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Enhancing Productivity of Blackgram through drip Fertigation

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ABSTRACT: Blackgram is mostly grown under rainfed situation and due to the uneven distribution of rainfall; the crop faces moisture stress during the critical stages of their life cycle. Drip fertigation is one of the best available options to increase productivity with less quantity of water and judicious use of fertilizer input. In this regards, field experiments were conducted at Tamil Nadu Agricultural University to evaluate the effect of drip fertigation with Water-Soluble Fertilizer (WSF) on the yield and economics of blackgram cultivation. Blackgram, being a short-duration pulse crop, is widely cultivated under rainfed conditions in sub-marginal land. It results in low productivity. To enhance the productivity of blackgram, study was proposed to evaluate drip fertigation with WSF and straight fertilizer on yield, water use efficiency and net returns in blackgram. The result revealed that 75 per cent yield increment was observed in blackgram with drip fertigation of 100 percent recommended dose of fertilizer through water soluble fertilizer compared to surface irrigation with conventional method of fertilizer application. The same treatment also gave higher net return of Rs. 43132 /ha with benefit cost ratio of 1.98. Hence, it might concluded that drip fertigation of 100% RDF through WSF enhances the productivity and profitability of blackgram.

Keywords: Drip fertigation, Water soluble fertilizer, Blackgram, WUE, Economic efficiency.

INTRODUCTION

Pulses are widely cultivated in rainfed situations. Due to the frequent failure of monsoon rain, and uneven distribution of rainfall during the cropping period, the water requirements of the crop does not meet. Besides this crops also faced moisture stress during the critical stages of the crop growth period. Being a short duration nature pulses can fit into any cropping system. In Tamil Nadu pulses are cultivated in an area of 8.24 lakh ha with a productivity of 648 kg /ha. Pulses are cultivated in sub-marginal land without any proper nutrient management, growing as catch crops or intercrop owing to low productivity in pulses. Efficient management of water is of utmost importance for sustaining and enhancing agricultural production. While there is demand to bring more area under assured irrigation, availability of water for irrigation is expected to diminish in coming years due to competing demand for other uses. As compared to surface water, a greater proportion of irrigation water comes from the groundwater, and this source is increasingly being exploited in an unscientific manner. Thus the importance of scientific water management and the need to adopt advanced techniques such as drip irrigation to enhance productivity and water-use efficiency of field crops became imperative (Palanisami *et al.,* 2012). In addition to other management practices such as irrigation and plant protection, blackgram respond markedly to précised application of plant nutrients especially when applied in balanced amount and at appropriate time (Ayyadurai *et al.,* 2017). Drip fertigation is one of the best options to increase productivity with less amount and judicious use of water and nutrient. Drip fertigation help to increase in branches/plant, nodule/plant, pods/plant which ultimately increases the yield (Harcini *et al*., 2020). While the pulses are cultivated as inter crop in irrigated conditions or as a pure crop in a rainfed situation, the concept of drip fertigation not be adopted in short-duration pulse crops.

To enhance pulses productivity in a sustainable manner, the cultivation of pulses as pure crop under irrigated condition is warranted. Blackgram is highly susceptible to both water stress and water logging throughout its growing period. So water management becomes the most indispensable factor for the productivity of black gram. Drip fertigation is one of the effective methods to increase the use efficiency of two major key inputs *viz.,* water and nutrient. Drip fertigation allows frequent and uniform distribution of water and nutrients, it is an efficient and agronomically sound method of providing water and nutrient directly to the active root zone of the crop. The fertigation system maximises crop water and nutrient uptake while minimising nutrient leaching. The drip irrigation with 80% pan evaporation at five days interval and fertigation with either MAP or phosphoric acid as a source of phosphorus could be recommended for improving the productivity of green gram under sodic soil condition. Hence, an experiment has been conducted to assess the effect of drip fertigation with

water soluble fertilizer on growth, yield and economics of blackgram cultivation.

MATERIALS AND METHODS

The study was conducted at the Department of Pulses, Tamil Nadu Agricultural University, Coimbatore during the *kharif* season of 2018-19 and 2019-20.The experiment consisted of four treatments *viz.,* T_1 – Drip fertigation of 100 % N & K through straight fertilizer and P as a basal soil application, T_2 – Drip fertigation of 75% RDF through Water Soluble Fertilizer, T_3- Drip fertigation of 100 % RDF through Water Soluble Fertilizer (WSF), and T_4- Surface irrigation with a basal application of 100 % RDF and replicated five times. RDF adopted for Blackgram was 25:50:25 kg NPK/ ha. Urea, Single Super Phosphate, and Muriate of potash were used as sources of conventional fertilizer for N, P & K, respectively. Urea, Mono Ammonium Phosphate (MAP), and Sulphate of Potash were sources for N, P, and K respectively.

Raised bed with furrow formed at the size of 90cm bed width and 30 cm furrow width (Fig. 1 and 2). An inline lateral was placed on the centre of the raised bed so that maintained the lateral spacing of 120 cm. Blackgram variety CO 7 (75-80 days duration) was sown with a seed rate of 20 kg /ha during the first week of June and harvested during the third week of August during both years of experimentation. The seed was treated with *Rhizobium* and Phosphobacteria each @ 30 g /kg of seed. Treated seeds are dibbled at a spacing of 30 × 10 cm in such a way to accommodate 4 rows per bed.

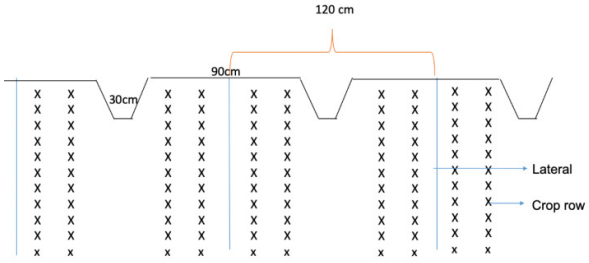

Fig. 1. Schematic representation of Raised bed system.

Fig. 2. Experimental Field View during vegetative growth of blackgram.

Treatment was imposed as per the standard method. In T_1 100 % Phosphorus was applied as basal and N and K were given through drip fertigation with urea and white KCl (0:0:60 NPK). In treatment T_2 and T_3, fertigation was given through water soluble fertilizers viz. urea (46% N), mono ammonium phosphate (12:61:0 NPK), and sulphate of potash (0:0:50 NPK) in 8 splits at an interval of six days, out of which during the vegetative growth period (0-20 DAS) 60% N, 80% P and 20% K in three splits and 40% N, 10% P, and 40% K in three splits at 21-40 DAS (flowering stage). The remaining 10% P and 40% K in 2 splits at 41-55 DAS (Pod formation stage). Fertigation was stopped at 55 DAS. Weeds were controlled by spraying pendimethalin + imazethapyr (valor 32) @ 3liter /ha as pre-emergent on 3DAS followed by one hoeing on 25-30 DAS. The entire quantity of fertilizer (100% N, P, K) was applied as basal in treatment T_4. Drip fertigation was given once in three days at the vegetative stages and once in 6 days at the reproductive stage (flowering and pod formation stage) as per the treatment schedule. Pulse wonder was applied @ 5 kg/ha at flowering stage. One hand weeding and pest and disease management adapted to control sucking pests and pod borer.

The crop growth and yield parameters were recorded. Crop water requirement was calculated by using the weather parameters of 100 % PET and effective rainfall during the cropping period.

Water Use efficiency and Nutrient Use Efficiency. Water Use efficiency (WUE) and Nutrient Use Efficiency (NUE) were calculated as per the formula given in standard method.

$$\text{Water Use Efficiency} = \frac{\text{Yield (kg /ha)}}{\text{Consumptive use of water (mm)}}$$

$$\text{Nutrient Use Efficiency} = \frac{\text{Yield (kg/ha)}}{\text{Kg of fertilizer appplied}}$$

Data collection. The observation on plant height, number of primary branches, number of clusters /plant, number of pods/ plant, number of seeds /pod, and seed yield was recorded. At physiological maturity, the above-ground portion was harvested manually and

dried in direct sunlight for 3-4 days. After that, it was threshed with a tractor and winnowed manually to separate seeds. The yield from each plot was weighed and expressed as kg /ha. The water supplied through surface irrigation and drip irrigation was recorded and summed up to quantify the total amount of irrigation water applied during the crop growth period.

Statistical analysis. For each measured or computed parameter, an analysis of variance was carried out by the following method described by Gomez and Gomez (1984).

RESULT

Effect on growth and yield attributes. The pooled data regarding the growth and yield contributing characteristics of black gram revealed that drip fertigation significantly influenced the plant height, number of primary branches per plant, number of pods per plant, number of seeds per pod, and 100 seed weight. Drip fertigation of 100 % RDF through Water Soluble Fertilizer (WSF) recorded the highest values for all these parameters. Closely followed b drip fertigation of 75% RDF through WSF.

However, the lowest values for all the growth and yield contributing characteristics were recorded in surface irrigation with the conventional method of fertilizer application (T4). Split application coupled with a readily available form of nutrients through fertigation increases the plant height and the number of branches per plant at 30 DAS and 60 DAS which might be due to readily available and enhanced uptake of nutrients leading to expansion of leaves, enhanced photosynthesis, and translocation of nutrients to the reproductive parts as compared to the basal application of nutrient combined with surface irrigation. These results were similar to the findings of Vanishree *et al.* (2019) who reported that a higher number of pods and seed yield were recorded with drip fertigation of recommended N and P_2O_5 in five splits using water soluble fertilizers.

Application of 100 % recommended dose of NPK through water-soluble fertilizer recorded a higher number of pods/plant (82), a number of seeds /pod (6.2), and 100 seed weight (5.3g) and showed its significance over drip fertigation with conventional fertilizers and surface irrigation with the basal application of fertilizers.

The substantial increase in the number of pods /plant and number of seeds/pod due to 100 % RDF through WSF than lower levels and conventional fertilizers was associated with the increased availability of nutrients enhanced the various growth parameters *viz.,* plant height, number of primary branches, functional leaves and its subsequent translocation to sink. The cumulative effect of these growth parameters finally improved the number of pods/plant, its length and filling percentage, 100 seed weight because of the ability of the black gram crop to produce and support more number of pods /plant and a number of seeds/ pod depends on photosynthates production and its translocation to sink. Enhanced availability and uptake of nutrients under 100 % recommended nutrient dose with WSF leads to enhanced production of photosynthesis and its translocation to reproductive parts as compared to conventional fertilizer and its application method (through drip and soil). A significantly lower number of pods /plant (49.4) and the number of seeds /pod (5.6) were recorded in conventional methods of irrigation and fertilizer application (T_4) than in drip fertigation treatments might be due to single-time application of 100 % recommended dose of nutrients as basal leads to leaching of nutrients and variation in available moisture content between two successive irrigation with lower nutrient uptake. A similar result was also reported Manikandan and Sivasubramanian (2014).

Table 1: Effect of drip fertigation on growth and yield component of black gram.

Treatment	Plant height (cm)	No. Primary branches	Number of pods/plant	Number of seeds/pod	100 seed weight (g)
T_1 -DF of 100 % N & K through straight fertilizer and P as a basal	49.5	5.5	66.2	6.9	5.2
T_2 - DF of 75% RDF through WSF	49.4	5.2	70.4	7.1	5.2
T_3 - DF of 100% RDF through WSF	51.1	5.7	82.1	7.4	5.3
T_4-SI with basal application of 100% RDF	47.2	4.6	49.4	6.1	5.0

(DF - Drip Fertigation, RDF - Recommended Dose of Fertilizer, WSF -Water Soluble Fertilizer, SI - Surface Irrigation)

Grain yield and harvest index. Pooled data of two years presented in Table 2 showed, that drip fertigation of 100 % RDF through WSF had recorded a significantly higher seed yield of black gram (1324 kg /ha) and followed by drip fertigation of 75 % RDF through WSF. Fertigation of all nutrients in different splits with water-soluble fertilizer during the crop growth period had significant responses in seed yield of black gram drip fertigation coupled with conventional fertilizers and soil surface application of water and nutrients. The lowest seed yield of 769 kg /ha was recorded in surface irrigation with a basal application of fertilizer which might be due to losses of nutrients through leaching, volatilization, and fixation on soil colloids in a conventional method of fertilizer application. Further, it's also coupled with lesser availability of nutrients during the reproductive period. Drip fertigation of 75 % recommended nutrient dose with WSF registered comparable yield with 100 % RDF during 2019-20 and 2020-21 and pooled of two years also showed similar trends. The increased yield in drip fertigation treatment might be due to balanced availability of nutrients throughout the cropping period, reduction in losses of nutrients through volatilization and leaching, application of easily available forms of nutrient directly to the rhizosphere region, and also

better movement of nutrients under drip irrigation as against soil application of fertilizer. Drip fertigation of 100% and 75% RDF had 75 and 50 percent more yield, respectively than surface irrigation and basal application of fertilizers. Better crop growth influenced the yield attributes favourably at drip fertigation with a water-soluble fertilizer. The increases in yield might be due to a better proportion of soil –water – air which was maintained throughout the crop growth period in drip fertigation compared conventional method of water and fertilizer application. Increased seed yield under drip fertigation might be due to enhanced availability of nutrients and moisture and its increased absorption by the crop coupled with the frequent supply of nutrients by fertigation and consequent better formation and translocation of assimilates from source to sink. This finding was in conformity with the findings of Vimalendran and Latha (2016); Praharaj *et al.* (2016).

The methods of fertilizer application significantly influenced the harvest index. The highest harvest index of 28.04 percent was registered in drip fertigation of 100 % RDF with WSF followed by 75 % RDF through drip fertigation with WSF. This result indicated that the harvest index increased the availability of nutrients and enhanced the efficient utilization of biomass for conservation in seed yield.

Table 2: Effect of drip fertigation on seed yield and harvest index of blackgram.

Treatment	Seed yield (kg /ha)			Harvest index		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1 -DF of 100 % N & K through straight fertilizer and P as basal	987	1025	**1006**	29.93	26.13	27.03
T_2 - DF of 75% RDF through WSF	1145	1137	**1141**	29.41	22.88	26.14
T_3 - DF of 100% RDF through WSF	1285	1363	**1324**	30.09	25.99	28.04
T_4 - SI with a basal application of 100% RDF	769	749	**759**	23.81	19.89	21.85

(DF - Drip Fertigation, RDF - Recommended Dose of Fertilizer, WSF -Water Soluble Fertilizer, SI - Surface Irrigation)

Water Use Efficiency and Nutrient Use Efficiency.

The important tool to assess the productivity of crops per unit of water utilized is water use efficiency. The data shown in Table 3 revealed that a higher WUE of 4.70 kg /ha mm was registered with the application of 100 % RDF through drip fertigation with water-soluble fertilizer followed by 75 % RDF through drip fertigation. The lowest level of WUE of 1.96 kg/ha mm was noticed where water was given through the surface method with soil application of conventional fertilizer. This might be due to the conventional method more amount of water was consumed to produce less yield compared to all drip fertigation treatments. All major nutrients *viz.,* N, P, and K applied through drip fertigation had distinct flowering and podding as evident from higher WUE with 100 % RDF through water-soluble fertilizer. Markedly higher WUE was recorded with drip fertigation of 100 % RDF with WSF than 100 % RDF with conventional fertilizer in drip and soil method of application because of timely and adequate amount of water and nutrient availability and their interaction might have simulated the early growth and increased yield components.

Maximum Nutrient Use efficiency (NUE) was observed in drip fertigation treatments as compared to soil application of fertilizer with surface irrigation. The NUE was considerably increased in drip fertigation with WSF compared to drip fertigation with conventional fertilizer. A higher NUE of 15.2 kg /kg of nutrient applied was recorded with 75% RDF followed by 100%RDF. This might be due to the frequent application of N, P, K combined with readily available forms along with irrigation water to the rhizosphere of the crop directly. Further, uniform distribution of nutrients in the root zone with minimum leaching of nutrients away from the root zone also contributed to increased NUE. These findings are in accordance with the findings of Praharaj *et al.* (2014); Kakade *et al.* (2020).

Table 3: Effect of drip fertigation on economics of black gram cultivation.

Treatment	COC (Rs./ha)	GMR (Rs./ha)	NMR (Rs./ha)	BCR	Economic efficiency	WUE (kg / ha mm)	NUE (kg /kg ha
T_1 -DF of 100 % N & K through straight fertilizer and P as basal	35773	65726	29953	1.84	399	3.58	10.1
T_2 - DF of 75% RDF through WSF	40933	72728	31795	1.77	424	4.08	15.2
T_3 - DF of 100% RDF through WSF	43362	86494	43132	1.98	575	4.70	13.2
T_4 - SI with a basal application of 100% RDF	30017	49294	19277	1.65	257	1.96	7.6

(DF - Drip Fertigation, RDF - Recommended Dose of Fertilizer, WSF -Water Soluble Fertilizer, SI - Surface Irrigation, COC- Cost of Cultivation, GMR – Gross Monetary return, NMR – Net Monetary Return, BCR – Benefit Cost Ratio)

Fertigation at 100 per cent recommended dose of N, P, K through water soluble fertilizer registered the maximum GMR (Rs. 86494 ha^{-1}) and NMR (Rs. 43132 ha^{-1}) when pooled over two years being comparable with values of 75 percent fertigation of N, P and K (Table 3). The fertigation of 100 percent recommended

dose of NPK ha^{-1} registered 123 percent increase in NMR to 100 percent soil application of N, P, and K through the conventional method with surface irrigation. The similar trend was observed in the B:C ratio. The data presented in Table 3 indicated that drip fertigation of 100 % N, P, and K through water soluble fertilizers also improved the economic efficiency (net returns per day) in blackgram and higher economic efficiency (Rs. 575 day^{-1} ha^{-1}) was noticed with drip fertigation with water soluble fertilizer (100 % RDF) followed by drip fertigation of 75% RDF through Water Soluble fertilizer.

CONCLUSION

In blackgram**,** low productivity mainly due to cultivation under rainfed condition. To enhance blackgram productivity in a sustainable manner, its cultivation under irrigated condition is highly warranted. The available water for agrarian purpose has been highly used for cultivation of cultivation of high value commercial crops. Hence, effective irrigation strategies may help to achieve maximum productivity with minimum water. This study result revealed that drip fertigation of 100 percent recommended dose of fertilizer through water soluble fertilizer had 75 per cent yield increment over surface irrigation with conventional method of fertilizer application along with high WUE of 4.70 kg/ha mm. The economics also higher with this treatment (net return of Rs. 43132 /ha and benefit cost ratio of 1.98). Hence, it might concluded that drip fertigation of 100% RDF through WSF enhances the productivity and profitability of blackgram.

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Conflict of Interest. None.

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