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Effect of basal and foliar application of N, P, and K on growth and yield of soybean (*Glycine max* L.)

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Abstract
A field experiment entitled "Effect of basal and foliar application of N, P, and K on growth and yield, of soybean (*Glycine max* L.)." was conducted at the Crop Research Centre, School of Agriculture, ITM University Gwalior (M.P.) during the *Kharif* season of 2022-The experiment was laid out in a randomized block design with 10 treatment combinations, which includes include RDF (100%) @ at the time of sowing, RDF + DAP @ 2% at 30 DAS and DAP @ 2% at 50 DAS, RDF + UREA @ 2% at 30 DAS and @ 2% UREA at 50 DAS, RDF + KNO_3 @ 2% at 30 DAS and KNO_3 @ 2% at 50 DAS, RDF + MOP @ 2% at 30 DAS and MOP @ 2% at 50 DAS, RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS, RDF + DAP @ 2% + KNO_3 @ 2% at 30 DAS and DAP @ 2% + KNO_3 @ 2% at 50 DAS, RDF + DAP @ 2% + MOP @ 2% at 30 DAS and DAP @ 2% + MOP @ 2% at 50 DAS, RDF + UREA @ 2% + MOP @ 2% + KNO_3 @ 2% at 30 DAS and UREA @ 2% + MOP @ 2% + KNO_3 at 50 DAS, and one absolute control, and each treatment was replicated thrice. The result of the experiment revealed that an increase in the basal and foliar fertilizer application had significantly increased the growth of soybeans viz., plant height (cm), No. of leaves per plant, leaf area index, and dry weight (g plant^{-1}), yield attributes viz., Number of seed pods, Number of pods plant^{-1} seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), and Harvest index, gross returns, net returns, and B-C ratio, the Application of RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS which was significantly superior over rest of the treatment. However, it was at par with the RDF (100%) + UREA @ 2% + MOP @ 2% + KNO_3 @ 2% at 30 DAS and UREA @ 2% + MOP @ 2% + KNO_3. The lowest grain yield was recorded in the control.

Keywords: Basal and foliar application of N, P, and K, growth, and yield of soybean

1. Introduction
Soybean is one of the major global crops that also have a unique role in sustainable agriculture due to its ability to fix atmospheric nitrogen through symbiotic interactions with rhizobia in the soil. Commonly known as 'Soya' is an unique crop with high nutritional value, providing 40-42% protein and 20-22% edible oil besides Soybean contains 26% carbohydrates, 4% minerals and 2% phospholipids, rich in polyunsaturated fatty acids. In addition, it contain good amount of vitamin C, 5-6% crude fiber. Soybean (*Glycine max* (L.) Merrill) is the major *Kharif* crop of Madhya Pradesh or particularly in the central part of the country, such as Maharashtra, Rajasthan, Karnataka, and Andhra Pradesh. The total area and production is higher in Madhya Pradesh so it is called 'Soya-state' and also known as the 'Soybean Bowl'. Madhya Pradesh, Maharashtra, Rajasthan, together contribute about 97% to the total area and 96% production of soybean in the country. In India soybean acquired third position among the oilseed after the groundnut and mustard and emerged as a main oilseed crop in a short span of time.

The low productivity in the state and country calls for optimizing it through efficient nutrient management. The lack of integrated nutrient management approach coupled with unbalanced nutrition not only limits the productivity, but also leads to deterioration in soil quality. In India, soybean is grown in about 12.20 M ha under diverse agro-climatic and soil conditions with average production and productivity of 13.45 million tonnes and 1.18 t ha^{-1}, respectively. While in Madhya Pradesh it is cultivated in an area of 55.68 Lakh ha with productivity of 1.43 t ha^{-1} and contributes about 60% production from around 55% of soybean grown area of the country.

2. Materials and Methods

This experiment was carried out at the Crop Research Centre, ITM University Gwalior, during the *Kharif* season of 2022. The experimental field's coordinates were $26^0$22` North (N) and $78^0$18` East (E). with a 228-meter elevation above sea level. The research Centre falls under the grid zone of agroecological zones of Madhya Pradesh. The average annual rainfall was 700mm to 800mm received during the monsoon season from June to September. The data indicates that the mean maximum temperature ranged between $29^0$9 to 37.9 °C while the mean minimum temperature ranged between 14.8 to 26.9 °C during the period of experimentation in the year 2022. The mean relative humidity recorded in the morning and evening ranged between 76.5 to 95.4 and 47.0 to 76.2 percent, respectively. A total rainfall of 663.8 mm in 22 rainy was received during the crop period. The pan evaporation (mm/day) ranged between 2 to 9.4 mm/day during experimentation from July to October 2022. The experiment was laid out in a Randomized Block Design effect of basal and foliar application of N, P, and K in experimental plots with three replications. which include RDF (100%) @ at the time of sowing, RDF + DAP @ 2% at 30 DAS and DAP @ 2% at 50 DAS, RDF + UREA @ 2% at 30 DAS and @ 2% UREA at 50 DAS, RDF + KNO_3 @ 2% at 30 DAS and KNO_3 @ 2% at 50 DAS, RDF + MOP @ 2% at 30 DAS and MOP @ 2% at 50 DAS, RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS, RDF + DAP @ 2% + KNO_3 @ 2% at 30 DAS and DAP @ 2% + KNO_3 @ 2% at 50 DAS, RDF + DAP @ 2% + MOP @ 2% at 30 DAS and DAP @ 2% + MOP @ 2% at 50 DAS, RDF + UREA @ 2% + MOP @ 2% + KNO_3 @ 2% at 30 DAS and UREA @ 2% + MOP @ 2% + KNO_3 at 50 DAS, and one absolute control and each treatment were replicated thrice. The soybean variety "JS9560" was sown by line sowing (seed drills) method. And the recommended dose of fertilizer is 20:40:40 kg ha^{-1} NPK. Observations are taken while carrying out the experiment, growth parameters like Initial plant population, plant height (cm), No. of leaves, Leaf area index (LAI), No. of seed pods, No. of pods per plant, and 50% flowering. Yield attributing characters like, Grain yield, Straw yield, Test weight (100 seeds g^{-1}), and Dry matter accumulation (g^{-1}). In economics, gross return, net return, and B: C ratio.

3. Results and Discussion

The present investigation of the experiment revealed that an increase in the application Effect of basal and foliar application of N, P, and K on growth, yield, and quality of soybean (*Glycine max* L.). gradually impacted growth parameters like Initial plant population, plant height (cm), no. of leaves, leaf area index (LAI), and no. of seed pods, no. of pods per plant, 50% flowering, and dry matter accumulation (g). In all the growth parameter aspects maximum basal and foliar fertilizer application of N, P, and K show maximum growth. with an Initial plant population (6.33), plant height (41.45cm), no. of leaves (7.18), No. Leaf area index (6.03), no. of seed pods (2.80), no. pods per plant (56.53), 50% flowering (56), and Dry matter accumulation (35.02), Superior highest with RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS and *at par* with RDF + UREA @ 2% + MOP @ 2% + KNO_3 @ 2% at 30 DAS and UREA @ 2% + MOP @ 2% + KNO_3 at 50 DAS. 10 kg N ha^{-1} growth was statistically less compared to RDF + DAP @ 2% + MOP @ 2% at 30 DAS and DAP @ 2% + MOP @ 2% at 50 DAS and RDF + DAP @ 2% + KNO_3 @ 2% at 30 DAS and DAP @ 2% + KNO_3 @ 2% at 50 DAS, increased chlorophyll content along with more functional leaves and leaf area may have improved the interception, absorption, and utilization of radiant energy. This in turn may have improved photosynthesis, which in turn increased plant height, and no. of leaves ultimately leading to better growth. Patel *et al*. (2018) [12] In phosphorous levels also the same as nitrogen, Initial plant population (19.56), Plant height (68.37 cm), no. of leaves (50.98), No. of branches (9.64), Leaf area index (5.66), no. of seed pods (16.75), no. pods per plant (23.07), 50% flowering (52.97), and Dry matter accumulation (15.93), Superior highest with RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS and *at par* with RDF + UREA @ 2% + MOP @ 2% + KNO_3 @ 2% at 30 DAS and UREA @ 2% + MOP @ 2% + KNO_3 at 50 DAS. 10 kg N ha^{-1} growth was statistically less compared to RDF + DAP @ 2% + MOP @ 2% at 30 DAS and DAP @ 2% + MOP @ 2% at 50 DAS and RDF + DAP @ 2% + KNO_3 @ 2% at 30 DAS and DAP @ 2% + KNO_3 @ 2% at 50 DAS, compared to other treatments significantly lower and one absolute control. The numerous metabolic and physiological functions are improved by phosphorus fertilization, which is also referred to as "energy currency" and is employed for vegetative and reproductive growth through photophosphorylation (Choudhary 2017) [7].

The yield attributes characters like gain yield (kg ha^{-1}), Straw yield (kg ha^{-1}), Biological yield (kg ha^{-1}), Harvest index (%), and Test weight (100 seed g^{-1}). Application of RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS recorded significantly highest grain yield (2181kg ha^{-1}), Straw yield (2906.67 kg ha^{-1}), Biological yield (5087.66 kg ha^{-1}), Harvest index (42.87%), and Test weight (12.67g). *at par* with 20 kg N ha^{-1}. A significant increase in grain yield under these fertility levels appears to be due to their influence on dry matter production and indirectly via., the increase in plant height, number of leaves, number of branches, 50% flowering, and leaf area index. The present findings are in close agreement with the results obtained by (Patel *et al*. (2018) [12] in cowpeas. In phosphorous levels also the same as nitrogen increase in the level of grain yield (1479.84 kg $P_2O_5ha^{-1}$), Straw yield (2547.72 kg P_2O_5 ha^{-1}), Biological yield (4027.56 kg P_2O_5 ha^{-1}), Harvest index (36.80% P_2O_5), and Test weight (19.87 g P) in RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS, it is *at par* with RDF + UREA @ 2% + MOP @ 2% + KNO_3 @ 2% at 30 DAS and UREA @ 2% + MOP @ 2% + KNO_3 at 50 DAS and is significant over RDF + DAP @ 2% + MOP @ 2% at 30 DAS and DAP @ 2% + MOP @ 2% at 50 DAS, it is *at par* with RDF + DAP @ 2% + KNO_3 @ 2% at 30 DAS and DAP @ 2% + KNO_3 @ 2% at 50 DAS, significant with other treatment and absolute control. significant increase in grain yield under these fertility levels appears to be due to their influence on dry matter production and indirectly via., the increase in plant height, number of leaves, number of branches, 50% flowering, and leaf area index. The present findings are in close agreement with the results obtained by (Apaez Barrios 2013) [13].

Economics studies Gross return, Net return, and B: C ratio. Application of RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS and recorded significantly highest Gross return (103379 ₹ ha^{-1}), Net return

(71803 ₹ ha^{-1}), and B: C ratio (2.27₹ ha^{-1} Re^{-1} Invested), *at par* with 20 kg N ha^{-1} and lowest was observed in 10 kg N ha^{-1}. The highest gross return (105068 ₹ ha^{-1}), Net return (67447 ₹ ha^{-1}), and B: C ratio (1.79 ₹ ha^{-1} Re^{-1} Invested) was observed with the application RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS *at par* with RDF + UREA @ 2% + MOP @ 2% + KNO_3 @ 2% at 30 DAS and UREA @ 2% + MOP @ 2% + KNO_3 at 50 DAS and lowest was observed in absolute control.

Table 1: Effect of different treatments on growth parameters of Soybean

Treatment combination	Plant Height (cm)	No. of leaves per plant	No. of nodules per plant	Leaf area index	Dry matter accumulation per plant (g)	AGR	CGR	RGR
Control	22.95	6.82	32.47	2.13	21.18	0.07	0.24	0.0076
RDF (100%) @ at the time of sowing	28.93	7.91	38.63	3.23	33.27	0.09	0.38	0.0115
RDF + DAP @ 2% at 30 DAS and DAP @ 2% at 50 DAS	29.98	8.65	41.61	3.53	33.84	0.09	0.39	0.0123
RDF + UREA @ 2% at 30 DAS and @ 2% UREA at 50 DAS	30.30	8.83	42.33	3.89	33.87	0.09	0.39	0.0125
RDF + KNO_3 @ 2% at 30 DAS and KNO_3 @ 2% at 50 DAS	29.62	8.21	39.81	3.27	33.28	0.09	0.38	0.0121
RDF + MOP @ 2% at 30 DAS and MOP @ 2% at 50 DAS	29.79	8.38	40.52	3.37	33.66	0.09	0.39	0.0120
RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS	35.18	10.18	47.72	6.03	36.28	0.10	0.42	0.0158
RDF + DAP @ 2% + KNO_3 @ 2% at 30 DAS and DAP @ 2% + KNO_3 @ 2% at 50 DAS	30.84	8.99	42.93	4.84	34.14	0.09	0.39	0.0129
RDF + DAP @ 2% + MOP @ 2% at 30 DAS and DAP @ 2% + MOP @ 2% at 50 DAS	31.46	9.09	43.36	5.01	34.25	0.09	0.40	0.0134
RDF + UREA @ 2% + MOP @ 2% + KNO_3 @ 2% at 30 DAS and UREA @ 2% + MOP @ 2% + KNO_3 at 50 DAS	32.73	9.73	45.93	5.95	36.17	0.10	0.42	0.0142
S. Em±	1.13	0.36	1.32	0.31	0.73	0.003	0.008	0.0006
C.D.	3.38	1.07	4.16	0.93	2.17	0.009	0.02	0.0019

Table 2: Effect of different treatments on yield, yield attribute and Economics studies of Soybean

Treatment combination	No. of pods per plant	No of seeds per pods	Seed index	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index	Gross return	Net return	B-C Ratio
Control	35.04	1.8	9.93	11.46	18.93	37.55	54320	24716	0.83
RDF (100%) @ at the time of sowing	35.94	3.1	10.26	14.70	23.80	38.03	69678	38119	1.21
RDF + DAP @ 2% at 30 DAS and DAP @ 2% at 50 DAS	37.09	3.34	10.65	16.33	24.62	39.68	77388	45818	1.45
RDF + UREA @ 2% at 30 DAS and @ 2% UREA at 50 DAS	39.06	3.53	11.12	16.39	24.82	39.79	77689	46125	1.46
RDF + KNO_3 @ 2% at 30 DAS and KNO_3 @ 2% at 50 DAS	36.28	3.18	10.32	16.10	24.15	40.01	76314	44745	1.42
RDF + MOP @ 2% at 30 DAS and MOP @ 2% at 50 DAS	36.57	3.27	10.52	16.24	24.28	39.88	76993	45412	1.44
RDF + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS	46.53	3.69	12.67	20.81	29.07	41.76	98639	67064	2.12
RDF + DAP @ 2% + KNO_3 @ 2% at 30 DAS and DAP @ 2% + KNO_3 @ 2% at 50 DAS	42.11	3.49	11.20	17.13	24.84	40.87	81180	49600	1.57
RDF + DAP @ 2% + MOP @ 2% at 30 DAS and DAP @ 2% + MOP @ 2% at 50 DAS	42.78	3.42	11.34	17.76	25.47	41.38	84167	52573	1.66
RDF + UREA @ 2% + MOP @ 2% + KNO_3 @ 2% at 30 DAS and UREA @ 2% + MOP @ 2% + KNO_3 at 50 DAS	45.90	3.64	12.45	19.13	28.53	40.09	90692	59095	1.87

4. Conclusion

Based on one year study it is concluded that T7 (RDF (100%) + DAP @ 2% + UREA @ 2% at 30 DAS and DAP @ 2% + UREA @ 2% at 50 DAS) treatment combination showed good in terms of growth parameters, yield attribute, quality parameters and economics of Soybean in Gwalior region.

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