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Effect of Weed Management Practices and Bio-fertilizers with and without FYM on Weed Flora, Growth and Yield of Blackgram (*Vigna mungo* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted in farmer's field at Narasipuram block, Coimbatore, Tamil Nadu during summer season, 2021-22, to study the influence of weed management practices and bio-fertilizers with and without FYM on weed flora, growth and yield of blackgram. The experiment was laid out in split plot design with three replications. Treatments consisted of four weed management practices as main plots, *viz.*, M_1- PE Pendimethalin 30% EC 1 kg ha^{-1} sprayed at 3 DAS, M_2 - EPoE imazethapyr 10% SL 50 g ha^{-1}, M_3 – EPoE Quizalofop-p-ethyl 5% EC 50 g ha^{-1}applied at 10 DAS and M_4 - two hand weeding (15 and 30 DAS) and four different treatments of bio-fertilizers with and without FYM *viz.*, S_1 – Rhizobium + Phosphobacteria, S_2 – Rhizobium + Phosphobacteria + *AM* fungi, S_3 – S_1 + FYM, S_4 – S_2 + FYM and S_5 - control. The results revealed that interaction effect of pendimethalin 1 kg ha^{-1} (M_4) and *Rhizobium* + Phosphobacteria + *AM* fungi with FYM (S_4) recorded

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maximum growth and yield parameters *viz.*, plant height, dry matter production, number of pods plant^{-1}, seeds pods^{-1}, pod length and 100 grain weight. Moreover, produce higher grain and haulm yield compared over rest of treatments.

Keywords: Blackgram; herbicide; bio-fertilizers; FYM; weed control efficiency.

1. INTRODUCTION

In pulse, blackgram is one of the short duration crops. This crop does not had potential to compete with different weed species [1] and highly shy with weeds [2]. Hence, weed competition was higher during early growth stages as well as critical period usually between 15 – 45 days after sowing [3]. Therefore, weed control practices have to be carried out at initial stage that ensured proper crop growth. Weeds caused severe yield loss varied from 41.6 to 64.1 percent depends on its nature, intensity and period of growth [4,5]. Two hand weeding was most effective compared to other weed control methods, but due to labour scarcity, higher labour charges and time consuming, it was not adopted by farmer. So, the best alternative practices to control weeds were either use of pre-emergence or early post emergence herbicides. But, pre-emergence herbicides mostly efficient in short period and thereafter, late emerging weeds were competing for spacing, nutrients and sunlight. So, use of early post emergence herbicides offers ways to manage late emerging weeds. Pendimethalin is a herbicide of di-nitroaniline class, used as a pre-emergence purpose. Application of pre-emergence (PE) herbicides after first shower were effective against weeds if weeds were not germinated. Whereas Imazethapyr belongs to imidazoline class and had selective chemical compound to inhibits metabolism of grasses and broad-leaf weeds. Quizalofop-p-ethyl was selective herbicide, to control an annual and perennial weed which belongs to chemical family aryloxyphenoxy group, that inhibited fatty acid synthesis in weeds, while applied as early post emergence herbicide (EPoE). Bio-fertilizers (*AM* fungi, *Rhizobium*, Phosphobacteria) were living organisms, cost effective, eco-friendly and alterative for chemically synthesized fertilizers, which substituted inorganic fertilizers by fixing atmospheric nitrogen and mobilize inorganic phosphorous followed by solubilization led to more availability of nutrients to plants and better yield performance [6]. Earlier works [7] revealed that blackgram seeds were treated with phosphorous solubilizing bacteria and *AM* fungi might had substituted for 50% phosphatic fertilizer under silt loam soil in blackgram.

To increase the productivity of blackgram, timely weed management with proper care is necessary. With this context, a research work was carried out to study the influence of weed management practices and bio-fertilizers combined application of organics (with and without Farm Yard Manure) on weed flora and yield of blackgram under field conditions.

2. MATERIALS AND METHODS

The field experiment was conducted at farmer's field in Narasipuram block at Coimbatore during summer season, 2021- 22 under irrigated condition. The soil of experimental field was clay loam in texture. Analysed results of initial soil sample carried out at Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore were furnished below in (Table 1). The field experiment was laid out in split plot design with nine treatments. Among this main plot consisted of four treatments and five treatments for subplots resulted in twenty combinations with three replications. The main plots consisted three herbicides as M_1- Pendimethalin 30% EC @ 1 kg ha^{-1}on 3DAS , M_2 – Imazethapyr 10% SL @ 50 g ha^{-1} on 10 DAS and M_3- Quizalofop-p-ethyl 5% EC @ 50 g ha^{-1} on 10 DAS and M_4 – Two hand weeding at 15 and 30 DAS. In subplots, S_1- *Rhizobium* + Phosphobacteria, S_2 – *Rhizobium* + Phosphobacteria + *AM* fungi, S_3 – S_1 + FYM, S_4 – S_2 + FYM, S_5- Control. The biofertilizers and FYM were applied at recommended dose, as given in Crop Production Guide (2020).

Blackgram variety 'Vamban 9' was sown in line method at seed rate of 20 kg ha^{-1} during summer season, 2021 - 22 with plant spacing of 30 × 10 cm. Before sowing, seeds were treated with biofertilizer @ 600 g ha^{-1} followed by soil application of 2 kg ha^{-1}. Basal nutrient requirement of (per hectare) 25 kg N , 45 kg P_2O_5 ,25 kg K_2O and 10 kg S (CPG, 2020) supplemented by addition of Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP). Life irrigation was given on 3rd day

Table 1. Initial soil analysis

S. No.	Parameters	Value
Mechanical properties		
1	Bulk density (Mg m^{-3})	1.28
2	Particle density (Mg m^{-3})	2.08
3	Total porosity (%)	38.46
Chemical properties		
4	pH – (1:2.5 ratio soil : water)	6.53
5	EC (dSm^{-1} 25 °C)	0.13
6	Organic carbon (%) - Walkley and Black method	0.72
7	Available N (kg ha^{-1}) - $KMnO_4$-Oxidizable method	238
8	Available P (kg ha^{-1}) - Bray's no - 1 method	65
9	Available K (kg ha^{-1}) - 1 N Neutral NH_4OAc method	218
10	Available S (mg kg^{-1}) - 1% $CaCl_2$ Turbidimetric method	7.9

Table 2. Weed density (no m^{-2}) as influenced by herbicides, organics and bio-fertilizers in blackgram

Herbicides	Organics and bio - fertilizers											
	20 DAS						40 DAS					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
M_1	4.58 (21.0)	4.54 (20.7)	3.87 (15.0)	3.55 (12.7)	5.00 (25.0)	4.31 (18.9)	7.11 (50.6)	6.96 (48.4)	6.06 (36.8)	5.27 (28.0)	7.83 (61.3)	6.64 (45.0)
M_2	5.06 (25.7)	4.27 (18.8)	4.04 (16.5)	4.50 (20.3)	5.48 (30.1)	4.67 (22.3)	8.37 (70.2)	7.55 (57.0)	7.01 (50.3)	6.80 (46.8)	8.57 (73.8)	7.66 (59.6)
M_3	5.32 (28.4)	4.93 (24.6)	4.35 (19.0)	4.40 (19.4)	5.81 (33.0)	4.96 (25.0)	9.03 (81.8)	8.53 (73.3)	7.32 (53.9)	7.02 (49.4)	9.40 (88.3)	8.26 (69.4)
M_4	2.70 (7.33)	3.02 (9.17)	2.61 (6.83)	2.76 (7.67)	3.74 (14.0)	2.97 (9.00)	4.72 (22.5)	4.23 (18.0)	4.09 (16.7)	4.32 (19.0)	5.86 (34.3)	4.64 (22.0)
Mean	4.41 (20.6)	4.19 (18.4)	3.73 (14.4)	3.89 (15.0)	5.01 (25.7)	4.23 (18.8)	7.31 (56.3)	6.82 (49.2)	6.12 (39.4)	5.86 (35.8)	7.91 (64.4)	6.80 (49.0)
	SEd			**CD (P=0.05)**			**SEd**			**CD (P=0.05)**		
Main plot	0.12			0.30			0.20			0.48		
Sub plot	0.16			0.32			0.24			0.48		
M×S	029			NS			0.46			NS		
S × M	0.30			NS			0.47			NS		

Note:

Main plot

M_1 : PE Pendimethalin 30% EC @ 1 kg ha^{-1} on 3 DAS
M_2 : EPoE Imazethapyr 10% SL @ 50g ha^{-1} on 10 DAS
M_3 : EPoE Quizalofop - p- ethyl 5% EC @ 50g ha^{-1} on 10 DAS
M_4 : Hand weeding on 15 and 30 DAS

Sub plot

S_1 : *Rhizobium* and Phosphobacteria inoculation
S_2 : *Rhizobium*, Phosphobacteria and *AM* fungi
S_3 : S_1 + FYM
S_4 : S_2 + FYM
S_5 : Control

after sowing followed by PE and EPoE herbicides were sprayed on 3 and 10 DAS by using knapsack power sprayer with 500 L ha^{-1} of water. Crop was irrigated for four to five times till harvest by visual observations of crop and field conditions. The weed species were counted in trial plots by using quadrate (0.25 m^2) at four random sites in each plot at 20 and 40 DAS, which expressed in terms of number m^{-2}. Then, weeds were grouped into grasses, sedges and broad leaf weeds based on morphology. Weed dry weight was recorded at 20 and 40 days after sowing, expressed as g m^{-2}. Weeds were pulled out from trial plots, where quadrate was used to record weed population. Weeds were kept in open condition for drying, followed by oven dried until it attains constant weight. An unweeded plot was maintained outside the experimental layout plan, for the purpose of calculating weed control efficiency and to know the predominant weed flora. Weed control efficiency (%) was worked out, [8],

$$WCE\ (\%) = \frac{\text{(Weeds dry weight in control plot – Weeds dry weight in treatment plots)}}{\text{Weeds dry weight in control plot}} \times 100$$

All data were statistically analysed by subjecting with Analysis of Variance (ANOVA) as reported by Panse and Sukhatme (1967). The pooled data of weeds were transformed to square root method (x+0.5) and probability of significant difference made at P≤ 0.05.

3. PLANT OBSERVATIONS

Biometric observation of plant height was carried out at 25, 50 DAS and at harvest. While, dry matter production was recorded after attained constant weight in hot air oven at 65°C on 25 and 50 DAS. Then, yield parameters like pods $plant^{-1}$, seeds pod^{-1}, pod length, 100 grain weight, grain and haulm yield of blackgram were also recorded.

4. RESULTS AND DISCUSSION

Application of PE pendimethalin at before emergence of seedlings and EPoE Imazethapyr and Quizalofop-p-ethyl at 3-4 leaf stage had not shown any adverse effect in terms of germination, yellowing of leaves and leaf injury or change in morphology of leaves in blackgram. But, harmful effects of these herbicide against weeds were discussed below

4.1 Effect on Weed Floral Growth

The weed species identified in experimental field were arranged in the order of broad leaf weeds > grasses > sedges depending upon weed density during crop period. Major weeds species were found in field trials were *Trianthema portulacastrum (*Horse pursulane*), Digera* arvensis (False amaranth)*, Portulaca oleracea (*Purslane)*, Amaranthus viridis (*Slender amaranth)*, Parthenium hysterophorus (*Congress weed)*, Cleome viscosa (*Tick weed) as broad leaf weeds*,* then grasses like as *Echinochola colona (*Jungle rice)*, Echinochola crusgalli (*cockspur) and finally *Cyperus rotundas (*purple nut sedge*)* as sedges*.*

4.2 Effect on Weed Density

Total weed density was influenced by various weed control practices. At 20 and 40 DAS, hand weeding twice at 15 and 30 DAS recorded lowest weed population of 9.00 and 22.0 no m^{-2}, respectively, which was superior over remain chemical weed control methods (Table 2). These results were confirmed by Rajib, 2014 [9]. Among the different herbicides used, pendimethalin 30% EC @ 1 kg ha^{-1} secured last position on decreasing order of weed population of 18.9 and 45.0 no m^{-2} on 20 and 40 DAS, respectively, followed by imazethapyr 10% @ SL 50 g ha^{-1}. This might have happened due to the suppression of weeds at critical growth period and exposure of toxic effects of herbicide. Further, Imazethapyr 10% @ SL 50 g ha^{-1} recorded weed density of 22.3 and 59.6 no m^{-2} followed by treatment of quizalofop-p-ethyl @ 50 g ha^{-1}.

The effect of bio-fertilizers with and without farmyard manure was found to be significant on weed density recorded at 20 and 40 DAS.

4.3 Effect on Weed Dry Weight

During all growth stages, weed management practices showed significant effect on total weed dry weight. At 20 and 40 DAS, minimum weed dry weight of 1.39 and 3.83 g m^{-2} was noticed on hand weeding twice treatment. Among the herbicide weed management practices, PE pendimethalin 30% EC @ 1kg ha^{-1} recorded least weed dry weight accumulation of 2.95 and 8.03 gm^{-2} on 20 and 40 DAS, respectively which caused harmful effect on indeterminate

weeds at early growth period, followed by imazethapyr 10% SL @ 50 g ha^{-1} achieved lower weed dry weight of 3.51 and 9.67 g m^{-2}, respectively (Table 3). PE pendimethalin 30% EC @ 1 kg ha^{-1} reduced weed germination that was predominant factor for reduction of weed dry weight accumulation [10] and inhibiting weeds development at early stages [11]. Higher weed dry weight accumulation of 3.88 and 10.8 g m^{-2} and weed density of 25 and 69.4 no m^{-2} were attributed in quizalofop- p - ethyl 5% EC @ 50 g ha^{-1} on 20 and 40 DAS due to uninterrupted weed growth was observed compared to other weed management practices.

The effect of bio-fertilizers with and without farmyard manure were found to be significant on weed dry matter recorded at 20 and 40 DAS.

4.4 Effect of Weed Control Efficiency

The highest weed control efficiency (74.8%) was registered in hand weeding twice on 15 and 30 DAS [12] (Fig. 1), which was significantly recorded lower weed counts and reduced dry weight until entire crop period, compared over herbicidal practices. However, pendimethalin 1 kg ha^{-1} recorded minimum weed biomass of 8.03 g m^{-2} on 40 DAS, resulted of satisfactory weed control efficiency about 69.7% was achieved than remaining treatments. Similar, results were confirmed by Sharma et al, [13].

Among the treatments of bio-fertilizers with and without FYM application, the treatment received *Rhizobium* + Phosphobacteria +*AM* fungi + FYM had shown one step ahead performance of crop growth under stress conditions. It might be eventuated due to better water status induced by *AM* fungi via stimulating drought inducible genes in standing crop [14], high suppressive of weeds and also improved uptake of macronutrients and micro nutrients, [15].

4.5 Growth Attributes

The effect of different weed management practices on growth parameters i.e., plant height and dry matter production were observed. From the concluded data on 25, 50 DAS and at harvest, pendimethalin 1 kg ha^{-1} was recorded maximum plant height of 14.2, 33.5 and 48.3 cm and plant dry matter of 51.5 and 122 g m^{-2}, respectively (Tables 4,5) which was on par with hand weeding twice on all stages of plant growth and dry matter production at 50 DAS, followed by rest of treatments. The results were confirmed by finding of Khairnar et al, [16,17].

Among the bio-fertilizers with and without FYM, the treatment received *Rhizobium* + Phosphobacteria+*AM* fungi + FYM was recorded maximum plant height of 14.5, 35 and 51.5 cm on 25, 50 DAS and at harvest, respectively.

Table 3. Weed dry weight (g m^{-2}) as influenced by herbicides, organics and bio-fertilizers in blackgram

Herbicides	Organics and bio - fertilizers											
	20 DAS						40 DAS					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
M_1	3.99	3.27	2.13	1.80	3.55	2.95	9.05	8.26	6.94	6.12	9.78	8.03
M_2	4.07	3.09	2.77	3.31	4.28	3.51	11.1	8.65	9.19	7.85	11.6	9.67
M_3	4.46	3.96	3.13	3.04	4.79	3.88	12.7	11.2	8.73	7.85	13.7	10.8
M_4	1.04	1.30	1.18	1.43	1.99	1.39	3.58	3.88	3.40	3.36	4.92	3.83
Mean	3.39	2.91	2.30	2.40	3.65	2.93	9.11	8.00	7.06	6.30	9.98	8.09
	SEd			CD (P=0.05)			SEd			CD (P=0.05)		
Main plot	0.21			0.51			0.35			0.87		
Sub plot	0.23			0.47			0.48			0.97		
M×S	0.46			NS			0.92			NS		
S × M	0.46			NS			0.95			NS		

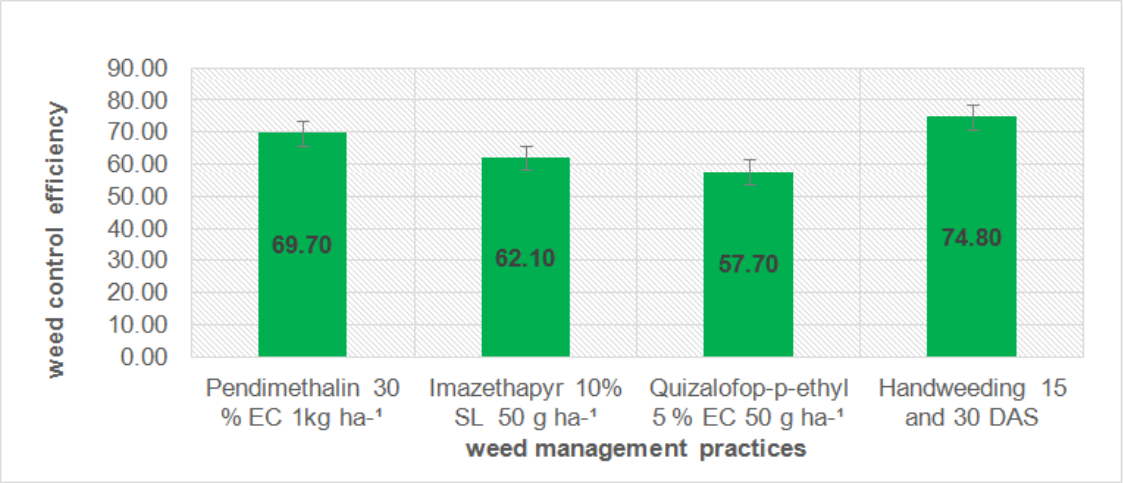

Fig. 1. Effect of weed management practices on weed control efficiency in blackgram

Table 4. Plant height (cm) as influenced by herbicides, organics and bio-fertilizers in blackgram

Herbicides	Organics and bio - fertilizers																	
	25 DAS						50 DAS						At harvest					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
M_1	13.1	13.9	14.6	15.6	13.9	14.2	30.9	33.4	36.2	38.0	29.1	33.5	45.6	48.9	49.7	56.3	40.9	48.3
M_2	12.7	12.9	13.3	14.0	12.1	13.0	28.8	31.4	31.2	34.0	26.9	30.5	40.2	42.8	47.9	48.8	36.4	43.2
M_3	12.4	13.1	13.1	13.7	12.5	12.9	29.7	30.8	31.1	33.0	27.3	30.4	40.9	44.4	43.4	44.2	35.9	41.8
M_4	12.8	13.8	14.3	14.8	12.4	13.6	31.4	32.6	32.6	35.1	28.9	32.1	43.8	47.8	50.4	55.2	40.3	47.5
Mean	12.7	13.4	13.6	14.5	12.7	13.5	30.2	32.1	32.8	35.0	27.8	31.6	42.6	46.0	47.9	51.5	38.4	45.2
	SEd			**CD (P=0.05)**			**SEd**			**CD (P=0.05)**			**SEd**			**CD (P=0.05)**		
Main plot	0.26			0.64			0.59			1.45			0.85			2.07		
Sub plot	0.32			0.66			0.74			1.51			1.34			2.73		
M×S	0.64			NS			1.45			NS			2.68			NS		
S × M	0.63			NS			1.48			NS			2.55			NS		

Table 5. Plant dry matter production (g m^{-2}) as influenced by herbicides, organics and bio-fertilizers in blackgram

Herbicides	Organics and bio - fertilizers											
	25 DAS						50 DAS					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
M_1	47.2	53.2	52.1	62.9	42.1	51.5	124	116	145	148	76.8	122
M_2	40.0	42.7	46.8	47.3	31.4	41.7	92.1	120	114	135	67.9	106
M_3	35.3	41.0	40.3	44.5	29.5	38.1	98.4	103	115	128	66	102
M_4	41.2	47.7	52.7	56.0	33.2	46.3	100	131	123	145	72	114
Mean	41.1	46.1	48.0	52.7	34.0	44.4	104	117	124	139	70.6	111
	SEd			CD (P=0.05)			SEd			CD (P=0.05)		
Main plot	0.75			1.83			3.32			8.14		
Sub plot	1.23			2.51			3.32			6.75		
M×S	2.33			NS			6.80			14.51		
S × M	2.46			NS			6.63			13.51		

Table 6. Number of productive pods plant^{-1} (no) and seeds pod^{-1} (no) as influenced by herbicides, organics and bio-fertilizers in blackgram

Herbicides	Organics and bio - fertilizers											
	No.of productive pods plant^{-1} (no)						Seeds pod^{-1} (no)					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
M_1	20.4	22.4	25.0	24.3	14.9	21.4	5.53	5.74	5.52	6.64	4.16	5.52
M_2	15.2	16.7	21.0	25.3	12.0	18.0	4.67	4.91	5.42	5.91	4.08	5.00
M_3	16.6	18.8	17.9	19.1	11.1	16.7	4.51	5.25	5.28	5.38	4.14	4.91
M_4	19.5	21.2	21.9	23.5	14.5	20.1	4.73	5.72	5.93	6.04	4.02	5.29
Mean	17.9	19.8	21.4	23.1	13.1	19.1	4.86	5.40	5.54	5.99	4.10	5.18
	SEd			CD (P=0.05)			SEd			CD (P=0.05)		
Main plot	0.59			1.44			0.20			NS		
Sub plot	0.68			1.38			0.20			0.40		
M×S	1.35			2.76			0.40			NS		
S × M	1.35			2.85			0.39			NS		

Table 7. Pod length (cm) and 100 grain weight (g) as influenced by herbicides, organics and bio-fertilizers in blackgram

Herbicides	Organics and bio - fertilizers											
	Pod length (cm)						100 grain weight (g)					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
M_1	4.99	5.11	5.19	5.35	4.39	5.01	4.06	4.33	4.84	5.36	4.03	4.53
M_2	4.30	4.28	4.37	5.04	4.27	4.45	3.81	4.17	3.79	4.26	3.59	3.92
M_3	4.09	4.30	4.62	4.67	4.13	4.36	3.73	4.35	4.30	4.51	3.51	4.08
M_4	4.26	4.98	5.12	5.60	4.17	4.83	4.43	4.53	4.78	4.80	3.65	4.44
Mean	4.41	4.67	4.82	5.16	4.24	4.66	4.01	4.35	4.43	4.73	3.69	4.24
	SEd			**CD (P=0.05)**			**SEd**			**CD (P=0.05)**		
Main plot	0.12			0.30			0.12			0.30		
Sub plot	0.11			0.23			0.15			0.30		
M×S	0.24			0.51			0.29			NS		
S × M	0.23			0.47			0.29			NS		

Table 8. Grain and haulm yield (kg ha^{-1}) as influenced by herbicides, organics and bio-fertilizers in blackgram

Herbicides	Organics and bio - fertilizers											
	Grain yield (kg ha^{-1})						Haulm yield (kg ha^{-1})					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
M_1	892	914	952	979	628	873	1310	1380	1426	1524	971	1322
M_2	775	812	813	849	614	773	1138	1213	1240	1312	930	1166
M_3	718	774	760	794	609	731	991	1081	1055	1108	922	1031
M_4	857	872	902	932	636	840	1215	1308	1391	1441	1035	1278
Mean	811	843	857	888	622	804	1163	1245	1279	1346	965	1200
	SEd			CD (P=0.05)			SEd			CD (P=0.05)		
Main plot	18.8			46.1			30.0			73.4		
Sub plot	15.2			30.9			26.8			54.6		
M×S	33.0			71.7			56.6			121.7		
S × M	30.0			61.8			53.6			109.2		

Similarly, higher dry matter production of 52.7 and 139 g m^{-2} was recorded on 25 and 50 DAS, respectively. Rest of treatments recorded superior performance over the control.

4.6 Yield Attributes

The yield parameters have shown significant difference among various weed management practices. pendimethalin 1 kg ha^{-1} has recorded maximum number of productive pods $plant^{-1}$, pod length and 100 grain weight of 21.4 no, 5.01 cm and 4.53 g, respectively, (Tables 6,7) which were being statistically on par with hand weeding twice, followed by remaining treatments. Similar results reported by researcher [17] that was application of pendimethalin @ 1 kg ha^{-1} along with one hand weeding imposed similar performance on pods $plant^{-1,}$ seeds pod^{-1}, grain yield and haulm yield (kg ha^{-1}) as compared with hand weeding on 15 and 30 DAS.

The treatment engaged with *Rhizobium* + Phosphobacteria +*AM* fungi + FYM achieved maximum number of productive pods $plant^{-1}$, pod length and 100 grain weight of 23.1 no, 5.16 cm and 4.73 g, respectively, followed by the treatment received *Rhizobium* + Phosphobacteria + FYM. Subsequently, control expressed inferior performance on yield attributes compared to rest of the treatments. More flowering and grain development while combined form of organics and bio-fertilizers application [18]. Thereafter, phosphorous, macro and micro nutrients had undergone mineralization process during decomposition of farmyard manure as well as availability of adsorbed phosphorous increased through solubilization process induced by organic acid synthesized from organic matter decomposition [19]. Phosphorous solubilizing bio-fertilizer facilitated to mineralization, solubilization and translocation of organic and inorganic phosphorous led to improved availability and uptake of phosphorous by plants [20].

4.7 Grain and Haulm Yield

Yield data were recorded for different weed control treatments (Table 8). The higher grain (873 kg ha^{-1}) and haulm yield (1322 kg ha^{-1}) were recorded in pendimethalin @ 1 kg ha^{-1} applied treatment, which was statistically on par with hand weeding twice [21,22], followed by imazethapyr 50 g ha^{-1} and Quizalofop-p-ethyl 50 g ha^{-1} respectively. Finally, quizalofop-p-ethyl 5% EC recorded least performance on weed suppression during critical stages led to obtained lower grain yield of 731 kg ha^{-1} and haulm yield of 1031 kg ha^{-1}, respectively. More grain and haulm yield reported in blackgram, when pendimethalin applied as pre-emergence on 3 DAS by findings of earlier researchers [23] Further, proper plant growth establishment occurred by effective suppression of weeds at early growth period led to greater number of pods $plant^{-1}$ and grain yield.

Among the bio-fertilizers with and without FYM, the treatment engaged with *Rhizobium* + Phosphobacteria +*AM* fungi + FYM expressed significant performance of higher grain yield (888 kg ha^{-1}) and haulm yield (1346 kg ha^{-1}). It might be due to crop dominance and suffocation of weed at critical growth period [24], followed by treatment of *Rhizobium* + Phosphobacteria + FYM (857 kg ha^{-1} and 1279 kg ha^{-1}) . Remaining treatment showed superior effect over the control. Rhizobium induced root nodules development through symbiosis with blackgram resulted in maximum plant height, no. of pods $plant^{-1}$, grain and haulm yield in blackgram. It might be happened by positive plant-microbes interaction led to enhanced microbial activity and colonization in rhizosphere region. Consequently, nutrient assimilation from deeper layer of soil resulting in more nutrient absorption, increased growth and yield attributes. Earlier researcher [25] found that the treatment received FYM at 4 tonnes per hectare respond properly with blackgram, results of obtained higher yield.

Interaction between herbicide and bio-fertilizers with and without FYM showed significant differences in respect of grain and haulm yield from the data given in (Table 8) it was observed that the combination of M_1S_4 (Pendimethalin @ 1 kg ha^{-1} and *Rhizobium* + Phosphobacteria +*AM* fungi + FYM) recorded maximum grain (979 kg ha^{-1}) and haulm yield (1524 kg ha^{-1}), respectively. Existing studies [26] revealed the combination effect of phosphatic fertilizers, farm yard manure and phosphorous solubilizing bio-fertilizers recorded higher grain and haulm yield due to imposing of synergistic effect among inorganic phosphatic fertilizers, phosphorous solubilizing fertilizer and FYM.

5. CONCLUSION

The results of experiment revealed that application of pendimethalin @ 1 kg ha^{-1} was best alternative weed management practice

which noticed higher yield attributes and yield in blackgram than hand weeding twice. Moreover, *Rhizobium* + Phosphobacteria + *AM* fungi + FYM produced better grain and haulm yield in summer blackgram. It was concluded that combined effect of pendimethalin application on 3 DAS with bio-fertilizer and FYM achieved distinct performance on grain (979 kg ha^{-1}) and haulm yield (1524 kg ha^{-1}).Further, research was needed with special focus to fine tuning the dose and time of application of herbicides along with cost-effective management practices, to enhance the productivity of blackgram in different varieties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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