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Effect of Growth Hormones on Morphological Parameters, Yield and Quality of Soybean (*Glycine max* L.) During Changing Scenario of Climate Under Mid Hill Conditions of Uttarakhand

R. G. Upadhyay* and Rajeev Ranjan*

ABSTRACT: *Growth hormones are effective in several crops and found to balance the source and sink relationship, leading to increase in the yield of crops. Exogenous application of growth regulators is one approach to improve crop productivity. The plant normally produces large number of flowers but most of them abscise and fruit setting is controlled by many factors. So the use of growth hormones proved better to increase the yield. The present study has been under taken to see the effect of growth hormones on growth, biochemical constituents, yield and quality of Soybean under mid hill conditions of Uttarakhand during* kharif *season. The pot experiment was laid out in Complete Randomized Design with three replication. The experimental variable consisted of ten treatments having one main crop of Soybean as control (T_1-control, T_2-NAA-10 ppm, T_3-NAA-20 ppm, T_4-NAA-30 ppm, T_5-G.A.$_3$-10 ppm, T_6-G.A$_3$-20 ppm, T_7-G.A$_3$-30 ppm, T_8-Kinetin-10ppm, T_9-Kinetin-20 ppm, T_{10}-Kinetin-30 ppm. The pot soil in the ratio of 20:40:40 was fertilized with nutrients like N: P: K. The variety Harit Soya (*Glycine max L.) *was used in this experiment. The plant was sprayed with different concentrations of growth hormones about one week earlier to bud initiation. The second spraying was done at the stage of 50 percent flowering. The observations on progressive growth parameters like plant height (cm), number of leaves/plant, leaf area (cm^2/plant), R.G.R, C.G.R and N.A.R were recorded at regular interval after first spraying of growth hormones. The number of flowers/plant were counted after 5 days of first and second spray of growth regulators. All growth hormones tested enhanced the yield by retaining flowers better than control but application of NAA-20 ppm was superior than GA$_3$ and Kinetin. The significantly highest plant height (cm), leaf area (cm^2/plant), number of leaves/plant, R.G.R, C.G.R and N.A.R were recorded in NAA-20 ppm and lowest in control. The flowering pattern were influenced by application of various concentration of NAA, GA$_3$ and Kinetin. The significantly highest NR activity were recorded in all the treatment of NAA followed by GA$_3$ and Kinetin. The significantly maximum Chlorophyll content were observed in Kinetin 20 ppm followed by NAA and GA$_3$. The significantly highest Protein content were recorded in all the treatment of NAA followed by GA$_3$ and Kinetin. The significantly highest grain yield (g/plant) recorded in NAA-20 ppm and 30 ppm followed by all the concentration of GA$_3$and Kinetin.*

INTRODUCTION

Soybean (*Glycine max* L.) is the leading oil seed crop of the world in terms of both area and production. In the recent years, soybean has become an important crop in India since it yields oil, protein and other industrial products yielding crop. Growth hormones are reported to have an effect on morphological parameters of soybean (Senthil, 2003). Yield potential of pulses are greatly affected by non-leaf synchronous habit, flower drop, nodule disintegration at the time of flowering, heavy senescence at the time of pod development, excessive vegetative growth in response to excessive irrigation and less fruit setting in lower branches of the plant (Sinha, 1974; Chaturvedi *et al*., 1980). Growth regulators are effective in several crops and found to balance the source and sink relationship, leading to increase in the yield of crops (Cheema *et al*., 1987). Plant growth hormones are found to enhance growth and physiological activity of the plant (Reena *et al*., 1998).

Exogenous application of growth hormones is one approach to improve crop productivity (Pando and Srivastava, 1985). Plant growth hormones play an important role in circumventing limitation to improve production. According to Basole *et al*., (2003) the yield of soybean can be enhanced through physiological growth manipulation by way of foliar application of growth regulators like NAA and nutrients like KNO_3, $ZnSO_4$. The foliar application of nutrients and hormones

* VCSG Uttarakhand University of Horticulture & Forestry, Ranichauri-249199, Tehri Garhwal, (Uttarakhand)

to certain extent can help in making available the required nutrients to crop for optimum growth and productivity under adverse conditions of soil. The pulse and oil seed crop yields are very poor and this discourages the wide cultivation of it. The plant normally produces large number of flowers but most of them abscise and fruit setting i controlled by many factors. So the use of growth regulators proved better to increase the yield. In the present experiment the effect of growth hormones NAA, GA, and Kinetin was investigated on morphological parameters, biochemical constituents, yield and quality of soybean crop.

MATERIAL AND METHODS

Pot experiment was conducted in the College of Forestry, Uttarakhand University of horticulture and Forestry, Ranichauri campus, Tehri Garhwal (Uttarakhand) during Kharif, 2012-13 and 2013-14 to assess the effect of foliar application of growth hormones (NAA, GA3 and Kinetin) on morphological parameters, yield and quality of soybean in completely randomized block design (CRBD) with three replications and ten treatments comprised of three concentrations (10, 20 and 30 ppm) of NAA (Naphthalene Acid Acetic), G.A_3 (Gibbrelic Acid) and Kinetin and control. The seeds of soybean (c.v. Harit Soya) were sown in 30 pots and these were used to record the morphological observations at 15 days interval *i.e.* 45, 60, 75, 90 days after sowing (DAS) and at harvest. The growth hormones were sprayed at bud initiation and 50 per cent flowering stage of crop. T_1 - Control, T_2 - NAA @ 10 ppm, T_3 - NAA @ 20 ppm, T_4 - NAA @ 30 ppm, T_5 – GA_3 @ 10 ppm, T_6 – GA_3 @ 20 ppm, T_7 – GA_3 @ 30 ppm, T_8 -Kinetin@ 10ppm, T_9 - Kinetin @ 20 ppm, T_{10} - Kinetin@ 30 ppm.

RESULTS AND DISCUSSION

Significant increase in plant height was observed with the application of growth hormones at all stages of crop (Table 1). At 45 DAS there was slow increase in plant height with the treatments of various growth hormones. Thereafter a tremendous increase in plant height was noticed till 90 DAS. Among all the treatments NAA with 20 ppm (T_3) concentration showed maximum plant height followed by NAA @ 10ppm (T_2) and 30 ppm (T_4)and, GA_3 - 20 ppm (T_6), 10 ppm (T_5) and 30 ppm (T_7) and Kinetin - 20 ppm (T_9), 10 ppm (T_8) and 30 ppm (T_{10}) treatments respectively at all the developmental stages. While lowest plant height was obtained in control at all the developmental stages. All the treatments increased the plant height significantly higher than that of control. This implies that linearity of the plant is directly related to the endogenous level of auxin concentration. Similar results were obtained by Singh and Saxena (1972) who reported, greater plant height at lower concentrations of NAA, while at higher concentrations height decreased due to reduction in membrane permeability. It is evident from the data in Table.1 that all treatments were effective to increase number of leaves per plant over control. Treatment of 20 ppm (T_3) of NAA was found significantly superior over all the treatments and control during 45, 60, 75, 90 DAS & at harvest. Number of leaves per plant increased with time in all the treated plants till 75 DAS. Slow increase in number of leaves per plant by the application of treatments was observed at 45 DAS. With respect to increase in number of leaves per plant, highest number of leaves per plant was obtained in NAA treatments followed by GA_3 and kinetin treatments. Increase in number of leaves per plant might be due to the reason that growth hormones might have contributed to enhanced source-sink relationship. Deotale et al., 1998, support our results. Number of branches per plant were also influenced with the treatments at three stages of development *i.e.* bud initiation (40 DAS), flowering (60 DAS) and maturity stage (90 DAS) (Fig. 1). No marked increase in number of branches per plant was obtained with the application of growth hormones at bud initiation stage (45 DAS). It is revealed from the figure that highest number of branches per plant was observed in treatment of NAA with 20 ppm concentration (T_3) and lowest in control (T_1). All the treatments were significantly higher than that of control (T_1). In respect of increase in number of branches per plant, highest number was obtained in NAA - 20 ppm (T_3), 10 ppm (T_2) and 30 ppm (T_4) treatments followed by GA_3 - 20 ppm (T_6), 10 ppm (T_5) and 30 ppm (T_7) and Kinetin - 20ppm (T_9), 10 ppm (T_8) and 30 ppm (T_{10}) treatments, respectively. Table 2 shows that early flowering was achieved by the application of growth hormones. Treatment 20 ppm (T_3) of NAA hastened the flowering effectively as compared to other treatments followed by 10 (T_2) and 30 ppm (T_4) of NAA. These NAA treatments were in turn followed by GA_3 - 20 (T_6), 10 (T_5) and 30 ppm (T_7) and Kinetin- 20 (T_9), 10 (T_8) and 30 ppm (T_{10}). Maximum days to 50 and 100 per cent flowering were observed in control. Upadhyay, (2002) observed the same findings with the application of NAA @ 20 ppm which showed significant early flowering over control. Earliness of flowering is desirable feature to escape lower temperature at the time of maximum flowering. Application of NAA

induced earliness in different crops as reported by Warade and Singh (1977). The results are supported by Leport *et al* (1999) who suggested that early flowering would benefit yield if flowers were fertile, leading to early pod development and seed filling and thus, avoiding terminal soil moisture stress as in the case of chilling tolerant genotypes.

It is revealed from the Table 2, that number of flowers at 50 and 100 per cent flowering increased significantly by the application of growth hormones as compared to control. Highest numbers of flowers (45.0 and 80.6) were observed in pots treated with NAA – 20 ppm (T_3) at 50 and 100 per cent flowering, respectively, while lowest numbers of flowers (30.0 and 50.8) were obtained with control at 50 and 100 per cent flowering respectively. With respect to increase in number of flowers per plant, highest numbers were obtained in NAA treatments followed by GA_3 and kinetin treatments. Prakasa and Narayanan (1997) have reported similar findings. They found that the foliar application of NAA (20 ppm) had significantly increased the total number of flowers formed per plant (75%) as compared to unsprayed plants.

Number of shed flowers at 100 per cent flowering were minimum in pots treated with NAA -20 ppm followed by 10 ppm of NAA (Table 2). Number of shed flowers were same in treatments NAA with 30 ppm concentration and GA_3 with 30 ppm concentration. Maximum flowers shedding were observed in control. Similar results were recorded by Upadhyay, 1994 that NAA prevents flower drop by preventing the formation of the abscission layer. Effectiveness of NAA to check the flower drop may be due to creation of favourable balance of endogenous hormone relative to flowering which inhibits abscission accelerating enzymes like cellulases, succinic dehdrogenases, RNA ase, Malic dehydrogenases etc, Auxin induced nucleic acid synthesis to create better reproductive structure (Moore, 1980 and Addicot, 1977; Raskin ,1984; Troare M and C.Sullivan,1990). It was observed that all treatments were found effective to influence significantly variation in plant height (cm), leaf area (cm^2/plant), number of leaves/plant, number of flowers /plant, days to flowering, yield and yield attributes in all the treatments (Naeem et.al.2004). The R.G.R, C.G.R and N.A.R were also influenced by the application of growth hormones. The maximum R.G.R, C.G.R and N.A.R were observed in all the concentrations of NAA followed by GA_3 and Kinetin at various growth stages The significantly highest grain yield (g/plant) recorded in NAA-20 ppm was amongst all the concentrations of GA_3 and Kinetin. Significantly maximum number of pods/plant and test weight, biological yield and harvest index were recorded in all the concentrations of NAA followed by GA_3 and Kinetin. (Aktar *et.al.,* 2007; Ayala-Silva, *et.al.,* 2005; Bora and Sharma, 2006; Copur, *et al.,* 2010).

The significantly highest NR activity were recorded in all the treatment of NAA followed by GA_3 and Kinetin. The significantly maximum Chlorophyll content were observed in Kinetin 20 ppm followed by NAA and GA_3.The significantly highest Protein content were recorded in all the treatment of NAA followed by GA_3 and Kinetinanullah. (Faizanullah *et.al.,* 2010; Gulluoglu, 2004; Hussian *et. al.,* 2010; Jong *et.al.,* 2009). The significantly highest grain yield (g/plant) recorded in NAA-20 ppm and 30 ppm followed by all the concentration of GA_3 and kinetin.

Table 1
Effect of growth hormones on plant height (cm) and number of leaves/ plant

	Plant height				*Number of leaves/ plant*			
	Days after sowing							
Treatment	*60*	*75*	*90*	*At harvest*	*60*	*75*	*90*	*At harvest*
T_1 (Control)	48.0	54.0	64.0	65.0	28.73	39.55	38.00	13.55
T_2 (NAA 10 ppm	54.9	63.1	70.5	72.3	36.94	46.31	44.53	16.78
T_3 (NAA 20 ppm)	56.2*	65.2*	73.0*	74.9*	38.30*	48.56*	46.76*	17.01*
T_4 (NAA 30 ppm)	54.2	62.0	69.2	70.9	36.41	45.15	44.25	16.44
T_5 (GA_3 10 ppm)	53.3	60.5	67.3	68.8	34.93	44.58	43.67	15.24
T_6 (GA_3 20 ppm)	53.9	61.5	68.5	70.1	35.83	45.12	44.08	15.49
T_7 (GA_3 30 ppm)	52.6	59.7	66.3	67.7	34.50	44.29	43.01	15.18
T_8 (Kinetin 10 ppm)	51.8	58.6	56.0	66.2	33.33	43.23	42.23	14.77
T_9 (Kinetin 20 ppm)	52.5	59.5	66.0	67.3	33.96	44.17	42.88	14.91
T_{10} (Kinetin30 ppm)	51.3	57.9	63.7	64.8	33.00	43.17	41.33	14.67
CD (5%)	1.1	1.1	1.2	1.3	0.90	0.82	0.60	0.42

Table 2
Effect of growth hormones on leaf area (cm^2)/ plant and days to flowering of Soybean

	Days afetrsowing (DAS)						
Treatment	*45*	*60*	*75*	*90*	*At harvest*	*Days to 50% flowering*	*Days to 100% flowering*
T_1 (Control)	156.20	290.10	509.20	290.53	170.87	50.60	56.11
T_2 (NAA 10 ppm	157.60	356.23	582.50	321.57	210.37	47.30	51.55
T_3 (NAA 20 ppm)	158.00*	375.34*	592.73*	327.31*	213.16*	46.00	50.00
T_4 (NAA 30 ppm)	156.82	354.63	576.15	315.70	206.00	47.90	52.00
T_5 (GA_3 10 ppm)	156.59	350.53	560.63	312.89	202.99	48.20	52.08
T_6 (GA_3 20 ppm)	156.80	354.74	562.73	315.27	205.81	48.00	51.90
T_7 (GA_3 30 ppm)	156.75	345.45	558.66	310.04	195.03	48.66	53.33
T_8 (Kinetin 10ppm)	156.50	341.44	542.87	306.30	185.00	49.00	54.66
T_9 (Kinetin 20 ppm)	156.50	342.16	545.09	308.13	187.63	48.00	53.30
T_{10} (Kinetin30 ppm)	156.45	340.28	541.06	302.60	181.29	49.50	55.00
CD (5%)	NS	3.70	3.20	1.15	3.71	0.75	0.95

Table 3
Effect of growth hormones on crop growth rate (g/plant/cm^2/day) and relative growth rate (g/plant/day) of soybean

	Crop growth rate				*Relative growth rate*			
Treatment	*45-60*	*60-75*	*75-90*	*At harvest*	*45-60*	*60-75*	*75-90*	*At harvest*
T_1 (Control)	0.332	0.313	0.259	0.207	0.0395	0.0105	0.0080	0.00098
T_2 (NAA 10 ppm	0.345	0.334	0.278	0.217	0.0634	0.0330	0.0300	0.00185
T_3 (NAA 20 ppm)	0.356*	0.345*	0.285*	0.219*	0.0642*	0.349*	0.0320*	0.00200*
T_4 (NAA 30 ppm)	0.343	0.330	0.277	0.216	0.0632	0.0310	0.0278	0.00180
T_5 (GA_3 10 ppm)	0.340	0.322	0.275	0.215	0.0626	0.0242	0.0208	0.00137
T_6 (GA_3 20 ppm)	0.342	0.327	0.278	0.216	0.0627	0.0256	0.0215	0.00141
T_7 (GA_3 30 ppm)	0.340	0.321	0.273	0.214	0.0606	0.0241	0.0205	0.00133
T_8 (Kinetin 10 ppm)	0.338	0.318	0.266	0.212	0.0566	0.0231	0.0195	0.00120
T_9 (Kinetin 20 ppm)	0.339	0.320	0.270	0.213	0.0577	0.0240	0.0202	0.00125
T_{10} (Kinetin 30ppm)	0.337	0.317	0.265	0.211	0.0558	0.0224	0.0187	0.00115
CD (5%)	0.003	0.003	0.003	0.003	0.0002	0.0005	0.0003	0.0002

Table 4
Effect of growth hormones on crop growth rate (g/plant/cm^2/day) and relative growth rate (g/plant/day) of soybean

	Crop growth rate				*Relative growth rate*			
Treatment	*45-60*	*60-75*	*75-90*	*At harvest*	*45-60*	*60-75*	*75-90*	*At harvest*
T_1 (Control)	0.332	0.313	0.259	0.207	0.0395	0.0105	0.0080	0.00098
T_2 (NAA 10 ppm	0.345	0.334	0.278	0.217	0.0634	0.0330	0.0300	0.00185
T_3 (NAA 20 ppm)	0.356*	0.345*	0.285*	0.219*	0.0642*	0.349*	0.0320*	0.00200*
T_4 (NAA 30 ppm)	0.343	0.330	0.277	0.216	0.0632	0.0310	0.0278	0.00180
T_5 (GA_3 10 ppm)	0.340	0.322	0.275	0.215	0.0626	0.0242	0.0208	0.00137
T_6 (GA_3 20 ppm)	0.342	0.327	0.278	0.216	0.0627	0.0256	0.0215	0.00141
T_7 (GA_3 30 ppm)	0.340	0.321	0.273	0.214	0.0606	0.0241	0.0205	0.00133
T_8 (Kinetin 10 ppm)	0.338	0.318	0.266	0.212	0.0566	0.0231	0.0195	0.00120
T_9 (Kinetin 20 ppm)	0.339	0.320	0.270	0.213	0.0577	0.0240	0.0202	0.00125
T_{10} (Kinetin 30ppm)	0.337	0.317	0.265	0.211	0.0558	0.0224	0.0187	0.00115
CD (5%)	0.003	0.003	0.003	0.003	0.0002	0.0005	0.0003	0.0002

Table 5
Effect of growth hormones on net assimilation rate (g/plant/cm²/day), yield and yield attributes

Treatment	Days after sowing (DAS)				Test weight (g)	Grain yield (g/plant)	Biological yield (g/plant)	Harvest index (%)
	45-60	60-75	75-90	At harvest				
T_1 (Control)	0.00154	0.00080	0.00036	0.000058	128.21	12.01	35.61	33.73
T_2 (NAA 10 ppm	0.00224	0.00142	0.00092	0.000089	164.81	22.68	48.30	46.96
T_3 (NAA 20 ppm)	0.00229*	0.00146*	0.00005*	0.000091*	172.67*	24.83*	50.60*	49.09*
T_4 (NAA 30 ppm)	0.00210	0.00130	0.00080	0.000088	162.40	21.68	45.20	47.96
T_5 (GA_3 10 ppm)	0.00203	0.00125	0.00077	0.000063	160.47	20.36	42.90	47.46
T_6 (GA_3 20 ppm)	0.00209	0.00129	0.00079	0.000070	161.10	21.09	45.10	46.66
T_7 (GA_3 30 ppm)	0.00200	0.00121	0.00074	0.000060	158.33	19.30	41.40	46.62
T_8 (Kinetin 10ppm)	0.00183	0.00106	0.00059	0.000054	142.60	15.60	40.66	38.37
T_9 (Kinetin 20 ppm)	0.00188	0.00110	0.00065	0.000059	145.68	18.60	42.80	42.46
T_{10} (Kinetin 30 ppm)	0.00177	0.00101	0.00055	0.000053	140.45	14.30	38.40	37.24
CD (5%)	0.00004	0.00003	0.00002	0.000004	1.54	0.42	0.49	1.12

Table 6
Effect of growth hormones on Nitrate Reductase activity (µm No_3 reduced/g, fr. wt./h). Chlorophyll content (mg/ ml) in leaves and protein (%) of Soybean

Treatments	Vegetative stage 30 DAS	Flowering stage 60 DAS	Maturity stage 90 DAS	Chlorophyll Content				Protein (%)
				45 DAS	60 DAS	75 DAS	90DAS	
T1 (Control)	0.243	0.315	0.157	9.02	10.0	5.30	3.06	38.11
T2 (NAA 10 ppm)	0.253	0.369	0.199	9.12	11.55	7.00	4.72	42.41
T3 (NAA 20 ppm)	0.256*	0.400*	0.215*	9.16	11.58	7.02	4.74	44.30*
T4 (NAA 30 ppm)	0.250	0.368	0.197	9.10	11.52	6.90	4.71	42.1
T5 ($GA_3$10 ppm)	0.250	0.355	0.195	9.05	11.45	6.70	4.69	40.50
T6 ($GA_3$20 ppm)	0.248	0.360	0.200	9.07	11.48	6.72	4.70	41.96
T7 ($GA_3$30 ppm)	0.249	0.353	0.190	9.04	11.43	6.65	4.67	41.31
T8 (Kinetin 10ppm)	0.247	0.341	0.185	9.20	10.00	7.61	4.76	39.12
T9 (Kinetin 20ppm)	0.246	0.349	0.189	9.24 *	12.84 *	7.80*	4.89*	40.15
T10 (Kinetin30 ppm)	0.244	0.340	0.182	9.19	11.60	7.57	4.75	40.07
CD (5%)	NS	0.06	0.08	NS	0.06	0.05	0.08	0.11

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