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PRODUCTIVITY, PROFITABILITY, AND SEED QUALITY OF SOYBEAN (*GLYCINE MAX*) AS AFFECTED BY NUTRIENT MANAGEMENT THROUGH THE NUTRIENT OMISSION TECHNIQUE

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ABSTRACT

A field experiment was conducted during the *kharif* season, 2023 at the Instructional Farm, Rajasthan College of Agriculture, Udaipur, to evaluate the effect of nutrient management on the productivity, profitability and seed quality of soybean (*Glycine max* L.) using the nutrient omission technique. Eleven treatments, including a complete nutrient package (NPK + S + Zn + B + PSB + *Rhizobium*) and different nutrient omission combinations, were laid out in a randomized block design with three replications. Application of the full nutrient package (T_1) significantly improved vegetative growth, including plant height, branches per plant, and dry matter accumulation. Yield attributes such as pods per plant, grains per pod, and test weight were also maximized under T_1, resulting in the highest seed yield (1793.1 kg ha^{-1}), haulm yield (2963.1 kg ha^{-1}), and biological yield (4756.2 kg ha^{-1}). Seed quality improved with maximum protein (40.29%) and oil content (20.25%) recorded under balanced fertilization. Economic analysis revealed the highest net profit (Rs. 67,582 ha^{-1}) for T_1, while the maximum benefit–cost ratio (2.32) was observed under T_8.

Keywords**:** growth, nutrient omission, yield, seed quality, soybean.

Introduction

Soybean (*Glycine max* [L.] Merrill) is a major leguminous oilseed crop valued for its high protein content (~42%) and importance in food, feed, and edible oil security. Despite its high yield potential, productivity remains low due to rainfed conditions, climatic variability, and poor adoption of scientific crop management practices. Imbalanced nutrient management, with excessive reliance on nitrogen and phosphorus and neglect of secondary and micronutrients, has led to widespread deficiencies of potassium, sulfur, zinc, and boron, adversely affecting yield and seed quality. The nutrient omission technique is an effective approach to identify yield-limiting nutrients and improve fertilizer use efficiency under rainfed systems (Majumder *et al.*, 2023). Hence, the present study aimed to evaluate the effect of nutrient management using the nutrient omission technique on productivity, profitability, and seed quality of soybean for developing balanced and sustainable nutrient recommendations.

Materials and Methods

The experiment was conducted during *kharif* 2023 at Block C_7 of the Instructional Farm, Rajasthan College of Agriculture, Udaipur (24°35′ N, 74°42′ E; 579.5 m amsl) located in Agro-climatic Zone IVa (Sub-humid Southern Plain and Aravalli Hills). The region has a subtropical climate, receiving 500.9 mm well-distributed rainfall during the crop season, with maximum and minimum temperatures ranging from 29.2–34.4 °C and 16.2–23.9 °C, respectively. The experimental soil (0–15 cm) was clay loam in texture, mildly alkaline (pH 8.17), low in organic carbon (0.62%), medium in available N, P, K and deficient in sulfur and some micronutrients. The experiment consisted of 11 treatments laid out in a Randomized Block Design with three replications (Table 1) involving a complete nutrient package and omission of individual or combined nutrients including biofertilizers along with an absolute control. Soybean variety *JS-9560* was sown at 80 kg ha^{-1} with 30 × 10 cm spacing, and all agronomic practices, including nutrient application, weed, pest, and irrigation management, were followed as per recommendations. Observations on growth, yield attributes, yield, quality and economics were recorded using standard procedures.

Table 1: Treatment details

T_1	(NPK+ S+ Zn+ B+ PSB + *Rhizobium*)
T_2	B omission (T_1 - B)
T_3	Zn omission (T_1 - Zn)
T_4	S omission (T_1- S)
T_5	K omission (T_1 - K)
T_6	P omission (T_1- P)
T_7	N omission (T_1- N)
T_8	Secondary and Micronutrient omission (T_1 - S - Zn - B)
T_9	P and K omission (T_1- PK)
T_{10}	Bio-fertilizer omission (T_1 - PSB + *Rhizobium*)
T_{11}	Absolute Control

Results and Discussion

Growth, yield attributes and yield

The results showed (Table 2) that nutrients application at recommended rates maintained superiority in respect yield and yield components such as plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of grains pod^{-1}, dry matter accumulation, and test weight. However, this treatment failed to show any significant variation in harvest index. N omission resulted in more reduction in the yield and yield attributes such plant height, number of pods plant^{-1}, number of grains pod^{-1}, dry matter accumulation and test weight highlighting the importance of N in soybean production. The increase in soybean yields with the application of NPK fertilizers as compared to micronutrients application does not increase seed yield. The results indicate low seed yield was achieved for the treatment to which PK was applied (*i.e.* N omitted plot). This shows that N was the most seed yield limiting nutrient in this experiment. The absence of nitrogen before or at sowing results in highly reduced seed yield in soybean. N application increased yield and yield components of soybean. These results are in conformity with Atnafu *et al.,* 2021. P omission resulted in reduction of (27.68 per cent) in seed yield, (19.68 per cent) in biological yield in soybean crop. These findings were reported in the results of Kumar *et al.,* 2017.

The reduction in yields and yield components due to B omitted was marginal and statistically non-significant in soybean crop. These results are similar with the findings of Sherchan *et al.,* 2004 who reported that response of boron application on maize grain production was found not significant.

The treatments were omitted with B, Zn, S, P, N, K alone or S, Zn, B and PK, Zn, S, B, PSB and Rhizobium in combination recorded the lower values of yield and yield components. This might be due to lower content of nutrients in the plant and reduced yields of soybean. These results are in conformity with Paramasivan *et al.,* 2012.

Quality parameters

The presented in table reveals that the protein content and oil content in seeds of soybean maximum by the application of NPK + S + Zn + B + PSB + Rhizobium (40.29 and 20.25 per cent), respectively which was significantly higher over control. The protein content of seed is related to its nitrogen content, so when, the nitrogen is omitted quality of soybean was reduced by (6.55 per cent). Application of the recommended dose of urea significantly increased the oil and protein contents and best quality of soybean with high yield this was similarly reported by Alam *et al.,* 2009.

The effect of sulphur on oil content of soybean are given in Table 3. Seed oil content was significantly influenced by of sulphur. The omission of sulphur significantly reduce oil content by (13.47 per cent) but, it was at par with treatment T_2 and T_3 and lowest was observed in control. These findings are agreed with the results of Kesare *et al.,* 2015.

The protein and oil content of soybean were also significantly affected by S and B (Table 3). However, they showed better response to S application than to B. The protein and oil content both increased by application of S along with NPK, micronutrient and bio fertilizers. With concurrent application of S and B (the combination which produced the best yield), when sulphur is omitted 4.11 per cent decrease in protein and 13.47 per cent decrease in oil content while omission of boron alone didn't affect as much in protein and oil content of soybean as compared to T_1. Beneficial effects of S and B on oil and protein content of soybean can be understood by their crucial involvement in synthesis of these quality attributes (Brady 1990, Malewar *et al*., 2001, Cirak *et al*., 2006, Singh *et al.*, 2006 and Kumar *et al*., 2009).

Economics

The data presented in (Table 4.23) showed that application of T_1 (NPK + S+ Zn + B + PSB + Rhizobium) gave highest net return as compared to T_7 (T_1-N). The omission of sulphur, zinc, boron, treatment T_8 gave the highest B-C ratio as compared to nitrogen omitted treatment, similar results was obtained by Dass *et al.,* 2022.

Conclusion

Balanced nutrient management through the nutrient omission technique significantly improved soybean productivity, profitability, and seed quality. The complete nutrient package (NPK + S + Zn + B + PSB + *Rhizobium*) produced the highest yield, seed quality, and net returns, while nitrogen was identified as the most yield-limiting nutrient. Sulphur played a key role in enhancing oil and protein content. Overall, the nutrient omission technique proved effective for identifying critical nutrient deficiencies and developing balanced, sustainable nutrient management strategies for soybean.

Table 2 : Effect of nutrient management growth and yield attributes of soybean.

Treatments	Plant height (cm)	DMA (g/plant)	Number of branches plant^{-1}	Number of pods plant^{-1}	Number of grains pod^{-1}	Test weight (g/1000 seeds)	yield (kgha^{-1})			Harvest index (%)
							Seed	Haulm	Biological	
T_1	57.13	34.40	9.20	107.10	3.00	132.60	1793.1	2963.13	4756.24	37.55
T_2	52.72	33.27	9.23	102.77	2.80	130.93	1607.7	2761.22	4368.90	37.08
T_3	52.50	31.40	8.77	101.90	2.77	130.07	1544.4	2743.99	4288.36	35.99
T_4	52.00	29.57	8.67	95.83	2.67	129.40	1525.0	2735.24	4260.26	35.94
T_5	47.63	27.43	8.30	91.73	2.57	126.40	1416.3	2584.57	4000.83	35.41
T_6	46.17	26.43	8.07	87.47	2.50	123.53	1404.3	2565.74	3970.04	35.37
T_7	38.22	25.77	7.97	83.63	2.43	120.00	1287.8	2359.60	3647.41	35.32
T_8	51.17	27.93	8.63	93.60	2.60	127.37	1514.2	2659.27	4173.44	36.33
T_9	39.33	26.13	7.30	85.63	2.37	121.37	1393.5	2481.10	3874.57	36.11
T_{10}	38.83	25.80	6.47	84.27	2.30	121.00	1347.4	2465.68	3813.07	35.43
T_{11}	38.00	24.47	6.37	81.63	2.27	118.30	1128.3	2088.42	3216.76	35.14
SE(m)	2.01	1.27	0.43	3.44	0.14	3.05	66.25	142.34	150.81	1.64
CD (p=0.5)	5.93	3.74	1.27	10.14	0.41	9.00	195.44	419.90	444.90	NS

Table 3 : Effect of nutrient management on quality and economics of soybean

Treatment	Quality parameters		Economics	
	Protein content in grain (%)	Oil content (%)	B/C ratio	Net return (Rs ha^{-1})
T_1	40.29	20.25	2.14	67582
T_2	39.45	19.36	1.89	58413
T_3	39.43	19.03	2.03	57826
T_4	38.69	17.85	1.94	56291
T_5	38.98	19.07	1.62	49111
T_6	38.96	18.42	1.69	49494
T_7	37.81	18.84	1.32	41186
T_8	38.93	17.88	2.32	58986
T_9	38.88	18.81	1.76	49695
T_{10}	38.87	18.49	1.43	44546
T_{11}	37.69	17.80	1.97	42074
SE(m)	0.30	0.42	0.1	3123
CD (p=0.5)	0.89	1.23	0.3	9214

Table 4 : Correlation coefficient and regression equation showing relationship between independent variable (x) and dependent variable (y) on mean basis

Dependent variable (y)	Independent variables (x)		Correlation coefficient (r)	Regression coefficient (b)		R	R^2	$Y = a+b_1x_1+b_2x_2+b_3x_3+\ldots+b_nx_n$
Seed yield (kg ha^{-1})	X_1	Haulm yield	0.981**	b_1	0.734	0.9935	98.71	$Y=2126.851+0.7172x_1+3.8098x_2-67.6044x_3-30.3228x_4+9.7337x_5+22.7406x_6$
	X_2	Pods/plant	0.934**	b_2	18.851			
	X_3	Seeds pod^{-1}	0.937**	b_3	723.745			
	X_4	Test weight	0.935**	b_4	33.253			
	X_5	Plant height	0.906**	b_5	22.677			
	X_6	Plant dry matter	0.926**	b_6	49.139			

Haulm yield (kg ha^{-1})	X_1	Biological yield	0.997**	b_1	0.573	0.9978	99.56	$Y=226.5828+0.6084x_1+2.996x_2+0.5982x_3-14.1782x_4$
	X_2	Pods plant^{-1}	0.911**	b_2	24.573			
	X_3	Plant height	0.986**	b_3	130.772			
	X_4	Plant dry matter	0.996**	b_4	144.8076			

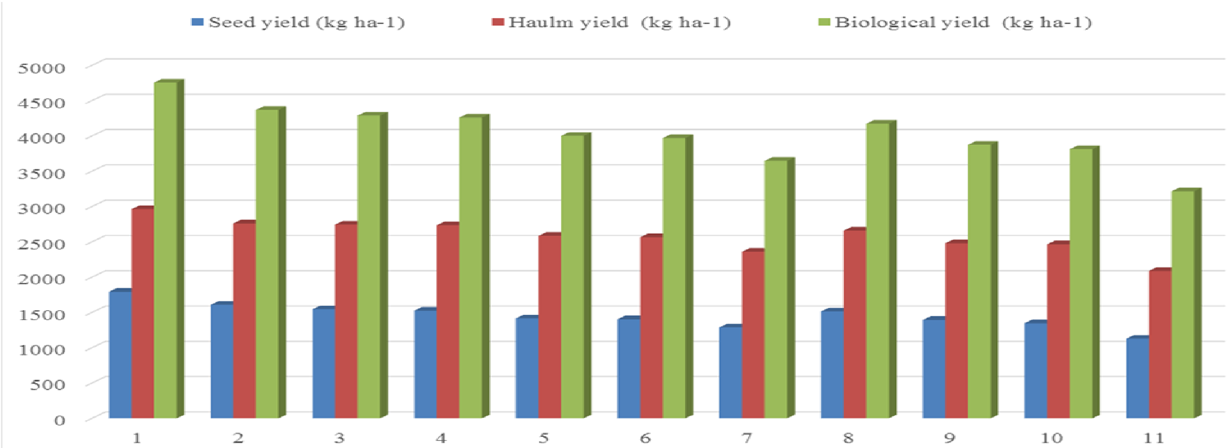

Fig. 1: Effect of nutrient management on yield of soybean

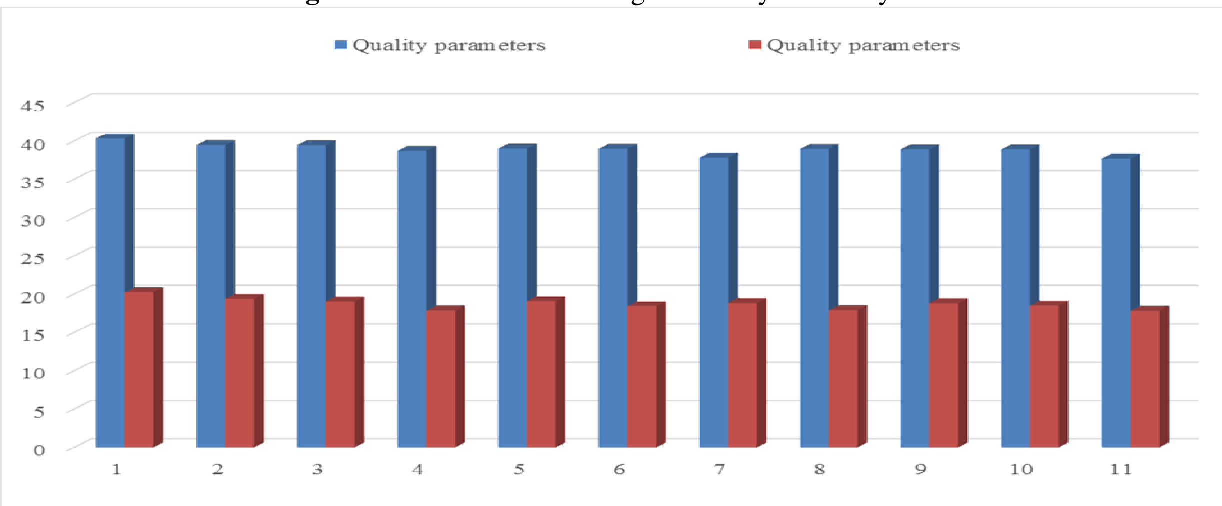

Fig. 2: Effect of nutrient management on quality parameters of soybean

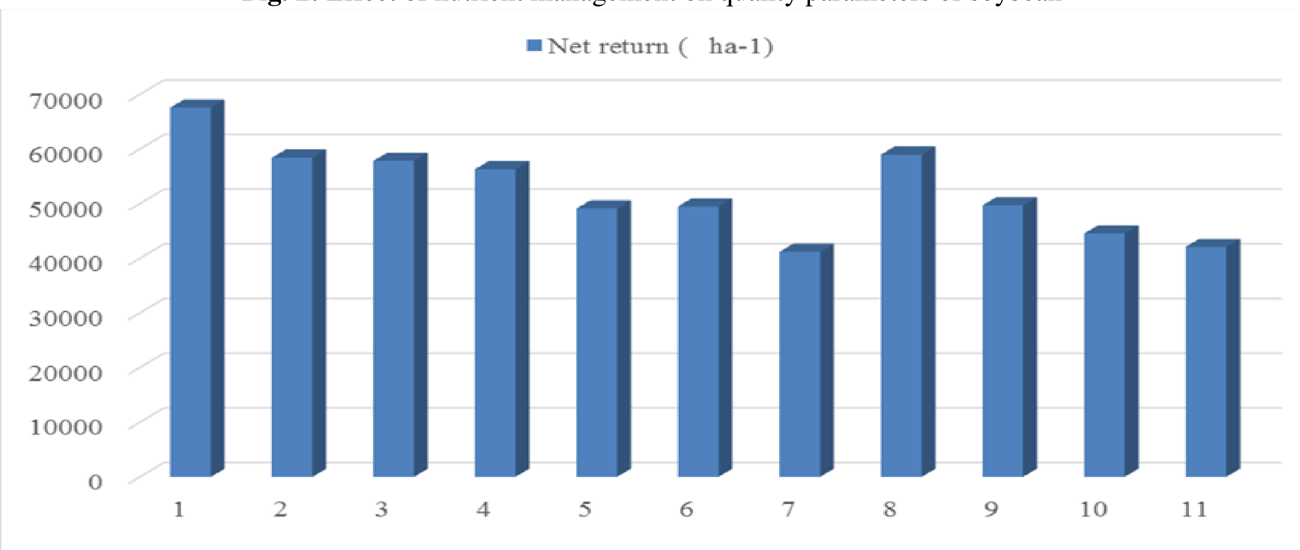

Fig. 3: Effect of nutrient management on net return of soybean

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