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Nutrient content in greengram as influenced by greengram + sesame intercropping system

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Abstract
The field experiment was conducted at Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M.P.) during the *kharif* season of 2017-18 and 2018-19 to study the effect of green gram + sesame intercropping system on the nutrient content in seed and straw of greengram. Nitrogen content in green gram seed was analysed significantly higher under sole crop of green gram over all intercropping system with a pooled average of 3.67%. Similarly, phosphorus and potassium content in seed of greengram was noted significantly more with 0.34% and 0.51%, respectively than that of intercropped treatment. Among the intercropping system, greengram + sesame (8:4 row ratio; 30 cm) and greengram + sesame (6:3 row ratio; 30 cm) treatment estimated significantly highest nitrogen content (3.61 and 3.35%), phosphorus content (0.34% and 0.33%) and potassium content (0.50% and 0.49%) in greengram seed, respectively. However, nitrogen, phosphorus and potassium content in green gram straw were recorded significantly higher under greengram + sesame with 8:4 row ratio; 30 cm (1.32, 0.23, 0.64%) followed by greengram + sesame of 6:3 row ratio; 30 cm (1.30, 0.22, 0.63%), respectively.

Keywords: Green gram, intercropping, nutrient content, sesame

Introduction
Intercropping, the practice of cultivating two or more crops together has long been a traditional agricultural method of tropical and subtropical areas and is becoming popular day by day among small farmers. Different intercropping systems are an effective way to address nutrient depletion in soils, especially given the rising costs of energy, limited availability of inputs, and increasing fertilizer prices, which prevent farmers from using these inputs optimally. Over-reliance on cereal-based cropping systems has further led to land degradation, negatively affecting crop production potential. Consequently, many previously productive soils are becoming unproductive. The main purpose of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop efficiently (Evan *et al*., 2001) [3].

Greengram with sesame is an important intercropping system of central India which presents a potential solution for improving crop production and nutrient content in seeds. The legume's ability to fix atmospheric nitrogen can help address poor nitrogen content in the soil. The most common reason for the adoption of intercropping systems is yield advantage, which is explained by the greater resource depletion by intercrops than monocultures, and N_2 fixation, particularly when cereal and legume crops; i.e. barley/fababean (Agegnehu *et al*., 2006) [1] are grown together. Moynihan *et al*. (1996) [7] mentioned that intercropping annual legumes with grain crops has been proposed as a cropping strategy to enhance ground cover, thereby reducing weed competition, suppressing soil erosion, and providing N for use by subsequent crops. So, with such systems synthetic N-fertilizer and herbicide use might be reduced. Therefore, there is a needs to examine how intercropping greengram with sesame influences the nutrient content of greengram. Keeping these facts in mind, the present investigation was taken up to assess the suitable intercropping system for enhancing nutrient content in seeds of greengram under intercropping cropping system.

Materials and Methods

This field study was carried out during the *kharif* season of 2017-18 and 2018-19 at the Agriculture farm of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M.P.). The farm is located beneath the Kymore Plateau in Northern Madhya Pradesh. It is positioned at 25°10′ N latitude, 80°32′ E longitude, and has an altitude ranging from 190 to 210 metres above mean sea level. The soil in the experimental field had a sandy loam texture and a slightly alkaline pH (8.0 and 7.9). It had low levels of organic carbon (0.44% and 0.49%), as well as available nitrogen with 214.48 and 219.54 kg N/ha, respectively in two years. On the other hand, it had high levels of available phosphorus with 42.6 and 47.41 kg P/ha, and medium levels of available potassium at 50.4 and 53.34 kg K/ha over the course of two consecutive years. The crop experienced rainfall of 774.1 mm and 748.7 mm during the crop period in two respective years.

The experiment consisted thirteen treatments *viz*. T_1: Green gram sole, , T_2: G + S (1:1; 20 cm), T_3: G + S (2:1; 40/20cm; 20 cm), T_4: G + S (4:2; 80/40cm; 20 cm), T_5: G + S (6:3; 120/60cm; 20 cm), T_6: G + S (8:4;160/80cm; 20 cm), T_7: G + S (1:1; 30 cm), T_8: G + S (2:2; 30 cm), T_9: G + S (3:3; 30 cm), T_{10}: G + S (4:2; 30 cm), T_{11}: G + S (6:3; 30 cm) and T_{12}: G + S (8:4; 30 cm) in a randomized block design with three replications. A tractor-drawn disc plough was used to plough the trial field, and then planking was completed. The field was weeded before it was sown at a depth of 2.5 cm with 20 kg of green gram seed (PDM-11) and 5 kg of sesame seed of the Pragati variety. Green gram seeds were treated with thiram (3 g/kg of seed) and *Rhizobium* culture (20g/kg seed) before sown, while sesame seeds received thiram @ 3 g/kg of seed. Through thinning operations, the 5 cm plant-to-plant spacing in both sole and intercropped greengram was maintained. In green gram sole, 20-kilogram N was applied along with 40 kg P_2O_5 and 20 kg K_2O/ha. In intercropping systems, the NPK ratio was established based on the row ratio/ plant population of both crops. The nitrogen, phosphorus and potassium content in seed and straw of green gram at harvest was estimated by adopting modified micro Kjeldhal's method for nitrogen, Molybdo-vanado phosphoric acid yellow colour method for phosphorus and Flame photometery method for potassium as described by Jackson (1973) [4]. Statistical analysis was applied to the data collected throughout the experiment. The "F" test and crucial differences with a 5% probability were used to test the treatment differences (Panse and Sukhatme, 1985) [8].

Result and Discussion

NPK content (%) of seed of Green gram

Nitrogen content in green gram seed was analysed significantly higher under sole cropping of green gram (T_1) of 3.67% and 3.68% in 2017-18 and 2018-19, respectively with a pooled average of 3.67%. Phosphorus content in seed was 0.34% in 2017-18 and slightly higher at 0.35% in 2018-19, resulting in a pooled average of 0.34% (Table 1). Potassium content showed similar stability with values of 0.51% and 0.52% for the two years, respectively, and a pooled average of 0.51%.

The treatments with the highest NPK content in green gram seeds, aside from the sole cropping system (T_1), are T_{12} **:** G + S (8:4; 30 cm) and $T_{11:}$ G + S (6:3; 30 cm) treatment. Treatment T_{12}, which features an 8:4 intercropping ratio with 30 cm alternate rows, exhibited the highest nutrient content followed by $T_{11:}$ G + S (6:3; 30 cm) among all intercropping treatments. The Nitrogen content of treatment T_{12}**:** G + S (8:4; 30 cm) was 3.61% closely followed by $T_{11:}$ G + S (6:3; 30 cm) with 3.35% on the basis of pooled average which showed statistical at par. Phosphorus content in greengram seeds was recorded high however, the treatment T_{12}**:** G + S (8:4; 30 cm) stands at 0.34% and 0.35% for the two years, pooling to 0.34% phosphorus content followed by $T_{11:}$ G + S (6:3; 30 cm) of 0.33% and 0.34% for the two respective years, with a pooled average of 0.33% phosphorus content which were statistically on par. Potassium content in greengram seed was noted higher in T_{12}: G + S (8:4; 30 cm) with 0.50% and 0.51%, pooling to 0.50% followed by $T_{11:}$ G + S (6:3; 30 cm) with potassium content of 0.49% and 0.50%, pooling to 0.49%. Both $T_{11:}$ G + S (6:3; 30 cm) and T_{12}**:** G + S (8:4; 30 cm) demonstrate that increasing the proportion of green gram relative to sesame can significantly enhance the nutrient content in green gram seeds. This might be owing to maintaining adequate row spacing provides an optimal balance to optimize nutrient uptake by minimizing competition between the crops leading to higher concentrations of nitrogen, phosphorus, and potassium in the green gram seeds. This high absorptance might be helpful for increasing the productivity of sesame under this row ratio (Jena, *et al.*, 2009) [5]. Similar findings were observed by Ashif *et al.* (2023) [2] and Malay and Mahadev (2014) [6].

NPK content (%) of straw of Green gram

In sole cropping (T_1), where green gram was planted in rows spaced 30 cm apart, the nitrogen content was consistently high, measuring 1.51% in 2017-18 and slightly increasing to 1.52% in 2018-19, resulting in a pooled average of 1.51% (Table 2). This indicates that green gram grown alone without inter species competition tends to accumulate higher nitrogen levels in its straw biomass.

Among the intercropping system, NPK content in green gram straw, T_{12}: G + S (8:4; 30 cm) treatments stand out for their notably high nutrient levels. This treatments exhibited the significant highest nitrogen content across all treatments, with values reaching 1.32% in 2017-18 and 1.33% in 2018-19, averaging 1.32% followed by $T_{11:}$ G + S (6:3; 30 cm) and T_6**:** G + S (8:4; 160/80; 20 cm) with polled N content in straw of 1.30. The phosphorus content in greengram straw was estimated significantly more in T_{12}: G + S (8:4; 30 cm) with 0.23% followed by $T_{11:}$ G + S (6:3; 30 cm) containing 0.22% on an average of two years. Similarly, potassium content in greengram straw was analysed significantly more in T_{12}: G + S (8:4; 30 cm) with 0.64% closely followed by $T_{11:}$ G + S (6:3; 30 cm) consisted 0.63% on polled basis.

This configuration (8:4 and 6:3 row ratio) of greengram and sesame intercropping likely minimized competition between green gram and sesame, enabling efficient nitrogen uptake by green gram and resulting in superior nutrient accumulation in its straw biomass. Additionally, T_{12} demonstrated competitive levels of phosphorus and potassium, indicating a balanced nutrient profile conducive to robust growth and development. The results are conformity with the findings of Malay and Mahadev (2014) [6].

Table 1: N, P, K content in seed of green gram under intercropping systems

Treatment combination	NPK content in seed of green gram								
	N content (%)			P content (%)			K content (%)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1:Green gram sole	3.67	3.68	3.67	0.34	0.35	0.34	0.51	0.52	0.51
T_2:G + S (1:1; 20 cm)	3.44	3.45	3.45	0.28	0.29	0.28	0.44	0.45	0.44
T_3: G + S (2:1; 40/20 cm; 20 cm)	3.46	3.47	3.46	0.29	0.30	0.29	0.45	0.46	0.45
T_4: G + S (4:2; 80/40 cm; 20 cm)	3.48	3.49	3.49	0.30	0.31	0.30	0.46	0.47	0.46
T_5: G + S (6:3; 120/60 cm; 20 cm)	3.50	3.51	3.50	0.31	0.32	0.31	0.47	0.48	0.47
T_6: G + S (8:4; 160/80; 20 cm)	3.52	3.53	3.53	0.33	0.34	0.33	0.48	0.49	0.48
T_7: G + S (1:1; 30 cm)	3.45	3.46	3.45	0.29	0.30	0.29	0.45	0.46	0.45
T_8: G + S (2:2; 30 cm)	3.48	3.49	3.49	0.30	0.31	0.30	0.46	0.47	0.46
T_9: G + S (3:3; 30 cm)	3.51	3.52	3.51	0.31	0.32	0.31	0.47	0.48	0.47
T_{10}: G + S (4:2; 30 cm)	3.54	3.55	3.55	0.32	0.33	0.32	0.48	0.49	0.48
T_{11}: G + S (6:3; 30 cm)	3.57	3.58	3.57	0.33	0.34	0.33	0.49	0.50	0.49
T_{12}: G + S (8:4; 30 cm)	3.60	3.61	3.61	0.34	0.35	0.34	0.50	0.51	0.50
S.E. (m) (±)	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C.D. at 5%	0.05	0.06	0.04	0.02	0.03	0.02	0.02	0.03	0.02

Table 2: N, P, K content in straw of green gram under intercropping systems

Treatment combination	NPK content of straw of Green gram								
	N content (%)			P content (%)			K content (%)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1:Green gram sole	1.51	1.52	1.51	0.22	0.23	0.23	0.67	0.68	0.67
T_2:G + S (1:1; 20 cm)	1.22	1.23	1.22	0.16	0.17	0.17	0.58	0.59	0.58
T_3: G + S (2:1; 40/20 cm; 20 cm)	1.24	1.25	1.24	0.17	0.18	0.18	0.59	0.60	0.59
T_4: G + S (4:2; 80/40 cm; 20 cm)	1.26	1.27	1.26	0.18	0.19	0.19	0.60	0.61	0.60
T_5: G + S (6:3; 120/60 cm; 20 cm)	1.28	1.29	1.28	0.19	0.20	0.20	0.61	0.62	0.61
T_6: G + S (8:4; 160/80; 20 cm)	1.30	1.31	1.30	0.20	0.21	0.21	0.62	0.63	0.62
T_7: G + S (1:1; 30 cm)	1.22	1.23	1.22	0.17	0.18	0.18	0.59	0.60	0.59
T_8: G + S (2:2; 30 cm)	1.24	1.25	1.24	0.18	0.19	0.19	0.60	0.61	0.60
T_9: G + S (3:3; 30 cm)	1.26	1.27	1.26	0.19	0.20	0.20	0.61	0.62	0.61
T_{10}: G + S (4:2; 30 cm)	1.28	1.29	1.28	0.20	0.21	0.21	0.62	0.63	0.62
T_{11}: G + S (6:3; 30 cm)	1.30	1.31	1.30	0.21	0.22	0.22	0.63	0.64	0.63
T_{12}: G + S (8:4; 30 cm)	1.32	1.33	1.32	0.22	0.23	0.23	0.64	0.65	0.64
S.E. (m) (±)	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01
C.D. at 5%	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.03

Conclusion

Thus, it can be concluded that greengram + sesame (8:4 ratio; 30 cm) and greengram + sesame (6:3 ratio; 30 cm) was found the equally best intercropping system in term of

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