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Sohil R Gharjale
PG Scholar, Agronomy Section,
College of Agriculture, Nagpur,
Maharashtra, India

Dr. SM Nawlakhe
Assistant Professor, Agronomy
Section, College of Agriculture,
Nagpur, Maharashtra, India

SS Juware
PG Scholar, Agronomy Section,
College of Agriculture, Nagpur,
Maharashtra, India

VG Mankar
PG Scholar, Agronomy Section,
College of Agriculture, Nagpur,
Maharashtra, India

Shilpa Ambatkar
PG Scholar, Agronomy Section,
College of Agriculture, Nagpur,
Maharashtra, India

Effect of liquid fertilizers and time of application on growth of soybean (*Glycine max* L.)

Sohil R Gharjale, SM Nawlakhe, SS Juware, VG Mankar and Shilpa Ambatkar

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Abstract

A field experiment was conducted at farm of the College of agriculture, Nagpur. The experiment was laid out in factorial randomized block design with four liquid fertilizers and three times of application and replicated three times. The treatments consisted of four liquid fertilizers viz., L₁ – Foliar application of 1% 19:19:19, L₂ – Foliar application of 1% 19:19:19 + PDKV Grade-2, L₃ – Foliar application of 1% 13:00:45, L₄ – Foliar application of 1% 13:00:45 + PDKV Grade-2 and three times of application viz., T₁ – Branching, T₂ – Pod development and T₃ – Branching + Pod development. The soil of the experimental site was clayey in texture, slightly alkaline in reaction (pH – 7.6), low in available Nitrogen (225.80 kg ha⁻¹), medium in available phosphorous (22.13 kg ha⁻¹) and high in available potassium (349.20 kg ha⁻¹). The result of the experiment revealed that among different Liquid fertilizers the growth attributes were significantly higher with L₄ – Foliar application of 1% 13:00:45 + PDKV Grade-2 plant height, number of branches plant⁻¹, number of nodules plant⁻¹ and dry matter accumulation plant⁻¹. Among time of application, T₃ – Branching + Pod development recorded plant height, number of branches, number of nodules plant⁻¹ and dry matter accumulation plant⁻¹. Interaction effect between liquid fertilizers and times of application was found non-significant in all the parameters.

Keywords: Soybean, liquid fertilizers, time of application, growth attributes, growth

1. Introduction

Soybean (*Glycine max* L. Merrill) is an important pulse as well as oilseed crop and is often referred to as the “Golden Bean” of the 21st century. It is believed to have originated in China around 2838 B.C. Soybean belongs to the family Leguminosae and sub-family Papilionaceae (Kolpe and Bodake, 2017) [10]. In India, it is cultivated extensively because of its wide adaptability to tropical and subtropical climatic conditions. A temperature range of 25–30°C, annual rainfall of 700–1000 mm and well-drained loamy soils with a pH of 6.0–7.5 are considered favourable for soybean cultivation. The availability of suitable soil and climatic conditions has contributed to its widespread cultivation in different regions of the country.

Soybean is one of the most important oil-bearing leguminous crops in the world. Its productivity potential is relatively high compared with many other legumes. It is a rich source of high-quality protein and therefore has considerable importance in addressing protein-calorie malnutrition. Soybean seeds contain approximately 20 per cent oil and 40–42 per cent high-quality protein, compared with about 20–25 per cent protein in other legumes (Agrawal *et al.*, 2013) [1]. Soybean oil is widely used as salad oil, vegetable shortening and margarine. It also has several industrial applications, including the manufacture of soaps, paints, resins and drying oils. In addition, soybean seeds are used to prepare various protein-rich products such as soy milk, soy cheese (paneer), soy sauce and soy flour (Thakur and Dhiman, 2016) [13].

Along with the recommended soil application of NPK fertilizers, micronutrients can be effectively supplied through foliar application at suitable time stages of the soybean crop. Balanced nutrient management improves the efficiency of applied nutrients and contributes to better plant growth and development. Although micronutrients are required in small quantities, they play essential roles in various metabolic and physiological processes in soybean plants. Deficiency of these nutrients can result in visible deficiency symptoms and reduced crop productivity. Therefore,

Corresponding Author:
Sohil R Gharjale
PG Scholar, Agronomy Section,
College of Agriculture, Nagpur,
Maharashtra, India

foliar application of micronutrients along with balanced fertilization and proper timing can play an important role in improving soybean growth and yield.

In recent years, foliar application of nutrients has gained importance as an effective approach for correcting plant nutritional deficiencies. It offers several advantages over conventional soil application and can improve nutrient-use efficiency (Alam *et al.*, 2010). Foliar fertilization involves applying fertilizers directly to the leaves of actively growing plants at appropriate concentrations. In many situations, foliar feeding is preferred because nutrients applied to the foliage can be absorbed relatively quickly and may produce a faster crop response than conventional soil application (Jamal *et al.*, 2006; Baloch *et al.*, 2008) [9, 3].

2. Materials and Methods

A field trial was conducted at the College of Agriculture, Nagpur, during the year 2025-26 *kharif* season to study effect of liquid fertilizers and time of application on growth and yield of soybean (*Glycine max* L.). The soil of the experimental site was clayey in texture, slightly alkaline in reaction (pH – 7.6) [Glass electrode digital pH meter (Jackson, 1967)] [8], low in available Nitrogen (225.80 kg ha⁻¹) [Alkaline permanganate method (Subbiah and Asija, 1956)] [12], medium in available phosphorus (22.13 kg ha⁻¹) [Olsen's colourimetric method (Olsen *et al.*, 1954)] [11] and high in available potassium (349.20 kg ha⁻¹) [Flame photometer method (Jackson, 1967)] [8]. The experiment was laid out in factorial randomized block design with four liquid fertilizers and three times of application and replicated three times. The treatments consisted of four liquid fertilizers viz., L₁ – Foliar application of 1% 19:19:19, L₂ – Foliar application of 1% 19:19:19 + PDKV Grade-2, L₃ – Foliar application of 1%

13:00:45, L₄ – Foliar application of 1% 13:00:45 + PDKV Grade-2 and three times of application viz., T₁ – Branching, T₂ – Pod development and T₃ – Branching + Pod development. Soybean variety (PDKV Amba) was sown at spacing of 45 x 5 cm with full dose of phosphorus, nitrogen was applied as basal and application of liquid fertilizers according to treatments. Data pertaining to growth and yield attributes were recorded from randomly selected five plants from each net plot and the mean value was calculated. Cost of cultivation was worked out with help of prevailing market prices of soybean. The data was statistically analyzed with standard method outlined for randomized block design (Gomez and Gomez, 1984) [7]. Statistically significance was tested by F-value at 5% level of probability and critical difference was worked out wherever the effect was significant.

Table 1: Details of the experimental treatments

Factor A: Liquid fertilizers (L)	
L ₁	Foliar application of 1% 19:19:19
L ₂	Foliar application of 1% 19:19:19 + PDKV Grade-2
L ₃	Foliar application of 1% 13:00:45
L ₄	Foliar application of 1% 13:00:45 + PDKV Grade-2
Factor B: Time of application (T)	
T ₁	At Branching
T ₂	At Pod development
T ₃	At Branching + Pod development
Method of application: Foliar spray of liquid fertilizers	
1 st Application: 30 Days after sowing: 2 nd Application: 60 Days after sowing	

3. Results and Discussion

In soybean (*Glycine max* L.) the plant growth attributes highly influenced by different treatments. Shown in Table no. 2 & 3.

Table 2: Mean growth attributing characters of soybean as influenced by liquid fertilizers and time of application

Treatments	Plant height (cm)				Dry matter accumulation plant ⁻¹ (g)			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Factor A – Liquid fertilizers								
L ₁	27.07	48.97	55.83	58.00	3.95	13.72	24.91	27.87
L ₂	27.76	50.13	57.22	60.03	4.05	14.06	25.46	28.50
L ₃	27.48	49.83	56.84	58.25	4.01	13.86	25.16	28.08
L ₄	28.26	51.21	58.02	60.93	4.23	14.50	25.60	28.83
SE (m) ±	0.21	0.39	0.34	0.62	0.03	0.13	0.16	0.22
CD at 5%	NS	1.15	0.99	1.81	NS	0.38	0.48	0.66
Factor B – Time of application								
T ₁	27.59	50.04	56.93	59.25	4.04	14.05	25.29	28.33
T ₂	27.31	49.03	55.98	58.58	3.96	13.74	24.96	27.97
T ₃	28.02	51.03	58.03	60.72	4.19	14.36	25.69	28.67
SE (m) ±	0.18	0.34	0.29	0.53	0.02	0.11	0.14	0.19
CD at 5%	NS	0.99	0.85	1.57	NS	0.33	0.41	0.57
Interaction (A x B)								
SE (m) ±	0.37	0.68	0.58	1.07	0.05	0.22	0.28	0.39
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
G.M.	27.64	50.03	56.98	59.51	4.07	14.03	25.28	28.32

3.1 Growth attributes

3.1.1 Effect of liquid fertilizers

Among liquid fertilizers growth attributes viz., maximum superior height of plant (cm) was recorded with Foliar application of 1% 13:00:45 + PDKV Grade-2 (L₄) However, it was found at par with foliar application of 19:19:19 + PDKV Grade-2 @1% (L₂) at 60 DAS, 90 DAS and at harvest. Higher plant height in soybean might be due to better nutrient availability through foliar nutrition. Nitrogen enhances chlorophyll and protein synthesis, while potassium promotes cell elongation and enzyme activation, resulting in improved plant growth. Foliar application at critical

growth stages improved nutrient uptake and vegetative development under rainfed conditions. Similar findings were reported by Deshmukh *et al.*, (2023) [6], Varma *et al.*, (2024) [14] evaluated foliar nutrition for improving the growth of soybean under rainfed conditions at ITM University, Gwalior. Treatments included different concentrations of 19:19:19 at 40 DAS and 13:00:45 at 60 DAS. The study reported that increasing the concentration of foliar fertilizers significantly improved plant height, number of leaves, leaf area index, branches plant⁻¹ and dry matter production. The highest growth was recorded with the combined application of 19:19:19 @ 1.5% and 13:00:45 @ 1.5%,

while the lower concentrations were generally inferior. Number of branches plant⁻¹ was found to be significant 60 DAS, 90 DAS and at harvest and give higher values for foliar application of 1% 13:00:45 + PDKV Grade-2 (L₄) and found to be at par with foliar application of 1% 19:19:19 + PDKV Grade-2 (L₂) at 90 DAS and at harvest, but remained non-significant at 30 DAS. Similar findings are found to Bodke *et al.*, (2022) ^[4] and Varma *et al.*, (2024) ^[14]. Number of nodules plant⁻¹ was found to be significant at 40 DAS and 60 DAS and gives higher values for foliar

application of 1% 13:00:45 + PDKV Grade-2 (L₄). Foliar application of liquid fertilizer 13:0:45 + PDKV Grade-2 @ 1% (L₄) resulted in significantly higher dry matter accumulation plant⁻¹ (14.50 g, 25.60 g, 28.83 g) than other liquid fertilizer at 60 DAS, 90 DAS and at harvest, respectively. However, it was found at par with foliar application of liquid fertilizer 19:19:19 + PDKV Grade-2 @ 1% (L₂) at 90 DAS and at harvest. these results conform with the findings of Anchal Dass *et al.*, (2022) ^[5], Deshmukh *et al.*, (2023) ^[6] and Warpe *et al.*, (2022) ^[15].

Table 3: Meant growth attributing characters of soybean as influenced by liquid fertilizers and time of application

Treatments	Number of nodules plant ⁻¹			Number of branches plant ⁻¹			
	20 DAS	40 DAS	60 DAS	30 DAS	60 DAS	90 DAS	At harvest
Factor A – Liquid fertilizers							
L ₁	8.16	16.98	23.40	2.11	4.49	5.86	5.86
L ₂	8.37	17.59	24.64	2.27	4.70	6.27	6.27
L ₃	8.23	17.24	23.93	2.15	4.53	6.06	6.06
L ₄	8.98	18.01	25.24	2.44	4.80	6.47	6.47
SE (m) ±	0.07	0.17	0.35	0.02	0.02	0.09	0.09
CD at 5%	NS	0.49	1.03	NS	0.07	0.26	0.26
Factor B – Time of application							
T ₁	8.43	17.71	24.09	2.21	4.63	6.10	6.10
T ₂	8.33	17.09	23.84	2.23	4.50	6.00	6.00
T ₃	8.53	18.08	24.98	2.30	4.77	6.38	6.38
SE (m) ±	0.06	0.15	0.30	0.01	0.02	0.08	0.08
CD at 5%	NS	0.43	0.89	NS	0.06	0.23	0.23
Interaction (A x B)							
SE (m) ±	0.06	0.29	0.61	1.16	0.51	0.93	1.93
CD at 5%	NS	NS	NS	NS	NS	NS	NS
G.M.	8.43	17.46	24.30	35.97	41.22	38.54	43.16

3.1.2 Effect of time of application

The plant height was significantly influenced by application of liquid fertilizer at different time and found to be significant at 60, 90 DAS and at harvest, while the effect was found non-significant at 30 DAS. The maximum and significantly superior plant height was recorded with Application liquid fertilizer at branching and pod development stages (T₃) recorded significantly superior plant height (51.03 cm, 58.03 cm, and 60.72 cm) than other time at 60 DAS, 90 DAS and at harvest, respectively but was found at par with application at branching stage (T₁) at 60 DAS and at harvest. these results conform with the findings of Deshmukh *et al.*, (2023) ^[6] and Warpe *et al.*, (2022) ^[15]. The number of branches plant⁻¹ was significantly influenced by application of liquid fertilizer at different time and found to be significant at 60, 90 DAS and at harvest, while the effect was found non-significant at 30 DAS. Significantly maximum number of branches plant⁻¹ was found with the application of liquid fertilizer at branching and pod development (T₃) (4.77, 6.38 and 6.38) at 60 DAS, 90 DAS and at harvest over remaining treatments. these results conform with the findings of Deshmukh *et al.*, (2023) ^[6] and Anonymous (2021) ^[2].

The number of nodules plant⁻¹ was significantly influenced by application of liquid fertilizer at different time and found to be significant at 40 and 60 DAS, while the effect was found non-significant at 20 DAS. Significantly maximum number of nodules plant⁻¹ was found with the application of liquid fertilizer at branching and pod development (T₃) (18.08 and 24.98) at 40 DAS and 60 DAS. However, it was found at par with application of liquid fertilizer at branching stage (T₁). These results conform with the findings of Deshmukh *et al.*, (2023) ^[6] and Bodke *et al.*, (2022) ^[4]. Dry matter was significantly influenced by application of liquid fertilizer at different time and found to be significant at 60, 90 DAS and at harvest, while the effect was found non-

significant at 30 DAS. The maximum and significantly superior dry matter accumulation was recorded with Application liquid fertilizer at branching and pod development stages (T₃) recorded significantly superior dry matter accumulation (14.36 g, 25.69 g and 28.67 g) than other growth stages at 60 DAS, 90 DAS and at harvest, respectively. However, it was found at par with fertilizer application at branching stage (T₁) at 60 DAS, 90 DAS and at harvest. These results conform with the findings of Deshmukh *et al.*, (2023) ^[6].

Interaction effect

Growth attributes were not significantly influenced by the interaction effect of liquid fertilizers and time of application of soybean. (Table 2 and 3).

4. Conclusion

Based on the experimental results of the present investigation, it can be concluded that. The foliar application of 1% 13:00:45 + PDKV Grade-2 is found best in respect growth attributes viz. plant height (cm), number of branches plant⁻¹, number of nodules plant⁻¹ and dry matter accumulation plant⁻¹ as compare to other treatments. However, the application of liquid fertilizers at branching + pod development are found to best in respect growth attributes viz. plant height (cm), number of branches plant⁻¹, number of nodules plant⁻¹ and dry matter accumulation plant⁻¹ as compare to other treatments.

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