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Effect of water soluble fertilizer on yield and economics of soybean [*Glycine max* (L.) Merrill]

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Abstract
A field experiment was conducted during *Kharif* seasons of 2017 at Zonal Agricultural Research Station (ZARS), in Gandhi Krishi Vigyan Kendra (GKVK), University of Agricultural Science (UAS), Bengaluru on red sandy clay loam soil which was medium in available NPK, to evaluate the effect of water soluble fertilizers on growth attributes of soybean crop. The experiment was laid out in a RCBD design with three replications and 10 treatments. Water-soluble fertilizers (WSF) (NPK: 19: 19: 19) was used at different growth stages with 1.5 %, 2 % and 2.5 % concentration. Significantly higher yield parameters like number of pods plant^{-1} (75.70), seed yield plant^{-1} (28.27 g), seed yield (3250 kg ha^{-1}), haulm yield (7129 kg ha^{-1}), harvest index (0.313), higher net returns (Rs. 70766 ha^{-1}) and higher B:C ratio (3.64) were obtained with the treatment recommended dose of fertilizer (RDF) + spraying of water-soluble fertilizer at 2.5 % at flowering + pod formation stage at 60 DAS, compared to other treatments.

Keywords: foliar spray, soybean, water soluble fertilizer, different growth stages

1. Introduction
Recognizing soybean as the 'golden bean' or the 'miracle bean', the western world provided a massive push to its growth during the early part of the century. The crop, in fact, has revolutionized the agricultural economy of the USA, with its immense potential for food, feed and numerous industrial products. At present, the USA, Brazil and China are the 'Big-3' in soybean production, with the USA enjoying hegemony. The USA now has over 50 percent of total soybean area in the world, producing over 50 percent of the world's soybeans. Soybean has come to be recognized as one of the premier agricultural crops today for various reasons. In brief, soybean is a major source of vegetable oil, protein and animal feed. Soybean, with over 40 percent protein and 20 percent oil, has now been recognized all over the world as a potential supplementary source of edible oil and nutritious food. The protein of soybean is called a complete protein, because it supplies sufficient amounts of the kinds of amino acids required by the body for building and repair of tissues. Its food value in heart disease and diabetes is well known. It is significant that Chinese infants using soybean milk in place of cow's milk are practically free from rickets.

Soybean is a major oilseed crop of the world grown in an area of 121.1 m ha (Anon. 2018) [1], with a production of 348.85 mt and productivity of 2.88 t ha^{-1}. In the world, it is cultivated mainly in the USA, Brazil, Argentina, China, and India (Anon, 2018) [1]. In India, it is grown over an area of 11.6 m.ha with a production of 8.57 mt and productivity of 738 kg ha^{-1}(Anon, 2018) [1]. Predominant soybean growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, and Gujarat. In Karnataka, soybean occupies in an area of 0.32 m ha with a production of 0.25 mt and productivity of 785 kg ha^{-1} (Anon. 2016) [1]. Belgaum, Dharwad, Bidar, Bagalkot, and Haveri are the major soybean growing districts of Karnataka.

Foliar application is considered as a preferred solution when the rapid supply of nutrients is held up or the soil conditions are not favorable for the absorption of nutrients (Salisbury and Ross, 1985) [5]. Foliar spray technique supports the nutrients to reach the place of food synthesis directly, leading no consumption and fast supply of food and thus reduce the requisite of fertilizers. Foliar nutrition can accelerate the growth of a crop quickly. It is also identified that active nodulation of pulse crop stops after 45 to 50 days after cultivation and at that time, the positive effect of supplying legume plants with additional nitrogen was found to have positive effects on increasing growth and enhances seed yield by the rapid supply of nitrogen.

2. Material and Methods
A field experiment was conducted during *Kharif* seasons of 2017 at Zonal Agricultural Research Station (ZARS), in Gandhi Krishi Vigyan Kendra (GKVK), University of Agricultural Sciences (UAS), Bengaluru, Karnataka. The experimental site was located between 13º 00' and Latitude and 77º 35' E Longitude at an altitude of 930 m above mean sea level (MSL). The soil was red sandy clay loam with organic carbon content of 0.42 per cent. The initial nitrogen, phosphorus and potassium status of the soil were 464.12, 56.2 and 216.24 kg per ha, respectively. The soil pH was 6.23 with an EC of 0.14 dSm^{-1}. The experiment was laid out in a randomized complete block design (RCBD) with ten treatments and three replications.

The land was prepared to a fine tilth before sowing of soybean. Plots were prepared with the of size was 3.60 m x 4.00 m, with the spacing of 30 x 10 cm. Soybean variety was MAUS-2 and sowing was done on 11/08/2017 and harvested on 23/11/2017. Water-soluble fertilizer (NPK 19: 19: 19) was used at different concentration as was given per the treatments. Rainfall during these months (August, September, October and November) was 198.5 mm, 275.6 mm, 264.4 mm, and 10 mm respectively. The crop was grown

with one life saving irrigation during flowering stage. Weeding and plant protection measures were undertaken as per the need of crop. The observations on growth, yield attributes and yield were recorded at 30, 60 days after sowing and at harvest. Growth and yield parameters like plant height, number of branches, leaf area, total dry matter accumulation, Chlorophyll contents (SPAD reading), pod number, seed yield plant^{-1} and test weight were recorded from five tagged plants in each plot, while seed yield, haulm yield, and harvest index were recorded on plot basis.

3. Results and Discussion

The data pertaining to number of pods per plant as influenced by different concentration of WSF in soybean is given in the Table 1. Significantly higher pod number was obtained with the treatment of RDF + foliar application of WSF @ 2.5 % at flowering + pod formation stages (75.70) and it was on par with two other treatments like application of RDF + Spraying of 2.5% water-soluble fertilizer at flowering stage (72.53) and RDF + Spraying of 2.5% water-soluble fertilizer at pod formation stage (73.27). Significantly lower pod number was recorded with control (63.27). The increased number of pods per plant was due to direct spraying of nutrients at flowering and pod formation stages which could be attributed to significant effect of macro elements on reproductive organs such as stamens and pollens. Further stamens activity enhances the number of flowers that can be fertile well and as a result, larger number of pods per plant produced. Similar results were observed by Das and Ali (1993) [4].

Significantly higher seed yield per plant was recorded with application of RDF + foliar application of WSF @ 2.5 % at flowering + pod formation stage (19.33 g) over other treatments. Significantly lower seed yield per plant was obtained with the treatment of RDF + Spraying of 2 % water-soluble fertilizer at flowering stage (13.83 g). The increased seed yield per plant might be due to higher growth parameters, due to sufficient nutrients available for the sink and utilization of radiation source effectively. Similar results were reported by Das and Ali (1993) [4].

The data pertaining to seed yield per hectare as influenced by different concentration of WSF in soybean is given in the Table 1. The seed yield differed significantly due to spraying of water-soluble NPK (19: 19: 19) fertilizers.

Table 1: Yield and yield parameters as influenced by water-soluble fertilizer in soybean

Treatments		Number of pods plant^{-1}	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest Index
T_1	RDF + Spraying of 1.5 % water-soluble fertilizer at flowering stage	14.40	14.40	2389	5879	0.289
T_2	RDF + Spraying of 1.5 % water-soluble fertilizer at pod formation stage	16.53	16.53	2470	5995	0.292
T_3	RDF + Spraying of 1.5 % water-soluble fertilizer at flowering stage + pod formation stage	15.97	15.97	2577	6180	0.294
T_4	RDF + Spraying of 2 % water-soluble fertilizer at flowering stage	13.83	13.83	2463	5902	0.294
T_5	RDF + Spraying of 2 % water-soluble fertilizer at pod formation stage	15.80	15.80	2691	6203	0.303
T_6	RDF + Spraying of 2 % water-soluble fertilizer at flowering stage + pod formation stage	15.77	15.77	3003	6388	0.320
T_7	RDF + Spraying of 2.5 % water-soluble fertilizer at flowering stage	16.13	16.13	2525	6018	0.296
T_8	RDF + Spraying of 2.5 % water-soluble fertilizer at pod formation stage	16.13	16.13	2798	6689	0.295
T_9	RDF + Spraying of 2.5 % water-soluble fertilizer at flowering stage + pod formation stage	19.33	19.33	3250	7129	0.313
T_{10}	RDF only (Control)	15.37	15.37	2299	5810	0.284
	S. Em ±	0.71	0.71	60.93	93.84	0.0045
	CD (5%)	2.10	2.10	181.04	278.81	0.01

Significantly higher seed yield per hectare was obtained with the application of RDF + spraying of water-soluble fertilizer at 2.5 % at flowering + pod formation stage (3250 kg ha^{-1}) and it was followed by RDF + Spraying of 2 % water-soluble fertilizer at flowering stage + pod formation stage (3003 kg ha^{-1}). Significantly lower seed yield of soybean was recorded with control (2299 kg ha^{-1}). The higher seed yield might be due to increased yield parameters such as number of pods per plant, pod yield per plant and seed yield per plant which might have influenced by water-soluble fertilizer and this increment might be due to increased growth parameters such as plant height, number of leaves per plant, branches per plant, leaf area, chlorophyll content (SPAD reading) and higher dry matter accumulation per plant in soybean crop. As NPK is required in large quantity and demand for the better crop yield, when it is applied in the form of foliar spray to the crop which influenced effectively due to fast absorption through leaf stomata and easily utilizable in the plant metabolic activities. Similar observations were recorded by Sathiyamoorthy and Vivekanandan (1988) [6].

Similar trend was obtained with the haulm yield also. Significantly higher haulm yield was obtained with application of RDF + spraying of water-soluble fertilizer at 2.5 % at flowering + pod formation stage (7129 kg ha^{-1}) over other treatments. Whereas, significantly lower haulm yield was recorded with control (5810 kg ha^{-1}). Similar results were recorded by Bahure (2014) [3].

Significantly higher harvest index was observed with application of RDF + foliar application of water-soluble fertilizer at 2 % at flowering + pod filling stages (0.320) and it was on par with the treatment RDF + Spraying of 2.5 % water-soluble fertilizer at flowering stage + pod formation stage (0.313) and also was on par with treatment RDF + Spraying of 2 % water-soluble fertilizer at pod formation stage (0.303). Significantly lower harvest index was observed with control (0.284).

The economics of use of foliar application of water-soluble fertilizers is a booster NPK in soybean crop production as worked out and presented in Table 2 and figure 1. All other costs of inputs, labour, cost of produce *etc.* were worked out considering the existing market prices. The RDF + Spraying of 2.5 % water-soluble fertilizer at flowering stage + pod formation stage given higher gross returns (Rs. 97521 ha^{-1}), net returns (Rs. 70766 ha^{-1}) and B:C ratio (3.64) when compared to other treatments and lower gross returns (Rs. 68986 ha^{-1}), net returns (Rs. 47231 ha^{-1}) and B:C ratio (3.17),

was recorded with recommended dose of fertilizer (control). This might be due to higher yield obtained in the treatment with application of RDF +foliar application of WSF @ 2.5 % at flowering + pod formation stage which resulted in getting higher returns and high B:C ratio. Similar results were obtained by Shruthi (2013) [7] in lima bean crop.

Table 2: Yield and economics of soybean as influenced by water soluble fertilizer application

Treatments		Yield (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1	RDF + Spraying of 1.5 % water-soluble fertilizer at flowering stage	2389	71691	23255	48436	3.08
T_2	RDF + Spraying of 1.5 % water-soluble fertilizer at pod formation stage	2470	74104	23255	50849	3.19
T_3	RDF + Spraying of 1.5 % water-soluble fertilizer at flowering stage + pod formation stage	2577	77316	24755	52561	3.12
T_4	RDF + Spraying of 2 % water-soluble fertilizer at flowering stage	2463	73906	23755	50151	3.11
T_5	RDF + Spraying of 2 % water-soluble fertilizer at pod formation stage	2691	80740	23755	56985	3.40
T_6	RDF + Spraying of 2 % water-soluble fertilizer at flowering stage + pod formation stage	3003	90111	25755	64356	3.50
T_7	RDF + Spraying of 2.5 % water-soluble fertilizer at flowering stage	2525	75771	24255	51516	3.12
T_8	RDF + Spraying of 2.5 % water-soluble fertilizer at pod formation stage	2798	83958	24255	59703	3.46
T_9	RDF + Spraying of 2.5 % water-soluble fertilizer at flowering stage + pod formation stage	3250	97521	26755	70766	3.64
T_{10}	RDF only (Control)	2299	68986	21755	47231	3.17

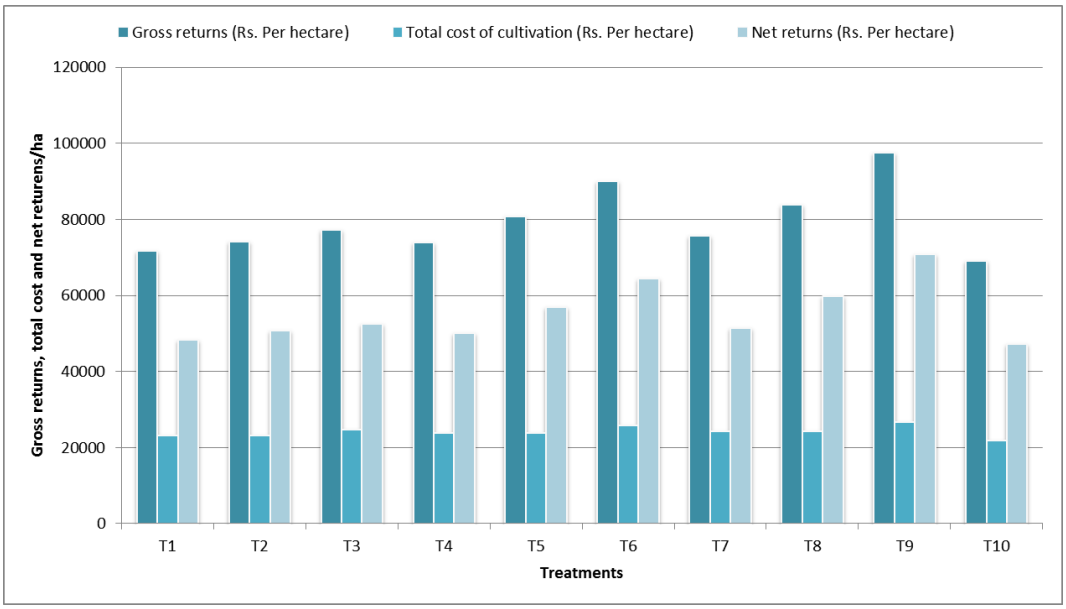

Fig 1: Showing influence of water-soluble fertilizers on yield and economics of soybean crop

The present study reveals the importance of water soluble fertilizer and its effects on enhancing of the crop yield. As discussed that treatment RDF + Spraying of 2.5 % water-soluble fertilizer at flowering stage + pod formation stage brought 41 per cent higher seed yield with higher net returns compared to control.

4. References

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