Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP3: 122-125

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National conference on "Conservation, Cultivation and Utilization of medicinal and Aromatic plants"
(College of Horticulture, Mudigere Karnataka, 2018)

Effect of integrated nutrient management on yield and quality of kalmegh (*Andrographis paniculata* Nees.)

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Abstract
An investigation on "integrated nutrient management in kalmegh (*Andrographis paniculata* Nees.)" was carried out at Kittur Rani Channamma College of Horticulture, Arabhavi (Karnataka) under Ghataprabha Left Bank Command area during the year 2015-16 at Department of Plantation, Spices, Medicinal and Aromatic Crops. The result revealed that maximum plant height (61.13 cm) and plant spread (44.89 and 43.66 cm East-West and North-South, respectively), higher fresh herb yield per hectare (10.39 t) and andrographolide yield (2.25 q) was recorded with the application of 100:75:50 kg NPK per ha + *Azatobacter* (1 q) enriched in FYM (5 t ha^{-1}) + vermicompost 1 t per ha at harvest. There was no significant variation in andrographolide content in plants.

Keywords: growth, yield, quality, days after planting, FYM, NPK

Introduction
Kalmegh (*Andrographis paniculata* Nees.) belonging to the family Acanthaceae is one of the nineteen species of the genus *Andrographis* indigenous to India and has been used in Indian systems of medicine since time immemorial. The fresh and dried leaves of kalmegh and juice extracted from the herb are official drugs in Indian pharmacopoeia. Due to its pharmacological properties, the kalmegh herb is collected indiscriminately from the wild sources causing a sharp decline in the availability of this herb to the industry.

The whole herb is the source of several diterpenoids of which andrographolide is important and is distributed all over the plant body in different proportions as reported in different parts of the world. In India, the entire plant is used to obtain andrograpolide (Randa and Sharma, 1990) [7]. The leaves contain the maximum andrographolide (2.5%), while the stem contains lesser amount (2.0%) of this active principle (Chakravarti and Chakravarti, 1952 Moktader and Sirchar, 1939) [2, 5]. Besides andrographolides, the flavonoids, caffeic acid and chlorogenic acid are also present in this plant. In Japan, its roots are used for extraction of several flavonoids such as andrographidin A, B, C, D, E, F and whose content varies from 0.015 – 0.15 per cent.

Kalmegh forms the principle ingredient of a house hold medicine called `Alui', extensively used in West Bengal for general debility and certain forms of dyspepsia amongst adults and infants. The expressed juice of leaves is prescribed with cardamom, cloves and cinnamon in the form of globules to infants for their relief of bowel complaints, irregular stools and loss of appetite. The plant is considered to be highly efficacious against chronic malaria and often used as substitute for *Swertia chirata.*

The modern and intensive agriculture calls for the heavy dependence of fertilizers and chemicals, which are not only costly but also cause soil and water pollution. It is, therefore, necessary to supply the plant nutrition in an integrated way. Hence, the present experiment was taken up to study the growth, yield and andrographolide content of the crop under the influence of integrated nutrients.

Material and Methods
The experiment was carried out in the experimental field of the Department of Plantation, Spices, Medicinal and Aromatic crops, Kittur Rani Channamma College of Horticulture, Arabhavi, Belgaum district, Karnataka. The soil of the experimental site is comprised of sandy

loam soil. Soil samples were collected from a depth of 10-15 cm from the experimental site adopting the standard procedure. The experiment was laid out as Randomized Block Design (RBD) with three replications.

Treatment Details

- Season: *Kharif* 2015

The details of the factors under study in the experiment are given below.

- T_1: 75:75:50 kg NPK per ha + FYM at10 t per ha. (Check)
- T_2 : 100: 75: 50 kg NPK per ha + FYM (5 t ha^{-1})
- T_3 : T_1 + *Azatobacter* (2 q) enriched in FYM (10 t ha^{-1})
- T_4 : T_2 + *Azatobacter* (1 q) enriched in FYM (5 t ha^{-1})
- T_5 : T_3 + Vermicompost (1 t ha^{-1})
- T_6 : T_3 + Poultry manure (1 t ha^{-1})
- T_7 : T_4 + Vermicompost (1 t ha^{-1})
- T_8 : T_4 + Poultry manure (1 t ha^{-1})

Forty five days old healthy, uniform sized seedlings were selected and transplanted to the main field at all the stages of planting at a spacing of 30 cm between rows and 15 cm between the plants. Full dose of FYM (farm yard manure), vermicompost, poultry manure and *Azatobacter* enriched in FYM were applied one week before sowing and mixed well with soil. Nitrogen, phosphorus and potash were applied in the form of urea, single super phosphate (P_2O_5) and muriate of potash (K_2O), respectively. Nitrogen was applied in two split doses. Before transplanting, 50 per cent nitrogen and full dose of phosphorus and potassium were applied to plots at 7-10 cm depth in the lines and the remaining 50 per cent of nitrogen was top dressed at 45 days after sowing (DAS). The crop was harvested 4 months after planting (120 DAP) at full flowering stage. While harvesting, the whole plants were cut at 15 cm above the ground level and dried under shade for 3-4 day before storing.

Growth parameters were recorded at 40, 80 DAP and at harvest (120 DAP) from randomly selected 5 plants. The height of the plants was measured from the ground level to the tip of the plant with the help of meter scale and the average value of five plants was computed and recorded and was expressed in centimeter (cm). The East- West and North-South spread of the plants was recorded. The average was worked out and expressed in centimeter. The fresh yield per hectare was estimated on the basis of fresh yield per plot and it was reduced by 10 per cent considering path, irrigation channels in the field. The fresh yield per hectare was expressed in terms of tonnes.

Andrographolide in kalmegh was estimated by using HPLC and expressed in percentage (%). The procedure includes the following. The plant material were extracted by cold maceration using methanol which was kept overnight and sonicated using ultra sonicator (Revotek), the extract was filtered and stored at 4 °C until further use. The extracts were diluted to 0.5 per cent for ultra-performance liquid chromatography (UFLC) analysis.

The reversed phase UFLC photo diode array (RP-UFLC-PDA) analysis was performed on Shimadzu chromatographic system (Model no. LC-20AD) consisting of a quaternary pump, manual injector, degasser (DGU-20A5) and dual λ UV absorbance diode array detector SPD-M20A. The built in LC-Solution software system was used for data processing. Chromatographic separation was achieved on Waters Nova – pak RP C_{18} column (5 □m, 4.6 x 250 mm). The system suitability test was assessed by three replicates of standards' solution at a particular concentration (5, 10 and 25 µg ml^{-1}). The peak areas were used to evaluate repeatability of the method, and analyzed for resolution and tailing factors. The limit of detection (LOD) and limit of quantification (LOQ) were determined with the signal: noise method. Signal: noise ratios of 3.3 and 10 were used for estimating the LOD and LOQ, respectively.

Calculations, calibration curves and linearity: The standard was accurately weighed and dissolved in methanol to prepare each 1000 PPM solution. The solution standard was mixed to prepare stock solution for simultaneous detection and serially diluted with methanol to obtain working concentrations for plotting calibration curves. Seven different concentration levels of mixed stock solution (5, 10, 25, 50, 100, and 250 µg ml^{-1}) were used during the study.

Table 1: Plant height as influenced by integrated nutrient management at different stages of crop growth in kalmegh (*Andrographis paniculata* Nees.)

Treatments	Plant height (cm)		
	40 DAP	80 DAP	At harvest (120 DAP)
T_1 : 75:75:50 kg NPK ha^{-1} + FYM at10 t ha^{-1} (Check)	16.96	36.90	41.17
T_2 : 100: 75: 50 kg NPK ha^{-1}+ FYM (5 t ha^{-1}).	19.18	39.67	42.87
T_3 : T_1 + *Azatobacter* (2 q) enriched in FYM (10 t ha^{-1})	27.33	38.97	44.67
T_4 : T_2 + *Azatobacter* (1 q) enriched in FYM (5 t ha^{-1})	26.95	40.90	45.67
T_5 : T_3 + Vermicompost (1 t ha^{-1})	28.60	41.70	52.50
T_6 : T_3 + Poultry manure (1 t ha^{-1})	30.97	41.47	56.43
T_7 : T_4 + Vermicompost (1 t ha^{-1})	34.87	57.93	61.13
T_8 :T_4 + Poultry manure (1 t ha^{-1})	33.60	53.17	58.47
SEm ±	1.00	2.14	1.41
CD at 5%	3.04	6.51	4.28
CV %	11.02	14.68	8.40

DAP = Days after planting

Table 2. Plant spread (East-West and North-South) as influenced by integrated nutrient management at different stages of crop growth in kalmegh (*Andrographis paniculata* Nees.)

Treatments	East-West (cm)			North-South (cm)		
	40 DAP	80 DAP	At harvest (120 DAP)	40 DAP	80 DAP	At harvest (120 DAP)
T_1 : 75:75:50 kg NPK ha^{-1} + FYM at10 t ha^{-1} (check)	17.07	24.73	35.07	14.87	21.35	29.99
T_2 : 100: 75: 50 kg NPK ha^{-1}+ FYM (5 t ha^{-1}).	17.53	25.87	35.93	15.18	22.17	32.27
T_3 : T_1 + *Azatobacter* (2 q) enriched in FYM (10 t ha^{-1})	18.90	26.67	37.00	17.13	23.59	33.33
T_4 : T_2 + *Azatobacter* (1 q) enriched in FYM (5 t ha^{-1})	19.20	28.97	38.57	17.29	23.92	34.00
T_5 : T_3 + Vermicompost (1 t ha^{-1})	21.63	29.83	40.97	18.51	25.89	35.05
T_6 : T_3 + Poultry manure (1 t ha^{-1})	22.13	30.07	40.03	18.30	25.63	35.01
T_7 : T_4 + Vermicompost (1 t ha^{-1})	24.37	33.97	44.89	22.80	30.46	43.66
T_8 :T_4 + Poultry manure (1 t ha^{-1})	23.53	33.20	44.15	22.53	30.07	42.69
SEm ±	0.89	0.95	0.93	0.62	0.65	1.16
CD at 5%	2.70	2.87	2.81	1.87	1.97	3.52
CV %	13.01	9.74	7.02	10.08	7.66	9.75

DAP = Days after planting

Table 3. Fresh herbage yield, Andrographolide content and androgapholide yield as influenced by integrated nutrient management in kalmegh (*Andrographis paniculata* Nees.)

Treatments	Fresh herb yield Per hectare (t)	Andrographolide content (%)	Anrographolide yield (q ha^{-1})
T_1 : 75:75:50 kg NPK ha-1 + FYM at10 t ha^{-1} (Check)	8.11	3.92	1.57
T_2 : 100: 75: 50 kg NPK ha-1+ FYM (5 t ha^{-1}).	8.33	4.03	1.71
T_3 : T_1 + *Azatobacter (*2 q) enriched in FYM (10 t ha^{-1})	8.51	3.35	1.62
T_4 : T_2 + *Azatobacter* (1 q) enriched in FYM (5 t ha^{-1})	8.70	3.08	1.49
T_5 : T_3 + Vermicompost (1 t ha^{-1})	9.04	3.49	1.84
T_6 : T_3 + Poultry manure (1 t ha^{-1})	8.76	3.55	1.66
T_7 : T_4 + Vermicompost (1 t ha^{-1})	10.39	3.73	2.25
T_8 :T_4 + Poultry manure (1 t ha^{-1})	10.05	3.14	1.99
SEm ±	0.27	0.15	0.08
CD at 5%	0.82	NS	0.26
CV %	9.02	12.60	14.36

NS = Non-significant

Result and Discussion

The plant height was significantly influenced by integrated source of nutrients at all the stages of crop growth (Table 1). The maximum plant height was found with plants provided 100:75:50 kg NPK per ha + *Azatobacter* (1 q) enriched in FYM (5 t ha^{-1}) + vermicompost 1 t per ha (T_7) and 100:75:50 kg NPK per ha + *Azatobacter* (1 q) enriched in FYM (5 t ha^{-1}) + poultry manure 1 t per ha (T_8) (61.13 and 58.47 cm, respectively) which were on par with each other at 120 days after planting. Increase in plant height could be attributed to balanced dose of NPK nutrients along with vermicompost and *Azatobacter*. The maximum plant height may also be due to creation of favourable environment by FYM, *Azatobacter* and vermicompost around rhizosphere which helps in better availability and uptake of nutrients by plants. Similar results of increased plant height due to combined application of bio-fertilizer, vermicompost and inorganic fertilizers have been reported by Hemalatha and Suresh (2012) [3], Mishra and Jain (2014) [4] in kamegh.

At harvest, maximum plant spread (44.89 and 43.65 cm, East-West and North- South, respectively) was recorded in T_7. This increased plant spread might be due to increased number of branches and leaves. This is because of crop requirement of major nutrients was met through this treatment. The addition of *Azatobacter*, FYM and vermicompost along with inorganic fertilizers might have helped in release and uptake of macro and micro nutrients, which are essential for the growing plants. These findings are in agreement with the results reported by Srinivas *et al*. (2008) [9] and Nadukeri (2006) [6] in medicinal coleus.

Fresh herbage yield per plant, per plot and per hectare differed significantly due to integrated nutrient management. Application of 100:75:50 kg NPK per ha + *Azatobacter* (1 q) enriched in FYM (5 t ha^{-1}) + vermicompost 1 t per ha (T_7) resulted in production of maximum fresh herbage weight per hectare (10.39 t) which was on par with T_8, while minimum fresh herbage weight per hectare (8.11 t) was observed in control (T_1). The reason for the increased herbage yield might be due to FYM and vermicompost aiding mineralization of immobalized nutrients. Increased dosage of 'N' helps the plant for luxuriant vegetative growth by causing synthsized photosynthates to get metabolically converted into protein and there by adding to production of more vegetative tissues. The phosphorous, a constituent of DNA and RNA, plays a significant role in metabolic process of plants. 'K' aids in the effective converstion of photosynthates for the better growth and ultimately yield of the plant. Finally, *Azatobacter* increases the photosynthetic rate, nitrogen reductase activity, glutamine synthetase activity and chlorophyll content. The results are in conformity with the findings of Hemalatha and Suresh (2012) [3], Sanjutha *et al.* (2008) [8] in kalmegh.

Andrographolide content (%) was found to be non significant. However, significantly higher andrographolide yield per hectare (2.25 q) was recorded in T_7 (100:75:50 kg NPK ha^{-1} + *Azatobacter* (1 q) enriched in FYM (5 t ha^{-1}) + vermicompost 1 t ha^{-1}) which was on par with T_8. This is attributed to improvement in plant growth and yields due to sustained availability of all required plant nutrients and enzymes for crop growth as well as for accumulation of secondary metabolites in plants. These findings are line with the findings of Arpana and Bagyaraj (2007) [1] in kalmegh.

Acknowledgement
I express my deep sense of gratitude to Mr. J. S. Hiremath, Assistant Professor, Department of Plantation, Spices, Medicinal and Aromatic crops, KRCCH, Arabhavi and Chairman of my Advisory Committee for his scholarly guidance, constant supervision and inspiring encouragement throughout the period of my investigation

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