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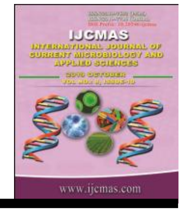

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Performance of Improved Integrated Pest Management (IPM) Technology Component for Enhancing the Productivity of *kharif* Black Gram (*Vigna mungo* L.) under Cluster Front Line Demonstration at Malda, West Bengal, India

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The experiment was conducted at Rukundipur village, Malda, WB, during *kharif* season of 2017-18 and 2018-19. The results showed 11.62-31.07% and 7.25-25.73% yield increase in demonstrated plots over control during respective years. Variety PU-31+seed treatment with *Rhizobium* sp. and PSB@10 g/kg + cow dung manure@750kg/ha, *Trichoderma viridae*@1.5kg/ha and *Pseudomonas fluorescence* @1.5kg/ha + Boron20% @1g/L + Dichlorvos 76% EC @ 1ml/L, Azadirachtin 10,000 ppm @ 1.5ml/L and Yellow Traps @ 15/acre + mixture of Mancozeb 50% and Carbendazim 25% WS @ 2.5gm/L recorded average highest yield (15.00 and 15.51q/ha) during respective years. The same trend was found in gross (Rs. 78456 and Rs. 77594/ha) and net returns (Rs. 63003 and Rs. 62358/ha) and benefit cost ratio (4.08 and 4.09) in T8 during respective years. The extension gap, technology gap and technology index were 2.8 and 2.08q/ha, 2.9 and 2.4q/ha and 17.88% and 15.00% during respective years. It can be concluded that this technology was effective for increasing productivity of Black gram through changing knowledge, attitude and skill of farmers and creating awareness and motivating other farmers to adopt this practice.

Introduction

Pulses on account of their vital role in nutritional security and soil ameliorative properties have been integral part of sustainable agriculture since ages. Developing countries contribute about 74%, among which 25% is shared by India alone in respect of global pulse production (Anonymous, 2011). Output of pulses was 17.06 MT during 2015-16 (Anonymous, 2017). Black gram (*Vigna mungo* L.) known as urd bean or mash kalai or black bean is native of India and the fourth most important pulse crop with high nutritive value (Singh, 2004) and occupies a major position among pulses in Malda district as well as in West Bengal. It consists of good nutritional values of high seed protein (25-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins. In the vegetarian population of the Indian subcontinent it is usually known as "poor man's meat" due to its enriched nutritional values (Chubatemsu and Malini, 2017).It is grown over on an area of 3.10 million hectare with a production of 1.40 million tonnes and yield 451 kg/ha in 2010 in India (Anonymous, 2011). It is a short duration crop and thrives better in all seasons either as sole or as intercrop. It produces about 1.5–1.9 MT of Black gram annually from about 3.5 m ha area, with an average productivity of 600 kg/ha. Black gram output accounts for about 10 per cent of India's total pulse production. It is therefore, necessary to assess the technological gap in production and also to know the problems and constraints in adopting modern Black gram production technologies as observed by Islam *et al.* (2011). Indian Government imports large quantity of pulses to fulfill domestic requirement of pulses. In this regard, to sustain this production and consumption system, the Department of Agriculture, Cooperation and Farmers Welfare had sanctioned the project "Cluster Frontline Demonstrations on Rabi Pulses 2015-16'' to ICAR-ATARI, Hyderabad through National Food Security Mission. This project was implemented by Krishi Vigyan Kendra, Malegaon of Zone-V with main objective to boost the production and productivity of pulses through CFLDs with latest and specific technologies (Khedkar *et al.*, 2017). According to Duraimurugan and Tyagi (2014), the avoidable losses due to pest complex on different varieties of urdbean ranged from 15.62 to 30.96% with an average of 24.03%.The annual yield loss due to the insect pests has been estimated at about 30 per cent in urd bean and mung bean(Gupta and Bhattacharya, 2008).Fungal foliar diseases especially Cercospora leaf spot, web blight and powdery mildew have emerged as the most important ones and have been found causing immense loss in farmers' field (Akhtar*et al*., 2014). Cercospora leaf spot causes 0.0-100.0 per cent yield loss in wet season (Pandey *et al*., 2009). Web blight is responsible for significant yield loss in greengram and blackgram (Saksena and Dwivedi, 1973). Powdery mildew causes 9.0-50.0 per cent yield loss (Reddy *et al*., 2008; Pandey *et al*., 2009). It was revealed that Black Gram responded favorably to seed inoculation with PSB and phosphorus fertilization in influencing seed yield as well as in net return (Gupta and Sharma, 2006). Same trend was followed by Gupta *et al.* (2006) that the practice of seed inoculation with phosphorus-solubilizing bacteria showed a significant increase in seed yield and its attributes as well as protein content and nitrogen and phosphorous uptake over uninoculated treatment. Though many technologies for Black Gram cultivation have been evolved for increasing the productivity but farmers have hardly adopted a few of them and those in a non-scientific manner.Keeping this in view, the present investigation was undertaken to study the level of knowledge of farmers regarding Black Gram cultivation, extent of adoption of improved practices, to find out the yield gap in Black Gram production technology and also to demonstrate the productivity potential and economic benefit of improved technology components under farmers' conditions.

Materials and Methods

Site description

The CFLD on Black gram was conducted at Rukundipur village of Ratua-I Block

(25º13'1.51"N latitude and 87º55'29.02"E longitude), Malda district, West Bengal, India during *kharif* season of 2017-18 and 2018-19. Soil samples were collected from upper 15 cm for analysis of soil properties before basal fertilizers application. In field experiments, the soil was a sandy loam in texture with pH 6.98, Electrical Conductivity 0.42% and Organic Carbon 0.43%. The available Nitrogen, Phosphorus, Potash, Zinc and Boron of the experimental plot were 480.32, 98.07, 213.6 kg/ha and 0.89 and 0.65mg/ha, respectively.

Experimental design

The experiment was laid out in Randomized Block Design (RBD) with nine treatments including control and each treatment was replicated three times. The seed rate of 30 kg/ha was used in 30 cm x 15 cm spacing of variety PU-31. The treatments were as follows:

Time of application

Soil treatment was done with well rotten cow dung manure @ 750 kg/ha, *Trichoderma viridae*@ 1.5 kg/ha and *Pseudomonas fluorescence*@ 1.5 kg/ha 7 days before sowing of seeds. Boron 20% @ 1 g/L and D.A.P. @ 9 kg/ha were sprayed at 25-30 and 35-40DAS, respectively. Azadirachtin 10, 000 ppm was applied at 30 and 45 DASfor Bihar hairy caterpillar and Dichlorvos 76% EC @ 1 ml/L was sprayed at 60 DAS and 75 DAS for Pod borer. Mancozeb 50% + Carbendazim 25% WS @ 2.5 gm/L was applied at 50 DAS and 65 DAS for Cercospora leaf spot and Powdery mildew. All the insecticides and fungicides were applied with sticker @ 0.5 ml/L. Installation of Yellow Sticky Trap @15 traps/acre was done at 25-30 DAS for management of white fly causing Yellow Vein Mosaic Virus and the traps will continue up to the maturity of the crop. The experiment was conducted in RBD with 3 replications. The experimental plot was 5m x 5m size and the crop was grown on a row spacing of 30cm. All the sprayings were done using knapsack sprayer at an interval of 15 days. The data was collected from 10 randomly selected plants from each experimental plot. All the data on growth attributes were collected at peak growing stage i.e. at 45 DAS. Yield attributes were collected at maturity stage (85 DAS). The data were analyzed using statistical tools (Gomez and Gomez, 1984).

Percent yield increase over control =

$$\frac{\text{Demonstration yield} - \text{Control yield}}{\text{Demonstration yield}} \times 100$$

The extension gap, technology gap and the technology index were work out with the help of formulas given by Samui *et al.*, (2000) as mentioned below:

Extension gap = Demonstration yield-farmers' yield (control)

Technology gap = Potential yield-demonstration yield

$$\text{Technology index (\%)} = \frac{\text{Technology gap}}{\text{Potential Yield}} \times 100$$

Results and Discussion

Effect on growth attributes

The perusal of the data (Table 1 and 2) indicated that the maximum increase in growth attributes like no. of branches/plant (19.07, 19.83), no. of nodules/plant (29.27, 31.23), no. of pods/m^2 (266.50, 267.87) and no. of seeds/pod (10.63, 11.67) of *kharif* Black gram were found statistically significant due to Seed treatment + Soil Treatment + Micronutrient spray + Insect Management + Disease Management during 2017-18 and 2018-19, respectively. The application of T8 i.e. seed treatment with mixture of *Rhizobium* sp. and PSB @ 10 g/kg + soil treatment with well rotten cow dung manure @ 750 kg/ha, *Trichoderma viridae* @ 1.5 kg/ha and *Pseudomonas fluorescence* @ 1.5 kg/ha + micronutrient spray with Boron 20% @ 1 g/L + insect Management with Dichlorvos 76% EC @ 1 ml/L, Azadirachtin 10, 000 ppm (Phytonim) @ 1.5 ml/L and installation of Yellow Sticky Trap @ 15 traps/acre + disease Management with Mancozeb 50% + Carbendazim 25% WS @ 2.5 gm/L produced maximum growth during both years. However, it was found statistically at par with the treatments of T7 and T6 in respective years. The no. of branches/plant (17.17, 16.03, 15.90, 16.33, 14.10, 14.53, 14.67 and 6.47), no. of nodules/plant (27.77, 25.60, 25.40, 25.70, 24.63, 25.77, 24.77 and 13.03), no. of pods/m^2 (260.37, 241.03, 237.47, 236.03, 219.63, 22.20, 215.13 and 167.87) and no. of seeds/pod (9.73, 7.83, 7.57, 7.37, 6.93, 7.53, 7.07 and 5.33) were recorded in T7, T6, T5, T4, T3, T2, T1 and control plots during 2017-18, respectively. During 2018-19, the treatments of T7, T6, T5, T4, T3, T2, T1 and control plots exhibited the no. of branches/plant (16.87, 16.00, 15.63, 15.27, 14.13, 13.83, 13.27 and 6.42), no. of nodules/plant (30.60, 27.27, 26.60, 25.90, 25.27, 25.37, 24.00 and 12.10), no. of pods/m^2(265.40, 243.73, 243.80, 242.97, 22.23, 222.47, 215.93 and 168.90) and no. of seeds/pod(10.83, 10.13, 7.80, 7.53, 7.33, 6.87, 7.27 and 4.03), respectively. Biswas *et al.* (2015) observed that Rhizobium + PSB produced significantly taller plants (40.0 cm) and maximum dry matter accumulation (114.78 g/m^2) in lentil. Similar results i.e. significantly improved plant height, dry matter accumulation per plant, number of pods per plant, highest branches and pod per plant were recorded in crop receiving PSB+VAM inoculation at twice spraying of homo-brassinolide at pre-flowering and pod development stage of lentil as experimented by Bera*et al.* (2013).Inoculations of PSB which are known to produce growth hormones (Sattar and Gaur, 1987) are likely to favorably increase plant height. These results are in agreement with the earlier findings of Mukherjee and Rai (2000)in lentil and Biswas*et al.* (2008) in urdbean. It was observed that the seed treatment with bio-fertilizer viz. *Rhizobium* and PSB helped for supply of appropriate quantity of nitrogen and phosphorus nutrients for better root ramification and higher nodulation which is more important in pulse productivity as compared to the control plot (Mandal and Mondal, 2018).

Effect on yield attributes and yield

It was observed that different yield components of Blackgram like dry weight of shoots (497.16, 481.35 g/m^2) and test weight i.e. 1000 seed weight (39.09, 41.39g) were found significantly higher during respective years with the application of T8 (Table 1 and 2). However, T7 and T6 were found statistically at par with T8. The dry weight of shoots (487.32, 424.43, 419.42, 410.57, 403.05, 408.13, 404.24 and 303.03 g/m^2) and test weight i.e. 1000 seed weight (36.68, 36.20, 36.08, 34.92, 34.60, 33.93, 33.96 and 25.12 g) were observed in T7, T6, T5, T4, T3, T2, T1 and control plots during 2017-18, respectively. During 2018-19, the dry weight of shoots (463.70, 429.51, 423.28, 421.15, 406.39, 405.87, 401.42 and 298.98 g/m^2) and test weight i.e. 1000 seed weight (38.07, 37.22, 36.35, 35.54, 33.31, 35.41, 32.99 and 25.80 g) were recorded in T7, T6, T5, T4, T3, T2, T1 and control plots, respectively. Similarly, the significantly highest seed yield (15.00, 15.51q/ha) was obtained by application of bio-fertilizers, micronutrient, microbial pesticides and proper IPM packages in the treatment T8 followed by T7 and T6. The yield of the treatments in T7, T6, T5, T4, T3, T2, T1 and control plots were 14.04 and

14.11, 13.99 and 13.82, 13.14 and 13.63, 12.83 and 13.42, 11.88 and 13.23, 12.51 and 12.63, 11.70 and 12.42, 10.34 and 11.52 during 2017-18 and 2018-19, respectively. The per cent increase of yield over control was noticed as 31.07% and 25.73% during 2017-18 and 2018-19, respectively. The per cent increase of yield over control were 26.35% and 18.36% in T7, 26.09% and 16.64% in T6, 21.31% and 15.48% in T5, 19.41% and 14.16% in T4, 12.96% and 12.93% in T3, 17.35% and 8.79% in T2, 11.62% and 7.25% in T1 during respective years. Similar type of results was obtained by Mandal and Mondal (2018) in summer Black gram that the maximum increase in growth attributes, yield, net returns and BC ratio were found with the application of Urea+SSP+Biofertilizer+Sea weed extract treatment. The mixture of *Rhizobium* sp. and PSB and soil treatment with well rotten cow dung manure, *Trichoderma viridae* and *Pseudomonas fluorescence* were common treatment in all the cases. The result may be due to the appropriate supply of key nutrient phosphorus for increasing pod formation, seed formation, seed size and ultimately seed yield. Alabadan *et al.*, (2009) also observed that use of organic manures alone or in combination with chemical fertilizers, helps in improving physico-chemical properties of the soil and improves the efficient utilization of applied fertilizers resulted in higher seed yield and quality. Further, it stimulates the activity of micro-organisms that makes the plant to get the macro and micronutrients through enhanced biological processes, increase nutrient solubility. It was also observed by Biswas *et al.* (2015) that Rhizobium + PSB produced significantly maximum seed yield (709.10 kg/ha), stalk yield (1363.30 kg/ha) and harvest index 33.99% at harvest than other biofertilizers treatments. Combined effect of 60 kg ha P_2O_5+ Rhizobium +PSB produced significantly higher grain yield (1024.30 kg/ha) and phosphorous uptake by grain (5.32kg/ha) in lentil. Increase in grain yield of lentil by seed inoculation with PSB has also been reported by Bera *et al.* (2013).

Economics of cultivation

The selling price of Black gram of Rs. 39.00 per kg (local market rate) was considered while calculating the economics. It was observed (Table 3) that maximum gross and net monetary returns i.e. Rs. 78456/- and Rs. 63003/-ha were found in T8 during 2017-18 and Rs. 77594/- and Rs. 62358/-ha during 2018-19. In control plots, gross and net monetary returns were Rs. 49367/- and Rs. 36980/-ha during 2017-18 and Rs. 37265/- and Rs. 26941/-ha during 2018-19.Benefit cost ratio were 4.08 and 4.09 in T8 and 2.99 and 2.61 in control during 2017-18 and 2018-19, respectively. The highest pooled gross return, net return and BC ratio were also observed in T8 (Rs. 78025/-, 62681/- and 4.08, respectively) and lowest in control (Rs. 43316/-, 31961/- and 2.80, respectively).The pooled gross return, net return and BC ratio were Rs. 63919/-, Rs. 49225/- and 3.35 in T7; Rs. 62595/-, Rs. 48041/- and 3.30 in T6; Rs. 58582/-, Rs. 44681/- and 3.21 in T5; Rs. 57987/-, Rs. 44197/- and 3.20 in T4; Rs. 53602/-, Rs. 40783/- and 3.18 in T3; Rs. 51939/-, Rs. 39333/- and 3.12 in T2 and Rs. 48586/-, Rs. 36441/- and 2.99 in T1, respectively.

Extension gap

Extension gap means the differences between demonstration plot yield and farmers yield. The extension gap were 2.8 q/ha and 2.08 q/ha during 2017-18 and 2018-19, respectively (Table 4). On an average extension gap under two years of CFLD programme was 2.44q/ha which emphasized the need to educate the farmers through various extension means i.e. frontline demonstration for adoption of improved production and protection technologies, to revert the trend of wide extension gap.

Table.1 Effect of different technology component/treatments on growth, yield component and yield of *kharif* Black gram var. PU-31 during 2017-18

Treatment	No. of branches/plant	No. of nodules/plant	Dry weight of shoots (g/m^2)	No. of pods/m^2	No. of seeds/pod	Test Weight i.e. 1000 seed wt (g)	Yield (q/ha)	% yield increase over control
T1	14.67	24.77	404.24	215.13	7.07	33.96	11.70	11.62
T2	14.53	25.77	408.13	222.20	7.53	33.93	12.51	17.35
T3	14.10	24.63	403.05	219.63	6.93	34.60	11.88	12.96
T4	16.33	25.70	410.57	236.03	7.37	34.92	12.83	19.41
T5	15.90	25.40	419.42	237.47	7.57	36.08	13.14	21.31
T6	16.03	25.60	424.43	241.03	7.83	36.20	13.99	26.09
T7	17.17	27.77	487.32	260.37	9.73	36.68	14.04	26.35
T8	19.07	29.27	497.16	266.50	10.63	39.09	15.00	31.07
Control	6.47	13.03	303.03	167.87	5.33	25.12	10.34	-
SEM ±	0.36	0.47	1.34	1.55	0.35	0.58	0.26	-
CD at 5%	1.07	1.43	4.02	4.67	1.04	1.74	0.80	-

Table.2 Effect of different technology component/treatments on growth, yield component and yield of *kharif* Black gram var. PU-31 during 2018-19

Treatment	No. of branches/plant	No. of nodules/plant	Dry weight of shoots (g/m^2)	No. of pods/m^2	No. of seeds/pod	Test Weight i.e. 1000 seed wt (g)	Yield (q/ha)	% yield increase over control
T1	13.27	24.00	401.42	215.93	7.27	32.99	12.42	7.25
T2	13.83	25.37	405.87	222.47	6.87	35.41	12.63	8.79
T3	14.13	25.27	406.39	220.23	7.33	33.31	13.23	12.93
T4	15.27	25.90	421.15	242.97	7.53	35.54	13.42	14.16
T5	15.63	26.60	423.28	243.80	7.80	36.35	13.63	15.48
T6	16.00	27.27	429.51	243.73	10.13	37.22	13.82	16.64
T7	16.87	30.60	463.70	265.40	10.83	38.07	14.11	18.36
T8	19.83	31.23	481.35	267.87	11.67	41.39	15.51	25.73
Control	6.42	12.10	298.98	168.90	4.03	25.80	11.52	-
SEM ±	0.253	0.492	1.064	0.836	0.198	0.274	0.23	-
CD at 5%	0.765	1.489	3.216	2.529	0.598	0.828	0.696	-

Table.3 Effect of demonstration technology components on economics of *kharif* Black gram cultivation during 2017-18 and 2018-19

Treatment	Average cost of Cultivation (Rs/ha)			Average Gross return (Rs/ha)			Average Net Returns (Rs/ha)			B:C ratio		
	2017-18	2018-19	Pooled data	2017-18	2018-19	Pooled data	2017-18	2018-19	Pooled data	2017-18	2018-19	Pooled data
T1	12544	11745	12145	52548	44623	48586	40004	32878	36441	3.19	2.80	2.99
T2	12645	12567	12606	53724	50154	51939	41079	37587	39333	3.25	2.99	3.12
T3	12945	12693	12819	55475	51728	53602	42530	39035	40783	3.29	3.08	3.18
T4	13856	13723	13790	63217	52756	57987	49361	39033	44197	3.56	2.84	3.20
T5	13976	13826	13901	63876	53287	58582	49900	39461	44681	3.57	2.85	3.21
T6	14734	14374	14554	66540	58649	62595	51806	44275	48041	3.52	3.08	3.30
T7	14925	14463	14694	68375	59463	63919	53450	45000	49225	3.58	3.11	3.35
T8	15453	15236	15345	78456	77594	78025	63003	62358	62681	4.08	4.09	4.08
Control	12387	10324	11356	49367	37265	43316	36980	26941	31961	2.99	2.61	2.80

Table.4 Production of performance Black gram var. PU-31 under CFLD programme during 2017-18 and 2018-19

Year	Average yield (q/ha)		% increase over farmer's practice	Extension gap (q/ha)	Technology gap (q/ha)	Technology index (%)
	Demonstration	Farmer's practice				
2017-18	13.14	10.34	21.31	2.8	2.9	17.88
2018-19	13.60	11.52	15.29	2.08	2.4	15.00
Average	13.37	10.93	18.3	2.44	2.65	16.44

Potential yield = 16 q/ha

Technology gap

The technology gap means the differences between potential yield and yield of demonstration plot. The technology gap was found 2.9 q/ha and 2.4 q/ha during 2017-18 and 2018-19, respectively (Table 4). On an average technology gap under two years CFLD programme was 2.65 q/ha. The technology gap observed may be attributed to dissimilarity in the soil fertility status, crop production practices and local climatic situation.

Technology index

Technology index indicates the feasibility of the evolved technology in the farmers' fields. Lower the value of technology index, more is the feasibility of technology demonstrated (Sagar and Chandra, 2004; Arunachalam, 2011 and Kumar *et al.*, 2014). As such reduction of technology index from 17.88per cent (2017-18) to 15.00 per cent (2018-19) exhibited the feasibility of technology demonstrated (Table 4). Similar yield enhancement in different crops in front line demonstration has amply been documented by Haque (2000), Mishra *et al.*, (2009) and Kumar *et al.,* (2010). On an average technology index was observed 16.44 per cent during the two years of CFLD programme, which showed the efficacy of good performance of technical interventions. This will accelerate the adoption of demonstrated technical intervention to increase the yield performance of black gram.

It can be concluded that among the different technology component/ treatments on growth, yield component and yield of *kharif* Black gram var. PU-31,T8 i.e. Seed treatment with mixture of *Rhizobium* sp. and PSB 1 X 10^7 CFU/g@ 10 g/kg +Soil treatment with well rotten cow dung manure @ 750 kg/ha, *Trichodermaviridae*2 x 10^6 CFU/g @ 1.5 kg/ha and *Pseudomonas fluorescence*2 x 10^6 CFU/g @ 1.5 kg/ha + Micronutrient spray with Boron 20% @ 1 g/L+ Insect Management with Dichlorvos 76% EC @ 1 ml/L, Azadirachtin 10, 000 ppm (Phytonim) @ 1.5 ml/L and Installation of Yellow Sticky Trap @ 15 traps/acre + Disease Management with Mancozeb 50% + Carbendazim 25% WS @ 2.5 gm/L treatment produced higher yield and benefits in *kharif* Blackgram cultivation and also maintained soil fertility satisfactorily under old alluvial soil of Malda district of West Bengal. The productivity achieved under CFLD over farmers' practices created awareness and motivated the other farmers to adopt critical innovations for Blackgram cultivation viz., seed treatment, soil treatment, integrated pest management and other technology of Black gram in the district. Therefore, the treatment of T8 is to be suggested for commercial cultivation of Black gram for getting higher yield with maximum net returns per unit area.

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