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Effect of growth regulators, seaweed extract and potassium nitrate on growth, yield and quality of soybean (*Glycine max* (L.) Merrill)

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Abstract
The field investigation entitled "Effect of growth regulators, seaweed extract and potassium nitrate on growth and yield 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 seven treatments and three replications with a view to find out the influence of different growth regulators, seaweed extract and potassium nitrate applied at flowering and pod developing stage of soybean. From the result it was revealed that application of seaweed extract-20% at flowering and developing stage recorded higher plant height, more number of functional leaves, higher leaf area, higher number of branches, higher dry matter accumulation, higher seed yield, higher oil content and oil yield, higher protein content and protein yield, and it was at par with GA_3-100ppm and Salicylic acid-50ppm.

Keywords: Soybean, growth regulators, seaweed extract, potassium nitrate, growth, yield, quality

1. Introduction
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. It is the cheapest and main source of dietary protein of majority of vegetarian (hence it is known as poor man's meat). In Maharashtra soybean production during *kharif* 2018 was 18.22 lakhs ton from an area 17.40 lakh hectares with the productivity of 967 kg ha^{-1} (Anonymous 2018) [2].

Soybean, a wonder legume has high nutritive value and has manifold uses in agriculture, medicine and industrial sector. It is economically profitable as compared to cereals and other oilseed crops. It is highly remunerative crop with comparatively less input demand. Due to its short duration (85 to 90 days) fits well as an intercrop and photo insensitiveness of crops made it as suitable crops made in double cropping system. Being a leguminous crop, capable of fixing atmospheric nitrogen to an extent 65 to 100 kg ha^{-1} and help to improve the soil fertility. The area under soybean cultivation is increasing due to some reason such as soybean is short duration crop (90-110 days) and good market price with its higher productivity compared to other pulses. It can be processed easily for different products *viz.*, soy cheese, soy milk, soy protein, soy yogurt, soybean oil, soy nut. Soybean also used for making the soy ink, soy paint and soy molasses. It can give a boost to the food-processing industry in rural areas of India. Soybean is miracle crop of 21st century which possesses potential to revolutionize Indian economy by correcting the health of human being and soil.

Seaweed extract contains major and minor nutrients, amino acids, vitamins, cytokinins, auxin and abscisic acid like growth promoting substances (Mooney and Van Staden, 1986) [7]. The beneficial effect of seaweed extract application is as a result of many componants that may work synergistically at different concentrations, although the mode of action still remains unknown (Fornes *et al*., 2002) [4]. Marine bioactive substances extracted from marine algae are used in agricultural crops, and many beneficial effects in the terms of yield and quality have been reported. Liquid extracts obtained from sea weed extracts have recently gained importance as foliar sprays for many crops including various grasses, cereals, flowers and

vegetable species (Crouch and Van Staden, 1994).
In recent years, use of seaweed extracts have gained in popularity due to their potential use in organic and sustainable agriculture, especially in rainfed crops, as a means to avoid excessive fertilizer applications and to improve mineral absorption. Unlike, chemical fertilizers, extracts derived from seaweeds are biodegradable, non-toxic, non-polluting and non-hazardous to humans, animals and birds (Dhargalkar and Pereira, 2005) [3].

2. Materials and Methods

2.1 Site description

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 black cotton. The experimental site is under subtropical climatic condition.

2.2 Experimental treatments

The experiment was consisted of seven treatments *viz*., Salicylic acid-50ppm (T_1), GA_3-100ppm (T_2), Nitrobenzene-400ppm (T_3), NAA-20ppm (T_4),Seaweed extract-20% (T_5), Potassium nitrate-2% (T_6), Water spray (T_7) and two stages of application i.e. at the time of flowering and pod developing stage.

2.3 Seeds, design and plot size

The variety MAUS-71 was used and experiment was arranged in Randomized Block Design with three replications and comprised of 21 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.

2.4 Fertilizer application and sowing of seeds in the plot

Urea, Single super phosphate (SSP), Muriate of potash (MOP) were used as a source of nitrogen, phosphorous, potassium, respectively. The fertilizers urea, SSP, MOP were applied as per recommendation.

2.5 Application of treatments

All the growth regulators, seaweed extract and potassium nitrate are applied in two sprayings as foliar spray, 1st spraying at the time of flowering and 2nd spraying at pod developing stage.

2.6 Statistical analysis

Collected data on different parameters were statistically analyzed by using "analysis of variance method (ANOVA)" (Panse and Sukhatme, 1967) [8].

3. Results and Discussion

3.1 Effect of growth regulators, seaweed extract and potassium nitrate on growth and growth attribute of soybean

Foliar application of different growth regulators, seaweed extract and potassium nitrate exposed variation on growth characteristics of soybean such as plant height, number of functional leaves, leaf area, number of branches, total dry matter accumulation. Among all the treatments application of treatment T_5- Seaweed extract-20% to soybean crop at flowering and pod developing stage showed better result (Table 1) with respect to plant height (49.90cm), number of functional leaves (23.57), leaf area (9.60 dm^2), number of branches (6.18), mean dry matter accumulation (16.73 g) and at par with treatment T_2- GA_3-100ppm and T_1- Salicylic acid-50ppm. However lower values were recorded in treatment T_7-Water spray. Similar trend of observation observed by Patel *et al.* (2008) [9], Jagadeshwari *et al*. (2004) [5].

Table 1: Effect of growth regulators, seaweed extract and potassium nitrate on growth and growth attribute of soybean as influenced by different treatments

Treatment details	Plant height (cm)	Number of functional leaves	Leaf area (dm^2)	Number of branches	Dry matter (g)
T_1- Salicylic Acid-50 ppm	43.22	21.97	8.27	5.40	14.40
T_2 - GA_3-100 ppm	47.28	22.86	9.02	5.98	15.40
T_3 - Nitrobenzene-400 ppm	38.23	19.81	7.08	4.93	12.60
T_4 - NAA- 20 ppm	37.20	16.13	6.41	4.71	12.40
T_5 - Seaweed extract-20%	49.90	23.57	9.60	6.18	16.73
T_6 - KNO_3- 2%	41.56	13.74	5.86	3.22	11.05
T_7 - Water spray	32.02	13.28	5.48	3.16	9.40
S.E.(m) ±	2.20	1.07	0.44	0.37	0.84
C.D. at 5%	6.79	3.31	1.36	1.13	2.61
General mean	41.34	18.77	7.39	4.80	13.24

3.2 Effect of growth regulators, seaweed extract and potassium nitrate on yield and yield attributes of soybean.

The foliar application of different growth regulators, seaweed extract and potassium nitrate showed variation on yield characteristics of soybean such as number of pods $plant^{-1}$, Number of seeds $plant^{-1}$, Seed yield $plant^{-1}$ (g), Seed index (g) (Weight of 100 seeds),, Seed yield kg ha^1, Straw yield kg ha^{-1}, Harvest index %. Among all the treatments application of T_5-seaweed extract-20% increased all the yield parameters except harvest index and being significantly better (Table 2). The highest number of pods $plant^{-1}$ (32.97), Number of seeds $plant^{-1}$ (72.83), Seed yield $plant^{-1}$ (6.57 g), Seed index (9.62 g) Seed yield (2307 kg ha^1), Straw yield (3055 kg ha^{-1}) were observed at seaweed extract@400ppm which was significantly higher over all the treatments but highest harvest index (43.28%) was observed in T_2- GA_3-100ppm., and at par with treatment T_2-GA_3-100ppm and T_1- Salicylic acid-50ppm. However lower values were recorded in treatment T_7-Water spray. Similar trend of observation observed by by Kavitha *et al*. (2008) [6]. Agwane and Parhe (2015) [1], Kumar *et al*. (2018) [12].

Table 2: Effect of growth regulators, seaweed extract and potassium nitrate on yield and yield attributes of soybean as influenced by different treatments

Tr. No	Treatments	No. of pods plant^{-1}	No. of seeds plant^{-1}	Seed yield plant^{-1} (g)	Seed index (g)	Seed yield kg ha^{-1}	Straw yield kg ha^{-1}	Harvest index %
T_1	Salicylic Acid-50 ppm	29.09	68.50	5.70	8.90	2014	2877	42.03
T_2	GA_3-100 ppm	30.29	70.90	6.20	9.39	2246	2943	43.28
T_3	Nitrobenzene-400 ppm	27.05	63.30	5.12	8.37	1909	2661	41.78
T_4	NAA-20 ppm	26.24	60.04	4.83	8.02	1821	2520	41.95
T_5	Seaweed extract-400ppm	32.97	72.83	6.57	9.62	2307	3055	43.02
T_6	KNO_3-2%	25.41	58.16	4.59	7.98	1722	2455	41.22
T_7	Water spray	24.00	49.90	3.17	7.05	1509	2235	40.30
S.E.(m) ±		1.61	2.94	0.37	0.50	111.91	155.63	-
C.D. at 5%		4.96	9.07	1.14	NS	344.03	479.52	-
General mean		27.86	63.38	5.17	8.44	1932.57	2678	42.04

3.3 Effect of growth regulators, seaweed extract and potassium nitrate on quality parameters of soybean

The foliar application of different growth regulators, seaweed extract and potassium nitrate showed variation on quality parameters of soybean such as oil content (%), Oil yield (kg ha^{-1}), Protein content (%) and Protein yield (kg ha^{-1}).

The oil content (%) was not influenced significantly with the application of different treatments (Table 3). While, mean oil yield (373.05 kg ha^{-1}) was found to be statistically significant with the application of different treatments. Treatment T_5- Seaweed extract-20% produced the highest value of oil content (19.96%) whereas, it also recorded significantly higher oil yield (460.40 kg ha^{-1}). Application of seaweed extract helped in increasing mean oil yield (kg ha^{-1}). Rathore *et al.* (2009) also recorded similar kind of results.

The effect of different treatments on protein content (%) was found to be non-significant, whereas, mean protein yield (kg ha^{-1}) was found to be statistically significant (Table 3). Treatment T_5- Seaweed extract-20% recorded higher protein content (39.98%) and protein yield (910.00 kg ha^{-1}). Similar results were reported by Renuka Bai *et al.* (2007) [11].

Table 3: Oil content (%), oil yield (kg ha^{-1}) and protein content (%), protein yield (kg ha^{-1}) as influenced by various treatments

Sr. No.	Treatments	Oil content (%)	Oil yield (kg ha^{-1})	Protein Content (%)	Protein yield (kg ha^{-1})
T_1	Salicylic Acid-50 ppm	19.71	396.95	38.66	773.33
T_2	GA_3-100 ppm	19.83	445.38	39.89	890.30
T_3	Nitrobenzene-400 ppm	19.60	364.14	38.60	716.67
T_4	NAA-20 ppm	19.67	349.94	38.49	680.33
T_5	Seaweed extract-400ppm	19.96	460.40	39.98	910.00
T_6	KNO_3 -2%	19.35	320.01	38.40	653.33
T_7	Water spray	19.02	279.57	38.26	560.25
S.E.(m) ±		0.30	32.93	0.52	60.03
C.D at 5%		NS	101.47	NS	184.96
General mean		19.59	373.77	38.89	740.60

4. Conclusion

The foliar application of growth regulators, seaweed extract and potassium nitrate at flowering and pod developing stage performed well growth, yield and quality parameters of soybean as compared to water spray but application of seaweed extract-20% at flowering and pod developing stage increase growth, yield and quality parameters 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% at flowering and pod developing stage would be promising practice for soybean growth, yield and quality parameters.

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