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

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Experimental planning, executions, observations on effects of foliar applications in field and seedling studies were done by authors MD, SC and KNN. Author MS involved in fixing the treatments of the experiments based on responses. Authors SG and KS involved in critical review, interpretation of results and writing of the article. Author AS performed statistical analysis and prepared graphs. All authors read and approved the final manuscript.*

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## 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

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improve the seed yield and quality in rice fallow blackgram variety ADT3. The combined foliar spraying of 0.5% NPK (macro) and 0.2% chelated micro nutrients mixture (Fe 2.5%, Mn 1.0%, Zn 3.0%, Cu 1.0%, Mo 0.1% and B 0.5%), were sprayed on 15th (Vegetative phase), 30$^{th}$ (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). Rice fallow pulses cultivation is an important pulses production system contributes 60% of the state pulses production (Area, Crop and Production report, TN Govt, 2021). Blackgram grains are important pulse diet of the nation and used in different food preparations. Though the blackgram is cultivated as rainfed in Kharif, rabi and irrigated crop during summer, the major production system with vast rice growing region of CDZ is contributed through rice fallow cultivations. 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 [1,2]. Rice fallow blackgram cultivation starts as relay crop with samba rice (145-160 days duration). The yield of rice fallow blackgram is under reducing trend which influences the area of cultivation of rice fallow blackgram. 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 [3]. 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 (30-37.5 kg/ha 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 [3]. 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). 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 [4]. Rice fallow blackgram cultivation is proven to increase pulse production and an important cropping method for protein security of the nation [5,6,7] (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. Rice fallow cultivation of blackgram is highly dependent upon the responsive variety. So far, only ADT3 rice fallow variety has been well adapted and adopted for rice fallow cultivations [1]. 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 (Shanmugasundaram et al., 1993). 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. Yield of rice fallow blackgram is influenced by several factors. The agronomic practices of rice cultivation, inherent soil fertility of rice field, soil fertility parameters viz., organic matter content, available major and micro nutrients, microbiome diversity and populations are directly and indirectly influence the yield of rice fallow blackgram cultivations [8]. 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 [9,10,11].

Source Sink imbalances in pulses are caused due to deficiencies of macro and micro nutrients. Few nutrients exhibit nutrient deficiencies visibility, but most of the micronutrients and Phosphorous does not exhibit visual symptoms in pulses and they are always characteristics with hidden hunger, it is assumed and studied through yield responses and nutrient analysis in soil. Characteristics of poor source sink balances are 1) initial stunted growth of younger seedlings which results in reduced plant height and with few brances and less number of leaves. The poor source directly attributes to reduced flowers, reduced pod set and reduced seed filling. 2) Excess vegetative growth of plants due to higher nitrogen applications in soil and the source is large but conversion to sink is poor it results in poor yield 3) poor sink ration: formation few flowers, few pods and poor seed filling, but the source is large with many leaves. Balanced uptake and utilization of major and micro nutrients of rice fallow blackgram will be resulting in better development of source viz., plant height, number of branches, more number of leaves and proportionate development of sink for translocation of nutrients from source viz., more number of flowers, pods, and better filling of seeds [11]; Source-Sink should always be proportionate for achieving the yield potentials of rice fallow blackgram. The nutrient uptake is primarily mediated by microbiome present in rhizosphere and endophytic regions of rice fallow blackgram. The diversity and population of microbiome in rice soil is highly influenced by cropping pattern, soil physical and chemical properties, application of chemical inputs like fertilizers, fungicides and pesticides [12]. The fertility of rice soil of CDZ is in reduction trends and the average organic matter content is 0.4%. with poor microbiome population and diversity, the nutrient uptake of rice fallow blackgram is affected severely resulting poor sink sources which is the major cause for poor yield. Improving microbiome population and diversity is a long term and sustainable processes with coordinated efforts [2]. Foliar spraying of 2% DAP was found to increase the yield to certain extend, but not to the fullest potentials. DAP is having incompatabilities with micronutrients. 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. Here we described the effective combination of compatible macro and micronutrients through foliar applications during critical growth period which resulted in higher seed yield and seed quality enhancement of rice fallow blackgram variety ADT3.

## 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 whitefly 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. 2% DAP spraying during flowering stage did not improve the plant height, number of branches, which resulted in below average yield of 550 kg/ha of the rice fallow variety ADT3.

Treatment 2 (0.5% NPK+0.2% MN chelated 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. Foliar application of NPK and MN chelated during initial vegetative phase induced more vegetative growth by increasing the plant height, number of branches, number of pods than 2% DAP spraying during flowering stage indicating vegetative growth is required for yield improvement and under rice fallow conditions initial seedling vigour and growth which are induced by both micro and macro nutrients.

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. Combination of MAP and MN chelated increased the plant height, number of pods per plant and over all yield of rice fallow blackgram variety. The results are better than 2% DAP spraying during flowering stage.

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. Combination of NPK and MN during flowering and pod formation stage increased yield, number of pods and improved the seed quality. The treatment 4 is better than treatment 3 in terms of yield increase.

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, Fig. 1 and Fig. 2). Three foliar spraying schedules with NPK and Micronutrients during vegetative, reproductive and pod formation stages substantially and significantly increased the yield and yield attributing traits. The treatment also enhanced the quality of seeds through seedling parameters. It indicates the coordinated growth and development from vegetative to reproductive to maturity are required by combination of macro and micronutrients in rice fallow blackgram. The soil parameters necessarily lack to support the growth and development and uptake of nutrients (micro and macro) by ADT3 rice fallow blackgram variety was poor.

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 [13]. 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 application of 2% DAP+40 ppm NAA+ 0.5% MN chelated form gave highest yield in Blackgram under dry land ecosystem as rainfed crop [10]. 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 [10], 2% DAP with 40 PPM NAA [13,14,8,15]. Foliar spraying of 2% urea had highest yield on blackgram than 2% DAP with combinations of micronutrients, salicylic acid [16]. 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 [11]. 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 [17-20].

**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: Di ammonium 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<br>0.5% MAP + 0.2% MN | 15, 45<br>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 |

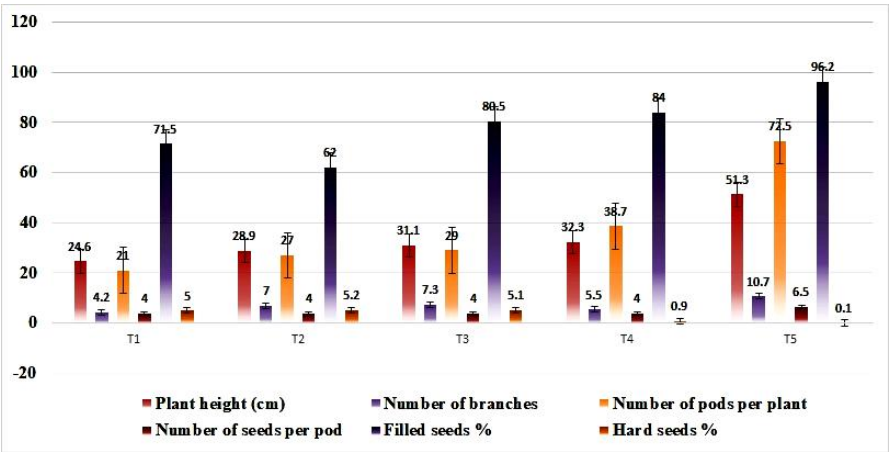


**Fig. 1. Effect of foliar application of macro and micro nutrients on yield attributing traits in rice fallow Blackgram variety, ADT3**

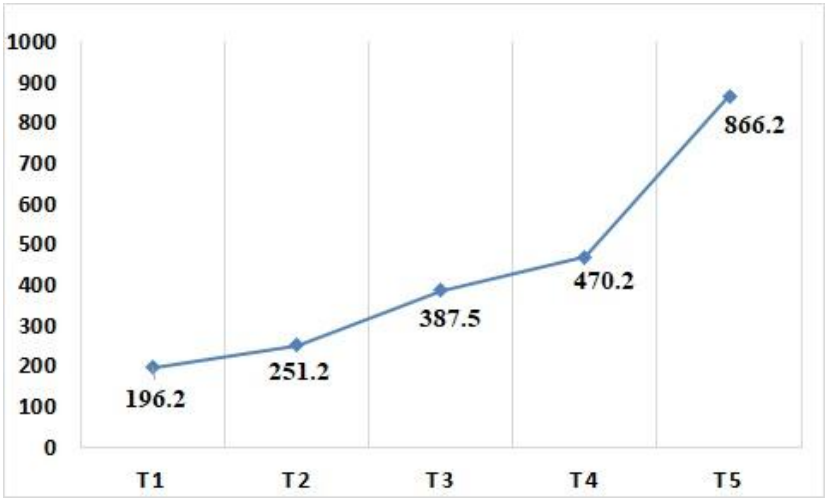


**Fig. 2. Effect of foliar application of macro and micro nutrients on yield of rice fallow Blackgram variety, ADT3**

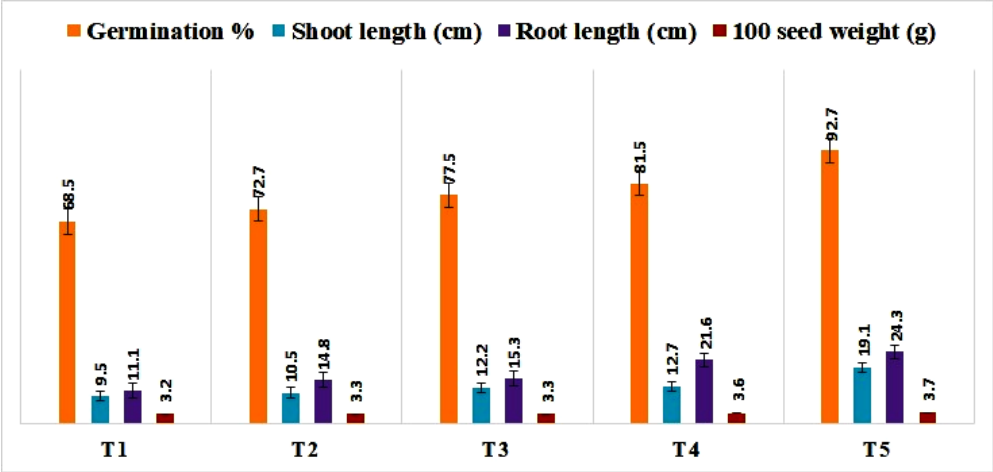


**Fig. 3. Effect of foliar application of macro and micronutrients on germination and seedling parameters of rice fallow Blackgram variety, ADT3**

## 4. CONCLUSION

Balanced application of macro and micronutrients through foliar mode increased the yield of seed and enhanced quality of seeds. It indicates the poor nutrient uptake of rice fallow blackgram variety ADT3 from soil in relay cropping system. This improved foliar application of macro and micronutrients can be successfully disseminated for increased yield. 0.5% Macro and 0.2% micronutrients effectively played the roles of induction of growth and development during vegetative, reproductive and maturity phases. 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 [8].

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Kandasamy S, Kuppuswamy G. Agronomic performance of blackgram varieties under rice-fallow condition in Cauvery delta zone of Tamil Nadu. Plant Archives. 2007;7(1): 273-274
2. Tanveer M, Anjum SA, Hussain S, Artemi Cerdà, Ashraf U. Relay cropping as a sustainable approach: problems and opportunities for sustainable crop production. Environmental Science and Pollution Research. 2017;24:6973–6988
3. Raju M, Subrahmaniyan K, Porpavai S, Sharmila R. Diversification of suitable alternate cropping system for enhancing productivity, profitability and resource use efficiency in Cauvery delta zone of Tamil Nadu. International Journal of Chemical Ecology. 2020;8(6):407-410
4. Narendrakumar, Hazra KK, Singh S, Nadarajan N. Constraints and prospects of growing pulses in rice fallows of India. Indian Farming. 2016;66(6): 13-16.
5. Satyanarayana A, Seenaiah P, Sudhakara Babu K, Prasada Rao MP. Extending pulses area and production in rice fallows. (In) Recent Advances in Pulses Research. 1997;569–558.
6. Ghosh PK, Das A, Saha R, Enboklang K, Tripathi AK, Munda GC, Ngachan SV. Conservation agriculture towards achieving food security in North East India. Current Science. 2010;99:915–921.
7. Pretty J, Zareen, PB. Sustainable intensification in agricultural systems. Annals of botany. 2014;114(8): 1571–1596.
8. Senthilvelan P, Ravichandran M. Post-harvest soil fertility status of Rice-Blackgram cropping system in typic haplusters influenced by integrated nutrient management and crop cultivation techniques. Plant Archieves. 2020;20(1): 2644-2649.
9. Mahala CPS, Dadheech RC, Kulhari RK. Effect of plant growth regulators on growth and yield of blackgram (*Vigna mungo*) at varying levels of phosphorus. Crop Res. 2001;18(1):163-165.
10. Shashikumar R, Basavarajappa SR, Salakinkop, Hebbar M, Basavarajappa MP, Patil HY. Influence of foliar nutrition on performance of Blackgram (*Vigna mungo*) nutrient uptake and economics under dryland ecosystems. Legume Res. 2013; 36(5):422–428.
11. Smith MR, Rao IM, Merchant A. Source-sink relationships in crop plants and their influence on yield development and nutritional quality. Frontiers in Plant Science. 2018; 8:10.
12. Rascovan N, Carbonetto B , Perrig D, Díaz M, Canciani W, Abalo M, Alloati J, González-Anta G, Vazquez MP. Integrated analysis of root microbiomes of soybean and wheat from agricultural fields. Nature: Scientific Reports; 2016.

    DOI: 10.1038/srep28084
13. Ganapathy M, Baradhan G, Ramesh N. Effect of foliar nutrition on reproductive efficiency and grain yield of rice fallow pulses. Legume. Res. 2008;31(2): 142-144.
14. Perumal APS, Sundari A. Response of rice-fallow blackgram C.V. ADT 5 to the application of DAP and phosphobacteria. Legume Research. 2004; 27(1):73-74.
15. Deivasigamani S, Anandhakrishnan S, Ashok V, Balachandar E, Niranjana Devi M, SaravanaKumar J. Influence on Plant Growth Regulators and Micro Nutrients in Growth and Yield of Blackgram (*Vigna mungo* L.). J Plant Biol Crop Res. 2021; 4(2): 1043.
16. Sritharan N,, Rajavel M and Senthilkumar R. Physiological approaches: Yield improvement in blackgram. Legume Res. 2015;38:91-95.
17. Manonmani V, Srimathi P. Influence of mother crop nutrition on seed and quality of blackgram. Madras Agric. J. 2009; 96(16):125-128.
18. Shanmugasundaram P, Mohanasundaram K, Rangaswami M, Thangasamy A. Performance of blackgram cultivars under rice fallow condition in Thamiraparani delta. The Madras agricultural Journal. 1999:80(2):44-45.
19. Available:www.nfsm.gov.in/Guidelines/Guideline_nfsmandoilseed201819to201920.pdf

20. Marimuthu M, Surendran U. Effect of nutrients and plant growth regulators on growth and yield of black gram in sandy loam soils of Cauvery new delta zone, India. Cogent Food and Agriculture. 2015;1:1010415.



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