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## Studies on influence of foliar application of water-soluble fertilizers on growth and yield of soybean (*Glycine max* L.)

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### Abstract

A field experiment was carried out to study the impact of application of water-soluble fertilizers at different growth stages on growth and yield of soybean at Experimental Research Farm, College of Agriculture, Latur during kharif season of the year 2021-22. A set of nine treatments viz., T<sub>1</sub>-Control, T<sub>2</sub>-RDF, T<sub>3</sub>-RDF+19:19:19 @0.5% at 30 DAS, T<sub>4</sub>-RDF + 00:52:34 @1.0% at 45 DAS, T<sub>5</sub>-RDF + KNO<sub>3</sub> @1.0% at 60 DAS, T<sub>6</sub>- T<sub>3</sub> + T<sub>4</sub>, T<sub>7</sub>- T<sub>4</sub> + T<sub>5</sub>, T<sub>8</sub>- T<sub>3</sub> + T<sub>5</sub> and T<sub>9</sub>- T<sub>3</sub> + T<sub>4</sub> + T<sub>5</sub> were taken out for the field experiment under Randomized Block Design with three replications. The experimental results revealed that application of treatment T<sub>9</sub> which received foliar spray of 19:19:19 @0.5% at 30 DAS + 00:52:34 @1.0% at 45 DAS + KNO<sub>3</sub> (13:00:45) @1.0% at 60 DAS along with RDF recorded significantly higher growth parameters viz., plant height (71.66 cm), number of branches plant<sup>-1</sup> (9.55) at harvest stage, number of leaves plant<sup>-1</sup> (61.70) at 60 DAS and total chlorophyll content (10.66 mg g<sup>-1</sup> fresh weight) in soybean at 45 DAS. The similar trend was observed in case of yield attributes viz., Number of Pods plant<sup>-1</sup> (75.70), Number of seeds pod<sup>-1</sup> (3.68) and seed yield (2206.52 kg ha<sup>-1</sup>) and straw yield (3444.27 kg ha<sup>-1</sup>) with the application of T<sub>9</sub> which was found at par with treatment T<sub>6</sub> which receives foliar application of 19:19:19 @0.5% at 30 DAS+ 00:52:34 @1.0% at 45 DAS along with RDF.

**Keywords:** Foliar application, water-soluble fertilizers, yield of soybean

### Introduction

India is one of the major oilseed's grower and importer of the edible oils. India's vegetable oil economy is world's fourth largest after USA, China & Brazil. Soybean (*Glycine max* (L.) Merrill) is well known and is one of the oldest crops in the world. The word "soy" originated as Japanese names for soy sauce. The soybean is a species of legume having native to East Asia widely grown for its edible bean and it belongs to the family Fabaceae (Leguminosae) and sub family Papilionaceae which has numerous uses, owing to its multiplicity of uses as food and industrial products, it is called as wonder crop This particular crop is considered as a miracle crop of 20th century and often designated as "Gold bean". India ranks fourth in area and fifth in production in the world. By symbiotically nitrogen fixing, this crop also aids in enhancing the soil's fertility. The crop, known as the "wonder bean," offers a number of benefits and in addition to enhancing soil fertility, has the enormous potential to be used for food, feed, a variety of industrial items, and export commodities. Various macro and micro nutrients are essential to complete growth, reproduction and for obtaining high yield of soybean. More presence of particular nutrient element in the soil is not enough to meet the plant nutritional demand to produce higher yield.

The nutrient deficiency during reproductive stage can be managed or meet through foliar nutrition and is one of the fastest way to boost up the crop growth, facilitates nutrient availability during pod filling stage. It is also known that active nodulation of soybean or any pulse crop stops 45-50 days after sowing and at that time for legume plants if supply nutrients through foliar spray found to have beneficial effects on enhancing growth, increasing seed yield and quality parameters. (Sharifi *et al.* 2018) [15]. Foliar spray of nutrients is the fastest way to boost up crop growth because the nutrients are available to plants quickly in the initial and critical stages of crop and the nutrients will reach the site of food synthesis directly leading to no wastage and quickly supply of food, thereby reduce the requirement of fertilizers.

Complex fertilizers are available in the crystalline powder form, such as 19:19:19, as a water-soluble fertilizer. This might provide great development in all stages of crop growth, including the seedling stage, vegetative stage, reproductive stage, and grain filling stage, because it includes an equivalent amount of NPK.

Application of fertilizer as foliar spray resulted in efficient absorption and it is most economical way fertilization to achieve quality produce and higher productivity, especially when sink competition for carbohydrates among plant organs take place, while nutrient uptake from the soil is restricted. Foliar fertilization of soybean with N, P, K and S during the seed filling period promises to increase soybean yield. This approach helps to avoid the depletion of nutrients in the leaves and avoid reduction in photosynthetic rate during this period due to poor nutrient uptake from the soil and translocation of these elements from the leaves to the developing seeds (Warpe *et al.* 2022) [16].

## Materials and Methods

A field experiment was carried out at Experimental Research farm of Department of Soil Science and Agricultural Chemistry, college of Agriculture, Latur under Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra during *kharif* season of the year 2021-22. The soil of experimental field was deep black with pH of 7.62, bulk density 1.43 Mg m<sup>-3</sup>, organic carbon 0.61% having low available nitrogen (148.58 kg ha<sup>-1</sup>), medium available phosphorus (148.58 kg ha<sup>-1</sup>) and high available potassium (368.31 kg ha<sup>-1</sup>) content in it. The crop with variety "MAUS-158" was raised using RDF @ 30 kg N, 60 kg P and 30 kg K per hectare at the time of sowing. Seeds were sown by dibbling method at a spacing of 45 cm x 05 cm. The field experiment was laid out in Randomized Block Design with three replications. The nine treatments consisted of various combination of nutrition application sprayed at different growth stages of soybean i.e., vegetative stage, flowering stage and pod formation stage. Treatment details are- T<sub>1</sub> – Control, T<sub>2</sub> – RDF, T<sub>3</sub> – RDF + 19:19:19 @ 0.5% at 30 DAS, T<sub>4</sub> – RDF + 00:52:34 @ 1.0% at 45 DAS, T<sub>5</sub> – RDF + KNO<sub>3</sub> (13:00:45) @ 1.0% at 60 DAS, T<sub>6</sub> – T<sub>3</sub> + T<sub>4</sub>, T<sub>7</sub> – T<sub>4</sub> + T<sub>5</sub>, T<sub>8</sub> – T<sub>3</sub> + T<sub>5</sub> and T<sub>9</sub> – T<sub>3</sub> + T<sub>4</sub> + T<sub>5</sub>. The data on plant height, number of leaves, number of branches per plant, no. of pods per plant, no. of seeds per pod were collected from randomly selected five plants per plot at the time of harvest. Harvesting was carried out at physiological maturity of crop plot wise with the help of manual labour. At first plants were cut at the base of the plant of each plot was tied in bundles properly labelled and it was kept for sun drying for 3-4 days. Then threshing was carried out as per treatment and seeds were separated by winnowing. The clean seeds were weighed in kilograms as final yield. The data on grain yield and straw yield were collected after harvest of soybean crop. The data were analysed by statistical method as suggested by Panse and Sukhatme (1985) [13].

## Results and Discussion

### Growth parameters of soybean influenced by foliar application of water soluble fertilizers

Data presented in Table 1 showed that The maximum plant height was recorded in treatment T<sub>9</sub> (RDF+ 19:19:19 @ 0.5% at 30 DAS+ 00:52:34 @ 1.0% at 45 DAS+ KNO<sub>3</sub> @ 1.0% at 60 DAS) at harvest stage (71.66 cm), while found to be at par with treatments T<sub>6</sub> (RDF + 0.5% 19:19:19 at 30 DAS + 1.0% 00:52:34 at 45 DAS) which were (69.64 cm) respectively and followed by T<sub>8</sub> (RDF + 0.5% 19:19:19 at 30 DAS+ 1.0% KNO<sub>3</sub> at 60 DAS) which were (70.65 cm) and it is significantly superior over rest of the all treatments. However, with treatment T<sub>1</sub> (control), recorded lowest plant height at

harvest i.e., 55.39 cm. The noticeable effect of water soluble fertilizers on plant height also been reported by Mankar *et al.* (2014) [10] studied response of mustard on foliar spray of water soluble fertilizer sujala (19:19:19) recorded maximum plant height (166.1 cm) at harvest stage. Ram *et al.* (2018) reported that foliar spray of 19:19:19 (N:P: K) @ 0.5% at flower initiation and pod development stages recorded significantly highest plant height (59.4 cm) of lentil similarly. Gour *et al.* (2019) [7] reported that plant height (107.34 cm) of mustard were significantly increased with 75% basal N+2 foliar sprays of KNO<sub>3</sub> @ 1% or urea @ 2%.

Data indicated in Table 1 showed that treatment T<sub>9</sub> (RDF + 19:19:19 @ 0.5% at 30 DAS + 00:52:34 @ 1.0% at 45 DAS + 1.0% KNO<sub>3</sub> at 60 DAS) showed significantly and higher number of branches plant<sup>-1</sup> at harvest stage (9.55) across all the treatments. Moreover, treatment T<sub>9</sub> was found at par with treatment T<sub>8</sub> (RDF+ 19:19:19 @ 0.5% at 30 DAS+ KNO<sub>3</sub> @ 1.0% at 60 DAS) i.e., 9.34 branches per plant and which was followed by treatment T<sub>6</sub> (RDF+19:19:19 @ 0.5% 30 DAS + 00:52:34 @ 1.0% at 45 DAS) at harvest stage i.e., 9.39 branches per plant. Treatment T<sub>1</sub> recorded lowest number of branches at harvest stages of crop. The remarkable effect of water soluble fertilizers on number of branches plant<sup>-1</sup> also been reported by Dalei *et al.* (2014) [4] conducted an field experiment on Niger and reported that foliar application of 2% urea at flowering and capitula formation stage remarkably recorded highest number of branches plant<sup>-1</sup> (7.7). Andhale *et al.* (2016) [2] quoted that the application of FYM @ 7.5 t ha<sup>-1</sup> + 100% RDF + foliar spray of water soluble fertilizers at 30, 45 and 60 DAS recorded significantly highest number of branches plant<sup>-1</sup> (6.13) of summer groundnut. Dandge *et al.* (2018) [5] also reported that significantly maximum number of branches (2.43) with foliar spray of 19:19:19 (NPK) @ 2%.

Number of leaves in soybean were found significantly maximum with treatment T<sub>9</sub> which receives 19:19:19 @0.5% at 30 DAS + 00:52:34 @ 1.0% at 45 DAS + KNO<sub>3</sub> (13:00:45) @ 1.0% at 60 DAS along with RDF i.e., 61.70 at 60 DAS which was found at par with treatment T<sub>6</sub> (RDF+19:19:19 @ 0.5% at 30 DAS + 00:52:34 @ 1.0% at 45 DAS) at 60 DAS i.e., 59.83 followed by treatment T<sub>8</sub> (59.77). Lowest number of leaves plant<sup>-1</sup> were recorded in T<sub>1</sub> treatment (Control) with 41.12 at 60 DAS respectively. The similar findings were given by Ahmad *et al.* (2019) quoted that treatment with RDF + foliar application of WSF (19:19:19) @ 2.5% at flowering + pod formation stage recorded remarkably highest number of leaves plant-1 (27.53) of soybean. Similarly, Marskile *et al.* (2021) [11] reported that the maximum number of leaves plant-1 (18.53) were recorded by two foliar sprays of 1% KNO<sub>3</sub> solution at 25-30 and 55- 60 days after sowing.

Data presented in Table 1 showed that treatment T<sub>9</sub> (RDF + 19:19:19 @ 0.5% at 30 DAS + 00:52:34 @ 1.0% at 45 DAS + KNO<sub>3</sub> @ 1.0% at 60 DAS) recorded significant and highest amount of total chlorophyll content i.e., 10.66 mg g<sup>-1</sup> fresh weight which was found at par with treatment T<sub>6</sub> (10.47 mg g<sup>-1</sup>), T<sub>3</sub> (10.18 mg g<sup>-1</sup>) and T<sub>8</sub> (10.31 mg g<sup>-1</sup>) and significantly superior over rest of the treatments. Whereas the minimum total chlorophyll (4.95 mg g<sup>-1</sup>) was recorded in treatment T<sub>1</sub> (control). Maximum chlorophyll concentration might be occurred due to foliar application of nitrogen at vegetative, flowering and pod filling stages along with RDF resulted in maximum photosynthesis due to more availability of nitrogen, which turn in enhancing the photosynthetic activity and leaf stomatal opening of leaf. The noticeable effect of water soluble fertilizers on chlorophyll content also been reported

by Nirmal (2021) <sup>[12]</sup> who reported chlorophyll content in the soybean 60 DAS was significantly highest by the application of GRDF + foliar spray of 19:19:19 @ 1% at 45 DAS. Yadav *et al.* (2021) recorded the effects of foliar feeding of lentil with urea and potassium chloride KCl @ 2% each gave significant increase in mean value of total chlorophyll content (12.44  $\mu\text{g g}^{-1}$ , 13.24  $\mu\text{g g}^{-1}$ ) at 50% flowering and 50% podding, respectively.

#### Yield attributes and yield of soybean enhanced by foliar application of water soluble fertilizers

Data presented in Table 2 showed that number of pods plant<sup>-1</sup> are influenced by different water soluble fertilizers in soybean. The soybean crop in experimental field applied with recommended dose of fertilizers along with foliar spray of water soluble fertilizer 19:19:19 @ 0.5% at 30DAS + 1.0% 00:52:34 at 45 DAS+ 1.0% KNO<sub>3</sub> at 60 DAS (T<sub>9</sub>) produced significantly highest number of pods plant<sup>-1</sup> (75.70) at par with T<sub>8</sub> (RDF+0.5% 19:19:19 at 30 DAS+ 1.0% KNO<sub>3</sub> at 60 DAS) (73.04) and T<sub>6</sub> (RDF+0.5% 19:19:19 at 30 DAS + 1.0% 00:52:34 at 45 DAS) (71.61). This might be due to the substantial influence of macro elements on reproductive organs like stamens and pollen, direct nutrient treatment from 00:52:34 to 13:00:45 through foliar spray throughout the flowering and pod-formation stages resulted in an increase in the number of pods per plant. Similar findings were confirmed by Gutte *et al.* (2018) <sup>[8]</sup> found that foliar application of 19:19:19 @ 1% at 40 DAS + 13:00:45 @ 1.0% at 60 DAS (T<sub>9</sub>) recorded remarkably higher mean number of pods plant<sup>-1</sup> (23.93) in soybean.

Data regarding the number of seeds pod<sup>-1</sup> of soybean as influenced by application of different water soluble fertilizers in soybean is presented in the table 2. foliar spray of water soluble fertilizer 19:19:19 @ 0.5% at 30DAS + 00:52:34 @ 1.0% at 45 DAS+ 1.0% KNO<sub>3</sub> at 60 DAS along with recommended dose of fertilizers (T<sub>9</sub>) produced significantly highest number of seeds pod<sup>-1</sup> (3.68). Which was at par with T<sub>8</sub>, T<sub>7</sub> and T<sub>6</sub> treatments, which has 3.60, 3.66 and 3.48 seeds pod<sup>-1</sup> respectively. The highest number of grains pod<sup>-1</sup> might be due to the efficient utilization of nitrogen helped for formation of amino acids and boost of the production of carbohydrate. Phosphorus is vital for seed formation. Potassium plays important role in translocation of starch and protein synthesis. The remarkable effect of water soluble fertilizers on number of seeds pod<sup>-1</sup> also been reported by Warpe *et al.* (2022) <sup>[16]</sup> reported that the number of seeds pod<sup>-1</sup> (2.70) in soybean were found significantly higher with the application of 1% foliar spray of 19:19:19 and it was found at

par with the application of foliar spray of DAP @ 2%. Banjara and Porte (2022) <sup>[3]</sup> quoted that foliar application of urea @ 2% at flower initiation and pod development stages recorded significantly maximum number of seeds pod<sup>-1</sup> (1.65) in chick pea.

The influence of foliar application of different water soluble fertilizers on seed yield (kg ha<sup>-1</sup>) was found to be significant which is presented in table 2. The maximum seed yield *i.e.*, 2203 kg ha<sup>-1</sup> was recorded in treatment T<sub>9</sub> (RDF+ 19:19:19 @ 0.5% at 30 DAS+ 00:52:34 @ 1.0% at 45 DAS+ KNO<sub>3</sub> @ 1.0% at 60 DAS) which was at par with treatment T<sub>6</sub> (RDF+0.5% 19:19:19 at 30 DAS + 1.0% 00:52:34 at 45 DAS) with 2079.33 kg ha<sup>-1</sup> and with T<sub>7</sub> *i.e.*, 2070.33 kg ha<sup>-1</sup> and significant over remaining treatments. Whereas the lowest seed yield (1209 kg ha<sup>-1</sup>) was recorded in treatment T<sub>1</sub> (control). Similarly seed yield per plot was also found to be significant with treatment T<sub>9</sub> (2.68 kg ha<sup>-1</sup>) which was at par with treatment T<sub>6</sub> (2.57 kg ha<sup>-1</sup>). Least seed yield per plot was found in T<sub>1</sub> (Control) (1.71 kg ha<sup>-1</sup>). Similar findings were confirmed by Dandge *et al.* (2018) <sup>[5]</sup> noticed that the treatment with RDF + foliar application of 19:19:19 @ 2% at pod initiation stage recorded highest seed yield (1599 kg ha<sup>-1</sup>). Deepthi *et al.* (2018) <sup>[6]</sup> also found that treatment with application of 125% RDF along with foliar application 19:19:19 @ 1.0% at early budding stage followed by 1.0% KNO<sub>3</sub> at early capsule formation stage recorded the highest seed yield (838 kg ha<sup>-1</sup>) compared to other treatments.

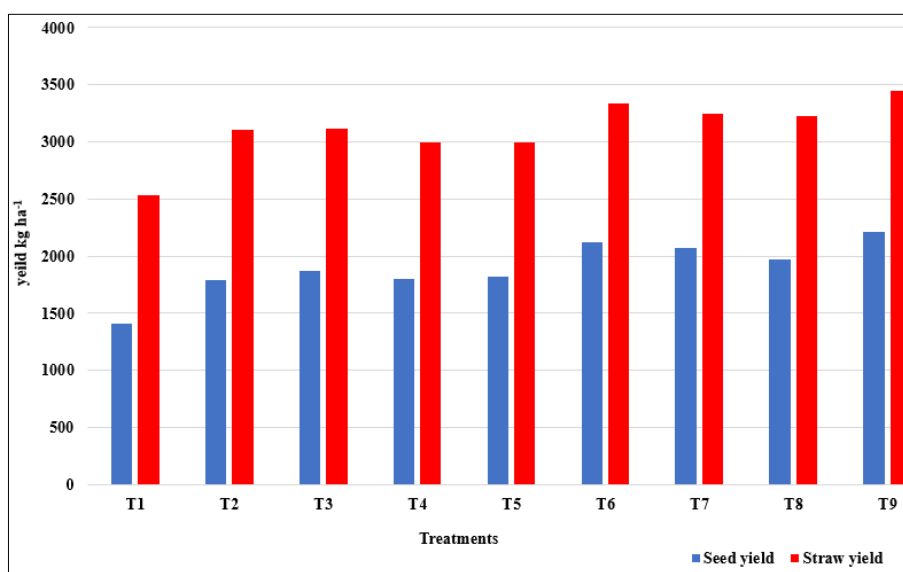
Straw yield of soybean found to be significantly increased with foliar application of water soluble fertilizers at different growth stages is presented in table 2. The application of treatment T<sub>9</sub> with RDF + 0.5% 19:19:19 at 30 DAS+1.0% 00:52:34 at 45 DAS + 1.0% KNO<sub>3</sub> at 60 DAS was recorded significantly highest straw yield *i.e.*, 3287.92 kg ha<sup>-1</sup> which is at par with treatment T<sub>6</sub> (3189.27 kg ha<sup>-1</sup>) followed by T<sub>7</sub> *i.e.*, 3137.67 kg ha<sup>-1</sup>. Significantly lowest straw yield was obtained in T<sub>1</sub> treatment (control) *i.e.*, 2119.67 kg ha<sup>-1</sup>. Similarly, straw yield per plot of the soybean which shows that the highest straw yield per plot was found with the foliar application of T<sub>9</sub> *i.e.*, 4.18 kg ha<sup>-1</sup> which was at par with treatment T<sub>6</sub> (4.08 kg ha<sup>-1</sup>). Similar findings were confirmed by Zambre *et al.* (2017) <sup>[18]</sup> quoted that that application of GRDF + foliar spray of 19:19:19 NPK @ 0.5% + H<sub>3</sub>BO<sub>3</sub> @ 0.5%+ ZnSO<sub>4</sub> @ 40.5% remarkably resulted in significantly higher straw yield (21.00 q ha<sup>-1</sup>). Kirnapure *et al.* (2020) <sup>[9]</sup> reported that straw yield (36.54 q ha<sup>-1</sup>) was significantly maximum with foliar application of urea @ 2% at vegetative and pre-flowering stage and it was followed by foliar spray of KNO<sub>3</sub> @ 1% and 0.5% zinc.

**Table 1:** Growth parameters in soybean as influenced by foliar application of Water soluble fertilizers

Treatments	Plant height (cm) at harvest	No. of branches plant <sup>-1</sup> at harvest	No. of leaves plant <sup>-1</sup> at 60 DAS	Total chlorophyll (mg g <sup>-1</sup> fresh weight) at 45 DAS
T <sub>1</sub> : Control	55.39	6.92	41.12	4.95
T <sub>2</sub> : RDF	61.59	8.35	48.94	9.26
T <sub>3</sub> : RDF+0.5% of 19:19:19 at 30 DAS	66.14	8.80	54.56	10.18
T <sub>4</sub> : RDF+1.0% of 00:52:34 at 45 DAS	62.34	8.37	49.12	9.37
T <sub>5</sub> : RDF+1.0% of KNO <sub>3</sub> at 60 DAS	58.52	8.05	51.21	9.76
T <sub>6</sub> : RDF+0.5% 19:19:19 at 30 DAS + 1.0% 00:52:34 at 45 DAS	69.64	9.39	59.83	10.47
T <sub>7</sub> : RDF+1.0% 00:52:34 at 45 DAS + 1.0% KNO <sub>3</sub> at 60 DAS	65.6	8.84	52.88	9.83
T <sub>8</sub> : RDF+0.5% 19:19:19 at 30 DAS+ 1.0% KNO <sub>3</sub> at 60 DAS	70.65	9.34	59.77	10.31
T <sub>9</sub> : RDF+0.5% 19:19:19 at 30 DAS +1.0% 00:52:34 at 45 DAS+1.0% KNO <sub>3</sub> at 60 DAS	71.66	9.55	61.70	10.66
SE $\pm$	1.63	0.28	1.42	0.22
CD at 5%	4.91	0.84	4.28	0.67

**Table 2:** Yield attributes in soybean as enhanced by foliar application of water soluble fertilizers

Treatments	Number of Pods plant <sup>-1</sup>	Number of seeds pod <sup>-1</sup>	Seed yield (kg ha <sup>-1</sup> )	Seed yield (kg plot <sup>-1</sup> )	Straw yield (kg ha <sup>-1</sup> )	Straw yield (kg plot <sup>-1</sup> )
T <sub>1</sub> : Control	37.34	2.63	1409.1	1.71	2537.77	3.08
T <sub>2</sub> : RDF	56.02	2.80	1788.5	2.17	3102	3.77
T <sub>3</sub> : RDF+0.5% of 19:19:19 at 30 DAS	68.71	3.03	1866.53	2.26	3110.51	3.78
T <sub>4</sub> : RDF+1.0% of 00:52:34 at 45 DAS	67.82	3.26	1804	2.19	2992.59	3.64
T <sub>5</sub> : RDF+1.0% of KNO <sub>3</sub> at 60 DAS	62.53	3.19	1815.26	2.20	2999.75	3.64
T <sub>6</sub> : RDF+0.5% 19:19:19 at 30 DAS + 1.0% 00:52:34 at 45 DAS	71.61	3.48	2118.57	2.57	3336	4.05
T <sub>7</sub> : RDF+1.0% 00:52:34 at 45 DAS + 1.0% KNO <sub>3</sub> at 60 DAS	68.67	3.66	2070.33	2.51	3246.39	3.94
T <sub>8</sub> : RDF+0.5% 19:19:19 at 30 DAS+ 1.0% KNO <sub>3</sub> at 60 DAS	73.04	3.60	1975	2.40	3229.21	3.92
T <sub>9</sub> : RDF+0.5% 19:19:19 at 30 DAS +1.0% 00:52:34 at 45 DAS+1.0% KNO <sub>3</sub> at 60 DAS	75.70	3.68	2206.52	2.68	3444.27	4.18
SE ±	2.32	0.13	55.23	0.03	63.54	0.06
CD at 5%	6.96	0.41	165.58	0.11	190.51	0.19

**Fig 1:** Yield attributes in soybean as enhanced by foliar application of water soluble fertilizers

## Conclusion

The results of present investigation suggests that foliar spray of 19:19:19 @ 0.5% at 30 DAS + 00:52:34 @ 1.0% at 45 DAS + KNO<sub>3</sub> (13:00:45) @ 1.0% at 60 DAS along with RDF leads to highest growth parameters viz., plant height, no. of branches plant<sup>-1</sup>, no. of leaves plant<sup>-1</sup>, total chlorophyll and significantly influenced yield attributes like seed yield and straw yield of soybean.

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