on decreasing from sowing to harvest. This was because of the population of Zn solubilizers and other microbes could be observed only in hand weeding and weedy check treatments and not in any of the plots receiving the herbicides, as all the herbicides used in the present study inhibited the growth of Zn solubilising and other microorganisms in the root zone soil [30], [31] and [32], However T8 recorded numerically higher microbial load (11.33, 11.20 and 4.10 cfu X 10^{6} g^{-1} soil, respectively) compared to other weedicide treatments [33] and [34]. Significantly higher numbers of root nodules were recorded with T2 Hand weeding at 30 DAS and Intercultivation at 45 DAS (17.73 and 17.28 plant^{-1} at 25 and 50 DAS respectively). Whereas, all the weedicide treatments recorded significantly lower number of root nodules. However, in T8 lesser decrease of number of root nodules (15.87 and 14.31 plant^{-1} at 25 and 50 DAS respectively) [35] and [36].

3.4 Effect of treatments on nutrient uptake by weeds, crop and soil available nutrients

Significantly higher quantities of nutrients are utilised by weeds from the soil for their growth (Table 4). Weedy check recorded significantly higher nitrogen, phosphorus and potash uptake (71.03, 32.00 and 56.67 kg ha^{-1}). This was mainly attributed to higher weed density in that treatment that have

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utilised higher amount of nutrients competing with crop plants. Among all the treatments, application of sodium acifluorfen 16.5% + clodinofop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS recorded lower uptake of nitrogen, phosphorus and potash (4.20, 2.34 and 3.98 kg ha^{-1}) by weeds due to lower number of weeds (caused by the application of weedicides that has lead to effective control of weeds) compared to other treatments and hence lower uptake of all nutrients was observed [35], [37] and [38] In case of blackgram, significantly higher uptake of nutrients (126.25, 28.20 and 109.30 kg ha^{-1} nitrogen, phosphorus and potassium respectively) by blackgram was observed in T2 hand weeding at 30 DAS and intercultivation at 45 DAS due to lower weed density in that treatment. This was followed by T8 sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS (117.01, 26.43 and 98.40 kg ha^{-1} nitrogen, phosphorus and potassium respectively) At the time of sowing, there was no significant difference in nutrient status of soil and all were numerically comparable Whereas, after the harvest of the crop, available nutrient status was significantly higher with T2 hand weeding at 30 DAS and intercultivation at 45 DAS (141.38, 42.10 and 298.53 kg ha^{-1} nitrogen, phosphorus and potassium respectively). This was followed by T8 sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS (140.43, 41.90 and 297.80 kg ha^{-1} nitrogen, phosphorus and potassium respectively) due to lower weed density leading to sufficient nutrient level[38] and [39]. The weedy check recorded significantly lower nutrient content (122.93, 30.17 and 220.10 kg ha^{-1} nitrogen, phosphorus and potassium respectively) in the soil after the harvest, as there was severe competition between weeds and blackgram crop for growth resources especially nutrients which lead to more depletion of soil nutrients

4. CONCLUSION

Hand weeding at 25-30 DAS and intercultivation at 45 DAS reduced the weed density of grassy weeds, sedges and broad leaf weeds and weed dry weight. Among the chemical weedicides, sodium acifluorfen 16.5% + clodinafop propargyl 8% EC @ 1.0 kg *a.i.*ha^{-1} at 20-25 as post-emergence was found most effective in controlling weeds at all stages and it recorded higher weed control efficiency and seed yield and lower weed index after hand weeding at 25-30 DAS and intercultivation at 45 DAS. Lower seed yield and higher weed density and dry weight and higher weed index was observed in weedy check. Higher number of root nodules and microbial population was found with hand weeding followed by weedy check and sodium Acifluorfen 16.5% + Clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25. Nutrient uptake by weeds was higher with weedy check, where as in blackgram uptake was higher with hand weeding at 25-30 DAS and intercultivation at 45 DAS followed by sodium Acifluorfen 16.5% + Clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25. Available nutrient was also higher with hand weeding at 25-30 DAS and intercultivation at 45 DAS followed by sodium Acifluorfen 16.5% + Clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25.

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Table 1. Number of grassy weeds, sedges and broad leaf weeds at 25, 50 DAS and at harvest as influenced by weed management practices in blackgram

Treatments	Number of grassy weeds			Number of sedges			Number of BLW		
	25 DAS	50 DAS	At harvest	25 DAS	50 DAS	At harvest	25 DAS	50 DAS	At harvest
T_1-Weedy check	2.89 (7.87)	4.04 (15.88)	4.45 (19.34)	2.35 (5.17)	3.07 (9.17)	3.57 (12.41)	3.66 (13.13)	3.85 (14.59)	4.08 (16.39)
T_2-Hand weeding at 30 DAS and Intercultivation at 45 DAS	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_3-Alachlor 50% EC @ 1.0 kg *a.i.* ha^{-1} as PE *fb* Intercultivation at 30 DAS	1.86 (2.98)	2.65 (6.50)	2.24 (4.53)	1.73 (2.50)	2.55 (5.98)	2.35 (5.02)	2.55 (5.98)	2.68 (6.70)	2.73 (6.97)
T_4-Pendimethalin 38.7% CS @ 0.75 kg *a.i.* ha^{-1} as PE *fb* Intercultivation at 30 DAS	1.73 (2.50)	2.34 (4.98)	2.13 (4.05)	1.57 (1.98)	2.49 (5.68)	2.31 (4.86)	2.32 (4.90)	2.55 (5.98)	2.57 (6.10)
T_5-Pendimethalin 30% EC + Imazethapyr 2% EC @ 2 kg *a.i.* ha^{-1} as PE (Velor)	2.10 (3.90)	2.65 (6.55)	2.63 (6.51)	1.90 (3.10)	2.57 (6.09)	2.59 (6.20)	2.72 (6.92)	2.80 (7.34)	2.76 (7.12)
T_6-Propaquizafop 10 EC @ 50 g *a.i.* ha^{-1} at 20-25 DAS	2.29 (4.76)	2.92 (8.00)	3.11 (9.20)	2.30 (4.80)	2.85 (7.60)	2.91 (7.95)	2.98 (8.40)	3.32 (10.50)	3.22 (9.86)
T_7-Propaquizafop 2.5% + Imazethapyr 3.7% w/w @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS (shaked)	1.54 (1.87)	1.68 (2.31)	2.00 (3.55)	1.19 (0.91)	1.82 (2.85)	1.86 (2.95)	2.06 (3.76)	2.32 (4.87)	2.34 (5.00)
T_8-Sodium Acifluorfen 16.5% + Clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25 (Irish)	1.08 (0.67)	1.26 (1.12)	1.83 (2.90)	1.03 (0.56)	1.57 (1.97)	1.47 (1.65)	1.72 (2.45)	2.06 (3.75)	2.11 (3.95)
T_9-Imazethapyr + Imazamox @ 100 g *a.i.* ha^{-1} at 20-25 DAS (Odyssy)	1.61 (2.10)	2.09 (3.85)	2.05 (3.75)	1.27 (1.12)	2.11 (3.98)	1.93 (3.24)	2.12 (3.98)	2.37 (5.10)	2.43 (5.40)
S. Em. ±	**0.05**	**0.07**	**0.11**	**0.09**	**0.12**	**0.09**	**0.10**	**0.12**	**0.11**
C.D. at 5 %	**0.15**	**0.20**	**0.32**	**0.28**	**0.36**	**0.27**	**0.31**	**0.37**	**0.33**

*figures in parenthesis are the original values

Table 2. Total weed density, total weed dry weight, weed index, weed control efficiency and seed yield of blackgram as influenced by weed management practices in blackgram

Treatments	Total weed density (No's)			Total dry weight of weeds (g /0.5m^2)			Weed index (%)	Weed control efficiency (%)			Seed yield (kg ha^{-1})
	25 DAS	50 DAS	At harvest	25 DAS	50 DAS	At harvest		25 DAS	50 DAS	At harvest	
T1-Weedy check	5.16 (26.17)	6.34 (39.64)	6.97 (48.14)	3.98 (15.54)	4.42 (19.33)	4.83 (22.96)	52.61	0.00	0.00	0.00	540
T2-Hand weeding at 30 DAS and Intercultivation at 45 DAS	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.00	100.00	100.00	100.00	1139
T3-Alachlor 50% EC @ 1.0 kg a.i. ha-1 as PE fb Intercultivation at 30 DAS	3.46 (11.46)	4.44 (19.18)	4.13 (16.52)	2.79 (7.30)	2.71 (6.87)	2.81 (7.40)	16.98	50.96	64.02	66.99	946
T4-Pendimethalin 38.7% CS @ 0.75 kg a.i. ha-1 as PE fb Intercultivation at 30 DAS	3.14 (9.38)	4.14 (16.64)	3.94 (15.01)	2.64 (6.46)	2.69 (6.74)	2.78 (7.24)	15.51	56.60	64.70	67.56	962
T5-Pendimethalin 30% EC + Imazethapyr 2% EC @ 2 kg a.i. ha-1 as PE (Velor)	3.80 (13.92)	4.53 (19.98)	4.51 (19.83)	2.88 (7.80)	2.93 (8.10)	3.01 (8.55)	23.45	47.60	57.58	61.69	871
T6-Propaquizafop 10 EC @ 50 g a.i. ha-1 at 20-25 DAS	4.30 (17.96)	5.16 (26.1)	5.24 (27.01)	2.93 (8.10)	3.00 (8.50)	3.06 (8.89)	24.51	45.58	55.48	60.15	859
T7-Propaquizafop 2.5% + Imazethapyr 3.7% w/w @ 1.0 kg a.i. ha-1 at 20-25 DAS (shaked)	2.65 (6.54)	3.24 (10.03)	3.46 (11.5)	2.39 (5.20)	1.62 (2.14)	1.67 (2.30)	8.95	65.07	88.50	89.74	1036
T8-Sodium Acifluorfen 16.5% + Clodinafop propargyl 8% EC @ 1.0 kg a.i. ha-1 at 20-25 (Irish)	2.04 (3.68)	2.71 (6.84)	3.00 (8.5)	1.44 (1.56)	1.53 (1.85)	1.57 (1.98)	6.56	89.52	90.31	91.17	1059
T9-Imazethapyr + Imazamox @ 100 g a.i. ha-1 at 20-25 DAS (Odyssy)	2.77 (7.20)	3.66 (12.93)	3.59 (12.39)	2.71 (6.87)	2.67 (6.65)	2.71 (6.87)	10.78	53.85	65.17	69.35	1016
S. Em. +	**0.1**	**0.13**	**0.11**	**0.09**	**0.13**	**0.09**	**-**	**3.29**	**3.81**	**2.03**	**28**
C.D. at 5 %	**0.31**	**0.38**	**0.34**	**0.28**	**0.38**	**0.27**	**-**	**9.86**	**11.44**	**6.09**	**86**

*figures in parenthesis are the original values

Table 3. Number of root nodules, population of bacteria, fungi and actinomycetes as influenced by weed management practices in blackgram.

Treatments	Number of root nodules (plant^{-1})		Microbial population ((cfu X 106 g^{-1} soil)					
			Bacteria		Fungi		Actinomycetes	
	25 DAS	50 DAS	Before sowing	After harvest	Before sowing	After harvest	Before sowing	After harvest
T_1-Weedy check	17.71	17.26	14.97	12.27	13.12	11.90	4.73	4.30
T_2-Hand weeding at 30 DAS and Intercultivation at 45 DAS	17.73	17.28	16.30	13.82	13.74	12.49	5.25	4.73
T_3-Alachlor 50% EC @ 1.0 kg *a.i.* ha^{-1} as PE *fb* Intercultivation at 30 DAS	9.85	8.54	13.14	9.67	11.39	9.20	3.61	3.57
T_4-Pendimethalin 38.7% CS @ 0.75 kg *a.i.* ha^{-1} as PE *fb* Intercultivation at 30 DAS	10.96	8.98	12.27	9.73	9.80	10.02	3.88	3.67
T_5-Pendimethalin 30% EC + Imazethapyr 2% EC @ 2 kg *a.i.* ha^{-1} as PE (Velor)	9.15	8.01	12.03	9.59	10.52	9.10	3.29	2.94
T_6-Propaquizafop 10 EC @ 50 g *a.i.* ha^{-1} at 20-25 DAS	9.02	7.67	12.30	8.37	10.40	8.60	2.51	2.37
T_7-Propaquizafop 2.5% + Imazethapyr 3.7% w/w @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS (shaked)	14.39	13.40	12.81	10.33	11.60	10.28	4.49	3.93
T_8-Sodium Acifluorfen 16.5% + Clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25 (Irish)	15.87	14.39	13.35	11.33	13.20	11.20	4.62	4.10
T_9-Imazethapyr + Imazamox @ 100 g *a.i.* ha^{-1} at 20-25 DAS (Odyssy)	14.12	11.74	12.30	10.00	11.90	10.11	4.35	3.70
S. Em. ±	**0.43**	**0.66**	**0.95**	**0.90**	**0.98**	**0.50**	**0.68**	**0.15**
C.D. at 5 %	**1.28**	**1.97**	**NS**	**2.70**	**NS**	**1.49**	**NS**	**0.45**

Table 4. Nutrient uptake by weeds, blackgram, and available nutrient status of soil before and after harvest of crop as influenced by weed management practices in blackgram.

Treatments	Nutrient uptake by weeds (kg ha^{-1})			Nutrient uptake by blackgram (kg ha^{-1})			Available nutrient status (kg ha^{-1})					
							Before sowing			After harvest		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1-Weedy check	71.03	32.00	56.67	68.77	15.73	53.82	176.07	23.10	319.00	122.93	30.17	220.10
T_2-Hand weeding at 30 DAS and Intercultivation at 45 DAS	0.00	0.00	0.00	126.25	28.20	109.30	178.40	22.80	328.40	141.38	42.10	298.53
T_3-Alachlor 50% EC @ 1.0 kg *a.i.* ha^{-1} as PE *fb* Intercultivation at 30 DAS	8.67	5.12	6.20	99.70	24.24	83.90	177.81	21.48	317.50	128.40	37.40	264.70
T_4-Pendimethalin 38.7% CS @ 0.75 kg *a.i.* ha^{-1} as PE *fb* Intercultivation at 30 DAS	8.43	4.70	5.98	100.70	25.12	85.20	177.46	21.10	321.20	130.63	38.20	270.38
T_5-Pendimethalin 30% EC + Imazethapyr 2% EC @ 2 kg *a.i.* ha^{-1} as PE (Velor)	9.01	5.60	6.74	89.50	19.87	79.50	177.12	23.10	312.40	127.09	37.20	269.37
T_6-Propaquizafop 10 EC @ 50 g *a.i.* ha^{-1} at 20-25 DAS	9.30	6.14	7.60	78.66	18.34	76.40	167.27	20.25	310.60	123.48	36.80	262.20
T_7-Propaquizafop 2.5% + Imazethapyr 3.7% w/w @ 1.0 kg *a.i.* ha^{-1} at 20-25 DAS (shaked)	6.10	2.90	4.20	104.50	25.97	94.20	176.86	21.00	326.43	138.75	39.90	274.60
T_8-Sodium Acifluorfen 16.5% + Clodinafop propargyl 8% EC @ 1.0 kg *a.i.* ha^{-1} at 20-25 (Irish)	4.20	2.34	3.98	117.01	26.43	98.40	178.00	22.70	327.40	140.43	41.90	297.80
T_9-Imazethapyr + Imazamox @ 100 g *a.i.* ha^{-1} at 20-25 DAS (Odyssy)	7.80	3.76	5.53	103.37	25.24	89.40	175.82	23.10	324.20	137.23	38.70	271.30
S. Em. ±	**0.51**	**0.25**	**0.65**	**3.43**	**0.79**	**3.88**	**2.84**	**0.73**	**5.19**	**4.47**	**1.67**	**7.85**
C.D. at 5 %	**1.53**	**0.75**	**1.94**	**10.27**	**2.36**	**11.62**	**NS**	**NS**	**NS**	**13.41**	**5.01**	**23.54**