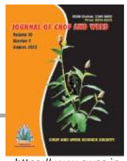
Journal of Crop and Weed, 19(2): 52-56 (2023)

ISSN- O : 2349 9400 ; P : 0974 6315



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Impact of drip fertigation effect on yield and economics of blackgram

*S. ANITTA FANISH AND S. PANNERSELVAM

Department of Agronomy, Pulses
Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Received : 20.01.2023 ; Revised : 08.02.2023 ; Accepted : 15.02.2023

DOI : https://doi.org/10.22271/09746315.2023.v19.i2.1702

ABSTRACT

Field experiments on drip fertigation in blackgram were conducted at Department of Pulses, Tamil Nadu Agricultural University to assess the influence of fertigation of 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 submarginal land. It results in low productivity. Result revealed that 75 per cent yield increment was observed in blackgram with drip fertigation of 100 percent Recommended Dose of Fertilizer (RDF) through WSF compared to surface irrigation basal application of fertilizer. The same treatment also gave higher water use efficiency of 4.70 kg/ha mm, net monetary returns of ¹ . 43132 /ha with benefit cost ratio (BCR) of 1.98 while higher nutrient use efficiency of 15.2 kg /kg of fertilizer had been recorded with drip fertigation of 75 % RDF through water soluble fertilizer. Hence, it might have concluded that drip fertigation of 100% RDF through WSF enhances the yield and profitability in blackgram.

***Keywords**:* Blackgram, drip fertigation, economic efficiency, water soluble fertilizer, WUE, NUE, yield

Pulses are widely cultivated in rainfed situations. Due to the frequent failure of monsoon rain, and uneven spreading of rainfall during the crop growth period, the crop water requirement 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. Pulses are cultivated in 8.24 lakh ha area with a productivity of 648 kg /ha in Tamil Nadu.

To enhances 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 waterlogging 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 agronomically sound and an efficient method for providing water and nutrient directly to the active rhizosphere region of the crop.

MATERIALS AND METHODS

The field experiments were carried out in Department of Pulses farm Tamil Nadu Agricultural University, Coimbatore on 2018-19 and 2019-20 during *kharif* seasons. 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, 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. In treatment T_4 Urea (46% N), Single Super Phosphate (SSP – 16% P), and Muriate of Potash (MOP -60% K) were used as sources of fertilizer for N, P & K, respectively. For treatment T_2 and T_3 all nineteen (19:19:19), Mono Ammonium Phosphate (MAP 12% N & 60% P), and Sulphate of Potash (50%K) were used as water soluble fertilizers for N, P, and K respectively where as in treatment T_1 urea and MOP for drip fertigation of N &K and Single Super Phosphate for basal application of P.

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 center of the raised bed so that maintained the lateral spacing of 120 cm. Blackgram variety CO 7 was sown with a seed rate of 20 kg /ha on first week of June and harvested on 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 30 x 10 cm spacing in such a way to accommodate 4 rows per bed.

**Email: anittasolomon@tnau.ac.in*

How to cite : Fanish, S. A. and Pannerselvam, S. 2023. Impact of drip fertigation effect on yield and economics of blackgram. *J. Crop and Weed*, 19(2): 52-56.

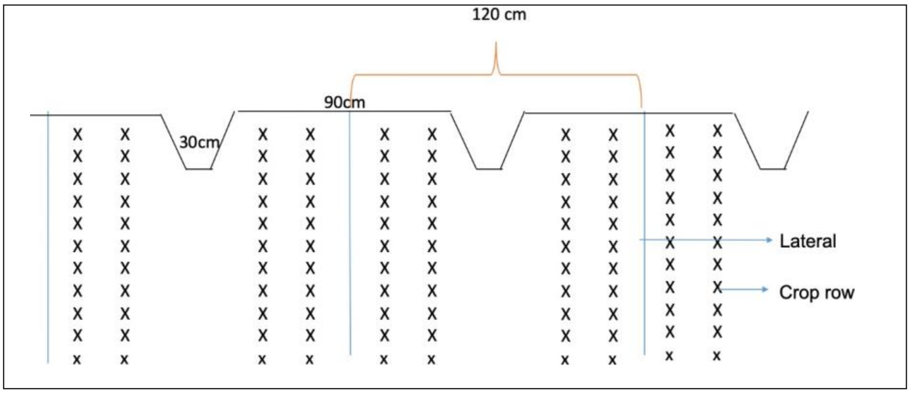

Fig .1 : Schematic representation of Raised bed system

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 one day before sowing and N and K through drip fertigation with urea and MOP. In treatment T_2 and T_3, fertigation with water soluble fertilizers in 8 splits at once in 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 (from bud initiation to pod development stage) as per the treatment schedule. Pulse wonder was applied @ 5 kg/ha at flowering stage. One hand weeding and to control sucking pests and pod borer thiomethaxam 25% WG @ 100 g ha^{-1} and chlorantraniliprole 18.5 SC @ 150ml ha^{-1} respectively were sprayed. The crop growth and yield parameters were recorded. Calculate the crop water requirement by using weather parameters *viz.*, 100 % PET and effective rainfall during the cropping period.

Water Use Efficiency (WUE) and fertilizer Use Efficiency (NUE)

Calculated the Use efficiencies of water and fertilizer as per the formula given in standard method.

$$\text{Water Use Efficiency (kg ha mm}^{-1} = \frac{Yield\ (kg/ha)}{Consumptive\ use\ of\ water\ (mm)}$$

$$\text{Fertilizer Use Efficiency (kg kg}^{-1}) = \frac{Yield\left(\frac{kg}{ha}\right)}{Kg\ of\ fertilizer\ applied}$$

Data collection

The observation on growth and yield parameters *viz.,*plant height, number of primary branches, number of clusters /plant, number of pods/ plant, and number of seeds /pod were 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 seed 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 quantity of irrigation water supplied during the crop cultivation period. In surface method, irrigation was given immediately after sowing followed by life irrigation of 5 cm depth, thereafter irrigation was given as per the IW/CPE ratio of 0.5. Irrigation through drip was applied on the basis of Pan Evaporation method by calculating ETc (Crop evapotranspiration) which was estimated from the following formula; ETc = ETo x Kc; where ETo is reference evapo-transpiration and Kc is crop coefficient (covering crop aspects of a weed and disease free crop including stage of crop growth and ground coverage). Irrigation to blackgram through drip system was applied once in three days, the amount being equal to 1.0 times of ETc.

Statistical analysis

Field experiment was laid out in Randomized block design with five repslication. For each measured or computed parameter, an analysis of variance was found out by the method described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Yield attributes and yield

The pooled data on the growth and yield contributing characteristics of black gram revealed that drip fertigation significantly influenced the plant height, number of primary branches / plant, number of pods / plant, number of seeds / pod, and 100 seed weight. Fertigation of 100 % RDF through WSF (T_3) recorded the highest values for all these parameters and closely followed by fertigation of 75% RDF through WSF (T_2).

However, the lowest values for all the growth and yield contributing characteristics were recorded in surface method of irrigation with the basal application of fertilizer (T_4). Split application coupled with a readily available form of nutrients *via* fertigation increases the height of plant and the number of branches / plant at 30 DAS and 60 DAS of observation which might be due to readily available and increased nutrients uptake leading to expansion of leaves, improved photosynthesis, and translocation of nutrients to flower buds and developed pods as compared to the basal application of nutrient combined with surface irrigation. Similar result was reported by Vanishree *et al.,* (2019) .

Treatment in which supply of NPK (100% RDF) through WSF recorded 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 pods number /plant and seeds count /pod due to 100 % RDF through WSF than lower levels and conventional fertilizers was associated with the increased availability of nutrients enhanced the growth of crop which was exhibit through taller plant with more number of primary branches, functional leaves and its subsequent translocation to sink. The cumulative effect of these growth parameters finally improved the yield attributes *viz.,* pod count / plant, pod length and its filling percentage, 100 seed weight because of the ability of the black gram crop to produce and support more pods /plant and 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 less number of pods /plant (49.4) and seeds /pod (5.6) were observed in conventional methods of irrigation and fertilizer application (T_4) than in 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 soil moisture content between two successive irrigation with lower nutrient uptake. A similar result was also reported b Manikandan and Sivasubramanian (2014).

Pooled data presented in Table 1 showed, that significantly higher seed yield of 1324 kg ha^{-1} in blackgram was recorded in treatment T_3 (fertigation of 100 % RDF through WSF) and followed by fertigation of 75 % recommended dose 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 surface application of water and nutrients. The lowest per ha seed yield of 769 kg 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 the year 2019 and 2020 and pooled data 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

Table 1 : Effect of drip fertigation on growth and yield component of black gram (Pooled)

Treatment	Plant height (cm)	No. primary branches	Pods count plant^{-1}	Seed count plant^{-1}	100 seed weight (g)	Seed yield (kg ha^{-1})	Harvest index (%)
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	1006	27.03
T_2 - DF of 75% RDF through WSF	49.4	5.2	70.4	7.1	5.2	1141	26.14
T_3 - DF of 100% RDF through WSF	51.1	5.7	82.1	7.4	5.3	1324	28.04
T_4 - SI with basal application of 100% RDF	47.2	4.6	49.4	6.1	5.0	759	21.85
SEm(±)	**0.71**	**0.2**	**3.0**	**0.16**	**0.2**	**56.4**	**-**
LSD (0.05)	**1.65**	**0.5**	**8.4**	**0.4**	**NS**	**135.0**	

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

Table 2: Effect of drip fertigation on economics of black gram cultivation

Treatment	COC (Rs. ha^{-1})	GMR (Rs. ha^{-1})	NMR (Rs. ha^{-1})	BCR	Economic efficiency	WUE (kg ha^{-1} mm)	FUE (kg ha^{-1})
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)

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. As compared to application of water and fertilizer in soil surface, application of these inputs through drip fertigation helps to provide a better proportion of water - soil- air which was maintained during the entire period of crop growth. Also enhanced availability of nutrients and moisture and its increased absorption by the roots coupled with the frequent supply of nutrients by fertigation and subsequent formation and translocation of potosnthathes from source to sink leads to increased seed yield in drip fertigation treatments. This finding was in conformity with the reports of Vimalendan and Latha (2016) and 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. It may be due to efficient utilization of biomass for conservation in seed yield under drip fertigation with water soluble fertlizer.

Water Use Efficiency and Fertilizer Use Efficiency

Water Use Efficiency is the important indices to evaluate the productivity of crops per unit of water used. The data shown in Table 2 revealed that a higher WUE of 4.70 kg /ha mm was registered with the application of 100 % RDF *via* drip fertigation of water-soluble fertilizer followed by fertigation of 75 % RDF. Higher water use efficiency in drip irrigation treatments is attributed to higher yields accompanied by saving of irrigation water (26 per cent) as compared to surface method of irrigation. (Rajak *et al*., 2006: Singh M and Singh Bhati A 2018). The lowest level of WUE of 1.96 kg/ha mm was noticed where water was given through the surface method with basal application of straight 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 supplied *via* 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 moisture and nutrient availability and its interaction might have enhanced the early growth and increased yield components. Same results in maize was reported by Fanish *et al.* (2011)

Maximum Fertilizer Use efficiency (FUE) was observed in fertigation treatments as compared to basal application of fertilizer with surface irrigation. The FUE was considerably higher in fertigation with WSF when compared to 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 through the irrigation directly near to crop rhizosphere directly. Further, uniform distribution of nutrients in the root zone with reduced leaching of nutrients away from the root zone also contributed to increase FUE. These results are in accordance with Praharaj *et al.* (2014) and Kakade *et al.* (2020) findings. As reported by Haoru Li et al (2021) drip fertigation can synchronize the water and nutrient supply with crop demand, offering the potential for enhanced water use efficiency and nutrient use efficiency.

Fertigation of 25:50:25 kg N, P, K /ha (100 per cent recommended dose) through water soluble fertilizer registered the maximum GMR (` 86494 ha$^{-1}$) and NMR (` 43132 ha^{-1}) when pooled over two years being comparable with values of 75 percent fertigation of N, P and K. (Table 5). Fertigation of a 100 percent recommended dose of NPK ha^{-1} registered 123 percent increase in NMR to 100 percent basal application of N, P, and K through the conventional method with surface irrigation. The similar trend was observed in the B: C ratio. The derived data (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 (` 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.

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