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Influence of Bio-Stimulants on Growth, Yield and Economics of Kalmegh, *Andrographis paniculata*

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Kalmegh or andrographis (*Andrographis paniculata)* otherwise is known as King of bitters. Investigations undertaken aiming to increase the growth and yield parameters of kalmegh using different bio-stimulants produced positive results. Spraying of combination of 2% Panchakavya + 0.2% Humic Acid + 2% Moringa Leaf Extract resulted in higher plant height, number of branches, number of leaves, leaf area and leaf area index of kalmegh both at 60 and 90 days after planting. Further the same treatment also pronounced effect on fresh and dry herb weight at both the stages of plant growth. The highest dry herbage yield of 1956 kg ha^{1} was recorded from the treatment combination of 2% Panchakavya + 0.2% Humic Acid + 2% Moringa Leaf Extract (T_7) and was significantly differed from other treatments. The combined bio stimulant at lower doses spray recorded 31.8 per cent over the control. The same treatment also registered the highest benefit: cost ratio of 2.47. Hence it is concluded that combined bio-stimulant spraying (2% Panchakavya + 0.2%Humic Acid + 2% Moringa Leaf Extract) at 30 and 60 days after planting is economically viable in producing higher dry herbage yield in andrographis.

Key words: andrographis, kalmegh, bio-stimulants, panchakavya, humic acid, moringa leaf extract, herb yield

Medicinal plant sector has traditionally occupied an important position in the socio-cultural, spiritual and medicinal arena of rural and tribal lives of India. Demand for medicinal plant is increasing in both developing and developed countries due to growing recognition of natural products, being non-narcotic, having no side-effects, easily available at affordable prices and sometime the only source available to the mankind who cares for their health. India's share in the global export market of medicinal plants related trade is just 0.5 per cent i.e. Rs. 446 crores during the year 2000. India, with its varied biodiversity has a tremendous potential and advantage in this emerging area as indicated by the National Medicinal Plants Board (NMPB), New Delhi. Kalmegh (*Andrographis paniculata,* which is otherwise known as King of bitters and it belongs to the family Acanthaceae. It is one among the prioritized 32 medicinal plants by the NMPB. Since time immemorial, village and ethnic communities in India have been using this herb mainly for treating fever, liver diseases, diabetes, snake bite, common cold and bronchitis and a variety of ailments. The demand of kalmegh is 2197.3 tonnes during 2004-2005 with the annual growth rate of 3.1 per cent according to the NMPB report. For increased herbage yield in kalmegh, many experiments were conducted using inorganic fertilizers and reported by various authors from different parts of South East Asia (Anonymous, 2001). It is a mandate for the medicinal plants to be cultivated by organic means considering their therapeutic values. Hence the attempt has been made by employing three different bio-stimulants such as Panchakavya, humic acid and moringa leaf extract each at two different concentrations and their respective combinations to study the influence on growth, yield and benefit-cost ratio of kalmegh.

Materials and Methods

The experiment was laid out in a Randomized Block Design (RBD) with 9 treatments replicated thrice. The field layout and randomizations of

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treatments to each plot of size 1.5 x 3.0 m (4.5 m^2) were carried out as per the statistical methods given by Panse and Sukhatme (1985).

The bio - stimulants were sprayed at 30 and 60 days after planting. The trial was conducted in three different seasons in the same location in order to obtain concurrent results and the data were subjected for pooled analysis. Plant height was measured from the base of the plant to the tip of the plant at 60 and 90 days after planting (DAP) and the mean value was expressed in cm. The number of branches was counted at 60 and 90 DAP and the mean value was worked out and expressed as number per plant. The total number of leaves was counted at 60 and 90 DAP and the mean value was calculated and expressed as number per plant. The leaf area was measured at 60 and 90 DAP by following the graphical method and the mean value was calculated and expressed as cm^2 $plant^{-1}$. Leaf Area Index (LAI) was determined at 60 and 90 DAP by following the formula of Williams (1946).

$$LAI = \frac{\text{Leaf Area per plant}}{\text{Ground area occupied by the plant}}$$

Plants were selected randomly in each treatment, the samples were collected, and the fresh weight of the herbage was computed and the mean value was expressed as g $plant^{-1}$. The collected fresh herb was shade dried for two days and then kept in a hot air oven at 50°C for 24 hours for complete drying. The dry weight of the herb was recorded and the mean value was expressed both as g $plant^{-1}$ and kg ha^{-1}. The benefit cost ratio (BCR) was worked out by using the following formula.

$$BCR = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs. ha}^{-1}\text{)}}$$

The statistical analysis of data was done by adopting the standard procedures of Panse and Sukhatme (1985).

Results and Discussion

Effect of bio-stimulants on growth parameters

Any crop management practice should be aimed to produce better growth parameters such as plant height, number of branches, number of leaves etc. In the present experiment plant height was significantly influenced by foliar spraying of different bio-stimulants in andrographis at different stages of growth i.e. both at 60 to 90 days after transplanting. The treatment consisting of combination of three bio-stimulants T_7 (2% Panchakavya + 0.2% Humic Acid + 2% Moringa Leaf Extract) resulted in higher plant height at both the stages of plant growth (28.13cm and 59.15cm respectively) and were significantly different from rest of the treatments. The treatment having same combination of bio-stimulants at higher concentrations (T_8 - 4% Panchakavya + 0.4% Humic Acid + 4% Moringa Leaf Extract) resulted in relatively higher plant height at both the stages of observation, but next only to T_7. Spraying of each bio-stimulants individually at either lower or enhanced concentrations were not equally effective as that of combined spray, however they were on par with each other when sprayed individually at both the concentrations. Overall the least influence was noticed in T_9 (Control). Number of branches per plant showed increasing trends from 60 to 90 days after planting. Different treatments had significant effect on number of branches at both the stages of growth i.e. 60 and 90 days after planting. Treatment T_7, combination of three different bio-stimulants at lower concentrations registered the highest number of branches (8.31 and 22.32 at 60 and 90 DAP respectively) which was statistically different from spraying of individual bio-stimulants. Combined spraying of all the three bio-stimulants at higher concentrations recorded 7.25 and 19.80 number of branches at 60 and 90 DAP respectively while the individual spraying at higher concentrations (T_4, T_5 and T_6) were on par with each other at both the stages of plant growth. Treatment T_9 [Control-water spray] registered the lowest number of branches at both the three stages. Number of leaves per plant differed significantly among the treatments at both the growth stages from 60 to 90 DAP. The number of leaves was found to be progressively increasing during the

growth stages. The trend was similar to that of plant height at both the stages of observations. The highest number of leaves was recorded in the treatment T_7 (combined spray of bio-stimulants at lower doses) whereas the least number was registered in T_9 (control). Overall all the plant growth parameters such as plant height, number of branches and number of leaves were higher at combinations of bio-stimulants at lower concentrations than at either combination at higher concentrations or individual spraying of bio-stimulants.

Effect of bio-stimulants on leaf area and leaf area index (LAI)

All treatments showed increasing trend of leaf area at both the stages of growth. Treatment T_7 with combined spray of bio-stimulants at lower concentrations (2% Panchakavya + 0.2% Humic Acid + 2% Moringa Leaf Extract) registered significantly higher maximum leaf area at 60 and 90 DAP respectively. This was followed by combined spraying of bio-stimulants at lower concentrations. T_8 (4% Panchakavya + 0.4%Humic Acid + 4% Moringa Leaf Extract) comparatively recorded higher leaf area at both the stages of crop growth than their respective individual spray at similar concentrations. The treatment T_9 [Control-water spray] registered the minimum leaf area at both the stages of crop growth. Similar trend was noticed for leaf area index (LAI) also.

Effect of bio-stimulants on fresh and dry herb weight per plant

Fresh herb weight recorded at two different growth stages was significantly influenced by different bio-stimulant application. The highest fresh herb weight of 8.45 g per plant and 25.35 g per plant at 60 and 90 DAP was recorded from the treatment T_7 which contained combination of three bio-stimulants. This was followed by T_1 (Panchakavya @ 2 per cent foliar application) which was on par with T_2 and T_3. The next best fresh herb weight was recorded by T_8. This was followed by T_4 (Panchakavya @ 4 per cent foliar application) which was on par with T_5 and T_6. The lowest fresh herb weight was obtained in the

Table 1. Effect of different bio stimulants and their combinations on growth parameters of kalmegh at 60 days after planting

Treatment	Plant height (cm)	Number of branches per plant	No. of leaves per plant	Leaf area (cm^2 $plant^{-1}$)	Leaf area index	Fresh herb weight ($g\ plant^{-1}$)	Dry herb weight ($g\ plant^{-1}$)
T_1-2% Panchakavya	27.41	7.86	48.23	205.12	0.456	7.95	2.70
T_2-0.2%Humic Acid	27.13	7.96	48.02	204.36	0.454	7.92	2.66
T_3-2% Moringa Leaf Extract	27.22	7.89	48.09	205.01	0.456	7.90	2.55
T_4-4% Panchakavya	25.70	6.69	46.21	195.31	0.434	6.96	1.90
$T_{50.}$- 0.4%Humic Acid	25.64	6.75	46.02	194.25	0.432	6.69	1.83
T_6-4% Moringa Leaf Extract	25.33	6.79	45.97	194.39	0.432	6.85	1.87
T_7- T_{1+} T_{2+} T_3	28.13	8.31	49.23	210.33	0.467	8.45	3.23
T_8- T_{4+} T_{5+} T_6	26.44	7.25	47.11	200.03	0.445	7.43	2.07
T_9-Control	22.70	5.76	43.87	188.35	0.419	6.19	1.50
SE (d)	0.215	0.168	0.357	1.889	-	0.184	0.215
CD (P=0.05)	0.456	0.356	0.756	3.998	-	0.390	0.456

treatment T_9 (Control). Similar results were obtained for dry herb weight also at both the stages of observation.

Effect of bio-stimulants on estimated dry herbage yield

Dry herbage yield was recorded at the time of harvest which was significantly influenced by the spraying of different bio-stimulants. The highest dry herbage yield of 1956 kg ha^{1} was recorded from the treatment 2% Panchakavya + 0.2%Humic Acid + 2% Moringa Leaf Extract (T_7) and was significantly differed from other treatments. The lowest value for dry herbage yield per ha was recorded in control. The combined bio stimulant at lower doses spray recorded @ the yield increase of 31.8 per cent over control. Similarly the per cent increase in dry herb yield in combined bio-stimulant spray at higher concentrations (T_8) over control was 17.8 per cent. The difference in dry herbage yield between T_7 and T_8 was 14.0 per cent. The treatments T_1, T_2 and T_3 formed in to one single group and ranked second in order with respect to dry herbage yield and were on par with each other. Similarly the other treatments T_4, T_5 and T_6 formed into another single group next to T_4 and were on par with one another.

Effect of bio-stimulants on benefit: cost ratio

The highest gross income and net income realized in T_7 (2% Panchakavya + 0.2% Humic Acid + 2% Moringa Leaf Extract) resulted in the highest benefit: cost ratio of 2.47. The second highest ratio was recorded by T_3 (2% Moringa Leaf Extract) which was closely followed by T_1 and T_2. The economic analysis revealed that the cost of cultivation was found to be higher for the treatment T_8 due to its higher treatment cost. This led to relatively lower benefit: cost ratio (2.01) in this particular treatment. Similarly individual bio-stimulant spray at enhanced doses also registered lower ratios. Over all the least benefit : cost ratio was recorded in control.

The ultimate goal to be achieved in any crop management aspect is maximization of yield. In the present study the treatments involving Panchakavya, humic acid and moringa leaf

Table 2. Effect of different bio stimulants and their combinations on growth parameters at 90 days after planting, herbage yield and benefit: cost ratio of kalmegh

Treatments	Plant height (cm)	Number of branches	Leaf area (cm^2 $plant^{-1}$)	Leaf area index	Fresh herb weight (g $plant^{-1}$)	Dry herb weight (g $plant^{-1}$)	Estimated dry herbage yield (kg ha^{-1})	Benefit : Cost ratio
T_1- 2% Panchakavya	57.23	21.12	468.36	1.041	23.85	7.16	1789	2.21
T_2- 0.2% Humic Acid	57.36	20.96	466.25	1.036	23.77	7.13	1711	2.16
T_3- 2% Moringa Leaf Extract	56.98	21.05	465.36	1.034	23.69	7.11	1722	2.32
T_4- 4% Panchakavya	53.21	18.53	450.11	1.000	20.89	5.22	1567	1.86
T_5-0.4% Humic Acid	53.04	18.45	449.25	0.998	20.08	5.02	1556	1.80
T_6- 4% Moringa Leaf Extract	52.89	18.36	448.65	0.997	20.56	5.14	1533	1.98
T_7- T_{1+} T_{2+} T_3	59.15	22.32	476.65	1.059	25.35	8.87	1956	2.47
T_8- T_{4+} T_{5+} T_6	54.63	19.80	457.75	1.017	22.30	6.24	1622	2.01
T_9- Control	50.15	15.23	440.12	0.978	18.56	4.13	1333	1.47
SE (d)	0.487	0.737	2.886	-	0.543	0.534	26	-
CD (0.05)	1.032	1.562	6.118	-	1.151	1.132	55	-

extract produced the highest dry herbage yield. Combined application of Panchakavya, humic acid and moringa leaf extract significantly promoted the plant height and enhanced the plant growth *via* higher number of branches and number of leaves. The possible reason for this acceleration of growth might be due to the increased content of nitrogen, the chief constituent of protein, essential for the formation of protoplasm, which leads to cell division and cell enlargement. Panchakavya carries considerable amounts of nitrogen, which would be utilized for the protein synthesis and eventually resulted in stimulated growth. Another possible reason for highest growth character might be due to the growth of enzymes present in bio stimulants, which favored rapid cell division and multiplication. This view was also supported by Ganesh (2004) in Paprika. The effect of humic acid on growth characters of paprika may be due to presence of cytokinin (Cacco and Dell Agnola, 1984) and its effect on prolonged cell elongation.

The increase in the number of branches per plant due to auxins which is present in panchakavya attributed to the activation of cell division and cell elongation in the axillary buds which had a promoting effect in increased number of branches. The application of panchakavya would have induced the endogenous synthesis of native auxins resulting in an early active growth. Interaction with the synthesis of native cytokinins in the root cells and its transport at later stages to axillary buds, there by leading to the formation of more branches. This is quite obvious by the rapid increase in the number of branches of the crop in bio stimulants treated plants as compared to a slower rate of increase in the control. Similar results were obtained by Sridhar (2003) in *Solanum nigrum* with the application of Panchakavya. Application of humic acid also recorded higher plant spread, number of branches and this might be due to the presence and enhanced activity of gibberellins like substances in humic acid as reported by Vaughun *et al.* (1985).

Nitrogen being the essential constituent of protein might have increased the production of leaves associated with the increased leaf area and leaf area index (Maynard *et al.,* 1962).

Leaf area index (LAI) the good measure of plant growth was also found maximum under bio-stimulants spray. Leaf expansion due to the presence of growth regulators such as IAA, GA and cytokinin *etc.,* in Panchakavya might have enhanced the LAI. Similar results made in turmeric by Natarajan (2002).

Dry herbage yield also followed a similar trend as that of LAI. Application of bio stimulants spray had significantly increased the dry herbage yield. High organic matter content, presence of available macro and micronutrients might have contributed or increased the dry herbage yield. This might be due to improved plant height, number of branches, number of leaves, leaf area and LAI. Supportive evidence comes from Sridhar (2003) was reported that application of Panchakavya@ 3% increased the dry matter production ultimately leading to higher yield in *Solanum nigrum.*

The economics of cultivation in the present experiment showed that the bio-stimulants, sprayed at lower concentrations recorded the highest benefit: cost ratio. Higher dry herbage yield of andrographis led to the highest gross returns. Thus from the discussion made so far it is concluded that combined bio-stimulant spraying (2% Panchakavya + 0.2%Humic Acid + 2% Moringa Leaf Extract) at 30 and 60 days after planting was the promoting source of dry herbage yield in andrographis.

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