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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

Kalambe JD
Department of Agronomy, College of Agriculture, VNMKV. Parbhani, Maharashtra, India

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

Effect of plant growth regulators on growth yield attributes and yield of soybean (*Glycine max* (L.) Merrill)

Jawale SS, Mirza IAB, Pawar AD and Kalambe JD

Abstract
The field investigation entitled "Effect of plant growth regulators on growth, yield attributes 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 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 growth attributes such as plant height (cm), more number of functional leaves, higher leaf area (dm^2), higher number of branches, higher dry matter accumulation (g), also yield and yield attributes such as weight of seed plant^{-1}, number of pod plant^{-1}, number of seeds plant^{-1}, seed index (g), seed yield kg ha^{-1}, straw yield kg ha^{-1}, harvest index % and 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, yield attributes, yield

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 Marathwada the area under soybean was 17.40 lakh ha with production 18.22 lakh million tonnes and productivity was 1034 kg ha^{-1} (Anonymous 2018) [1].
Plant Growth Regulators (promoters, inhibitors or retardants) play major role in changing internal mechanism of plant growth by interacting with key metabolic processes such as nucleic acid metabolism and protein synthesis. Growth retardants are known to reduce internodal distance thereby enhancing source-sink relationship and stimulate the translocation of photosynthates to the seeds. Plant growth regulators (PGRs) are organic compounds also called biostimulants or bioinhibitors, act inside plant cells to stimulate or inhibit specific enzyme or enzymes systems and help regulate plant metabolism. They are normally active at very low concentrations in plants. When produced endogenously by plants, they are often referred to as phytohormones (plant hormones). Plant hormones have been viewed as chemical messengers regulating the normal progress of developmental changes as well as responses to environmental signals.
Plant growth regulators are known to enhance the source - sink relationship and stimulate the translocation of photosynthates thereby helping in effective flower formation, pods and seed development and ultimately enhance the productivity of the crop. Growth regulator improves the physiological efficiency including photosynthetic ability and can enhance the effective partioning of accumulates from source and sink in the field crops (Solaimalai *et al*., 2001) [11].
Seaweed extract is a new generation of natural organic fertilizers containing highly effective nutrition's and promotes faster germination of seeds and increase yield and resistant ability of many crops. Unlike, chemical fertilizers, extracts derived from seaweeds are biodegradable, non- toxic, nonpolluting and non-hazardous to humans, animals and birds. Jensen (1993) [3] and Noda (1993) [6] observed that seaweed is rich in mineral elements contain *viz*., calcium, magnesium, potassium, chlorine, sulphur, phosphorous, iodine, zinc, copper. Liquid fertilizers derived from natural sources like seaweeds are found to be viable alternatives to fertilizing input for agricultural crops due to its high level of organic matter, micro and macro elements, fatty acids, also rich in growth regulators. Brassinosteroids (BRs) are a class of polyhydroxysteroids that have been recognized as a sixth class of plant hormones.

These brassinosteroids were first explored during the 70s, when Mitchell *et al*. (1970) [5] reported promotion in stem elongation and cell division by the treatment of organic extracts of rapeseed (*Brassica napus*) pollen. Brassinolide was the first isolated brassinosteroid in 1979, when pollen from from *Brassica napus* was shown to promote stem elongation and cell divisions, and the biologically active molecule was isolated.

Brassinosteroids (BRs) are integrated in a complex signaling network and numerous brassinosteroids effects appear to be mediated via a modulation of levels and sensitivities of other phytohormones. Brassinosteroids activity was demonstrated in almost all auxin assays Yopp *et al*., (1981) [14]. The growth promoting effect of brassinosteroids results primarily from the stimulation of cell elongation. Several genes encoding cell wall-modifying enzymes such as xyloglucan endotransglycosylases are regulated after application of synthetic brassinosteroids (Koka *et al*., 2000) [4].

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 medium deep black and well drained. The experimental site is under subtropical climatic condition.

2.2 Experimental treatments

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.

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 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.

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 are applied in two sprayings as foliar spray, 1st spraying at 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) [7].

3. Results and Discussion

3.1 Effect of plant growth regulators on growth of soybean

Foliar application of different growth regulators and seaweed extract 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_3- seaweed extract (20%) + organic plant extract (80%) to soybean crop at flowering and pod developing stage showed better result with respect to plant height (50.43cm), number of functional leaves (23.26), leaf area (8.85 dm^2), number of branches (6.81), mean dry matter accumulation (15.75 g) 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 Rathod *et al.* (2009) [10], Thirumaran *et al*. (2009) [13], Ramesh and Ramprasad (2013) [9], Ramrajan *et al.* (2012) [8].

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

Tr. No.	Treatment details	Plant height (cm)	Number of functional leaves	Leaf area (dm^2)	Number of branches	Dry matter (g)
T_1	seaweed extract	43.14	20.22	7.96	5.86	14.12
T_2	organic plant extract	48.13	22.80	8.41	6.51	15.22
T_3	Seaweed extract (20%) + organic plant extract (80%)	50.43	23.26	8.85	6.81	15.75
T_4	brassinosteroides (0.01%) + organic plant extract	47.16	21.55	8.03	5.93	14.47
T_5	NATCA-5%	39.83	19.47	7.45	6.35	13.53
T_6	brassinosteroides-0.01%	37.28	18.93	6.56	6.16	13.02
T_7	amino acid-2%	41.43	18.88	7.87	5.93	14.00
T_8	nitrobenzene-400ppm	37.10	20.91	5.64	6.32	12.90
T_9	water spray	36.53	16.04	5.2	5.02	11.74
S.E.(m) ±		1.81	0.82	0.29	0.31	0.58
C.D. at 5%		5.45	2.47	0.88	0.94	1.75
General mean		42.34	20.23	7.33	6.10	13.86

3.2 Effect of plant growth regulators on yield and yield attributes of soybean: The foliar application of different growth regulators and seaweed extract 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_3 - seaweed extract (20%) + organic plant extract (80%) increased all the yield parameters and being significantly better (Table 2). The highest number of pods $plant^{-1}$ (37.05), Number of seeds $plant^{-1}$ (92.62), Seed yield $plant^{-1}$ (6.63 g), Seed index (9.76 g) 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) [12].

Table 2: Effect of plant growth regulators on yield and yield attributes of soybean as influenced by different treatments

Tr. No.	Treatments	Seed yield plant^{-1} (g)	No. of pod plant^{-1}	No. of seeds plant^{-1}	Seed index (g)	Seed yield kg ha^{-1}	Straw yield kg ha^{-1}	Harvest index %
T_1	seaweed extract	5.90	32.49	77.32	8.62	2180	2886	43.03
T_2	organic plant extract	6.52	35.34	85.87	9.48	2410	3097	43.76
T_3	Seaweed extract (20%) + organic plant extract (80%)	6.63	37.05	92.62	9.76	2465	3159	43.82
T_4	brassinosteroides (0.01%) + organic plant extract	6.09	34.16	79.59	8.94	2230	2945	43.08
T_5	NATCA-5%	5.74	30.02	68.44	8.25	2060	2885	41.66
T_6	brassinosteroides-0.01%	5.90	32.26	74.18	7.91	2177	2963	42.35
T_7	amino acid-2%	5.86	31.13	69.07	8.15	2082	2899	41.79
T_8	nitrobenzene-400ppm	5.72	29.35	63.98	8.31	2050	2820	42.09
T_9	water spray	5.19	25.53	51.31	6.92	1798	2600	40.88
SE(m) ±		0.25	1.42	2.72	0.56	80.85	91.32	--
C.D. at 5%		0.76	4.27	8.21	NS	243.38	274.92	--
General mean		5.95	31.93	73.59	8.48	2161	2917	42.55

Conclusion

The foliar application of growth regulators and seaweed extract at flowering and pod developing stage performed well growth, yield and yield attributes of soybean as compared to water spray but application of seaweed extract (20%) + organic plant extract (80%) at flowering and pod developing stage increase growth, yield and yield attributes 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 growth, yield and yield attributes.

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