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Crop Establishment Methods and Moisture Mitigation Practices in Rice Fallow Blackgram for Productivity Enhancement in Cauvery Delta Zone of Tamil Nadu

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ABSTRACT

Background: With extensive adoption of mechanised harvest in paddy, the population of blackgram in the rice - blackgram relay cropping system is drastically affected due to the chain traverse by combine harvester. This has emerged as another major abiotic stress in addition to moisture stress at flowering stage of the crop, which resulted in poor yield.

Methods: The studies were conducted during post rainy seasons of 2015-16 to 2017-18. with six treatments *viz*., T_1 - Sowing blackgram by broadcasting 7-10 days prior to manual harvest of paddy, T_2 - Sowing blackgram by no till seed drill on the day of harvest of paddy, T_3 - Sowing blackgram by broadcasting 4-6 days prior to harvest of paddy by combine harvester, T_4-T_1 + Life saving irrigation with mobile sprinkler once at 30-35 DAS, T_5-T_2 + Life saving irrigation with mobile sprinkler once at 30-35 DAS, T_6-T_3 + Life saving irrigation with mobile sprinkler once at 30-35 DAS.

Result: The results indicated that higher grain yield of 875 kg ha^{-1} was obtained with blackgram sown 7-10 days prior to manual harvest of paddy plus life saving irrigation on 30-35 DAS with mobile sprinkler using farm pond water, which was 31.6% higher than that of blackgram sowing with no till seed drill. The study also indicated that farm pond dug at an area of 100 m^3 would be sufficient to irrigate 1 ha of blackgram through mobile sprinkler once at flowering stage (30-35 DAS by which the net return could be increased by ` 61416 ha^{-1}.

Key words: Blackgram, Combined harvest, Farm pond, Life saving irrigation, Rice fallow, Seed drill.

INTRODUCTION

The Cauvery Delta Zone of Tamil Nadu has a total land area of 1.45 million ha, which is equivalent to 11% of the Tamil Nadu state area. In rotations with only one rice crop per year, long-duration rice (155-165 days) is grown from August to January, which is followed by blackgram as a relay crop normally grown under no-tillage conditions using the residual moisture and nutrients in the soil (Dobermann *et al*., 2004). In this zone, rice fallow pulses are cultivated in December-January which contributes a major share (>40%) to pulse production in the state (Ramanathan, 2000). In Cauvery Delta Zone alone, blackgram and greengram occupy an area of 1.76 lakh ha under rice fallow pulse cropping system. The yield realized under rice fallow blackgram ranged from 300 to 500 kg ha^{-1} which is low compared to the potential yield under irrigated conditions (Umamageswari *et al*., 2019).

The productivity of rice fallow blackgram is generally very low due to various biotic and abiotic stresses, poor crop management practices and socio-economic constraints (Behra *et al*., 2014). Soil and water are the two major limiting factors which lead to low productivity in rice fallow blackgram. Since irrigation is withdrawn 10-15 days before the harvest of rice crop, the moisture content in the soil decline rapidly with advancement of crop period. Especially from the second fortnight of February due to rise in temperature, the crop faces drought during flowering and pod formation stages which eventually resulted in poor yield.

If irrigation water is available, one light irrigation at pre flowering stage *i.e*., 30-35 days after sowing would be helpful in evading the terminal moisture stress and augment the grain yield in rice fallow pulses (Gupta *et al*., 2016). However flood irrigation is not advisable as the inundation of water in the cracked deep clayey soil would results in wilting of pulses. Hence life saving supplemental irrigations through mobile sprinklers with the use of stored water would be a viable strategy to increase the productivity in rice fallow situations (Gupta *et al*., 2016).

Maintenance of adequate plant population is a prerequisite to maximise returns from rice fallow pulse cultivation. Manual broadcasting 7-10 days prior to harvest of paddy at waxy soil moisture condition is the conventional practice (Ramesh *et al*., 2016). Uneven germination, population and distribution of plants are the common constraints associated. Unlike manual harvest, machine

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harvesting of paddy damages the establishing pulse plants due to the trampling effect of wheels on field traverse. With wider adoption of mechanised harvesting, it has emerged as a major abiotic stress in rice fallow cultivation. Under such circumstances, strategies should be worked out to improve crop productivity which should compensate the yield loss from the damaged crop. Hence to overcome the confronting issues, the present study was conducted to evaluate a moisture stress mitigating and crop establishment methods to increase the rice fallow blackgram productivity.

MATERIALS AND METHODS

Field experiment was conducted for 3 years during the post rainy season of 2015-16, 2016-17 and 2017-18 (December -March) at Tamil Nadu Rice Research Institute, Aduthurai (11°01′ N, 79°48′ E, 19.5 m altitude). The study area is characterized by a tropical climate with distinct wet and dry seasons with annual rainfall of 1169.4 mm. The experiment was conducted in randomized block design (RBD) with six treatments *viz*., T_1 - Sowing blackgram by broadcasting 7-10 days prior to harvest of paddy, T_2 - Sowing blackgram by No till seed drill on the day of harvest of paddy , T_3 - Sowing blackgram by broadcasting 4-6 days prior to harvest of paddy by combine harvester, T_4-T_1 + Life saving irrigation with mobile sprinkler once at critical stage, T_5-T_2 + Life saving irrigation with mobile sprinkler once at critical stage, T_6-T_3 + Life saving irrigation with mobile sprinkler once at critical stage. The treatments were replicated thrice. Soil of the experimental site was clayey soil with a pH 7.6, low in organic carbon (0.20%) and medium in available nitrogen (278 kg ha^{-1}), high in available phosphorus (32 kg ha^{-1}) and medium in available potassium (320 kg ha^{-1}). The blackgram variety ADT 3 was used as a test crop.

A manual drawn single row seed drill (IIPR prototype) was employed to place the seeds in the manually harvested fields with an inter row spacing of one feet apart (T_2). The sowing was taken up immediately after the harvest of paddy to avoid soil moisture loss. Seeds fell continuously into a V shaped furrow (7.5 cm depth) opened by the disc type wheel of the seed drill. A farm pond with a dimension of 15 m (Length) × 7 m (Breadth) × 2 m (Depth) was dug before the onset of monsoon to harvest the rainwater near the experimental field. The storage capacity was 210000 liters of water (210 m^3). The effective storage was only 50% in the month of February when the irrigation was done (105000 litres). Thus, even after the cessation of North east monsoon, the water harvested and stored in the farm pond was sufficient for life saving irrigation. The portable mobile sprinkler was used to irrigate the crop in which the discharge rate was 80 liters/minute and for life saving irrigation with mobile sprinkler once at 30-35 DAS, 1,00,000 lakh litres of water was utilized to irrigate 1 ha cm depth, The data on growth and yield attributes were observed at the time of harvest. The seed yield was measured as total yield per plot and transformed to kg ha^{-1}. Assessments on soil profile moisture depletion were calculated with gravimetric method taking soil cores at 0-5, 5-10 and 10-15 cm on the day of sowing, 30 DAS, 45 DAS and at harvest. The data were analyzed statistically as per the method suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth and yield attributes

The data on growth and yield attributes of blackgram (Table 1) indicated that the plant population per unit area differed for different crop establishment methods. The plant population/m^2 (32 plants) was significantly highest with sowing of blackgram by broadcasting 7-10 days prior to manual harvest of paddy, which was however comparable with sowing of blackgram by broadcasting 4-6 days prior to harvest of paddy with combine harvester. The crop establishment was poor with the no till seed drill sown on the day of paddy harvest. The results further indicated the residual moisture was lost rapidly under seed drill sown blackgram due to the deep furrow opened by the seed drill during sowing. This would have ultimately resulted in poor germination and establishment of blackgram. Similar to population/unit area, the plant height was also highest with sowing of blackgram by broadcasting 7-10 days followed by lifesaving irrigation on 30-35 DAS (29.3 cm). The microclimatic condition provided by the standing rice crop would have improved the growth of blackgram in the early stages and as a result, taller plants were observed with the particular treatment. Subsequently the life saving irrigation given on 30-35 DAS through mobile sprinkler increased the plant height in all the three crop establishment methods though it was non-significant. In seed drill sown blackgram, since the blackgram seeds were sown only after the harvest of paddy crop, the delay in establishment would be the reason for shorter plants under this treatment. Amuthaselvi *et al*. (2019) also observed that the plant population per unite area was higher in broadcasting method as compared to seed drill sown in rice fallow blackgram.

Sowing of blackgram by broadcasting 7-10 days before the manual harvest of paddy followed by lifesaving irrigation on 30-35 DAS had the highest number of pods/plant (20.6); however it was onpar with other two crop establishment methods followed by life saving irrigation. The number of pods per plant did not vary among the different crop establishment methods as even lesser population per unit area had favoured the per plant yield parameters. The reason might be due to less competition between the plants where the feeding zone per plant was more. No significant variation among the different treatments was observed for number of seeds per pod.

Grain yield

Different crop establishment methods and life saving irrigation at critical stages significantly altered the grain yield of blackgram (Table 1). Sowing of blackgram by broadcasting 7-10 days before the manual harvest of paddy followed by life saving irrigation on 30-35 DAS produced higher grain

Table 1: Growth, yield parameters and yield of black gram as affected by different crop establishment and moisture stress mitigation methods under rice fallow (Mean of three years).

Treatments	Plant population/ m^2	Plant height at harvest (cm)	No. of Pods/ plant	No. of Seeds/ pod	100 seed weight (g)	Yield (kg/ha)
T_1 - Sowing blackgram by broadcasting 7-10 days prior to harvest of paddy	31	29.3	17.2	6.0	4.97	618
T_2 - Sowing blackgram by No till seed drill on the day of harvest of paddy	22	24.8	16.4	5.6	4.55	457
T_3 - Sowing blackgram by broadcasting 4-6 days prior to harvest of paddy by combine harvester	28	27.4	16.2	6.0	4.94	598
T_4 - T_1 + Life saving irrigation with mobile sprinkler using farm pond water once at critical stage	32	31.4	20.6	7.4	5.89	875
T_5 - T_2 + Life saving irrigation with mobile sprinkler using farm pond water once at critical stage	22	25.9	18.8	6.8	4.68	594
T_6 - T_3 + Life saving irrigation with mobile sprinkler using farm pond water once at critical stage	28	28.8	20.2	7.2	5.89	844
S.Em±	2	1.5	1.2	0.9	0.04	53
CD (P = 0.05)	4	3.2	2.5	NS	0.10	112

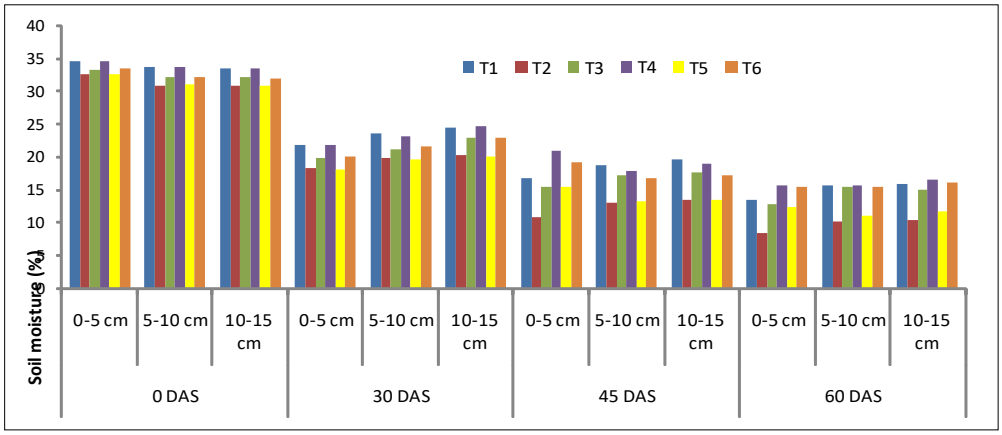

Fig 1: Soil moisture depletion (%) at different intervals as influenced by crop establishment methods and moisture mitigation practices.

yield of 875 kg ha^{-1}, which was 32.1% higher than blackgram sown with seed drill followed by life saving irrigation. However it was onpar with sowing of blackgram by broadcasting 4-6 days before the harvest of paddy with combine harvester followed by life saving irrigation. The optimum population maintained and moisture availability for a longer period due to earlier sowing in the blackgram sown 7-10 days before the harvest of paddy and life saving irrigation at 50 per cent flowering stage had resulted in more number of pods per plant and 100 seed weight. High grain yield due to more of pods per plant was also earlier reported by Ramesh *et al*. (2016) in rice fallow blackgram and Subrahmaniyan *et al*. (1999) and Kalaiselvan *et al*., (2001) in groundnut.

Soil moisture content

The moisture percentage on the day of sowing black gram ranged from 32.78 to 34.76 % in 0-5 cm depth, 31.02 to 33.83% in 5-10 cm depth and 30.91 to 33.68% in 10-15 cm depth across the treatments (Fig 1). The moisture level at surface layer (0-5 cm) was highest as compared to subsurface layer due to the last irrigation impounded for paddy crop. Among the different treatments, irrespective of the depth, the soil moisture was highest with blackgram sown 7-10 days before the manual harvest of paddy on the day of blackgram sowing (34.76%). However on 45 DAS, the soil moisture at the surface layer was highest with blackgram sown 7-10 days before the manual harvest of paddy followed by lifesaving irrigation on 30-35 DAS (20.89%). Moisture content was comparable with blackgram sown 4-6 days before the harvest of paddy with combined harvester followed by lifesaving irrigation on 30-35 DAS (19.26%). The life saving micro sprinkler irrigation to a depth of 10 mm would have improved the soil moisture content at the surface layer though it did not influence the moisture content in the sub surface layer to a greater extent. Senthil Kumar *et al*. (2018) also observed increase in soil moisture due to sprinkler irrigation in blackgram. Irrespective of the days of observation and depth, the lowest soil moisture was

Table 2: Economics of rice fallow blackgram as affected by different crop establishment methods and moisture stress mitigation methods (Mean of three years).

Treatments	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ ha)	BCR
T_1 - Sowing blackgram by broadcasting 7-10 days prior to harvest of paddy	14235	37080	22845	2.60
T_2 - Sowing blackgram by No till seed drill on the day of harvest of paddy	16186	27420	11234	1.69
T_3 - Sowing blackgram by broadcasting 4-6 days prior to harvest of paddy by combine harvester	14235	35880	21645	2.52
T_4 - T_1 + Life saving irrigation with mobile sprinkler using farm pond water once at critical stage	15487	52500	37013	3.39
T_5 - T_2 + Life saving irrigation with mobile sprinkler using farm pond water once at critical stage	17438	35640	18202	2.04
T_6 - T_3 + Life saving irrigation with mobile sprinkler using farm pond water once at critical stage	15487	50640	35153	3.27

observed with balckgram sown with the seed drill due to the V shape furrow opened during the sowing, which paved way for rapid depletion of moisture as compared to other treatments.

Economic analysis

Blackgram sown 7-10 days before the manual harvest of paddy followed by lifesaving irrigation on 30-35 DAS had the highest net return (`37013 ha$^{-1}$) and BCR of 3.39 (Table 2), which was closely followed by blackgram sown 4-6 days before the harvest of paddy with combined harvester followed by lifesaving irrigation on 30-35 DAS (`35153 ha^{-1} and 3.27). The additional net return obtained by one life saving irrigation at flowering stage ranged from `6968 ha$^{-1}$ to `14168 ha^{-1}. The net return and BCR was lowest with blackgram sown with seed drill either with life saving irrigation or without life saving irrigation in the respective group of treatments.

Thus, sowing of blackgram 4-6 days before the harvest of paddy with one life saving irrigation with micro sprinkler on 30-35 DAS by utilizing the water harvested in the farm pond would result in similar yield that of blackgram sown 7-10 days before the manual harvest of paddy followed by one life saving irrigation with micro sprinkler on 30-35 DAS.

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