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Efficacy of Phule Liquid Micro Grade II and water soluble fertilizer (19:19:19) on yield and quality of soybean

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Abstract

A field experiment was conducted during *kharif* 2025 at the Research Farm of the Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, to evaluate the "Efficacy of Phule Liquid Micro Grade II and water soluble fertilizer (19:19:19) on yield and quality of soybean". The experiment was laid out in a randomized block design with eight treatments and three replications using soybean variety *Phule Sangam* (*KDS 726*). The recommended dose of 50:75:45 N:P_2O_5:K_2O kg ha^{-1} was applied to the fertilizer treatments along with farmyard manure at 10 t ha^{-1} was applied except in the absolute control. Foliar treatments consisted of 19:19:19 and Phule Liquid Micro Grade II applied singly or in combination at 0.5 or 1.0 per cent at 30 and 45 days after sowing. The results indicated that the combined application of 19:19:19 @ 1.0 per cent at 30 DAS followed by Phule Liquid Micro Grade II @ 1.0 per cent at 45 DAS (T_3) was the most effective treatment. T_3 recorded the highest seed protein content (41.97%), oil content (19.95%), grain yield (25.38 q ha^{-1}) and straw yield (31.83 q ha^{-1}). For these major yield and quality attributes, T_3 was generally comparable with the higher-rate Phule Liquid Micro Grade II treatment (T_7). The findings demonstrate that appropriately timed foliar supplementation of balanced macronutrients followed by a micronutrient formulation can improve seed quality and productivity of soybean under the experimental conditions of Rahuri.

Keywords: Soybean, Foliar nutrition, Phule Liquid Micro Grade II, Water Soluble Fertilizer 19:19:19, Seed yield, Protein content, Oil content

Introduction

Soybean (*Glycine max* (L.) Merr.) is an important legume and oilseed crop, valued for its high-quality protein and edible oil and its contribution to soil fertility through biological nitrogen fixation. The crop contains about 38–43 per cent protein and 18–20 per cent oil, making it an important source of plant protein and vegetable oil (Endres, 2001) [1], while its ability to form symbiotic root nodules enables atmospheric nitrogen fixation (Akparobi, 2009) [2]. Efficient nutrient management is essential for sustaining growth, yield and quality, particularly during later crop stages when nodulation activity declines. Sharifi *et al.,* (2018) [3] reported that foliar nutrient application during critical growth stages can promote plant growth, seed yield and quality in soybean and other pulse crops. Micronutrient foliar feeding also helps to overcome nutrient deficiencies and improve crop performance; Narimani *et al.,* (2010) [4] reported the effectiveness of foliar micronutrients. Among foliar nutrient sources, water-soluble fertilizers provide readily available nutrients and can be used according to crop requirement and growth stage. Balanced NPK formulations such as 19:19:19 supply nitrogen, phosphorus and potassium in equal proportions and are suitable for different stages of crop growth; their complete water solubility facilitates rapid nutrient absorption and efficient nutrient utilization (Malhotra, 2016; Sadashiv, 2018) [5, 6]. Foliar application of nutrients during the reproductive and seed-filling period may help maintain leaf nutrient status and photosynthetic activity, thereby supporting pod development and seed filling (Sarika *et al.,* 2022) [7].

Phule Liquid Micro Grade II, developed by the Micronutrient Research Scheme, Department of Soil Science, MPKV, Rahuri, contains essential micronutrients including Fe, Zn, Mn, Cu, Mo and B. Although foliar application of water-soluble macronutrients and micronutrients has shown potential for improving crop growth, nutrient uptake, yield and quality, limited information is available on the combined efficacy of Phule Liquid Micro Grade II and WSF 19:19:19 in soybean. Therefore, the present investigation was undertaken to assess their effect on growth attributes, yield and quality, nutrient uptake and post-harvest soil chemical properties of soybean.

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Material and Methods

The experiment was conducted during *kharif* 2025 at the Research Farm of the Post Graduate Institute, Department of Soil Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra. The experimental soil was medium deep black soil. Soybean variety *Phule Sangam* (*KDS 726*) was used as the test crop. The experiment was laid out in a randomized block design with eight treatments and three replications. The gross plot size was 4.50 m × 3.60 m and the net plot size was 4.30 m × 2.70 m, with a spacing of 45 cm × 5 cm. Sowing was carried out on 8 July 2025 and the crop was harvested on 4 November 2025.

The recommended dose of fertilizers (50:75:45 kg N:P_2O_5:K_2O ha^{-1}) was applied as basal fertilizer through urea, diammonium phosphate and muriate of potash to all treatments except the absolute control. Farmyard manure at 10 t ha^{-1} was also applied to all treatments except the absolute control. Phule Liquid Micro Grade II was used as the micronutrient foliar formulation and 19:19:19 was used as the water soluble NPK fertilizer.

Treatment details

Treatment	Foliar treatment
T_1	Absolute control
T_2	Foliar sprays of 19:19:19 WSF @ 0.5% at 30 DAS and Phule Liquid Micro Grade II @ 0.5% at 45 DAS
T_3	Foliar sprays of 19:19:19 WSF @ 1% at 30 DAS and Phule Liquid Micro Grade II @ 1% at 45 DAS
T_4	Foliar sprays of Phule Liquid Micro Grade II @ 0.5% at 30 DAS and 19:19:19 WSF@ 0.5% at 45 DAS
T_5	Foliar sprays of Phule Liquid Micro Grade II @ 1% at 30 DAS and 19:19:19 WSF @ 0.5% at 45 DAS
T_6	Two foliar sprays of Phule Liquid Micro Grade II @ 0.5% at 30 and 45 DAS
T_7	Two foliar sprays of Phule Liquid Micro Grade II @ 1% at 30 and 45 DAS
T_8	Two foliar sprays of 19:19:19 WSF @ 0.5% at 30 and 45 DAS

Observations on Seed protein and oil contents were estimated from representative seed samples using the analytical procedures followed in the original experiment. Grain and straw yields were recorded at harvest and expressed in q ha^{-1}. The data were statistically analyzed using the standard analysis of variance for randomized block design, and treatment means were compared at the 5 per cent level of significance.

Results and Discussion

Yield attributing character

Effect of foliar application of Phule Liquid Micro Grade II and 19:19:19 on grain yield and straw yield of soybean

Grain yield was significantly affected by foliar nutrient management. Treatment T_3 recorded the highest grain yield of 25.38 q ha^{-1} and was statistically at par with T_7 (24.71 q ha^{-1}). T_5 recorded 23.55 q ha^{-1}, while T_4 and T_2 recorded 22.89 and 21.40 q ha^{-1}, respectively. The absolute control produced the lowest grain yield of 14.44 q ha^{-1}. Thus, T_3 increased grain yield by 75.8 per cent over the absolute control. The superiority of T_3 can be attributed to the complementary role of 19:19:19 and Phule Liquid Micro Grade II the former supplied readily available N, P and K during early reproductive growth, whereas the latter supplied several micronutrients during subsequent pod development. Better nutrient availability was reflected in greater pods plant^{-1}, grains pod^{-1} and seed quality, ultimately resulting in higher grain yield. Reported by Patil *et al.* (2024) [8], Meher *et al.* (2024) [9], Veer *et al.* (2025) [10]

Straw yield showed the same general response. The maximum straw yield was obtained with T_3 (31.83 q ha^{-1}), which was statistically at par with T_7 (29.12 q ha^{-1}). The absolute control recorded the minimum straw yield (15.53 q ha^{-1}). The greater biomass production under foliar nutrition may be associated with improved plant growth and maintenance of photosynthetic activity during the reproductive period. Comparable positive responses to foliar NPK nutrition have been reported in soybean by Patil *et al.,* (2024) [8] and Ahire *et al.,* (2024) [11]. The present findings therefore indicate that the combined 1.0 per cent 19:19:19 followed by 1.0 per cent Phule Liquid Micro Grade II was particularly effective under the experimental conditions.

Quality parameter

Effect of foliar application of Phule Liquid Micro Grade II and 19:19:19 on protein content and oil content of soybean

Seed protein content was significantly improved by foliar nutrient application. The highest protein content was recorded in T_3 (41.97%), followed by T_7 (41.43%) and T_5 (41.00%), while the absolute control recorded 37.43%. T_3 was statistically at par with T_7 and T_5. The 4.54 percentage-point increase in protein content over the control indicates that the combined and timely foliar supply was favorable for protein accumulation in soybean seed. Nitrogen supplied through 19:19:19 during the early reproductive phase, together with micronutrients supplied by Phule Liquid Micro Grade II, may have supported the biochemical processes associated with protein formation and seed filling. Reported by Meena *et al.* (2016) [12].

Seed oil content also responded positively to foliar nutrition. The maximum oil content was recorded in T_3 (19.95%), followed by T_7 (19.60%) and T_5 (19.47%), whereas the absolute control recorded 18.13%. T_3 was statistically at par with T_7 and T_5. The response indicates that adequate nutrient availability during seed development may have favored assimilate accumulation and lipid biosynthesis. Earlier studies have likewise reported improvement in soybean oil content with suitable foliar nutrient combinations (Kolekar *et al.,* 2017; Bhayal *et al.,* 2022) [14, 13].

Economic response

The higher productivity under T_3 was reflected in the economic analysis. T_3 recorded the highest gross monetary return (₹130,719.60 ha^{-1}), net monetary return (₹59,331.60 ha^{-1}) and benefit:cost ratio (1.83). The gross monetary return and net monetary return under T_3 were statistically at par with T_7, which recorded ₹127,044.40 and ₹55,006.40 ha^{-1}, respectively. These results indicate that the higher-rate combined foliar treatment was not only agronomically effective but also economically favorable under the prevailing experimental cost and price assumptions. The significantly higher economic returns obtained with higher concentrations of Phule Liquid Micro Grade II and 19:19:19 WSF can be attributed to the synergistic effect of balanced macro and micronutrient supply through foliar sprays. Foliar application of nutrients ensures direct absorption and efficient utilization of nutrients by the crop, which translates into improved crop growth, yield attributes, and ultimately higher grain yield and monetary returns. Patil *et al.* (2024) [8] and Avachar *et al.* (2024) [15].

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Table 1. Effect of foliar application of Phule Liquid Micro Grade II and 19:19:19 on yield and quality of soybean

Tr. No.	Treatment	Yield (q ha^{-1})		Protein (%)	Oil (%)
		Grain	Straw		
T_1	Absolute control	14.44	15.53	37.43	18.13
T_2	Foliar sprays of 19:19:19 WSF @ 0.5% at 30 DAS and Phule Liquid Micro Grade II @ 0.5% at 45 DAS	21.40	23.18	40.20	18.60
T_3	Foliar sprays of 19:19:19 WSF @ 1% at 30 DAS and Phule Liquid Micro Grade II @ 1% at 45 DAS	25.38	31.83	41.97	19.95
T_4	Foliar sprays of Phule Liquid Micro Grade II @ 0.5% at 30 DAS and 19:19:19 WSF @ 0.5% at 45 DAS	22.89	25.23	40.50	19.07
T_5	Foliar sprays of Phule Liquid Micro Grade II @ 1% at 30 DAS and 19:19:19 WSF @ 0.5% at 45 DAS	23.55	25.84	41.00	19.47
T_6	Two foliar sprays of Phule Liquid Micro Grade II @ 0.5% at 30 and 45 DAS	19.87	22.83	39.80	18.80
T_7	Two foliar sprays of Phule Liquid Micro Grade II @ 1% at 30 and 45 DAS	24.71	29.12	41.43	19.60
T_8	Two foliar sprays of 19:19:19 WSF @ 0.5% at 30 and 45 DAS	18.92	20.45	39.40	18.46
	SE m (±)	**0.52**	**0.90**	**0.44**	**0.22**
	CD (5%)	**1.60**	**2.74**	**1.35**	**0.66**

Table 2. Effect of foliar application of Phule Liquid Micro Grade II and 19:19:19 on Economics of soybean

Tr. No.	Treatment	Cost of cultivation	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C ratio
T_1	Absolute control	48134	74063.6	25929.6	1.53
T_2	Foliar sprays of 19:19:19 WSF @ 0.5% at 30 DAS and Phule Liquid Micro Grade II @ 0.5% at 45 DAS	70213	109781.6	39568.6	1.56
T_3	Foliar sprays of 19:19:19 WSF @ 1% at 30 DAS and Phule Liquid Micro Grade II @ 1% at 45 DAS	71388	130719.6	59331.6	1.83
T_4	Foliar sprays of Phule Liquid Micro Grade II @ 0.5% at 30 DAS and 19:19:19 WSF @ 0.5% at 45 DAS	70213	117478.4	47265	1.67
T_5	Foliar sprays of Phule Liquid Micro Grade II @ 1% at 30 DAS and 19:19:19 WSF @ 0.5% at 45 DAS	70963	120850.8	49887.8	1.70
T_6	Two foliar sprays of Phule Liquid Micro Grade II @ 0.5% at 30 and 45 DAS	70538	102089.6	31551.6	1.44
T_7	Two foliar sprays of Phule Liquid Micro Grade II @ 1% at 30 and 45 DAS	72038	127044.4	55006.4	1.76
T_8	Two foliar sprays of 19:19:19 WSF @ 0.5% at 30 and 45 DAS	69888	97014.0	27126.0	1.38
	SE m (±)	-	**2674.40**	**2674.40**	-
	CD (5%)	-	**8111.98**	**8111.98**	-

Conclusion

The application of GRDF (50:75:45 kg N:P_2O_5:K_2O ha^{-1}) + foliar sprays of Phule liquid micro grade II and water soluble fertilizer @ 1% 30 days after sowing and 45 days after sowing along with 10 t ha^{-1} FYM to soybean in medium deep black soil was found beneficial for increase in yield and quality of soybean, higher economic returns. The comprehensive investigation of Phule Liquid Micro Grade II and Water Soluble Fertilizer application on soybean production in medium deep black soil established that integrated macro micronutrient foliar supplementation at critical growth stages (30 DAS and 45 DAS) significantly enhanced quality and yield parameters. The application treatment (GRDF + 1% WSF at 30 DAS + 1% PLM Grade II at 45 DAS) emerged as the superior management strategy, delivering maximum grain yield (25.38 q ha^{-1}), enhanced nutritional quality (41.97% protein, 19.95% oil).

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Disclaimer

The results and conclusions of the present study are derived from a field experiment carried out during the *kharif* season of 2025 at the Post Graduate Institute Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra. The findings are applicable to the specific experimental conditions, soil characteristics, soybean variety *Phule Sangam (KDS-726)*, and treatments investigated in this study. As the experiment was conducted during a single cropping season, further research across multiple seasons and locations is necessary to validate the findings and establish their wider applicability.

Conflict of interest

The authors declare no conflicts of interest, and no external funding or sponsorship influenced the study design, data collection, analysis, publication decision, or manuscript preparation.

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