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Effect of plant growth regulators on morphological and physiological parameters in soybean (*Glycine max* (L.) Merrill.)

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Abstract
The growth regulating substances *viz.*,Indol Acetic Acid (IAA at 100 ppm, 150 ppm and 200 ppm, 250 ppm), Gibberlic acid (GA_3 at 100 ppm, 150 ppm ,200 ppm and 250ppm). Concentrations were applied as foliar spray 30 DAS. Application of IAA and GA_3 increases the plant height as compared to control. No. of leaves, Leaf area, Leaf dry weight, Stem dry weight and Total dry weight are increased due to application of IAA and GA_3 over control but IAA at 100 ppm and GA_3 150ppm is most significantly effective than all rest of treatments.

Keywords: growth, morphological, physiological, PPM, soybean etc.

Introduction
Soybean (*Glycine max* (L.) Merrill) belongs to genus *Glycine* which is a member of the family leguminaceae, from subfamily papillionaceae, and the tribe phaseoleace. It is one of the most important protein and oilseed crops throughout the world. Its oil is the largest component of the world's edible oils. It is native of China and was introduced to India in 1968 (Bragg cv.) from USA. It has emerged as one of the important commercial crop in many countries. Soybean is also known as the "Golden bean" or "Miracle crop" because of its multiple uses. Soybean seed contains 18-20 per cent oil, 40 per cent protein, 29 per cent carbohydrates, 4 per cent saponins and 5 per cent fiber.

At present, soybean occupies an area of 103.29 m ha in the world with a production of 251.47 m tons and productivity of 2430 kg per ha, as per the Department of Agriculture and Co-operation (DAC) estimates in the year 2014-2015.

Soybean is produced primarily for oil and secondarily for protein in western countries. Among the various pulses, soybean is recognized as an excellent source of high quality protein and oil. Soybean also contains superior quality (high linoleic acid) oil which can be processed to yield high value industrial products like lecithin, paints etc. protein is the only vegetable protein which resembles milk properties.

Beside nutrients, plant hormones (Auxins) are organic substances, which promote growth along the longitudinal axis, when applied in low concentration to shoot of plant. IAA is only naturally occurring in the plant. All these chemical activities are same as Auxins have common structural features in their molecules. Plant hormones play a pivotal role in regulation of growth and development (Davies, 2004) [2]. Indole Acetic Acid (IAA) is the most abundant naturally occurring plant hormone well known for its regulating function in the plant growth and development. IAA is a type of Auxin that stimulates growth through cell elongation and lateral root formation which support more absorption of minerals.

Investigation on gibberellins have been extended to several important phenomenon in plant life such as elongation of stem, expansion of leaves, production of dry matter, elimination of dwarfism, root growth, breaking of seed dormancy ,cell division and several metabolic processes.

Material and Methods
The experiment was conducted on field of Department of Agricultural Botany, College of Agriculture Parbhani, during *kharif* season of 2015. The soil was medium black with moderate moisture retention capacity. The land having uniform topography was used to study the effect of growth regulators IAA and GA_3 on morphological and physiological parameters in soybean (*Glycine max* (L.) Merrill.).The experiment was laid out in randomized block design with three replications and Nine (09) treatments. Concentrations of PGR are at 100, 150, 200 and 250 ppm of Bothe IAA and GA_3sprayed at 30 DAS and observations are to be recorded on 30, 45, 60, and at harvest.

T1:100ppmGA_3, T2:150ppmGA3,
T3:200ppmGA3, T4:250ppmGA3,
T5:100ppmIAA, T6:150ppmIAA,
T7:200ppm IAA, T8:250ppm IAA
T9: Control.

Result and Discussion

Morphological characters

The application of GA_3 and IAA by spraying on soybean showed significant effect on various growth and yield contributing characters. Evidences are accumulated in recent year to qualify Gibber elic acid (GA_3) and Indole acetic acid (IAA) as among those growth regulators influencing plant growth and development, (Mohammed, 2003) [6]. The exogenous application of GA_3 and IAA to shoot portion of soybean, oat, beans, wheat, pulses, vegetables etc. accelerates growth and development i.e. yield contributing characters. The Gibberelic acid (GA_3) was comparatively more effective than IAA to influencing the grain yield of soybean (Anu Rastogi *et al.*, 2013) [1].

In present investigation, spraying of growth regulators *viz.*, GA_3 at 100, 150, 200 and 250 ppm, IAA at 100, 150, 200and 250 ppm respectively were undertaken as per treatments on soybean plant (var. MAUS 162). The spraying of these substances was done at 30 days after sowing. Therefore, effects on growth were seen only after 30, 45 and 60 DAS and then reported.

In general, GA_3 at 150ppm and IAA at 100ppm exhibited increase in most of the growth parameters and yield such as height of plant, number of functional leaves, leaf area, leaf dry weight, stem dry weight, total dry weight, initial and 50 per cent flowering, AGR, RGR, NAR, LAI, CGR, number of pods per plant, number of seeds per pod, weight of straw per plant, seed yield. The growth regulators also have differential primitive effect on height of plant and morphological characters (Mervat,. 2013) [9]. The differences were observable right from initial stages of growth. In comparison between all growth substances, it was noted that the GA_3 was more effective than IAA. The significantly highest height (Table 1) was observed at IAA 100 ppm followed by IAA 150 ppm, GA_3 150 ppmand GA_3 100 ppm, Kumar (1992) [4, 5].

All concentration of GA_3 and IAA increased significantly higher height than control. The positive effect of growth substances on plant height were observed by several workers by Mehtre and Lad (1995) [8], and Galal(2012) [3] in soybean.

All growth regulators produced significantly higher number of leaves (Table 2) as compared to control at all growth stages of crop except 30 DAS. GA_3 150 ppm maintained its significance in more number of leaves throughout the growth periods over rest of the treatments. The significantly superiority of growth regulators treatments on number of branches (Table 3) were observed by Nimbalkar and Gujar (2000) [10] in soybean.

Similar trend in respect of leaf area (Table 4) was maintained by all the growth substances. The significantly higher number of functional leaves and leaf area above growth stages are of the prominent effect of GA_3 150 ppm concentration. It increased leaf area and functional leaves of plant might have contributed for increase in photosynthetic capacity of plant. The similar findings were observed and supported by Kothule *et al*. (2003) [6], in soybean.

Physiological parameters

There was more accumulation of dry matter in plant by the treatment of GA_3, and IAA, but GA_3 150 ppm exhibited increase significantly superior dry weight of leaf **(**Table 5), stem (Table 6) and total dry weight (Table 7) in soybean. This trend of total dry matter accumulation was maintained till harvest. These substances result in significantly higher dry weight of various plant growth components. The dry weight of stem and leaves were significantly higher at most of the stages. GA_3 150 ppm always had prominent effect in this respect followed by IAA 100 ppm, IAA 150 ppm, and GA_3 100 ppm (Madrap *et al.*, 1992) [7].

Significantly higher dry matter accumulation coupled with higher partitioning ratio towards the reproductive parts had given significantly higher grain yield. Such results were also obtained by Rahman *et al.* (2004) [11] in soybean.

Although the earlier formation of initial and 50 per cent flowering was advanced by the effect of GA_3 150 ppm and IAA 100 ppm,in soybean crops. GA_3 150 ppm showed significantly initial and 50 per cent flowering (Table 8) followed by IAA 100 ppm. This showed that there was overall enhancement in reproductive growth due to the application of these substances. Such results were also obtained in soybean by Sharma and Shah (1979) [12] and Mehetre and Lad (1995) [8]

Table 1: Mean plant height (cm) at various stages of crop growth in soybean.

Tr. No	Treatments	Days after sowing			
		30	45	60	At harvest
T_1	GA_3 100 ppm	13.46	29.13	42.28	55.46
T_2	GA_3 150 ppm	12.40	33.06	45.76	57.00
T_3	GA_3 200 ppm	13.86	27.20	39.06	56.46
T_4	GA_3 250 ppm	13.53	25.06	39.06	50.86
T_5	IAA 100 ppm	12.23	34.63	50.66	60.96
T_6	IAA 150 ppm	13.56	34.13	49.86	58.46
T_7	IAA 200 ppm	13.46	31.70	48.86	58.20
T_8	IAA 250 ppm	13.53	29.13	42.28	54.86
T_9	Control	13.60	23.13	37.66	49.13
	SE ±	1.25	2.12	1.96	2.06
	CD at 5%	NS	6.36	5.87	6.18

Table 2: Mean number of functional leaves per plant

Tr. No	Treatments	Days after sowing		
		30	45	60
T_1	GA_3 100 ppm	4.53	6.20	14.80
T_2	GA_3 150 ppm	4.81	6.86	15.13
T_3	GA_3 200 ppm	4.20	6.13	13.80
T_4	GA_3 250 ppm	4.80	5.86	13.60
T_5	IAA 100 ppm	4.00	6.53	14.86
T_6	IAA 150 ppm	4.60	6.43	12.93
T_7	IAA 200 ppm	4.80	5.93	11.73
T_8	IAA 250 ppm	4.43	5.86	12.46
T_9	Control	4.35	5.86	10.46
	SE ±	0.258	0.312	0.483
	CD at 5%	NS	0.930	1.448

Table 3: Mean number of branches per plant in soybean

Tr. No	Treatments	Days after sowing		
		30	45	60
T_1	GA_3 100 ppm	2.23	3.59	6.38
T_2	GA_3 150 ppm	2.81	3.65	6.81
T_3	GA_3 200 ppm	2.27	.3.39	6.30
T_4	GA_3 250 ppm	2.12	3.31	6.10
T_5	IAA 100 ppm	2.10	3.68	6.58
T_6	IAA 150 ppm	2.22	3.57	6.33
T_7	IAA 200 ppm	2.22	3.41	6.08
T_8	IAA 250 ppm	2.22	3.35	6.03
T_9	Control	2.16	3.15	5.99
	SE ±	0.072	0.148	0.120
	CD at 5%	NS	0.44	0.36

Table 4: Mean leaf area per plant (m^2).

Tr. No	Treatments	Days after sowing		
		30	45	60
T_1	GA_3 100 ppm	17.26	35.12	48.24
T_2	GA_3 150 ppm	17.40	37.14	53.37
T_3	GA_3 200 ppm	17.46	34.64	47.72
T_4	GA_3 250 ppm	17.22	32.93	45.94
T_5	IAA 100 ppm	16.96	35.49	48.84
T_6	IAA 150 ppm	17.28	34.59	48.80
T_7	IAA 200 ppm	16.62	34.49	47.74
T_8	IAA 250 ppm	15.99	32.81	45.70
T_9	Control	15.99	31.94	44.37
	SE ±	0.441	0.651	1.032
	CD at 5%	NS	1.949	3.091

Table 5: Mean leaf dry weight per plant (g)

Tr. No	Treatments	Days after sowing		
		30	45	60
T_1	GA_3 100 ppm	1.97	3.00	6.63
T_2	GA_3 150 ppm	2.03	3.60	6.85
T_3	GA_3 200 ppm	1.23	3.22	5.83
T_4	GA_3 250 ppm	1.96	2.32	5.72
T_5	IAA 100 ppm	1.92	3.16	6.74
T_6	IAA 150 ppm	1.78	2.66	6.53
T_7	IAA 200 ppm	1.76	2.41	6.23
T_8	IAA 250 ppm	1.66	2.32	4.98
T_9	Control	1.68	2.05	4.76
	SE ±	0.099	0.11	0.19
	CD at 5%	NS	0.34	0.58

Table 6: Mean dry weight of stem per plant (g)

Tr. No	Treatments	Days After Sowing		
		30	45	60
T_1	GA_3 100 ppm	1.71	2.67	5.16
T_2	GA_3 150 ppm	1.32	3.04	5.26
T_3	GA_3 200 ppm	1.13	2.58	4.51
T_4	GA_3 250 ppm	1.70	2.34	4.06
T_5	IAA 100 ppm	1.36	2.81	5.25
T_6	IAA 150 ppm	1.17	2.61	4.97
T_7	IAA 200 ppm	1.29	2.58	4.74
T_8	IAA 250 ppm	1.33	2.54	4.20
T_9	Control	1.28	2.31	3.56
	SE ±	0.09	0.11	0.25
	CD at 5%	NS	0.33	0.74

Table 7: Mean total dry weight per plant (g)

Tr. No	Treatments	Days after sowing		
		30	45	60
T_1	GA_3 100 ppm	3.15	4.82	12.34
T_2	GA_3 150 ppm	3.08	5.21	12.56
T_3	GA_3 200 ppm	2.88	4.65	11.74
T_4	GA_3 250 ppm	2.64	4.59	11.31
T_5	IAA 100 ppm	3.51	5.11	12.39
T_6	IAA 150 ppm	3.03	4.81	12.16
T_7	IAA 200 ppm	2.99	4.52	11.49
T_8	IAA 250 ppm	2.28	4.36	10.58
T_9	Control	2.99	4.06	08.96
	SE ±	0.29	0.27	0.49
	CD at 5%	NS	0.81	1.46

Table 8: Mean number of days for initial flowering and 50% flowering.

Tr. No	Treatments	Days to flowering	
		Initiation	50%
T_1	GA_3 100 ppm	39.33	41.33
T_2	GA_3 150 ppm	38.33	40.33
T_3	GA_3 200 ppm	40.66	42.66
T_4	GA_3 250 ppm	41.00	41.00
T_5	IAA 100 ppm	39.00	41.12
T_6	IAA 150 ppm	39.20	43.22
T_7	IAA 200 ppm	41.00	43.00
T_8	IAA 250 ppm	42.00	43.12
T_9	Control	44.00	45.89
	SE ±	0.51	0.63
	CD at 5%	0.53	1.89

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