STUDIES ON NUTRIENT USE EFFICIENCY IN SHORT DURATION RED GRAM (*Cajanus cajan* (L.) Millsp.) VARIETIES UNDER SITE-SPECIFIC NUTRIENT MANAGEMENT TECHNIQUES

ABSTRACT

Aim: To evaluate the nutrient use efficiency of short duration red gram varieties under site-specific nutrient management.

Place and duration of study: The experiment was carried out in the *rabi* season of 2023 at an experimental farm in Karunya Institute of Technology and Sciences, Coimbatore. Experimental field was silty clay loam in texture with medium in available N (295 kg/ha), high in available P_2O_5 (kg /ha) and high in available K_2O (285 kg/ha).

Study Design: Split plot design

Methodology: The treatments consisted of three varieties in main plot namely V_1- APK 1, V_2- VBN 3, V_3- VBN 1 and eight treatment in sub plots T_1- (+NPK), T_2 - N (-PK), T_3 - P (-NK), T_4 - K (-NP), T_5 - PK (-N), T_6 - NK (-P), T_7 - NP (-K), and T_8 - Control (-NPK).

Result: Applying fertilizer as per recommended dose of nutrients without nutrient omission, resulted in increased nutrient use efficiency, agronomic efficiency, partial factor productivity and partial nutrient budget.

Keywords: Red gram, SSNM, Agronomic efficiency, Partial factor productivity, Partial nutrient budget.

1. INTRODUCTION

Pulses are one of the important food crops grown globally due to their higher protein content. Pulses play a very versatile role in Indian agriculture and diet. Due to their higher protein and essential amino acid contents, they serve as the appropriate supplement to the cereal rich diet of the vegetarians in India. On an average, pulses protein is about twice as much as wheat and three times as much as rice.

Globally, the cultivation of pulses encompasses an extensive area of 93.18 million hectares, resulting in a production of 89.82 million tonnes, with a productivity rate of 964 kg/ha (DA & FW, 2021-2022). India with more than 28 million hectares of cultivation area, is the largest pulse producing country in the world. India ranks first in area 28.78 million hectares production 25.46 million tonnes productivity of 885 kg/ha (DA & FW, GOI, 2021-2022). In Tamil nadu, pulses are grown across 8.03 lakh hectares with the production of 254.63 lakh tonnes and productivity rate of 588 kg/ha (FW, 2021-2022).

Red gram [*Cajanus cajan* (L.) Millsp.] is the most versatile food legume with diversified uses as food, feed, fodder and fuel. Red gram is a protein rich staple pulse food. It is mostly consumed in the form of a split pulse called *Dal*, which is an important addition to a cereal based diet. It is notably high in lysine, riboflavin, thiamine, niacin, and iron.

One of the most valuable natural resources, soil, is deteriorating over time, and there is less land available for farming as a result of rising population, urbanization, and industrialisation. Application of fertilizer is one of the most effective ways to raise agricultural profitability. Practices for managing nutrients can significantly increase soil fertility for sustaining crop production. Due to the diversity in soil fertility in both the spatial and temporal dimensions, the current and general fertilizer recommendations that were created decades ago are no longer applicable. A shift in fertility from high to medium or medium to low nutrient status over time has also been caused by high crop removal combined with farmers adding fewer nutrients, which has led to large scale depletion of macro and micronutrients in the cultivated soil. Furthermore, due to variances in temperature, crop growing circumstances, and crop and soil management strategies, the crop requirements for different nutrients vary substantially throughout fields, years, and seasons. Therefore, the generalized fertilizer recommendations that are now in use and that were devised decades ago are no longer applicable, and a new nutrient management strategy that takes into consideration the individual nutritional needs of both fields and crops is needed.

An enhanced method of delivering nutrients to crops in accordance with soil variability across space and requirement during a certain growth period has been developed as a result of advances in nutrient management research. The approach is termed as site specific nutrient management (SSNM). The innovative SSNM method employs science based concepts to direct the prudent and effective administration of fertilizers as and when crops require them. It acknowledges the spatial variability associated with soil during crop development and offers recommendations for the best utilization of indigenous nutrients derived from soil, plant wastes, manures, and irrigation water. As a result, SSNM targets the ability to sustain better yields on the one hand, and the assurance of restoring soil fertility on the other, while taking into account the soil's native nutrient supply and productivity.

Plants with the ability to absorb and use nutrients effectively improve the effectiveness of fertilizers applied, lowering input costs and preventing nutrient losses to ecosystems. For a long time, increasing fertilizer use efficiency (FUE) and lowering its detrimental effects on the atmosphere have been global priorities. Fertilizer management can have a specific impact on it. The world's food demand has raised the need for fertilizer nutrients, yet there aren't enough of these resources accessible, and people's concerns about the negative effects of nutrient consumption are growing. As a result, there have been requests for improving NUE without sacrificing agricultural productivity. The ability of the plant to absorb nutrients from the soil effectively is a determinant of nutrient utilization efficiency (NUE), which is also dependent on nutrient internal transport, storage, and remobilization.

Nutrient use efficiency under different nutrient management strategies for red gram crop in this study was estimated in terms of agronomic efficiency (AE), partial factor of productivity and partial nutrient budget (PNB)..

2. MATERIALS AND METHODS

The field experiment was conducted during *rabi* season of 2023, at north farm in Karunya Institute of Technology and Sciences, Coimbatore during the late *rabi* season. The farm is located at 10 ^{0} 56' N and longitude 76 ^{0} 44' E at an elevation. During the cropping period, the mean maximum and minimum temperatures ranged from 28.11 ^{0}C to 19.49 ^{0}C respectively. The total rainfall received during the cropping period was 547.18 mm. The experimental plot was laid out in split plot design with three replications, comprising three varieties of red gram in the main plot namely V_1 - APK 1, V_2 - VBN 3 and V_3- VBN 1. In sub plot nutrient omission treatments were applied T_1- (+NPK), T_2 - N (-PK), T_3 - P (-NK), T_4 - K (-NP), T_5 - PK (-N), T_6 - NK (-P), T_7 - NP (-K), and T_8 - Control (-NPK). Nutrient use efficiency of the experiment was calculated by calculating Agronomic efficiency (AE), Partial factor productivity (PFP) and Partial nutrient budget (PNB) are among the several metrics of nutrient usage efficiency that are computed using the following formulae (Ray *et al*., 2017).

Agronomic efficiency (kg kg^{-1}) = $\frac{Grain\ yield\ in\ treated\ plot - Grain\ yield\ in\ control\ plot}{Applied\ fertilizer}$

Recovery efficiency (kg kg^{-1}) = $\frac{Nutrient\ uptake\ in\ treated\ plot - Nutrient\ uptake\ in\ control\ plot}{Applied\ fertilizer}$

Partial nutrient budget (kg kg^{-1}) = $\frac{Nutrient\ uptake\ in\ treated\ plot}{Applied\ fertilizer}$

3. RESULT AND DISCUSSION

Agronomic efficiency (AE) (kg/kg)

The agronomic efficiency of short duration red gram varieties (APK 1, VBN 3, VBN 1) and nutrient omission trials are presented in the table 1, 2, and 3. Higher agronomic efficiency of nitrogen (4.26 kg/kg), phosphorus (7.96 kg/kg) and potassium (15.93 kg/kg) was observed in the treatment with application of fertilizer 100%, followed by the treatment with the application N (4.26) and P alone without K. This might be due to the fact that this treatment (100% NPK) resulted in substantial yield escalation over control than other treatments at unit fertilizer application. Nitrogen being the primary nutrients for crop growth and having the nature of being lost from the root zone fast due to leaching and other factors, its time of application is crucial, which must be at and when the crop is needed. This could be the key reason for greater AE under this treatment. These results align with the findings reported by Ray *et al*. (2017) and Prakasha *et al*. (2020).

Partial factor productivity PFP (kg/kg)

Higher partial factor productivity of nitrogen (1.91kg/kg), phosphorus (0.11kg/kg) and potassium (15.93 kg/kg) nutrients was recorded in the treatment with no omission (100 % NPK) of nutrients followed by application of P and K alone (without N), the lower PFP was noted in the treatment with the application of N alone (with P and K). The partial factor productivity is a useful measure of nutrient use efficiency because it provides an integrative index that quantifies total economic output related to utilization of all nutrient resources added to the system (Cassman *et al*., 1996). According to Yadav (2003), improved crop management techniques led to a rise in PFP, which in turn improved plant systems' nutrient conversion ratio. Balanced crop management and fertilization techniques would have enabled solar energy to be efficiently converted into economic yields which increased the partial factor productivity.

Partial nutrient budget (PNB) (kg/kg)

Higher partial nutrient budget (4.99 kg/kg) was observed in the treatment with application of 25:50 nitrogen and phosphorus kg/ha, followed by the treatment nitrogen and phosphorus alone (without K). For the phosphorus (0.26 kg/kg) and potassium fertilizer (1.87kg/kg) the partial nutrient budget was observed to be higher in application of nitrogen, phosphorus and potassium followed by treatment of phosphorus and potassium with omission of nitrogen. Partial factor productivity is primarily affected by reduced N applications in split doses according to crop need, which in turn minimizes N losses through various methods. Ghosh *et al*. (2013). The outcomes align with the findings reported by Jat *et al*. (2011).

4. CONCLUSION

In site-specific nutrient management of red gram, higher uptake of NPK, maximum availability of nutrients after the post-harvest analysis and the maximum gain of N and P was recorded in the treatment with the application of 100 % NPK. Higher agronomic efficiency

(AE) and partial factor productivity (PFP) and partial nutrient budget (PNB) were also recorded in the treatment with the application of 100 % NPK**.**

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Table 1. Agronomic efficiency of nitrogen (N)

Treatments	Treated plot yield (kg/ha)	Control yield (kg/ha)	Treated -control yield plot (kg/ha)	N applied to the crop (kg/ha)	Agronomic efficiency (kg/kg)
V1 - APK 1	699.83	468.71	231.12	25	9.24
V2 - VBN 3	632.45	468.71	163.74	25	6.55
V3 - VBN 1	611.39	468.71	142.68	25	5.71
T1 - (+NPK)	866.87	468.71	398.16	25	15.93
T2 - N (-PK)	575.18	468.71	106.47	25	4.26
T3 - P (-NK)	612.9	468.71	144.19	-	-
T4 - K (-NP)	529.53	468.71	60.82	-	-
T5 - PK (-N)	707.99	468.71	239.28	-	-
T6 - NK (-P)	661.61	468.71	192.9	25	7.72
T7 - NP (-K)	760.33	468.71	291.62	25	11.66
T8 - Control	468.71	468.71	-	-	-

Table 2. Agronomic efficiency of phosphorus (P)

Treatments	Treated plot yield (kg/ha)	Control yield (kg/ha)	Treated -control yield plot (kg/ha)	P applied to the crop (kg/ha)	Agronomic efficiency (kg/kg)
V1 - APK 1	699.83	468.71	231.12	50	4.62
V2 - VBN 3	632.45	468.71	163.74	50	3.27
V3 - VBN 1	611.39	468.71	142.68	50	2.85
T1 - (+NPK)	866.87	468.71	398.16	50	7.96
T2 - N (-PK)	575.18	468.71	106.47	-	-
T3 - P (-NK)	612.9	468.71	144.19	50	2.88
T4 - K (-NP)	529.53	468.71	60.82	-	-
T5 - PK (-N)	707.99	468.71	239.28	50	4.79
T6 - NK (-P)	661.61	468.71	192.9	-	-
T7 - NP (-K)	760.33	468.71	291.62	50	5.83
T8 - Control	468.71	468.71	-	-	-

Table 3. Agronomic efficiency of potassium (K)

Treatments	Treated plot yield (kg/ha)	Control yield (kg/ha)	Treated -control yield plot (kg/ha)	K applied to the crop (kg/ha)	Agronomic efficiency (kg/kg)
V1 - APK 1	699.83	468.71	231.12	25	9.24
V2 - VBN 3	632.45	468.71	163.74	25	6.55
V3 - VBN 1	611.39	468.71	142.68	25	5.71
T1 - (+NPK)	866.87	468.71	398.16	25	15.93
T2 - N (-PK)	575.18	468.71	106.47	-	-
T3 - P (-NK)	612.9	468.71	144.19	-	-
T4 - K (-NP)	529.53	468.71	60.82	25	2.43
T5 - PK (-N)	707.99	468.71	239.28	25	9.57
T6 - NK (-P)	661.61	468.71	192.9	25	7.72
T7 - NP (-K)	760.33	468.71	291.62	-	-
T8 - Control	468.71	468.71	-	-	-

Table 4. Partial factor productivity of nitrogen (kg/kg)

Treatments	Treated plot N uptake (kg/ha)	Control plot N uptake (kg/ha)	Treated -control plot N uptake (kg/ha)	N applied to the crop (kg/ha)	Partial factor productivity(kg/kg)
V1 - APK 1	107.81	76.99	30.82	25	1.23
V2 - VBN 3	106.31	76.99	29.32	25	1.17
V3 - VBN 1	104.97	76.99	27.98	25	1.12
T1 - (+NPK)	124.64	76.99	47.65	25	1.91
T2 - N (-PK)	106.51	76.99	29.52	25	1.18
T3 - P (-NK)	107.65	76.99	30.66	-	-
T4 - K (-NP)	100.68	76.99	23.69	-	-
T5 - PK (-N)	112.05	76.99	35.06	-	-
T6 - NK (-P)	109.22	76.99	32.23	25	1.29
T7 - NP (-K)	113.19	76.99	36.2	25	1.45
T8 - Control	76.99	76.99	-	-	-

Table 5. Partial factor productivity of phosphorus (kg/kg)

Treatments	Treated plot P uptake (kg/ha)	Control plot P uptake (kg/ha)	Treated -control plot P uptake (kg/ha)	P applied to the crop (kg/ha)	Partial factor productivity(kg/kg)
V1 - APK 1	11.18	7.53	3.65	50	0.07
V2 - VBN 3	11	7.53	3.47	50	0.07
V3 - VBN 1	9.56	7.53	2.03	50	0.04
T1 - (+NPK)	12.78	7.53	5.25	50	0.11
T2 - N (-PK)	9.7	7.53	2.17	-	-
T3 - P (-NK)	9.61	7.53	2.08	50	0.04
T4 - K (-NP)	9.8	7.53	2.27	-	-
T5 - PK (-N)	11.78	7.53	4.25	50	0.09
T6 - NK (-P)	11.61	7.53	4.08	-	-
T7 - NP (-K)	11.81	7.53	4.28	50	0.09
T8 - Control	7.53	7.53	-	-	-

Table 6. Partial factor productivity of potassium (kg/kg)

Treatments	Treated plot yield (kg/ha)	Control yield (kg/ha)	Treated -control yield plot (kg/ha)	K applied to the crop (kg/ha)	Partial factor productivity(kg/kg)
V1 - APK 1	699.83	468.71	231.12	25	9.24
V2 - VBN 3	632.45	468.71	163.74	25	6.55
V3 - VBN 1	611.39	468.71	142.68	25	5.71
T1 - (+NPK)	866.87	468.71	398.16	25	15.93
T2 - N (-PK)	575.18	468.71	106.47	-	-
T3 - P (-NK)	612.9	468.71	144.19	-	-
T4 - K (-NP)	529.53	468.71	60.82	25	2.43
T5 - PK (-N)	707.99	468.71	239.28	25	9.57
T6 - NK (-P)	661.61	468.71	192.9	25	7.72
T7 - NP (-K)	760.33	468.71	291.62	-	-
T8 - Control	468.71	468.71	-	-	-

Table 7. Partial nutrient budget of N (kg/kg)

Treatments	N uptake ((kg/ha)	N Fertilizer applied (kg/ha)	Partial nutrient budget (kg/kg)

V1 - APK 1	107.81	25	4.31
V2 - VBN 3	106.31	25	4.25
V3 - VBN 1	104.97	25	4.20
T1 - (+NPK)	124.64	25	4.99
T2 - N (-PK)	106.51	25	4.26
T3 - P (-NK)	107.65	-	-
T4 - K (-NP)	100.68	-	-
T5 - PK (-N)	112.05	-	-
T6 - NK (-P)	109.22	25	4.37
T7 - NP (-K)	113.19	25	4.53
T8 - Control	76.99	-	-

Table 8. Partial nutrient budget of P (kg/kg)

Treatments	P uptake ((kg/ha)	P Fertilizer applied (kg/ha)	Partial nutrient budget (kg/kg)
V1 - APK 1	11.18	50	0.22
V2 - VBN 3	11	50	0.22
V3 - VBN 1	9.56	50	0.19
T1 - (+NPK)	12.78	50	0.26
T2 - N (-PK)	9.7	-	-
T3 - P (-NK)	9.61	50	-
T4 - K (-NP)	9.8	-	-
T5 - PK (-N)	11.78	50	0.24
T6 - NK (-P)	11.61	-	-
T7 - NP (-K)	11.81	50	0.24
T8 - Control	7.53	-	-

Table 9. Partial nutrient budget of K (kg/kg)

Treatments	K uptake (kg/ha)	K Fertilizer applied	Partial nutrient

		(kg/ha)	**budget (kg/kg)**
V1 - APK 1	40.54	25	1.62
V2 - VBN 3	39.78	25	1.59
V3 - VBN 1	39.31	25	1.57
T1 - (+NPK)	46.77	25	1.87
T2 - N (-PK)	38.45	-	-
T3 - P (-NK)	40.45	-	-
T4 - K (-NP)	37.18	25	1.49
T5 - PK (-N)	42.89	25	1.72
T6 - NK (-P)	41.4	25	1.66
T7 - NP (-K)	45.63	-	-
T8 - Control	26.25	-	-