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Effect of growth regulators on growth and yield of Kalmegh (*Andrographis paniculata* Nees)

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Abstract: The treatments comprised of growth regulators *viz*., NAA (40, 50 and 60 ppm), GA_3 (25, 50 and 100 ppm) and Paclobutrazol (100, 150 and 200 ppm) and distilled water spray as control. The growth regulators tried in this investigation failed to bring about any significant change in plant height, number of secondary branches and days to first flower appearance and 50% flowering. Application of GA_3 at 100 ppm resulted in maximum number of primary branches and secondary branches in main and ratoon crop respectively which was significantly higher compared to control. The plant spread was also improved by GA_3 at 50 and 100 ppm during main and ratoon crops respectively, while NAA at 50 ppm resulted in early flowering in both main and ratoon crops of kalmegh. Maximum leaf area was recorded both in main and ratoon crop of kalmegh due to GA_3 application at 100 and 50 ppm respectively. Fresh and dry weight of leaf, stem and their total biomass were significantly influenced by all the growth regulator treatments, wherein, paclobutrazol at 100 ppm registered maximum values. The foliar application of NAA at 50 ppm was very effective and recorded maximum cumulative dry herb yield and drying percentage.

Key words: *Andrographis paniculata*, Plant growth regulators, Whole plant biomass

Introduction

Kalmegh (*Andrographis paniculata* Nees.) is an herbaceous plant belonging to the family Acanthaceae. It is native to India and Sri Lanka (Kirtikar and Basu, 1994). It is used in traditional medicine in China, India and Southeast Asia. It is known as "king of bitters". Primary bio-active chemical constituent of the plant is Andrographolide which is responsible for the curative properties such as hepatoprotective, immunomodulator, anti-inflammatory, anti-malarial, anti–diarrhoeal with beneficial effect on respiratory and cardiovascular systems (Jarukamjorn and Nemoto, 2008). Recently, it has been utilized in treating HIV, hepatitis, diabetes, cancer and kidney disorders (Valdiani *et al*., 2012), which further enhances the value of kalmegh warranting its commercial cultivation. The leaves contain over 2% andrographolide before the plant blooms. The stem also contains Andrographolide in the range of 0.4 to 1.05% (Zhu and Liu, 1984). The heavy demand for andrographolide in Indian as well as in international markets has motivated Indian farmers to start commercial cultivation of this important medicinal plant (Kanjilal *et al*., 2002). However, low physical yield and andrographolide content coupled with highly fluctuating market are the discouraging factors for expansion of area under this most useful and important medicinal plant which finds place both in traditional and modern medicine across the world. Plant growth regulators are new generation chemicals which can modify the growth, yield and quality of medicinal plants. These bioregulators comprised of both retardants and promoters, if used in appropriate concentrations, influences the plant architecture in a typical fashion (Hermesz and Ferencz, 2009).

Hence, it is pertinent to increase the productivity by way of increasing the herb yield. There are possibilities of increasing herb yield by the use of growth regulators and hence the main objective of present investigation is to study the effect of growth regulators on growth and yield of kalmegh.

Materials and Methods

A field experiment was conducted during *kharif* 2013-14 at College of Horticulture, U.H.S. Campus, Gandhi Krishi Vignana Kendra. The experimental field is located at an altitude of 930 m above MSL 12° 58[1] North latitude and 77° 35[1] East longitude in the Eastern Dry Zone (zone-5) of Karnataka. The maximum and minimum temperatures varied from 26.6-29.9°C and 14.1-19.1°C respectively and relative humidity varied from 39-93 percent. The total rainfall of 540 mm was received during cropping period. The soil of the experiment site was red sandy loam in nature with a pH of 6.7 with 3.2% organic carbon and 223.4, 43.8 and 126.3 kg available NPK respectively per ha. The experiment comprised of ten treatments tested in randomized complete block design with three replications. The growth regulators tried were NAA (40, 50 and 60 ppm), GA_3 (25, 50 and 100 ppm) and PBZ (100, 150 and 200 ppm) and the distilled water being the control. The growth regulators were sprayed at 30 DAT and 30 days after harvesting of

main crop. Local kamegh seeds were sown in raised beds. Forty five days old seedlings were transplanted in 2.4 x 2 m size plots at a spacing of 30 x 20 cm. A recommended dose of 25 t ha^{-1} FYM and 75 kg P_2O_5 and 50 kg K ha^{-1} were supplied through single super phosphate and muriate of potash respectively as basal dose. Nitrogen was applied at 75kg per ha in two equal splits, one at the time of transplanting and another as top dressing at 30 DAT. Nitrogen at 20 kg ha^{-1} was used for top dressing of ratoon crop. Weeding and other intercultural practices were taken up at regular intervals to keep the plots free from weeds. The crop was irrigated with drip system using 12 mm inline drippers with 2LPH discharge with one lateral in alternate rows of kalmegh. The seedlings were transplanted on 9th September, 2013 and the crop was harvested at bloom stage after 62 DAT and ratoon crop was also harvested at similar stage after 63 days after harvest of the main crop.

Plant height was measured from the ground level to the growing tip of the main stem at 45 days after transplanting and at harvest of the main crop and again in ratoon crop at 30 days after harvesting of main crop and at harvest of ratoon crop. Number of branches arising from the main stem above the ground level in five tagged plants at 45 days after transplanting and number of shoots arising from the stubs in ratoon crop at 30 days after harvest of main crop was recorded. Secondary branches in five tagged plants was recorded at the time of harvest of main and branches on the shoots arising from the stubs in the ratoon crop was recorded. Plants in the experimental plots were regularly observed for flower appearance in main as well as in ratoon crops. Date on which flowers appeared was recorded. Number of days taken for 50% of the plants to flower in each treatment in each replication was recorded in main as well as ratoon crops.

Leaf area was recorded after harvesting the main as well as ratoon crop by separating the leaves from stem of 5 plants. The area of 100 leaves was measured on the graph sheet and the total leaf area was worked out. The length and breadth of same 100 leaves was measured and the product of length and breadth of each leaf was worked out and total area was computed. By dividing the actual leaf area using graph method by leaf area using length and breadth method, the factor was worked out. The factor for leaf area was 0.93. Five randomly selected and tagged plants were harvested and their leaves and stem were separated and their fresh weights were recorded and average weight was computed and expressed as gram per plant. After recording the fresh weight of leaf and stem in main crop and leaf, stem and root in ratoon crop, samples were kept for drying in an electric oven at 60^{0}C and their dry weight was recorded. Stem to leaf ratio was computed by dividing the stem dry weight per plant by the leaf dry weight per plant. Drying percentage parameter was computed by dividing the total dry weight of plant by respective total fresh weight of plant in each treatment multiplied by 100 and expressed as percentage.

Results and Discussion

Application of growth regulators had no significant impact on plant height in main crop and ratoon crop of kalmegh (Table 1). Maximum number of primary branches were present in plants sprayed with GA_3 at 100 ppm (19.13) in main crop, while, the same treatment induced maximum number of secondary branches in ratoon crop (23.09), which differed significantly from rest of the treatments. Higher number of branches in the plants applied with GA_3 can be related to enhance physiological activities such as cell division, cell elongation, photosynthesis and translocation of nutrients and photosynthates (Paleg, 1965 and Saxena, 1989). Similar finding was observed in coriander by Panda *et al.* (2007), Verma and Sen (2008) and Singh *et al.*(2012). GA_3 at 50 ppm (NS- 28.4 and EW- 27 cm) caused wider canopy in main crop and GA_3 at 100 ppm (NS- 29.9 and EW- 31.1) increased the canopy dimension in ratoon crop. GA_3 would increase membrane permeability (Crozier and Turnbull, 1984 and Al-Wakeelsam*et al*., 1995). The increase in membrane permeability would facilitate absorption and utilization of mineral nutrients and also transport of assimilates. Due to this canopy spread increases. The results are in accordance with the findings of Aftab *et al.* (2011) in *Artemisia annua* L.

In ratoon crop, flowering was advanced in plants sprayed with NAA at 50 ppm (42.33 days) which was at par with paclobutrazol at 100 ppm (44.33 days) and 50% of plants in the plots showed flowering in just 45.67 days (Table 2), which were applied with NAA at 50 ppm (main crop) These observations are in line with those obtained by Meena *et al.* (2006) in coriander. In main crop, the highest leaf area (429.4 sq cm/plant) was recorded in plants treated with GA_3 at 100 ppm and it was minimum (237.8 sqcm per plant) in untreated plants. In ratoon crop maximum leaf area (533.4 sqcm per plant) was recorded with the application of GA_3 at 50 ppm, which was closely followed by GA_3 at 100 ppm (531.1 sqcm per plant) and NAA at 50 ppm (516.5 sqcm per plant) which were on par and differed significantly from all other treatments. These results collaborated with the findings of Srivastava and Srivastava (2007) in *Catharanthus roseus,* Hassanpouraghdam *et al.* (2011) in lavender and Subir *et al.* (2013) in *Mentha arvensis.* In general higher dry weight and drying percentage was noticed in ratoon crop as compare to the main crop indicating higher dry biomass recovery in ratoon crop as compare to the main crop (Table 3). Paclobutrazol spray at 100 ppm resulted in maximum dry weight both in main and ratoon crop (3.14g and 7.74g / plant respectively) which differed significantly from all other treatments. While, NAA at 60 ppm observed lowest plant dry weight (0.93 g / plant) in main crop. Maximum drying percentage was recorded in plants fed with paclobutrazol at 150 ppm (30.13%) in main crop. However, in ratoon crop, highest drying percentage of 40.21% was associated with paclobutrazol at 100 ppm which were on par with other paclobutrazol treatments (150 ppm – 37.07 and 200 ppm – 35.25%) and NAA at 40 (38.15%) and 50 ppm (37.16%) treatments. Control (27.50%) recorded the lowest drying percentage indicating higher amount of moisture which was on par with all GA_3 treatments.

Growth regulators proved their superiority in increasing fresh herb yield and dry herb yield (Table 4). Cumulative fresh herb yield was highest (8105 kg per ha) with GA_3 at 100 ppm. NAA at 50 ppm contributed for highest cumulative dry herb yield (3662 kg per ha). The maximum dry herb recovery (shade dry) of 54.5% was also obtained with the same treatment. This also shows the interaction of growth regulators and cropping seasons indicating

Table-1: The effect of PGRs on growth parameters of kalmegh (*Andrographis paniculata* Nees.)

Treatments	Plant height (cm) at harvest		Number of branches (per plant)				Plant spread (cm)			
			Main crop at harvest		Ratoon crop at harvest		Main crop		Ratoon crop	
	Main crop	Ratoon crop	Primary branches at 45 DAT	Secondary branches at harvest	Primary branches at 30 DAHM	Secondary branches at harvest	N-S	E-W	N-S	E-W
Control	30.05	26.15	14.07	3.50	2.22	11.99	18.6	24.2	19.3	24.2
NAA 40 ppm	30.11	27.55	16.87	4.43	2.73	21.02	21.3	26.4	24.0	27.6
NAA 50 ppm	30.32	27.23	17.87	4.52	3.01	20.07	25.3	26.8	26.0	25.3
NAA 60 ppm	29.75	28.17	17.75	4.27	3.01	18.39	23.1	24.5	24.2	28.2
GA_3 25 ppm	30.95	26.14	18.18	4.75	2.76	17.59	22.2	26.0	23.3	25.3
GA_3 50 ppm	31.89	28.27	18.36	5.28	3.02	20.38	28.4	27.0	26.5	28.2
GA_3 100 ppm	33.02	30.73	19.13	5.87	3.11	23.09	24.8	26.3	29.9	31.1
Paclobutrazol 100 ppm	31.26	26.74	16.76	4.13	2.68	18.45	23.2	24.4	22.5	25.8
Paclobutrazol 150 ppm	28.19	23.61	14.72	3.60	2.80	18.32	21.3	25.9	22.3	27.4
Paclobutrazol 200 ppm	30.19	25.48	15.24	3.35	2.26	18.96	21.9	25.3	23.2	27.5
Mean	30.57	27.01	16.89	4.37	2.76	18.83	23.0	25.7	24.1	27.1
S.Em ±	1.79	1.28	0.59	0.32	0.18	0.60	0.7	0.4	0.7	0.7
CD at 5%	NS	NS	1.74	NS	NS	1.79	2.1	1.1	2.1	1.9

DAT = Days After Transplanting, DAHM = Days after harvesting of main crop, N-S = North-South, E-W = East- West, NS = Non significant

Table-2: The effect of PGRs on days to first flower appearance and 50 per cent flowering and leaf area in kalmegh (*Andrographis paniculata* Nees.)

Treatments	Main crop		Ratoon crop		Leaf area (sq.cm/plant)	
	First flower appearance	50 percent Flowering	First flower appearance	50 percent flowering	Main crop (at harvest)	Ratoon crop (at harvest)
Control	49.33	57.33	51.00	59.33	237.8	449.7
NAA 40 ppm	45.33	51.33	47.67	54.00	326.2	491.6
NAA 50 ppm	39.33	45.67	42.33	52.00	324.1	516.5
NAA 60 ppm	46.33	55.67	46.67	55.33	323.8	472.3
GA_3 25 ppm	45.00	52.04	49.67	52.33	360.0	492.1
GA_3 50 ppm	43.33	51.31	49.00	54.33	388.0	533.4
GA_3 100 ppm	45.00	52.00	45.33	50.33	429.4	531.1
Paclobutrazol 100 ppm	41.00	48.67	44.33	51.33	308.4	460.4
Paclobutrazol 150 ppm	46.00	54.63	46.67	54.67	308.7	431.7
Paclobutrazol 200 ppm	45.33	54.67	46.33	56.67	283.0	468.9
Mean	44.59	52.33	46.90	54.03	328.9	484.8
S.Em ±	1.04	1.13	0.72	1.09	12.7	15.5
CD at 5%	NS	3.35	2.14	NS	37.7	46.5

NS- Non significa

Table-3: Dry matter accumulation (g/plant) and drying percentage in kalmegh as influenced by growth regulators

Treatments	Main crop		Ratoon crop	
	Total dry wt.	Drying (%)	Total dry wt.	Drying (%)
Control	1.73	25.60	4.07	27.50
NAA 40 ppm	1.82	24.88	5.25	38.15
NAA 50 ppm	2.71	27.09	5.01	37.16
NAA 60 ppm	0.93	17.32	3.44	31.27
GA_3 25 ppm	1.82	17.71	4.36	33.69
GA_3 50 ppm	1.09	12.79	3.39	29.98
GA_3 100 ppm	2.03	22.63	5.02	33.60
Paclobutrazol 100 ppm	3.14	26.49	7.74	40.21
Paclobutrazol 150 ppm	2.51	30.13	4.58	37.07
Paclobutrazol 200 ppm	1.88	24.45	5.35	35.25
Mean	1.97	22.91	4.82	34.39
S.Em ±	0.11	3.30	0.37	2.17
CD at 5%	0.33	9.88	1.11	6.49

Table-4: The effect of PGRs on yield parameters of kalmegh (*Andrographis paniculata* Nees.)

Treatments	Cumulative fresh herb yield(kg/ha)	Cumulative dry herb yield (kg/ha)	Drying (%) (on shade dry basis)
Control	4924	2171	44.1
NAA 40 ppm	5760	2824	49.1
NAA 50 ppm	6728	3662	54.5
NAA 60 ppm	5592	2081	37.2
GA_3 25 ppm	6285	2487	39.5
GA_3 50 ppm	5673	1890	33.4
GA_3 100 ppm	8105	3248	40.1
Paclobutrazol 100 ppm	6391	2529	39.7
Paclobutrazol 150 ppm	5277	2496	47.4
Paclobutrazol 200 ppm	5262	2569	48.8
Mean	5999	2596	43.4
S.Em ±	120	83	1.6
CD at 5%	361	248	5.0

differential response of crop to these growth regulators in different seasons. This can be ascribed to comparatively higher drying percentage in NAA treated plants. The increase in yield due to the application of growth regulators may be attributed to the better efficacy of sink under the influence of growth regulators. Evans *et al.* (1972) reported the involvement of growth regulating substances with sink efficiency in influencing the yield potential. It is evident from the data that control registered significantly lower yields than growth regulator sprays which indirectly manipulate the morphological, physiological and growth parameters as reported by Channakesava *et al*. (2007). From the present investigation, it can be deduced that spraying with NAA at 50 ppm 30 days after transplanting or harvesting of main crop was most optimum for realizing maximum yield per hectare in kalmegh.

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