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Effect of phytohormones on morphophysiological parameter of Kalmegh (*Andrographis paniculata* Nees)

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Abstract
Kalmegh *Andrographis paniculata* is an erect annual herb consider as "king of bitter. The experiment was laid out in randomized block design with three replications. The various phytohormones were applied as foliar at 30 days after transplanting. The treatments comprised of T1 (NAA 50 mg/l), T2 (NAA 100 mg/l), T3 (NAA 200 mg/l), T4 (GA3 50 mg/l), T5 (GA3 100 mg/l), T6 (GA3 200 mg/l), T7 (paclobutrazol 50 mg/l), T8 (paclobutrazol 100 mg/l), T9 (paclobutrazol 200 mg/l) andT10 (control). Results were significantly increase plant height with GA3 100 mg/l treatment while minimum plant height was recorded in paclobutrazol 100 mg/l application during the different growth stages as compared to control. The various morphological growth parameter i.e. number of leaves, number of primary branches were significantly higher in GA3 100 mg/l treatment as compared to control during the growth period of Kalmegh. The results concern to physiological parameters indicated that the leaf area, relative growth rate and net assimilation rate increase significantly in the GA3 100 mg/l during the different growth stages.

Keywords: *Andrographis paniculata*, phytohormones, foliar spray, growth

Introduction
Andrographis paniculata (Burm. f.) Wall. ex Nees is an herbaceous plant in the family Acanthaceae (Niranjan *et al.*, 2005) [7] is about 30-110 cm height, stem acutely quadrangular with many branches widely, flowers white with rose-purple spots on the petals. It is an erect, annual, 1-3 ft high herbal drug native to India and Sri Lanka. In India, it is occasionally cultivated in plains of Uttar Pradesh, Madhya Pradesh, Chhattisgarh, West Bengal, Karnataka, Deccan, Assam, Gujarat and Kerala. The major bitter constituent in Kalmegh is due to the presence of diterpene lactone called andrographolide (Raina *et al*., 2013) [11]. Kalmegh has huge demand because of its pharmacological properties. Natural resource get declined because of indiscriminate collection of Kalmegh from forest area (Sowmya Kumariand Umesha 2018) [13]. Plant growth regulators composed of both retardants and promoters, if used in appropriate concentrations, influences the plant architecture in a typical fashion which regulate growth and development behaviour of plants without inducing malformative or phytotoxic effects (Hermesz and Ferencz, 2009) [5]. Considering the multiple uses of kariyatu and progressive farmers of Gujarat have come forward to cultivate this crop in their field. Therefore, keeping this in mind the present study has been carried out with foliar application of the growth regulators which directly enter in plant of the Kalmegh. So to know the potential of the plant harmone like NAA, GA_3 and paclobutrazol the present study was undertaken with the objective to study on influence of phytohormones on morpho-physiological growth of Kalmegh (*Andrographis paniculata* Nees).

Material and Methods
The experiment were undertaken, at department of plant physiology, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujrat), is situated on 22º-35' north latitude and 72º-55' east longitude and has an elevation of 45 metres above the mean sea level. The experiment was laid out in Randomized Block Design with three replications and ten different treatments of foliar spray of plant growth regulators on (*Andrographis paniculata* Nees). Variety Anand Kalmegh-1 (AK-1). The treatment comprising with plant growth

regulators *viz.* NAA,GA_3, and paclobutrazol at 50,100 and 200 mg/l concentrations respectively were used along with control. The foliar spray of phytohormones was imposed at 30 days after transplanting (DATP). The observations on growth and physiological parameters were recorded at four stages of plant growth *viz*., 45 DATP, 75 DATP, 105 DATP and at harvest. Five plants from the net plot area of each treatment were selected randomly and tagged in each plot for recording growth parameters while other five plants from border lines were up rooted randomly for physiological parameters at different growth stages.

Result and Discussion

Effect of phytohormones on morphophysiological parameter

Plant height

The results indicates that the plant height was increase with crop growth and treatments effect significantly at all phases from 45 days after transplanting to harvest. Table1 showed that the plant height influenced significantly with the different phytohormones treatments at 45, 75, 105 DATP and at harvest. The increase in plant height may be due to internodal elongation. The application of growth promotive substances increased the plant height and such effect was due to increased photosynthetic activity, enhancement in the mobilization of photosynthates and change in the membrane permeability. Osmotic driven responses under the influence of GA3 might have attributed for an increase in photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products, thus resulting in increased cell elongation and rapid cell division in growing portion. (Faldu, 2018) [2], while paclobutrazol has been shown to suppress plant shoot growth effectively. The growth regulating properties of paclobutrazol are mediated by altering the levels of plant hormones such as gibberellins, abscisic acid and cytokinins. paclobutrazol is mainly used as growth retardants has reduced plant height (Tesfahun, 2018) [14].

These results are conformity with finding of Raidas *et al*. (2020) [10] in Kalmegh, Yogita *et al*. (2013) [15] in ajwain while Gomathinayagam *et al.* (2009) [3] in Kalmegh.

Number of leaves

Results presented in Table1 revealed that various phytohormones treatments showed their significant effect on number of leaves per plant at 45, 75, 105 DATP and at harvest. At 45 days after transplanting, significantly highest number of leaves per plant (94.10) was recorded under treatment T5 (GA3 100 mg/l) and it was statistically at par with treatments T8, T9, T2 and T6. The lowest number of leaves per plant was recorded in control T10 (71.17). Sameway at harvest, significantly highest number of leaves per plant (502.37) was recorded under treatment T5 (GA3 100 mg/l) and it was statistically at par with treatments T8, T9 T6 and T2. The lowest number of leaves per plant was recorded in control T10 (347.40). The number of leaves were increased up 105 DATP and then stable or slightly increased up to harvest. Leaves are the essential source from which the photosynthates are channelled to the sink. Different phytohormones treatment like auxin (NAA) prevent senescence of leaves, GA3 might have attributed for an increase in photosynthetic activity (Faldu, 2018) [2].

Number of primary branches per plant

Results revealed that different phytohormones treatments showed their significant effect on number of primary branches per plant at 45, 75, 105 DATP and at harvest are showing Table 2 results indicated that number of primary branches was observed maximum at harvest. An increase in number of branches could be due to inhibition in the auxin activity in the plant due to phytohormones. These treatments might have resulted in inhibition of apical bud dominance, there by diverting the polar transport of auxins towards the basal nodes leading to breaking of lateral bud dormancy and increased branching. These results are in conformity with findings of Kumari *et al.* (2016) [6] in Kalmegh, Yogita *et al*. (2013) [15] in ajwain

Leaf area per plant (cm^2)

Phytohormones treatment showed their significant effect on leaf area per plant (cm^2) at 45, 75, 105 DATP and at harvest are represent in Table2 Over all experimental result showed that leaf area per plant (cm^2) during all periods was the highest in treatment T5 (881.40 cm^2). The leaf area was found a typical sigmoidal pattern with an initial slow increased in leaf area followed by a steep rise. The leaf area more or less leveled off during at harvest stage. This was happened due to number of leaves were increased up to 105 DATP and then stable or slightly increased up to harvest. Further leaf area increased up to 105 DATP and decreased thereafter may be due to senescence and ageing of leaves. However, Different phytohormones maintained a higher leaf area at harvest stage of the crop in the experiment. El-Sayed, (2014) [1] reported that GA3 was effective in *Schefflera arboricola* plant and also indicated that paclobutrazol increase the leaf area as the increase its concentration as compared to control. Foliar spray of phytohormones at onetime and explain that GA3 brings the inherent genetic potential of pant to cause increased cell division and cell wall-extensibility thereby resulting in increasing leaf area. The co-relation between the number of leaves per plant and number of branches increase in case of application of phytohormones helps to increased leaf area in the study. These results are same with previous finding of Raidas *et al*. (2020) [10] in kalmegh, Kumari *et al.* (2016) [6] in Kalmegh, Yogita *et al*. (2013) [15] in Ajwain and Gomathinayagam *et al.* (2009) [3] in Kalmegh.

Relative growth rate (g/g/day)

Relative growth rate decreased after 45-75 DATP and lowest at the 105 DATP- at harvest, the data revealed that different phytohormones treatments showed their significant effect on relative growth rate (g/g/day) during various Kalmegh growth stages up to maturity which are presented in Table 3. It is clear from the present investigation that relative growth rate (RGR) declined with the advancement in the crop growth. RGR represents the increase in dry matter per unit dry matter already present per unit time. The decline in RGR during the later stage of crop is due to the decline in the rate of dry matter production. The increase in the RGR due to the application of phytohormones might be due to increase in photosynthetic efficiency by increasing leaf thickness, retaining more chlorophyll content and efficient translocation of photosynthates. All the treatments differ significantly for RGR values and showed(table3)the highest RGR at 45-75 DATP, which declined after 75-105 DATP. These results are conformity with finding of Shende (2016) [12] in Kalmegh and Parashar *et al.* (2011) [9] in Kalmegh.

Net assimilation rate ($g/cm^2/day$)

The net assimilation rate was higher at the vegetative stage and decreased towards the harvest. The net assimilation rate

was maximum during 45-75 days after transplanting and it was lowest at the time of 105 DATP-at harvest phase. Net assimilation rate is influences due to the application of phytohormones at different growth stage of Kalmegh the results pertaining to the various phytohormones application reflect their significant effect on net assimilation rate (g/cm^2/day) during the different duration of Kalmegh growth period represent in Table3.Maximum net assimilation rate (0.219 g/cm^2/day) was recorded when applied GA3 100 mg/l which was statistically at par with 100 mg/l of paclobutrazol, 200 mg/l paclobutrazol as well as NAA 100 mg/l. when compared to control during 45-75 days after transplanting while during 75-105 DATP affected by different treatment of phytohormones found significantly highest net assimilation rate (0.075 g/cm^2/day) when GA3 100 mg/l applied as a foliar treatment and this is statistically at par with T8, T9, T6, T2, T7 and T3. The lowest (0.059 g/cm^2/day) net assimilation rate was recorded in control (T_{10}).

The data representing showed that net assimilation rate (0.063 g/cm^2/day) was found maximum in the treatment of GA3 100 mg/l foliar application and it was statistically at par with treatments T8 and T9 where 100 mg/l and 200 mg/l paclobutrazol spray respectively, the lowest net assimilation rate (0.040 g/cm2/day) was found in control where no foliar spray of phytohormones was given. Net Assimilation Rate (NAR) is used as a character for measure of the average efficiency of leaves of a plant or dry matter accumulation rate per unit of leaf area. NAR was recorded the highest in foliar spray of GA3 100 mg/l at 45-75 days after transplanting crop growth increased at pick period of vegetative phase thereafter crop growth was reflect steady or decrease due to transport of photosynthate towards the reproductive phase. Gregory (1926) [4] expressed net assimilation rate as a unit leaf rate that means the rate increases in dry weight at any instant on basis of leaf area with leaf represent an estimate of Sige of the assimilatory area. Similar results were reported in previous work of Shende (2016) [12] in Kalmegh and Padmavathi (1998) [8] in onion, which is conformity with this investigations.

Table 1: Effect of phytohormones on plant height and number of leaves per plant

Treatment	Plant height (cm)				Number of leaves per plant			
	45 DAS	75 DAS	105 DAS	At harvest	45 DAS	75 DAS	105 DAS	At harvest
T1: NAA 50 mg/l	29.77	51.40	58.27	64.17	73.57	293.20	342.40	352.97
T2: NAA 100 mg/l	32.50	56.63	66.03	71.70	85.03	342.03	429.40	440.57
T3: NAA 200 mg/l	31.83	51.90	63.10	70.30	77.93	316.67	364.07	376.00
T4: GA3 50 mg/l	29.30	49.27	56.07	61.90	75.37	294.17	344.27	354.00
T5: GA3 100 mg/l	33.47	58.97	67.80	73.00	94.10	400.30	490.37	502.37
T6: GA3 200 mg/l	32.03	55.73	64.83	70.43	83.43	362.03	430.90	440.83
T7: Paclobutrazol 50 mg/l	27.70	47.98	53.40	56.80	80.00	326.17	427.00	438.07
T8: Paclobutrazol 100 mg/l	25.23	44.27	48.53	52.43	89.63	390.43	442.07	455.37
T9: Paclobutrazol 200 mg/l	26.80	45.63	50.27	53.77	88.53	359.17	444.77	452.43
T10: Control (Water spray)	28.93	48.20	54.17	58.83	71.17	285.13	337.43	347.40
S.Em.±	1.38	2.53	2.88	3.32	4.17	17.33	21.54	21.55
C.D. at 5%	4.11	7.51	8.55	9.86	12.41	51.49	63.99	64.02
C.V. %	8.05	8.59	8.55	9.08	8.83	8.91	9.20	8.97

Table 2: Effect of phytohormones on number of primary branches per plant and leaf area per plant

Treatment	Number of primary branches per plant				Leaf area per plant (cm^2)			
	45 DAS	75 DAS	105 DAS	At harvest	45 DAS	75 DAS	105 DAS	At harvest
T_1: NAA 50 mg/l	13.40	23.17	30.77	34.07	152.57	511.07	625.20	638.83
T_2: NAA 100 mg/l	15.83	26.73	35.33	38.47	197.93	604.20	729.40	752.20
T_3: NAA 200 mg/l	14.03	24.10	32.50	35.97	178.00	557.80	676.57	694.97
T_4: GA3 50 mg/l	13.37	22.17	29.17	33.00	170.70	529.07	642.77	658.27
T_5: GA3 100 mg/l	16.27	28.43	37.47	41.07	220.87	710.23	853.13	881.40
T_6: GA3 200 mg/l	14.73	25.60	32.70	37.10	194.70	656.10	760.03	785.27
T_7: Paclobutrazol 50 mg/l	12.67	20.90	26.67	31.53	180.53	564.70	684.50	704.90
T_8: Paclobutrazol 100 mg/l	12.53	19.90	25.93	30.43	199.67	687.30	792.20	856.30
T_9: Paclobutrazol 200 mg/l	12.57	20.33	26.30	31.43	197.90	630.03	829.93	845.07
T_{10}: Control (water spray)	11.50	19.17	25.73	30.27	149.37	495.47	607.23	620.10
S.Em.±	0.71	1.13	1.41	1.72	9.43	30.14	35.68	36.04
C. D. at 5%	2.11	3.36	4.19	5.11	28.02	89.57	106.00	107.08
C. V. %	8.99	8.48	8.09	8.67	8.87	8.78	8.58	8.39

Table 3: Effect of phytohormones on RGR and NAR

Treatment	Relative growth rate (RGR) (g/g/day) × 100			Net assimilation rate (NAR) (g/cm^2/day) × 100		
	45-75 DATP	75-105 DATP	105 DAS-At harvest	45-75 DATP	75-105 DATP	105 DAS-At harvest
T1: NAA 50 mg/l	6.29	1.15	0.79	0.175	0.061	0.043
T2: NAA 100 mg/l	6.38	1.58	0.90	0.195	0.071	0.048
T3: NAA 200 mg/l	6.48	1.41	0.89	0.181	0.067	0.046
T4: GA3 50 mg/l	6.41	1.41	0.86	0.181	0.062	0.045
T5: GA3 100 mg/l	7.62	2.12	1.08	0.219	0.075	0.063
T6: GA3 200 mg/l	6.56	1.64	0.92	0.188	0.072	0.050
T7: Paclobutrazol 50 mg/l	6.54	1.52	0.90	0.184	0.068	0.046

T8: Paclobutrazol 100 mg/l	7.50	1.73	0.96	0.213	0.073	0.054
T9: Paclobutrazol 200 mg/l	7.13	1.70	0.93	0.196	0.073	0.053
T10: Control (water spray)	6.22	1.15	0.70	0.166	0.059	0.040
S.Em.±	0.32	0.07	0.06	0.010	0.003	0.004
C. D. at 5%	0.94	0.22	0.19	0.029	0.009	0.012
C. V. %	8.09	8.25	12.19	8.82	7.91	13.93

Conclusion

From the above discussion it can be concluded that the different morphological and physiological growth parameters were significantly higher in GA3 100 mg/l treatment as compared to control during the growth period of Kalmegh. It will help in growth and development and finally increase production of Kariyatu.

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