Original Research Article

Source-Sink Alterations in Rice Fallow Adaptive Blackgram Variety ADT3 for Enhancement of Yield and Quality of Seed

ABSTRACT

Seed Production of rice fallow blackgram variety, ADT3 has limitations due to inherent issues of soil fertility, climate change and thermo sensitivity results in poor flowering, reduced pod setting and poor seed filling. Macro and micro nutrients application during critical stages of growth were tried to improve the seed yield and quality in rice fallow blackgram variety ADT3. The foliar spraying schedule on 15th (Vegetative phase), 30th(Reproductive phase), 45th (Flowering and pod formation phase) days after germination improved the growth and seed parameters viz., plant height, number of branches, number of pods per plant, number of seeds per pod, filled seed % which resulted in increased seed yield in rice fallow blackgram variety, ADT3. Response of macro and micro nutrients through foliar mode revealed the lack of soil fertility resulting in poor uptake of macro and micro nutrients. Foliar application induced uniform flowering and synchronous maturity of pods with least shattering which would facilitate mechanical harvesting. Foliar application of macro and micro nutrients phenotypically altered the source-sink which greatly influenced the yield of seed, germination and seedling quality parameters.

Keywords: Rice fallow pulses, Cauvery Delta Zone, Foliar spray, Macro and micro nutrients, Poor seed filling, Soil Fertility, Relay cropping, Zero tillage

1. INTRODUCTION

Rice fallow pulses cultivation is an important and traditional cropping pattern of Cauvery Delta Zone (CDZ) of Tamil Nadu. Rice fallow pulses are being cultivated in 2.5-3.5 lakh ha in CDZ annually with varying levels of productivity (Blackgram: 450-550 kg/ha, Greengram: 350 kg/ha). The area under rice fallow pulses is diminishing trends recently due to change in climate pattern and farmers' preference towards rice crop cultivation during summer (Raju et al., 2020). Rice fallow pulses cultivation has tremendous potential as it fulfils more than 60% of the pulses production of the state. Rice fallow blackgram is cultivated in an area of 3.1 lakh ha in CDZ. One week Prior to harvesting of samba rice crops with moist soil conditions, the seeds are broadcast (12-15 kg per acre. During manual or mechanical harvesting, the seeds are being pressed in the moist soil which enables germination of seeds after the harvest of paddy crop. Sometimes, seeds are dibbled immediately after the mechanical harvest of paddy without field preparation. The seeds germinate, grow, develop and attain maturity in zero tillage (no intercultural operations) and low/no input application conditions (minimal sprays of plant protection and foliar nutrients). Rice fallow blackgram cultivation in CDZ is the classical example of relay cropping followed in the state without field preparation. Relay cropping has many advantages viz., conservation of soil and water, low inputs requirements for the crop production, nutrients replenishment, improving the microbial activity and diversity, improvement of soil fertility, and crop diversification (Kandasamy and Kuppusamy, 2007; Tanveer et al., 2017). Area under cultivation of pulses in rainfed and irrigated conditions is in decreasing trends due to various factors such as climate change, socio economic issues and poor yield (Narendrakumar et al., 2016). Rice fallow blackgram cultivation is proven to increase pulse production and an important cropping method for protein security of the nation (Satyanarayana et al.,1997; Ghosh et al., 2010; Pretty and Zareen, 2014; NFSM, Govt of India, 2020). However, lack of unavailability of good quality seeds during January month is the limiting factor for cultivation of rice fallow blackgram in CDZ. Poor seed yield of rice fallow blackgram variety ADT3 is attributed to various factors such as poor population, poor nutrients management, moisture stress during growth and development, poor pod setting percentage and improper filling of seeds. ADT3 blackgram variety is very popular among farmers of the CDZ zone due to its adaptive advantages (Shanmugasundaram et al., 1993; Kandasamy and

Kuppusamy, 2007). It is the only adapted variety of blackgram under rice fallow cultivations in CDZ with wider adaptability in all four districts viz., Thanjavur, Mayiladuthurai, Thiruvarur and Nagapattinam with varying levels of soil fertility and salinity. It is drought tolerant, high yielding and has excellent battering quality suitable for idli making. ADT3 was a pureline selection from Tirunelveli local released during 1983 from Tamil Nadu Rice Research Institute, Tamil Nadu Agricultural University, Aduthurai and recommended for the rice fallow cultivation in CDZ. Even after 4 decades of its release, it has been in cultivation for its adaptive advantages as a relay crop as the establishment, growth and development is a complex process and normal blackgram varieties are not performing well under rice fallow conditions. ADT3 is thermo and photosensitive and performs well during December-January sowing in CDZ. Timely availability of good quality seeds during january month will increase the area under cultivation of rice fallow blackgram in CDZ. Like any other pulse crops, rice fallow blackgram has source sink imbalances resulting in poor yield and it needs systematic interventions to normalize the source sink imbalances to promote both vegetative growth followed by reproductive growth to synchronize the flow of nutrients from vegetative regions to developing seeds (Mahala et al., 2001; Shashikumar et al., 2013; Smith et al., 2018). Role of micro nutrients in pulse crop through soil application studied. Micro nutrients like sulphur, zinc and Fe were studied on seed yield and nutritional quality (Jha and Warentin, 2020). But combined application of macro and micro nutrients on yield and quality of seeds have not been studied yet. This study aimed to increase the seed yield and improve the seed quality of rice fallow blackgram variety, ADT3 through foliar application of macro and micronutrients at critical stages of growth.

2. MATERIALS AND METHODS

2.1 Sowing

Rice fallow blackgram variety, ADT3 was dibbled manually in the harvested rice fields during January 2022. Genetically pure seeds obtained from Breeder seeds production Unit, TRRI, Aduthurai were chosen for raising the crop. Seeds are treated with imidacloprid (10 ml per kg of seeds) by continuous mixing and shade dried to prevent the white flies infestation and spread of yellow mosaic virus.

2.2 Plant protection measures

Prophylactic sprays of combinations of acephate+imidacloprid (2 g per liter) was done on 10th days after sowing to prevent white flies infestations and spread of YMV. During pod formation stage, combination of systemic fungicide (axoystrobin+debuconoxole, 2 ml per liter) was sprayed to prevent pre and post harvest infection of seed borne pathogens

2.3 Foliar spraying schedules and treatments

water soluble macronutrients (NPK(19:19;19), MAP(11:52) and micronutrients (Chelated mixture of Fe 2.5%, Mn 1.0%, Zn 3.0%, Cu 1.0%, Mo 0.1% and B 0.5%) were used in combination in this study. They were sprayed at the concentration of 0.5 % and 0.2% respectively. The foliar spray schedules were imposed on 15, 30, 45 days after sowing to coincide with the critical stages of growth of rice fallow blackgram. The treatment details given in Table 1.

2.4 Estimation of seedling parameters

Seeds collected from different treatments were soaked in water for 4 hours in respective containers and shade dried. They were sown in trays filled with fine sand. 100 seeds per tray were sown. The trays were covered with bigger plastic trays for three days and they were exposed to room temperature and light. They were maintained for 15 days till the observations on germination percentage, shoot length and root length were taken.

2.5 Statistical analysis

R statistical package was utilized to analyze the RBD design. The treatments were divided into five with four replications in RBD. Analysis of variances was performed for traits under study with different treatments imposed. Duncan multiple range test was performed to study the critical differences of individual traits on treatments.

3. RESULTS AND DISCUSSION

The results of the effect of foliar spraying schedules using macro and micronutrients (foliar grade: water soluble) on seed yield and yield associated traits and seedling parameters are presented below (Table 2 & Table 3).

Statistically significant differences between treatments on growth, yield and seedling parameters of rice fallow blackgram variety ADT3 was observed (Table 2). The first treatment (2% DAP at flowering stage) contributed the following seed yield and yield attributing parameters as follows, Plant height : 24.6 cm, number of branches : 4.2, number of pods: 21.0, number of seeds per pod : 4.0, filled seeds percentage: 71.5, hard seeds percentage: 5.0, with seed yield of 196.2 kg/ha. Treatment 2 (0.5% NPK+0.2% MN on 15th day) effected on active vegetative phase gave the following results. Growth and yield parameters: PH: 28.9, NB: 7.0 NP: 27.0, NSP: 4.0 FS%: 62.0 HS%: 5.2, SY: 251.2 kg/ha. Germination and seedling parameters: GMN%: 72.7% SL: 10.5cm, RL: 14.8 cm, HSW: 3.3 g. The results of treatment 3 (0.5 % MAP + 0.2% MN on flowering stage) had given the following results, Growth and yield parameters: PH: 31.1, NB: 7.3 NP: 29.0, NSP: 4.0 FS%: 80.0 HS%: 5.1, SY: 387.5 kg/ha. Germination and seedling parameters: GMN%: 77.5% SL: 12.2 cm, RL: 15.3 cm, HSW: 3.6 g.The treatment 4 (0.5% NPK + 0.2 % MN on flowering and pods formation stages) gave the following results. Growth and yield parameters: PH: 32.3 cm, NB: 5.5 NP: 38.7, NSP: 4.0 FS%: 84.0 HS%: 0.9, SY: 470 kg/ha. Germination and seedling parameters: GMN%: 81.5% SL: 12.7cm, RL: 21.6 cm, HSW: 3.6 g. The following results were obtained from the treatment 5 (0.5 % NPK + 0.2 % MN on vegetative, flowering and pod formation stages, 0.5 % NP (MAP)+0.2% MN chelated on reproductive phase), PH:51.3cm, NB:10.7 NP: 72.5, NSP: 6.5 FS%: 96.2 HS%: 0.1%, SY: 866.2 kg/ha. Germination and seedling parameters: GMN%: 92.7% SL:19.1cm, RL:24.3 cm, HSW: 3.7 g **(Table 1, Table 2, Figure 1 and Figure 2).**

It is a regular practice to spray 2% DAPS during flower initiation for induction of flowering and pod set in most of the pulse crops including rice fallow blackgram. foliar spraying of 2% DAP alters the C:N ratio of growing shoots to induce flowering (Ganapathy et al., 2008). Further, due to increased nutrients flow especially phosphorus increases the pod set and seeds formation. But for rice fallow blackgram, both source and sink are imbalanced due to poor nutrients uptake and moisture stress.

Foliar spraying of 0.2% micro nutrients and 0.5% macronutrients on 15th day induced more vegetative growth indicating nutrient responses of rice fallow blackgram during initial stages of vegetative growth and poor uptake of nutrients from rice fallow field due to nutrient deficiency, abiotic stresses like salinity and moisture stress. Foliar application of 2% DAP+40 ppm NAA+ 0.5% MN chelated form gave highest yield in Blackgram under dry land ecosystem as rainfed crop (Shashikumar et a., 2013). Foliar spraying of 0.5% MAP + 0.2% MN, an alternative to 2% DAP during flowering initiation produced better yield. Preparation of 2% DAP is a tricky process and often results in phytotoxicity during spraying on vegetative parts due to precipitation. DAP is highly insoluble; it takes 3-4 days for solubilisation. MAP is highly water soluble and readily sprayed. MAP has higher phosphorus content 52% than DAP. Hence it showed better yield response than the regular 2% DAP spraying during the flowering stage. DAP can't be mixed with other plant protection chemicals and foliar grade micronutrients. MAP has compatibility with latest plant protection chemicals and micronutrients. Hence, MAP was mixed with micronutrients to induce translocation and synthesis of nutrients in flowers and developing seeds. But most of the previous studies have shown effects on DAP with chelated micro nutrients (Shashikumar et al., 2013), 2% DAP with 40 PPM NAA (Ganapathy et al., 2008; Perumal and Sundari, 2004; Senthilvelan and Ravichandran, 2020). But the three foliar schedules viz., vegetative, reproductive, and pod formation stage with micro and macronutrients increased the seed yield almost two folds indicating the foliar nutrients responses of rice fallow blackgram variety, ADT3 which has average yield potential of 550 kg per ha which is 57.4% higher than the potential yield. Induction of synchronized vegetative growth, uniform flowering, modulations of source-sink by producing more number of branches to the developing pods with more number of seeds resulted in seed yield increase. It is also indicating the importance of foliar spray of nutrients during the initial vegetative stage, to increase the number of branches to produce more foliage to smother the weeds growth resulting in reduction of competitions. Second spraying of 0.5% MAP during flowering induced more flowers, as the plants had more leaves from the branches (Unlimited sources). Finally, third spraying resulted in more pods production from the flowers, improved seed yield, seed filling, germination percentage, shoot length, root length and 100 seed

weight. It is assumed that balanced application of macro and micronutrients nutrients during critical stages growth produced vegetative growth which synchronized with reproductive growth in rice fallow blackgram resulting in not only seed yield but also the improvement of seed quality parameters. Relay cropping system necessarily perform better under soil environment rich in microbiome diversity which are involved in nutrient mobilization, PGPR activity and abiotic stress tolerances (Smith et al., 2018). Mono cropping of rice severely affects the population and diversity of native microbiome of the rice soils due to indiscriminate usage of fertilizers, weedicides and pesticides, also continuous anaerobic conditions due to water submergence. Hence, performance of rice fallow blackgram as traditional relay cropping is greatly affected under traditional crop production method. It is proven that combination of macro and micronutrients responded to yield increase indication of poor uptake of macro and nutrients from soil under rice fallow Blackgram.

4. CONCLUSION

Climate change affects cropping patterns globally which will have a serious impact on food and nutritional security worldwide. Rice fallow blackgram cultivation is a traditional relay cropping method of CDZ of Tamil Nadu being practiced for centuries. The poor yield of rice fallow blackgram variety ADT3 is attributed to change in soil fertility due to various factors such as mono cropping of rice, indiscriminate applications of fertilizers, poor soil fertility, and abiotic stresses. Yield of rice fallow blackgram variety is declining gradually. farmers of CDZ are switching to summer rice cultivation with short duration varieties having a range of 100-120 days. Mono cropping pattern of rice-rice-rice in CDZ is adversely affecting the productivity, ecosystem, fertility and nutritional security. Foliar spraying schedules with combination of macro and micronutrients proved in the present study will be highly useful for stabilizing and maximizing the yield of rice fallow blackgram variety ADT3 and thus, Rice-Blackgram relay cropping can be sustained economically for increased productivity, nutritional security and income generation. Foliar spraying of macro and micro nutrients restored the yield levels and provided the nutrients requirement for the growth and development of rice fallow Blackgram variety, ADT3 irrespective of soil fertility levels. In long term basis, sustainable improvement of soil fertility in Rice/Blackgram relay cropping system should be done by integrated approaches viz., green manuring, need based fertilizers applications based on STCR, crop rotations, soil and water conservation measures (Senthilvelan and Ravichandran, 2020).

CONSENT

Not applicable

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Table 1. Details of foliar spray combinations on different growth phase of rice fallow blackgram variety, ADT3

Macronutrients: 1) 0.5% Water soluble: 19:19:19 (NPK), 2) 2 % DAP: Diammonium phosphate (18% N, 46% P) 0.5% 3) MAP : Mono ammonium phosphate (11% N, 52% P)0.2 % 4) MN mixture: 0.2% (MN-Chelated mixture of Fe 2.5%, Mn 1.0%, Zn 3.0%, Cu 1.0%, Mo 0.1% and B 0.5%),

S No	Treatments	Foliar spray combinations	Age of crop (DAS)	Growth phase
1.	T_1	2 % DAP Spraying	30	Reproductive phase
2.	T_2	0.5% NPK + 0.2% MN	15	Vegetative Phase
3.	T_3	0.5 % MAP+ 0.2% MN	30	Reproductive phase
4.	T_4	0.5% NPK + 0.2% MN	45	Reproductive and Maturity Phase
5.	T_5	0.5% NPK + 0.2% MN 0.5% MAP + 0.2% MN	15, 45 30	Vegetative, Reproductive and maturity phases

Table 2. Determination of higher seed yield, and seed yield attributing traits highly influenced by spraying of foliar at critical stages of Rice fallow black gram variety, ADT3 : Analysis of variance using RBD analysis

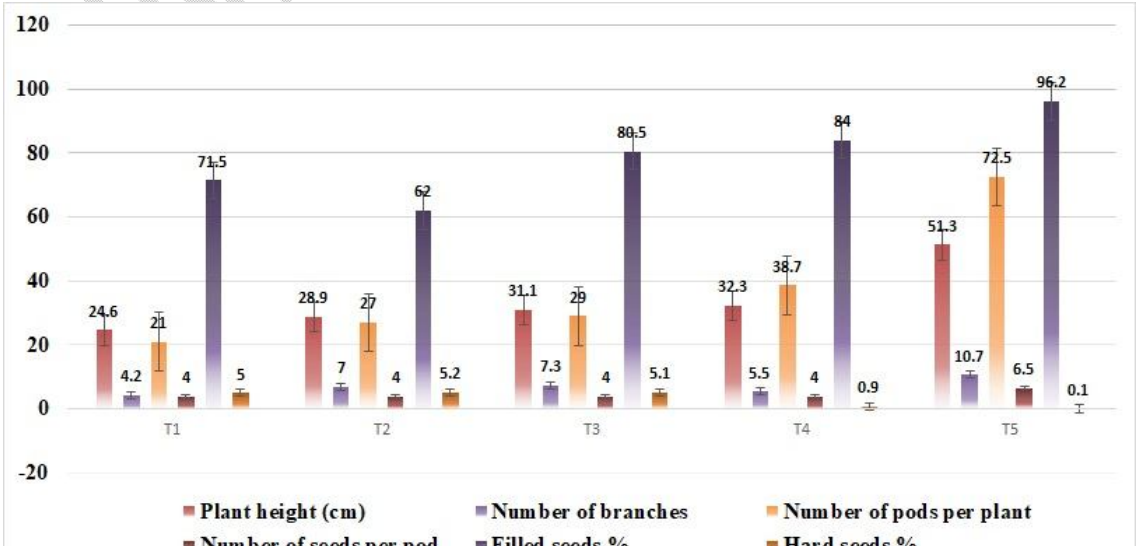
Treatments	Plant height (cm)	Number of branches	Number of pods per plant	Number of seeds per pod	Filled seeds %	Hard seeds %	Seed yield (kg/ha)
T1	24.6^{c}	4.2^{d}	21.0d	4.0b	71.5^{c}	5.0^{a}	196.2e

T2	28.9^{bc}	7.0^{bc}	27.0cd	4.0b	62.0^{d}	5.2^{a}	251.2d
T3	31.1^{b}	7.3^{b}	29.0c	4.0b	80.5^{b}	5.1^{a}	387.5c
T4	32.3^{b}	5.5^{cd}	38.7b	4.0b	84.0^{ab}	0.9^{b}	470.2b
T5	51.3^{a}	10.7^{a}	72.5a	6.5a	96.2^{a}	0.1^{b}	866.2a
CD(0.05)	4.8	1.6	7.0	0.6	14.5	1.2	40.0

Table 3. Influence of foliar spraying of macro and micronutrients on seed quality parameters of rice fallow blackgram variety, ADT3

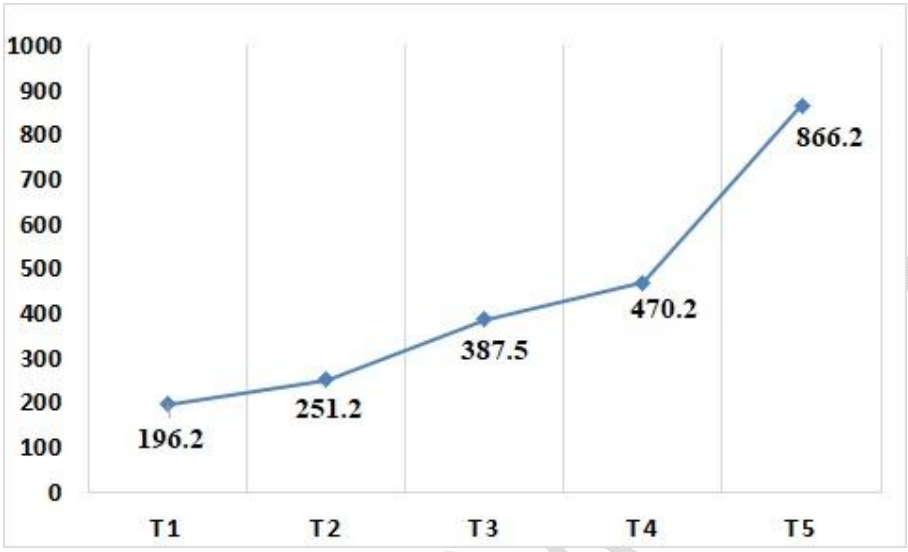
Treatments	Germination %	Shoot length (cm)	Root length (cm)	100 seed weight (g)
T1	68.5e	9.5c	11.1d	3.2c
T2	72.7d	10.5bc	14.8c	3.3c
T3	77.5c	12.2b	15.3c	3.3c
T4	81.5b	12.7b	21.6b	3.6b
T5	92.7a	19.1a	24.3a	3.7a
CD(0.05)	3.2	2.4	1.8	0.1

Fig. 1. Effect of foliar application of macro and micro nutrients on yield attributing traits in rice



fallow Blackgram variety, ADT3

Fig. 2. **Effect of foliar application of macro and micro nutrients on yield of rice fallow**



Blackgram variety, ADT3

Fig. 3. Effect of foliar application of macro and micronutrients on germination and seedling parameters of rice fallow Blackgram variety, ADT3.