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Evaluation of Nutrient Balance and Nutrition use Efficiency on Red Gram (*Cajanus cajan*) under Various Foliar Feeding

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

AIM: To assess the nutrient balance and nutrient use efficiency on red gram.
Place and Duration of Study: A field experiment was carried out during *Rabi* season 2023-24 at Instruction farm of Karunya Institute of Technology and Sciences, Coimbatore. Experimental field was silty clay loam in texture with available N (311.0 kg ha^{-1}), P2O5 (15.7 kg ha^{-1}), K2O (185 kg ha^{-1}).

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Statistical Design: Randomized Block Design (RBD).
Methodology: The study consist of 8 treatment and replicated three times T1- 100% RDF + FYM 12.5 t ha^{-1} + 2% DAP, T2- 100% RDF + FYM 12.5t ha^{-1} + 2% Urea, T3- 100% RDF + FYM 12.5 t ha^{-1} + 40 ppm NAA spray, T4- 100% RDF + FYM 12.5 t ha^{-1} + 10 ppm Salicylic, T5-100% RDF + FYM 12.5 t ha^{-1} + 75 ppm GA_3, T6- 100% RDF + FYM 12.5 t ha^{-1} + 5 kg TNAU Pulse wonder T7- 100% RDF + FYM 12.5 t ha^{-1} T8- Control.
Results: Application of 100% RDF along with 12.5 t ha^{-1} FYM + 5 kg ha^{-1} TNAU pulse wonder resulted in Maximum nutrient NPK uptake, nutrient availability and agronomic efficiency was observed.
Conclusion: Application of full dose of RDF along with FYM and TNAU pulse wonder reacted better in terms of NPK uptake, nutrient availability and agronomic efficiency when compared to other foliar treatment in the evaluation of nutrient balance and nutrient use efficiency.

Keywords: Nutrient balance; pulse wonder; agronomic efficiency; DAP; naphthalene acetic acid.

1. INTRODUCTION

Pulses are the important source of protein in the diet of vegetarians [1]. Pulses are significant food crops due to their high protein and essential amino acid content [2]. Pigeon pea (*Cajanus cajan* (L.) Millsp.), also known as red gram, arhar, or tur, it is a significant pulse crop that contributes towards the global nutritional security of the world's growing population. It ranks as the second most important pulse crop in India after bengal gram. India leads globally in both the area and production, accounting for 80% of the world's acreage and contributing 67% of global production [3]. Among the pulses, pigeon pea is a major contributor in meeting the population's protein demands. This versatile food legume has diverse uses, serving as food, feed, fodder, and fuel. Pigeon pea also serves as a soil enhancer and it is recognized for the various advantages and it offers to the soil in which it is cultivated [1].

Red gram has a low yield because of substantial flower and pod losses, excessive vegetative growth, an irregular growth habit, a poor source-sink relationship, and poor pod set. Low productivity in pulses especially red gram is premature flower abscission. Red gram produces prolific flowers, up to 90% of which are shed. Poor pod set and high flower drop and pod drop also contribute to low yields. Addressing the high rate of flower abscission and boosting pod production is vital for improving red gram yields [4].

In Red gram, the vegetative and reproductive stages coexist, hence there is always competition for available assimilates between vegetative and reproductive sinks. On the other side, there is always a limitation of leaves, especially during the flowering and pod formation periods. Plant growth regulators are known to improve physiological efficiency including photosynthetic ability of plant and offer significant role in realizing higher crop yields [5]. Foliar feeding along with soil application has numerous advantages in supplementing the nutritional requirements of crops. The foliar nutrition eliminates the problems like fixation and immobilization of nutrients. Hence, foliar nutrition is being recognized as an important method of fertilization in modern agriculture [6]. Plant growth regulators (PGRs) have emerged as the fourth generation of agricultural chemicals, surpassing fertilizers, insecticides, and herbicides, due to their ability to enhance production and quality. The objective of this paper is to evaluate the foliar application of agrochemicals for better flower retention and calculate the nutritional budgeting and agronomic efficiencies of the different rates of foliar application.

2. MATERIALS AND METHODS

The present study was conducted in the instructional farm of Karunya Institute of Technology and Sciences, Coimbatore. The experimental field is geographically located at 10° 55 'N and 76° 44 'E latitude and longitude respectively, with an altitude of 474 meters above the mean sea level in the western zone of Tamil Nadu.

A field experiment was conducted during *Rabi* 2023-24 to evaluate the effect of various plant nutrients and growth regulators on the growth and yield of red gram. The soil of the experimental plot was silty clay loam with pH 8.10, EC of 0.28 dS m^{-1} and organic carbon (0.41%) with the available N (312 ka ha^{-1}), P_2O_5 (15.2 kg ha^{-1}), K_2O (187 kg ha^{-1}). The experiment

was laid out in a randomized block design with three replication and eight treatments. The treatments are as follows- T_1 - 100% RDF + FYM 12.5 t ha^{-1} + 2% DAP, T_2 - 100% RDF + FYM 12.5t ha^{-1} + 2% Urea, T_3 - 100% RDF + FYM 12.5 t ha^{-1} + 40 ppm NAA spray, T_4 - 100% RDF + FYM 12.5 t ha^{-1} + 10 ppm Salicylic acid, T_5 - 100% RDF + FYM 12.5 t ha^{-1} + 75 ppm GA_3, T_6 - 100% RDF + FYM 12.5 t ha^{-1} + 5 kg TNAU Pulse wonder, T_7 - 100% RDF + FYM 12.5 t ha^{-1}, T_8 – Control. The variety selected was APK_1 which had a duration of 90-105 days was sown, with the seed rate of 15 kg ha^{-1}. Application of 100% RDF and farmyard manure was applied throughout the field except the control plot.

2% DAP solution was prepared by soaking 20 g of DAP in 1 liter of water for 12 hours and the supernatant solution was made up to one liter of water as stock solution [7]. Spraying was done twice at flowering stage and at 15 days after flowering.2% urea was formulated by dissolving 20 g of urea in 1 liter of water. Following the preparation, urea was applied once during the flowering stage and again 15 days post-flowering. The spray solution containing 40 ppm of NAA is prepared by blending 40 mg of NAA with 1 liter of water. After, the preparation of NAA was sprayed once during the pre-flowering stage and again 15 days after the initial application [8]. The spray solution of 10 ppm of salicylic acid was prepared by mixing 10 mg of Salicylic acid in 1 liter of water. After the preparation, salicylic acid is sprayed once at pre-flowering stage and another at 15 days after the first spray. The spray solution of 75 ppm of GA3 was prepared by mixing 75 mg of gibberellic acid in 1 liter of water [9]. After the preparation, gibberellic acid is sprayed once at flowering and pod initiation stage. The spray solution of TNAU pulse wonder was prepared by mixing 5kg of TNAU pulse wonder in 500 liters of water. After the preparation, TNAU pulse wonder was sprayed at flower initiation stage.

2.1 Nutrient Balance in the Cropping System

Soil available NPK nutrient balance in red gram was calculated for each treatment as per the specific nutrient added to the pigeon pea crop and as the same manner the total quantity of nutrient removal was also estimated. The nutrient balance was derived from difference between the total quantity of nutrient applied and the total quantity of specific nutrient removed. The specific nutrient balance was calculated by the difference between soil nutrient status at harvest stage and soil nutrient status at initial stage as per the procedure suggested by Sadanandan and Mahapatra (1973) and the nutrient balance (either positive or negative) was expressed in kg ha^{-1}.

2.2 Initial Soil Analysis

The initial soil analysis for the available N was analyzed using alkaline permanganate method suggested by Subbiah and Asija [10], P was analyzed using Olsen's method Olsen *et al*., [11], K was taken through Flame photometer method [12].

2.3 Agronomic Efficiency (AE)

The agronomic efficiency was estimated using the following formula (Yoshida, 1981).

> AE=(Grain yirld in fertilized plot (kg ha-1)-Grain yield in unfertilized plot (kg ha-1))/(Quantity of fertilizer N applied (kg ha-1)).

3. RESULTS AND DISCUSSION

3.1 Nutrition Balance

3.1.1 Nitrogen

In the nitrogen fertilizer balance sheet, application of 100% RDF along with FYM + TNAU pulse wonder (T_6) recorded the maximum availability of N in the soil and also maximum N uptake by plants. The computed balance recorded the highest value on application of 100% RDF along with FYM + Urea (T2).

3.1.2 Phosphorus

In the phosphorous fertilizer balance sheet, application of 100% RDF along with FYM + TNAU pulse wonder (T_6) recorded the maximum availability of P in the soil followed by, application of 100% RDF along with FYM + 10 ppm of salicylic acid (T_4). The computed balance is noted maximum at 100% RDF along with FYM + DAP (T1).

3.1.3 Potassium

In the potassium fertilizer balance sheet, application of 100% RDF along with FYM + TNAU pulse wonder (T_6) recorded the maximum availability of K in the soil followed by, application of 100% RDF along with FYM + 10 ppm of

salicylic acid(T_4). The maximum net gain is found in the application of 100% RDF along with FYM + TNAU pulse wonder(T_6) and the lowest net gain was recorded in the application of 100% RDF along with FYM (T_7).

3.2 Agronomic Efficiency

3.2.1 Nitrogen

In nitrogen nutrition assessment, application of 100% RDF along with 12.5t of FYM + TNAU pulse wonder (T_6) resulted in maximum agronomic efficiency in N followed by, the application of 100% RDF along with 10 ppm of salicylic acid(T_4). The lowest agronomic efficiency of N was noted in the application of 100% RDF along with FYM + 2% urea spray (T_2).

3.2.2 Phosphorus

In Phosphorous nutrition, application of 100% RDF along with 12.5t of FYM + TNAU pulse wonder (T_6) resulted in maximum agronomic efficiency in P followed by the application of 100% RDF along with 10 ppm of salicylic acid(T_4). The lowest agronomic efficiency was noted in the application of 100% RDF along with FYM(T_7).

Table 1. Nutrient balance sheet (N)

Treatment	Initial soil N (A)	N applied to crop (B)	N removal (c)	Computed balance (B-C)	Soil N at harvest (D)	Net gain or loss(D-A)
T1	311	90.34	43.19	47.15	276.9	-34.1
T2	311	146.34	36.81	109.53	261.3	-49.7
T3	311	54.34	42.43	11.91	272.13	-38.87
T4	311	54.34	42.94	11.4	275.69	-35.31
T5	311	54.34	37.73	16.61	262.7	-48.3
T6	311	54.34	47.89	6.45	286.3	-24.7
T7	311	54.34	32.11	22.23	286.3	-24.7
T8	311	54.34	27.41	26.93	242.5	-68.5

Table 2. Nutrient balance sheet (P)

Treatment	Initial soil P(A)	P applied to crop (B)	P removal (c)	Computated balance (B-C)	Soil P at harvest (D)	Net gain or loss(D-A)
T1	15.7	404.5	26.14	378.36	36.84	21.14
T2	15.7	312.5	21.93	290.57	32.69	16.99
T3	15.7	312.5	25.49	287.01	36.09	20.39
T4	15.7	312.5	25.63	286.87	36.51	20.81
T5	15.7	312.5	22.64	289.86	33.26	17.56
T6	15.7	312.5	28.99	283.51	39.67	23.97
T7	15.7	312.5	19.08	293.42	29.86	14.16
T8	15.7	312.5	16.23	296.27	27.03	11.33

Table 3. Nutrient balance sheet (K)

Treatment	Initial soil K (A)	K applied to crop (B)	K removal (c)	Computated balance (B-C)	Soil K at harvest (D)	Net gain or loss(D-A)
T1	185	15	22.73	-8.62	179.7	-5.3
T2	185	15	23.41	-4.84	171.1	-13.91
T3	185	15	20.03	-7.73	177.9	-7.15
T4	185	15	25.89	-8.41	178.6	-6.36
T5	185	15	17.58	-5.03	171.3	-13.72
T6	185	15	15.32	-10.89	186.3	1.27
T7	185	15	22.73	-2.58	164.5	-20.48
T8	185	15	23.20	-0.32	158	-27.05

Table 4. Agronomic efficiency (N)

Treatment	Treated plot Yield (A)	Control Yield (B)	Treated yield-Control plot yield	N applied to crop	Agronomic use Efficiency N
T1	910.43	453.76	456.67	90.34	5.05
T2	723.84	453.76	270.08	146.34	1.84
T3	879.45	453.76	425.69	54.34	7.83
T4	895.87	453.76	442.11	54.34	8.14
T5	745.45	453.76	291.69	54.34	5.37
T6	1043	453.76	589.24	54.34	10.84
T7	588.84	453.76	135.08	54.34	2.49

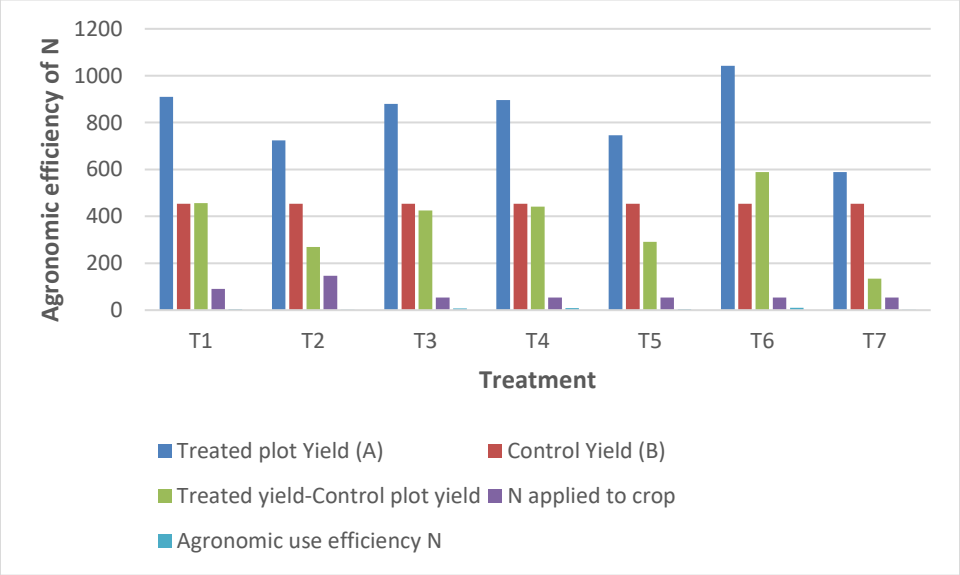

Fig. 1. Agronomic efficiency of Nitrogen

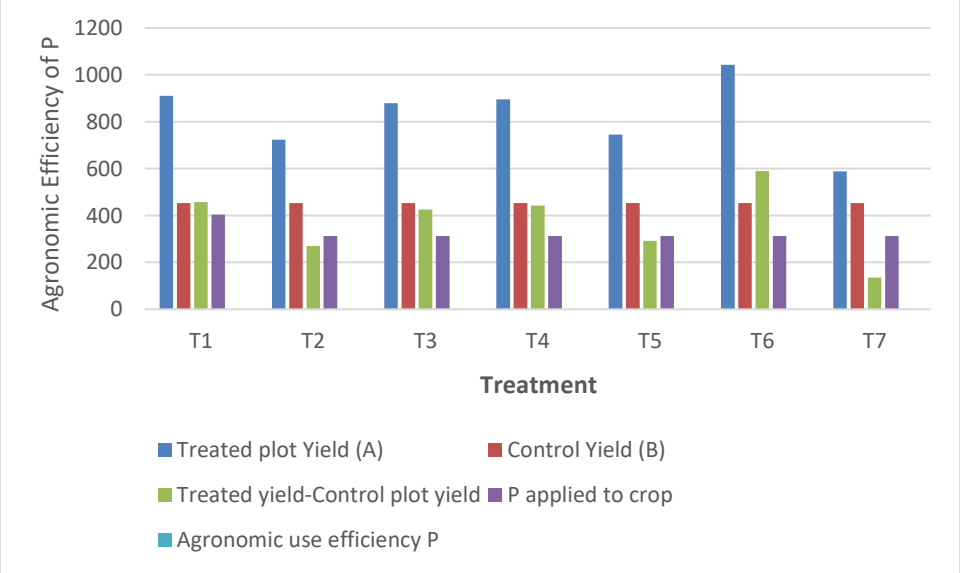

Fig. 2. Agronomic efficiency of Phosphorus

Table 5. Agronomic efficiency (P)

Treatment	Treated plot Yield (A)	Control Yield (B)	Treated yield-Control plot yield	P applied to crop	Agronomic use Efficiency P
T1	910.43	453.76	456.67	404.5	1.12
T2	723.84	453.76	270.08	312.5	0.86
T3	879.45	453.76	425.69	312.5	1.36
T4	895.87	453.76	442.11	312.5	1.41
T5	745.45	453.76	291.69	312.5	0.93
T6	1043	453.76	589.24	312.5	1.89
T7	588.84	453.76	135.08	312.5	0.43

Table 6. Agronomic efficiency (K)

Treatment	Treated plot Yield (A)	Control Yield (B)	Treated yield-Control plot yield	K applied to crop	Agronomic use Efficiency K
T1	910.43	453.76	456.67	15	30.44
T2	723.84	453.76	270.08	15	18.00
T3	879.45	453.76	425.69	15	28.38
T4	895.87	453.76	442.11	15	29.47
T5	745.45	453.76	291.69	15	19.45
T6	1043	453.76	589.24	15	39.28
T7	588.84	453.76	135.08	15	9.01

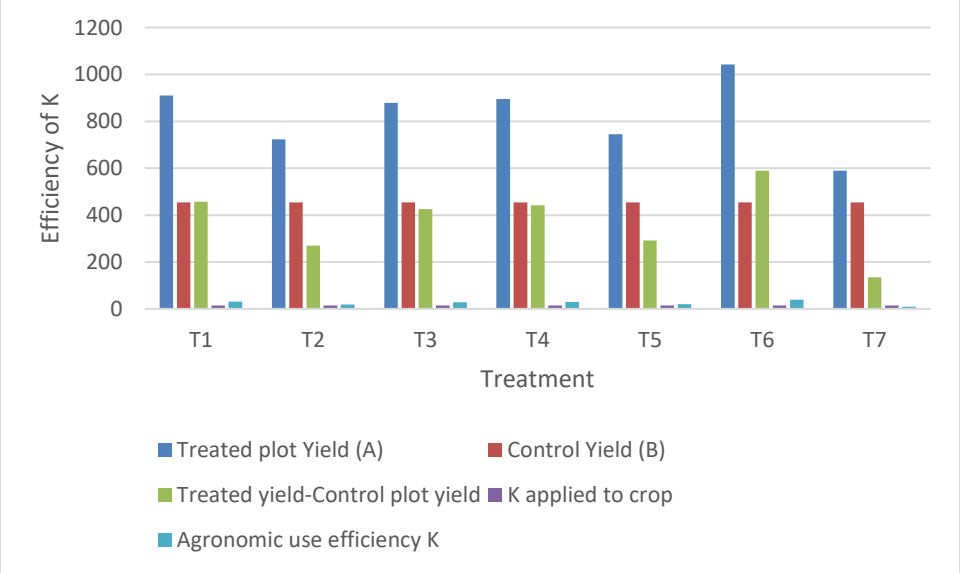

Fig. 3. Agronomic efficiency of Potassium

3.2.3 Potassium

In K nutrition, 100% RDF along with 12.5t of FYM + TNAU pulse wonder (T_6) resulted in maximum agronomic efficiency followed by the 100% RDF along with FYM + 2% DAP (T_1). The lowest agronomic efficiency was noted in the application of 100% RDF along with FYM (T_7).

4. CONCLUSION

Based on the results, the higher nutrient uptake and enhanced soil nutrient status was found in the combined application of full doses of RDF along with 12.5 t of FYM and foliar application of TNAU pulse wonder (T_6). This also tend to resulted in increased agronomic efficiency in nitrogen fertilizer by the inclusion of

Recommended dose of fertilizers with Farmyard manure and TNAU pulse wonder(T6).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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