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Jawale SS
Department of Agronomy, College of Agriculture, VNMKV. Parbhani, Maharashtra, India

Mirza IAB
Department of Agronomy, College of Agriculture, VNMKV. Parbhani, Maharashtra, India

Pawar AD
Department of Agronomy, College of Agriculture, VNMKV. Parbhani, Maharashtra, India

Hinge PP
Department of Agronomy, College of Agriculture, VNMKV. Parbhani, Maharashtra, India

Corresponding Author:
Jawale SS
Department of Agronomy, College of Agriculture, VNMKV. Parbhani, Maharashtra, India

Yield and economics of soybean (*Glycine max* (L.) Merrill) as influenced by biostimulants and foliar spray of plant growth regulators

Jawale SS, Mirza IAB, Pawar AD and Hinge PP

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Abstract
The field investigation entitled "Effect of plant growth regulators on yield and economics of soybean (*Glycine max* (L.) Merrill)" was conducted at experimental farm, Department of Agronomy, College of Agriculture, VNMKV, Parbhani during *kharif* 2018-19. The experiment was laid out in a randomized block design with nine treatments and three replications with a view to find out the influence of different growth regulators applied at flowering and pod developing stage of soybean. From the result it was revealed that application of seaweed extract (20%) + organic plant extract (80%) at flowering and developing stage recorded higher seed yield kg ha^{-1}, straw yield kg ha^{-1}, harvest index% and monetary returns, it was at par with organic plant extract and brassinosteroides (0.01%) + organic plant extract.

Keywords: Soybean, growth regulators, seaweed extract, organic plant extract, growth, economic, yield

1. Introduction
Soybean (*Glycine max* (L.) Merrill) belongs to family leguminoaceae, sub-family fabaceae and genus glycine. It is native of Eastern Asia cultivated from around 3000 BC. It is basically a pulse crop, but it has gained importance as an oilseed crop as it contains 20% cholesterol free oil. It is an important crop worldwide, majorly grown for its edible bean which has numerous uses with unique chemical composition, good nutritional value, health benefits, variety of end-uses (food, feed and non-edible) and also wide geographical adaption. Soybean has been principal food crop since long time as it produce 2-3 times more high quality protein per hectare than other pulses and cholesterol free oil. It is an excellent health food as it contains 40-42% quality protein, 23% carbohydrates and 20% cholesterol free oil. For such incredible chemical composition it is known as Wonder Crop, Miracle Crop and also Golden Bean.

In world the main producers of soybean are the United States of America, Brazil, Argentina, China, India, Paraguay, Canada, Mexico. India ranks fifth in soybean production and productivity. Major soybean growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh, Gujrat, Chhattisgarh. Maharashtra ranks 2nd in terms of production of soybean after Madhya Pradesh. (Anonymous, 2018) [1].

Plant growth regulators play important role in plant growth and development, but little is known about the roles of plant growth regulators in improving the yield components and seed qualities of soybean. Endogenous plant growth regulators determine many growths and development processes ultimately manifesting yield components and yield. Plant growth regulators are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit and seed development and ultimately enhance productivity of the crop.

Application of plant growth regulators at different stages plays an important role in soybean yield and economics. Thus, the economic importance of plant growth regulators is largely depends on their ability to increase the crop yields. Different plant growth regulators and stages of application had significant influence on seed yield of soybean. There is lack of comparative studies on application of different plant growth regulators in soybean and its effect on yield.

2. Materials and Methods

A field experiment was conducted at experimental farm, Department of Agronomy, VNMKV, Parbhani, MH., during kharif season 2018. The soil of the experimental field was medium deep black and well drained. The experimental site is under subtropical climatic condition.

The experiment was consisted of nine treatments *viz*., seaweed extracts (T_1), organic plant extracts(T_2), seaweed extracts (20%) + organic plant extracts (80%)(T_3), brassinosteroids (0.01%) + organic plant extracts (T_4), NATCA - 5% (T_5), brassinosteroides - 0.01% (T_6), amino acid - 2% (T_7), nitrobenzene - 400ppm (T_8), water spray (T_9). Time of spraying - at flowering and at pod developing. The variety MAUS-71 was used and experiment was arranged in Randomized Block Design with three replications and comprised of 27 unit plots. The gross and net size of each plot was 5.4 m x 4.5 m, 4.5 m x 4.0 m, respectively. All the growth regulators are applied in two sprayings as foliar spray, 1st spraying at flowering and 2nd spraying at pod developing stage.

Collected data on different parameters were statistically analyzed by using "Analysis of variance method (ANOVA)" (Panse and Sukhatme, 1967) [5].

3. Results and Discussion

3.1 Effect of plant growth regulators on yield of soybean.

The foliar application of different growth regulators and seaweed extract showed variation on yield characteristics of soybean such as Seed yield kg ha^1, Straw yield kg ha^{-1}, Harvest index%. Among all the treatments application of T_3 - seaweed extract (20%) + organic plant extract (80%) increased all the yield parameters and being significantly better (Table 1). The highest) Seed yield (2465 kg ha^1), Straw yield (3159 kg ha^{-1}), Harvest index (43.82%) were observed at seaweed extract (20%) + organic plant extract (80%) which was significantly higher over all the treatments, and at par with treatment T_2 - organic plant extract and T_4 - brassinosteroides (0.01%) + organic plant extract. However lower values were recorded in treatment T_9 - water spray. Similar trend of observation observed by Bhat *et al*. (2011) [2]. Tandon and Dubey (2015) [11].

Table 1: Effect of plant growth regulators on yield of soybean as influenced by different treatments

Trt. No.	Treatments	Seed yield kg ha^{-1}	Straw yield kg ha^{-1}	Harvest index%
T_1	seaweed extract	2180	2886	43.03
T_2	organic plant extract	2410	3097	43.76
T_3	seaweed extract (20%) + organic plant extract (80%)	2465	3159	43.82
T_4	brassinosteroides (0.01%) + organic plant extract	2230	2945	43.08
T_5	NATCA-5%	2060	2885	41.66
T_6	brassinosteroides-0.01%	2177	2963	42.35
T_7	amino acid-2%	2082	2899	41.79
T_8	nitrobenzene-400ppm	2050	2820	42.09
T_9	water spray	1798	2600	40.88
SE(m) ±		80.85	91.32	--
C.D. at 5%		243.38	274.92	--
General mean		2161	2917	42.55

3.2 Economics of the soybean crop

Gross and net monetary returns of soybean crop were significantly influenced due to different input factors Table 2. Treatment seaweed extract (20%) + organic plant extract (80%) (T_3) to soybean crop recorded significantly highest gross and net monetary returns as compared to rest of treatments. The effect of input factors on gross monetary return and net monetary returns was found to be significant. Application of seaweed extract (20%) + organic plant extract (80%) (T_3) to soybean crop was significantly superior over all other treatments and produced highest gross monetary returns of (₹85049 ha^{-1}) and which was found on at par with treatment and organic plant extract (T_2) (₹ 83154 ha^{-1}) and brassinosteroides (0.01%) + organic plant extract (T_4) (₹ 76986 ha^{-1}). Lowest gross monetary return of soybean was obtained by water spray treatment water spray (T_9) (₹ 62176 ha^{-1}). Similar type of trend was observed in net monetary returns. Application of seaweed extract (20%) + organic plant extract (80%) (T_3) to soybean crop recorded significantly highest net monetary return (₹ 48924 ha^{-1}) and found at par with treatment organic plant extract (T_2) and brassinosteroides (0.01%) + organic plant extract (T_4).

Table 2: Economics of soybean production as influenced by different treatments.

Trt. No.	Treatments	Gross monetary returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})	B:C ratio
T_1	Seaweed extract	75258	34725	40533	2.16
T_2	Organic plant extract	83154	35075	48080	2.37
T_3	Seaweed extract 20% + Organic plant extract 80%	85049	36125	48924	2.35
T_4	Brassinosteroides 0.01% + Organic plant extract	76986	37075	39912	2.07
T_5	NATCA-5%	71174	35325	35849	2.01
T_6	Brassinosteroides-0.01%	74943	35325	39618	2.12
T_7	Amino acid-2%	71929	34125	37804	2.10
T_8	Nitrobenzene-400ppm	70807	34345	36462	2.06
T_9	Water spray	62176	33325	29185	1.86
SE(m)+		2768.25	--	2082.30	-
C.D. at 5%		8333.25	--	6268.34	-
General mean		74608	315445	39596	2.12

4. Conclusion

The foliar spray of growth regulators and seaweed extract at flowering and pod developing stage to soybean give higher seed yield and monetary return as compared to water spray but application of seaweed extract (20%) + organic plant extract (80%) at flowering and pod developing stage increase yield as compare to other treatments and over water spray.

From the above results and discussion it may be concluded that, application of seaweed extract (20%) + organic plant extract (80%) at flowering and pod developing stage would be promising practice for soybean in terms of yield and economics.

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