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Effect of Phule Liquid Micro Grade-II on yield and quality of soybean (*Glycine max* (L.) Merr.)

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Abstract

The experiment was conducted to assess the "effect of Phule Liquid Micro Grade-II on yield and quality of soybean", with objectives to assess the efficacy of Phule Liquid Micro Grade-II on growth and yield attributes, nutrient uptake and economics of soybean at the Post Graduate Research Farm, Department of Soil Science, Mahatma Phule Krishi Vidyapeeth, Rahuri. The experiment was laid out in a Randomized Block Design with eight treatments and three replications. The treatments comprised of absolute control (T_1), GRDF (50:75:45 N: P_2O_5: K_2O kg ha^{-1} +10 t FYM ha^{-1}) (T_2), GRDF + Phule Liquid Micro Grade-II @ 1.00 % at 30 and 45 DAS (T_3), GRDF + Phule Liquid Micro Grade-II @ 1.50 % at 30 and 45 DAS (T_4), GRDF + Phule Liquid Micro Grade-II @ 2.00 % at 30 and 45 DAS (T_5), GRDF + Phule Liquid Micro Grade-II @ 2.50 % at 30 and 45 DAS (T_6), GRDF + Phule Liquid Micro Grade-II @ 3.00 % at 30 and 45 DAS (T_7) and GRDF + Phule Liquid Micro Grade-II @ 0.50 % at 30 DAS and @ 1.00 % at 45 DAS (T_8). The results revealed that application of GRDF + Phule Liquid Micro Grade-II @ 3.00 % at 30 and 45 DAS (T_7) recorded significantly highest plant height of soybean at 60 DAS (65.20 cm), 90 DAS (84.07 cm) and at harvest (86.33 cm), respectively, highest number of branches at 60 DAS (6.73), 90 DAS (8.20) and at harvest (9.53), respectively, number of pods plant^{-1} (68.00), chlorophyll content at 45 DAS (1.75 mg g^{-1} fresh tissue), grain yield (26.74 q ha^{-1}) and stover yield (37.97 q ha^{-1}) and was statistically at par with application of GRDF + Phule Liquid Micro Grade-II @ 2.50 % at 30 and 45 DAS (T_6) recorded significantly highest plant height of soybean at 60 DAS (64.67 cm), 90 DAS (83.07 cm) and at harvest (85.07 cm), respectively, highest number of branches at 60 DAS (6.60), 90 DAS (7.80) and at harvest (9.13), respectively, number of pods plant^{-1} (65.07), chlorophyll content at 45 DAS (1.72 mg g^{-1}fresh tissue), grain yield (26.07 q ha^{-1}) and stover yield (37.80 q ha^{-1}) and the application of GRDF + Phule Liquid Micro Grade-II @ 2.00 % at 30 and 45 DAS (T_5) recorded significantly highest plant height of soybean at 60 DAS (63.07 cm), 90 DAS (82.13 cm) and at harvest (84.47 cm), respectively, highest number of branches at 60 DAS (6.47), 90 DAS (7.60) and at harvest (8.95), respectively, number of pods plant^{-1} (63.00), chlorophyll content at 45 DAS (1.70 mg g^{-1}fresh tissue), grain yield (25.42 q ha^{-1}) and stover yield (37.27 q ha^{-1}) of soybean and the foliar application of Phule Liquid Micro Grade-II not influenced significantly on the number of grains pod^{-1} of soybean and no visual symptoms of phytotoxicity were observed at the tested concentrations of different treatments.

Keywords: Soybean, Foliar application, Phule Liquid Micro Grade-II, DAS, Growth, Yield

Introduction

Soybean (*Glycine max* (L.) Merr.) is widely recognized as an important food, feed and industrial crop because of its high nutritional and economic value. It is often referred to as the "Golden Bean" or "Miracle Crop" owing to its diverse applications and nutrient rich composition (Sahebagouda *et al.,* 2019) [1]. India is among the major soybean producing countries of the world and contributes substantially to global soybean production. The principal soybean-growing states in India include Maharashtra, Madhya Pradesh, *Karnataka*, Rajasthan and Telangana (Dilawari *et al.,* 2022) [2].

Among the micronutrients, zinc deficiency is considered one of the most widespread nutritional constraints in Indian soils and occurs across diverse soil and climatic conditions (Das *et al.*, 2013) [3]. Approximately 47 % of Indian soils have been reported to be deficient in available zinc (Veeranagappa *et al.*, 2010) [4]. An adequate supply of zinc, iron, manganese, boron and copper supports enzyme activity, photosynthetic function and reproductive development, which can ultimately influence seed formation and yield.

Phule Liquid Micro Grade-II is a liquid micronutrient formulation developed at Mahatma Phule Krishi Vidyapeeth, Rahuri, for supplying essential micronutrients through foliar application. The formulation contains Fe (2.5%), Zn (3.0%), Mn (1.0%), Cu (1.0%), Mo (0.1%) and B (0.5%).

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Foliar application of such a multi-micronutrient formulation provides nutrients directly to the plant canopy and can serve as a supplementary approach for correcting or preventing micronutrient deficiencies. Rapid nutrient absorption through foliage can support physiological and metabolic processes and may consequently contribute to improved crop growth and development. Foliar spraying represents a practical approach for supplying nutrients to crops in readily available liquid form through the leaf surface (Nasiri *et al.,* 2010) [5].

Material and methods

A field experiment was conducted during *kharif* 2025 at the Research Farm of the Department of Soil Science, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahilyanagar, Maharashtra, to study the effect of Phule Liquid Micro Grade-II on yield and quality of soybean. The soil of experimental site was alkaline in reaction having pH (7.84) with low soluble salt content (0.29 dS m^{-1}). Soil organic carbon content was low (0.45%). The soil was low in available nitrogen (184 kg ha^{-1}), low in available phosphorus (12.10 kg ha^{-1}), very high in available potassium (365 kg ha^{-1}) and medium in available sulphur (11.82 mg kg^{-1}). The soil was sufficient in DTPA extractable iron, manganese, zinc and copper. The experiment was conducted in a Randomized Block Design (RBD) comprising eight treatments with three replications. The soybean variety *Phule Sangam* was sown at a spacing of 45 cm × 10 cm. The eight treatments *viz*. absolute control (T_1), GRDF (50:75:45 N: P_2O_5: K_2O kg ha^{-1} +10 t FYM ha^{-1}) (T_2), GRDF + Phule Liquid Micro Grade-II @ 1.00 % at 30 and 45 DAS (T_3), GRDF + Phule Liquid Micro Grade-II @ 1.50 % at 30 and 45 DAS (T_4), GRDF + Phule Liquid Micro Grade-II @ 2.00 % at 30 and 45 DAS (T_5), GRDF + Phule Liquid Micro Grade-II @ 2.50 % at 30 and 45 DAS (T_6), GRDF + Phule Liquid Micro Grade-II @ 3.00 % at 30 and 45 DAS (T_7) and GRDF + Phule Liquid Micro Grade-II @ 0.50 % at 30 DAS and @ 1.00 % at 45 DAS (T_8). The recommended dose of fertilizers was supplied through urea, diammonium phosphate (DAP), and muriate of potash (MOP). Foliar application of Phule Liquid Micronutrient Grade-II was carried out at different concentrations at two critical growth stages, namely vegetative stage (30 DAS) and flowering stage (45 DAS). Phule Liquid Micro Grade-II was used as a source of foliar nutrition. For growth and yield observations plant height, number of branches $plant^{-1}$ and chlorophyll content were recorded periodically from five randomly selected and tagged plants within the net plot area. The number of grains pod^{-1}, number of pods $plant^{-1}$, grain and stover yields were determined after harvest, number of grains pod^{-1} and number of pods $plant^{-1}$ were recorded from five randomly selected and tagged plants within the net plot area and grains and stover from each treatment net plot were harvested, threshed, cleaned, air-dried, and weighed to record the final air dry grain and stover weight, which was subsequently expressed on a hectare basis.

Results and discussion

Growth parameters of kharif soybean as influenced by various treatments

The effect of different treatments on growth parameters such as plant height, number of branches $plant^{-1}$ and chlorophyll content is summarized in Table 1.

Plant height

Plant height is an important indicator of plant vigour and overall growth, exhibited significant variation in soybean under different concentrations of foliar application. Among all the treatments, GRDF + Phule Liquid Micro Grade-II @ 3.00% at 30 and 45 DAS (T_7) recorded the significantly highest plant height at 60 DAS (65.20 cm), 90 DAS (84.07 cm) and at harvest (86.33 cm). It was statistically at par with plant height at 60 DAS (64.67 cm), 90 DAS (83.07 cm) and at harvest (85.07 cm) recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 2.50% at 30 and 45 DAS (T_6) and plant height at 60 DAS (63.07 cm), 90 DAS (82.13 cm) and at harvest (84.47 cm) recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 2.00% at 30 and 45 DAS (T_5). The increase in plant height might be attributed to the enhanced availability and uptake of micronutrients, particularly, zinc which was involved in auxin metabolism and cellular growth, while iron contributed to chlorophyll formation and photosynthetic activity. The enhanced photosynthate production and cell elongation consequently promoted internodal growth and increased plant height. The results were in agreement with Shruthi (2013) [6], Falaknaz *et al.* (2022) [7] and Rathod *et al.* (2024) [8].

Number of branches plant-1

Among all the treatments, GRDF + Phule Liquid Micro Grade-II @ 3.00% at 30 and 45 DAS (T_7) recorded the significantly highest number of branches $plant^{-1}$ at 60 DAS (6.73), 90 DAS (8.20) and at harvest (9.53). It was statistically at par with number of branches $plant^{-1}$at 60 DAS (6.60), 90 DAS (7.80) and at harvest (9.13) recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 2.50% at 30 and 45 (T_6) and number of branches $plant^{-1}$ at 60 DAS (6.47), 90 DAS (7.60) and at harvest (8.95) recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 2.00% at 30 and 45 DAS (T_5). The increase in the number of branches $plant^{-1}$ might be attributed to the foliar application of micronutrients. Zinc mediated regulation of growth processes, together with improved photosynthetic activity supported by iron and manganese increased assimilate availability for lateral shoot development. Consequently, greater development of axillary shoots contributed to an increase in number of branches $plant^{-1}$. The results were in agreement with Ali *et al.* (2014) [9], Kale *et al.* (2024) [10] and Kolekar *et al.* (2025) [11].

Chlorophyll content

The chlorophyll content was significantly influenced by foliar application of Phule Liquid Micro Grade-II in soybean. At 45 DAS, significantly highest chlorophyll content (1.75 mg g^{-1} fresh tissue) recorded with the application of GRDF + Phule Liquid Micro Grade-II @ 3.00% at 30 and 45 DAS (T_7) except the treatment GRDF + Phule Liquid Micro Grade-II @ 2.50% at 30 and 45 (T_6) recorded chlorophyll content (1.72 mg g^{-1} fresh tissue) and the treatment GRDF + Phule Liquid Micro Grade-II @ 2.00% at 30 and 45 DAS (T_5) recorded chlorophyll content (1.70 mg g^{-1} fresh tissue) which was statistically at par with T_7. The increase in chlorophyll content might be attributed to micronutrient through foliar application. Iron played an important role in chlorophyll biosynthesis and electron transport, whereas manganese participated in the photosynthetic water splitting process. Improved micronutrient nutrition could therefore maintain greater pigment formation and photosynthetic capacity. The results were in accordance with Rajamani *et al.* (2011) [12] and Sale *et al.* (2017) [13].

Yield and yield parameters of kharif soybean as influenced by various treatments

The effect of different treatments on yield and yield parameters such as number of pods $plant^{-1}$, number of grains pod^{-1}, grain and stover yield is presented in Table 1.

Number of pods plant-1

The significantly highest number of pods $plant^{-1}$ (68.00) was recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 3.00% at 30 and 45 DAS (T_7) which was statistically at par with number of pods $plant^{-1}$ (65.07) recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 2.50% at 30 and 45 DAS (T_6) and number of pods $plant^{-1}$ (63.00) recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 2.00% at 30 and 45 DAS (T_5). This could be attributed to improved micronutrient through foliar application. Boron is particularly important for pollen viability, pollen tube development and successful fertilization, while zinc contributed to reproductive metabolism. Enhanced photosynthetic activity also increased the supply of assimilates to reproductive sinks, thereby favouring flower retention and pod formation. The similar results were reported in Chavan *et al.* (2020) [14], Dudde *et al.* (2023) [15] and Meher *et al.* (2024) [16].

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Number of grains pod-1

The foliar application of Phule Liquid Micro Grade-II not influenced significantly on the number of grains pod^{-1} of soybean. The number of grains pod^{-1} of soybean ranged from 2.05-2.68 % with no significant differences and minimal variation among treatments indicated that foliar application not markedly affected due to it is largely genetically controlled and relatively stable. The similar results were reported in Meher *et al.* (2024) [16].

Grain yield

The significantly highest grain yield (26.74 q ha^{-1}) was recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 3.00% at 30 and 45 DAS (T_7) which was statistically at par with treatment GRDF + Phule Liquid Micro Grade-II @ 2.50% at 30 and 45 DAS (T_6) recorded grain yield (26.07 q ha^{-1}) and the treatment GRDF + Phule Liquid Micro Grade-II @ 2.00% at 30 and 45 DAS (T_5) recorded grain yield (25.42 q ha^{-1}). The improved micronutrient nutrition could support photosynthesis, reproductive development, assimilate translocation and seed filling. The combined effect of these processes increased the quantity of assimilates partitioned towards developing grains, resulting in greater grain yield. The findings were in agreement with Rezaei *et al.* (2013) [17], Bhosale *et al.* (2024) [18] and Bobade *et al.* (2025) [19].

Stover yield

The significantly highest stover yield (37.97 q ha^{-1}) was recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 3.00% at 30 and 45 DAS (T_7). It was statistically at par with stover yield (37.80 q ha^{-1}) recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 2.50% at 30 and 45 DAS (T_6) and stover yield (37.27 q ha^{-1}) recorded in treatment GRDF + Phule Liquid Micro Grade-II @ 2.00% at 30 and 45 DAS (T_5). The improvement in stover yield might be attributed to micronutrients through foliar application. Adequate Fe, Mn and Zn nutrition supported chlorophyll formation, photosynthetic activity and several metabolic reactions. Consequently, increased plant height, branching and leaf activity, resulting in greater accumulation of biomass in vegetative plant parts. The findings were in agreement with Bobade *et al.* (2025) [19] and Rathava *et al.* (2025) [20].

Table 1. Growth and yield of kharif soybean as influenced by various treatments.

Tr No.	Treatment details	Plant height (cm)			Number of branches plant^{-1}			Chlorophyll content (mg g^{-1}) 45 DAS	Number of pods plant^{-1}	Number of grains pod^{-1}	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})
		60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest					
T_1	Absolute control	51.47	70.73	72.07	5.00	5.90	6.90	1.24	40.00	2.05	15.02	25.18
T_2	GRDF (50:75:45 N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1})	56.53	76.13	77.80	5.47	6.47	7.40	1.60	52.27	2.53	22.54	34.52
T_3	GRDF + Phule Liquid Micro Grade-II @ 1.00 % at 30 and 45 DAS	58.13	79.00	80.43	5.80	6.85	8.02	1.64	56.20	2.58	23.88	36.68
T_4	GRDF + Phule Liquid Micro Grade-II @ 1.50 % at 30 and 45 DAS	61.80	80.20	82.20	6.07	7.27	8.47	1.67	58.33	2.61	24.43	36.86
T_5	GRDF + Phule Liquid Micro Grade-II @ 2.00 % at 30 and 45 DAS	63.07	82.13	84.47	6.47	7.60	8.95	1.70	63.00	2.65	25.42	37.27
T_6	GRDF + Phule Liquid Micro Grade-II @ 2.50 % at 30 and 45 DAS	64.67	83.07	85.07	6.60	7.80	9.13	1.72	65.07	2.67	26.07	37.80
T_7	GRDF + Phule Liquid Micro Grade-II @ 3.00 % at 30 and 45 DAS	65.20	84.07	86.33	6.73	8.20	9.53	1.75	68.00	2.68	26.74	37.97
T_8	GRDF + Phule Liquid Micro Grade-II @ 0.50 % at 30 and @ 1.00 % at 45 DAS	57.73	78.07	79.07	5.67	6.60	7.75	1.62	54.93	2.55	23.44	36.01
	SE (m) ±	0.93	1.14	0.72	0.17	0.28	0.27	0.02	2.66	0.24	0.61	0.27
	CD at 5 %	2.83	3.45	2.19	0.51	0.85	0.82	0.06	8.08	NS	1.84	0.82

Conclusion

The application of GRDF (50 :75 :45 N: P_2O_5: K_2O kg ha^{-1} along with 10 t ha^{-1} FYM) and foliar application of Phule Liquid Micro Grade-II @ 3.00 % at vegetative (30 DAS) and flowering (45 DAS) was effective and enhanced nutrient availability, uptake and translocation at critical growth stages, leading to improved vegetative growth, grain and stover yield. It also offers the advantage of reducing micronutrient losses through soil application and maintaining yield levels. Therefore, for higher productivity and resource-use efficiency of soybean cv. *Phule Sangam* under semi-arid region of Maharashtra, application of GRDF (50:75:45 N: P_2O_5: K_2O kg ha^{-1}+ 10 t ha^{-1} FYM) + Phule Liquid Micro Grade-II @ 3.00 % at 30 and 45 DAS is recommended.

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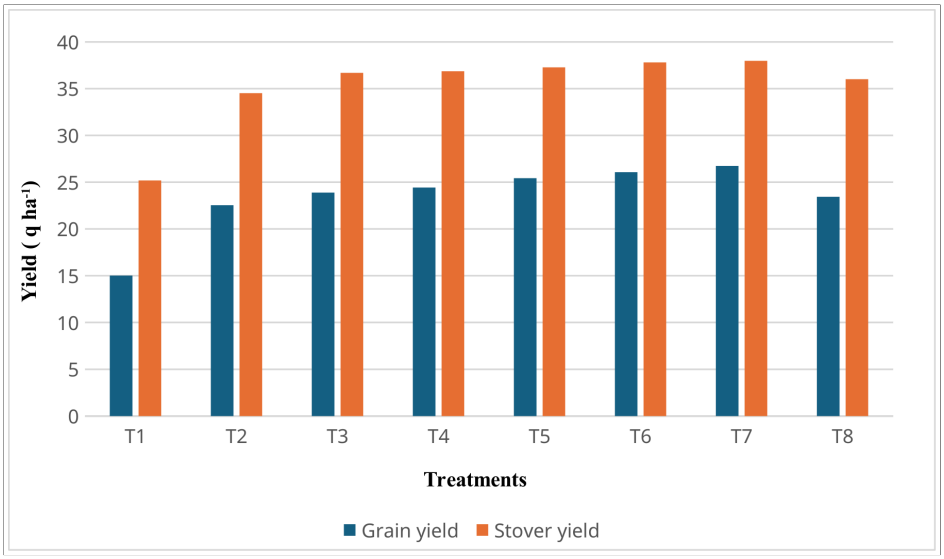


Figure 1. Effect of Phule Liquid Micro Grade-II on grain and stover yield of kharif soybean

Conflict of interest

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

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