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Effect of different weed control technique on weed persistence and yield attributing characters of kalmegh (*Andrographis paniculata* Nees)

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Abstract
Medicinal and aromatic plants are major crops of domestic and industrial interest but a limiting factor in medicinal and aromatic crop production is weed interference. Weed infestation is one of the major constraints in kalmegh cultivation. Field experiments were conducted at Medicinal Plants Research and Development Centre (MRDC), G.B. Pant University of Agriculture and Technology, Pantnagar in 2015, to study the Effect of different weed control technique on weed persistence and yield attributing characters of kalmegh (*Andrographis paniculata* Nees). The treatments were Pre (Pendimethalin) and PoE (Quizalofop ethyl) herbicide, mechanical weeding, straw mulch, hand weeding along with Weedy check and weed free. All type of weeds (grassy, broad leaved and sedges) presented in experiment field. Weeds were effectively controlled by hand weeding than any other methods of weed control. Maximum dry matter accumulation per plant and other growth factors were observed in weed free treatment.

Keywords: Medicinal, aromatic, pendimethalin, and quizalofop ethyl, weeding and interference

1. Introduction
Medicinal and aromatic plants play important role in Indian economy and dealing with different botanical, agronomic, and industrial features, endowed with specific properties that, in general terms, make them useful in therapy or prevention of diseases. (Carrubba *et al.* 2008 and Diederichsen 1996) [1, 2]. Kalmegh (*Andrographis paniculata* Nees) is a medicinal crop that has been effectively used in Asian medicines for centuries. Kalmegh belongs to family Acanthaceae. This plant is known as "Maha tita" which literally means "king of bitter". The genus *Andrographis* consists of 40 species and out of these, 19 species are reported to be available in India. Weed infestation is the major constraint for cultivation of medicinal plants in the country. The losses caused by weeds exceed the losses from any other category of agricultural pests, such as insects, nematodes and rodents. Among the total annual losses of agricultural produce from various pests, weeds account for 45% (Rao, 2000 and Singh *et al.* 1995) [3, 4]. Kalmegh is a short duration crop and grown for medicinal purpose in *kharif* season and thus weed infestation is very high in this crop. Weeds deteriorate the quality and quantity of kalmegh, so weed management is very essential for maintaining the herbage yield and quality of plant. Hand weeding is not feasible due to unavailability of labour so use of herbicide is another important economical way for control of weeds.

2. Methods and Materials
2.1 Experiment site
To investigate the effect of integrated weed management practices on nutrient content and uptake by weeds and kalmegh (*Andrographis paniculata* Nees) during kharif 2015. The experiment was conducted at the Medicinal Plants Research and Development Centre, GB Pant University of Agriculture and Technology, U.S. Nagar (Uttarakhand) while analytical work was carried out in the Laboratory. The experimental site was located at 79.5° E longitudes and 29° N latitude with average annual rainfall of 1420 mm. The soil of the experimental area was silty clay loam in texture being low in available nitrogen (215.76 kg ha^{-1}), high in available phosphorus (29.38 kg ha^{-1}), medium in available potassium (231 kg ha^{-1}) and high organic carbon (0.88%) contents with near neutral in reaction (pH 7.3). The gross and net plot sizes were 6 m x 4.8 m and 3.6 m x 2.8 m, respectively.

The kalmegh variety 'CIM-Megha' was sown at 40cm X 30 cm spacing on 15 July of year 2015. The experiment, comprisings of ten treatments in randomized complete block design with three replications.

2.2 Experimental design and details of treatments

The experiment, comprising of ten treatments, and replicated thrice in randomized complete block design. The data recorded for each parameter were subjected to analysis for variance for Randomised Block Design with the help of OPSTAT programme developed by the CCSHAU, Hissar. Data were analysed using the software automatically and the analysed data were presented in the tables.

Table 1: Treatment details of the experiment

S. No	Treatment	Treatment details
1.	T_1	Pendimethalin PE @ 1 kg a.i. ha^{-1} followed by mechanical weeding by hand hoe at 30-35 DAT
2.	T_2	Quizalofop ethyl PoE at 3-5 leaf stage of weeds @ 50 g a.i. ha^{-1} followed by mechanical weeding by hand hoe at 30-35 DAT
3.	T_3	Pendimethalin PE @ 1 kg a.i. ha^{-1} + Quizalofop ethyl PoE at 3-5 leaf stage of weeds @ 50 g a.i. ha^{-1}
4.	T_4	Pendimethalin PE @ 1 kg a.i. ha^{-1} + Quizalofop ethyl PoE at 3-5 leaf stage of weeds @ 50 g a.i. ha^{-1} followed by mechanical weeding by hand hoe at 30-35 DAT
5.	T_5	Pendimethalin PE @ 1 kg a.i. ha^{-1} + straw mulch @ 3 t ha^{-1}
6.	T_6	Pendimethalin PE @ 1 kg a.i. ha^{-1} + straw mulch @ 5 t ha^{-1}
7.	T_7	Two hand weedings at 15-20 and 30-35 DAT
8.	T_8	Three hand weeding at 15-20, 30-35 and 45-50 DAT
9.	T_9	Weedy check
10.	T_{10}	Weed free

PE = pre-emergence, @ = at the rate, a.i. = active ingredient, ha = hectare, DAT = days after transplanting, PoE = post-emergence,

2.3 Observations

The crop was harvested at 90 days after transplanting in the field. The observation on plant height, number of branches per plant and number of leaves per plant were recorded from three tagged plants in observation row at 30, 60 and 90 DAT (harvest). The plant height was measured from the ground surface to the tip of the longest leaf with the help of meter scale and expressed in cm at various growth stages. The primary, secondary and tertiary branches bearing pairs of fully developed leaves were counted and recorded as total number of branches per plant. The large, medium and small leaves were counted and recorded as total number of leaves per plant at various growth stages *i.e.* 30, 60 and 90 DAT (harvest). The three plants from the sampling row were cut near to the soil surface excluding roots and then dried in sun and subsequently into oven at 70 ^{0}C till constant weight were obtained and then dry weight was recorded by weighing machine at various growth stages. Total number of the functional leaves obtained from the plant sampled for dry matter studies were graded into three sizes (small, medium and large) and representative leaf from each category was taken for measurement with the help of leaf area meter. The total leaf area of individual category multiplied by the total number of leaves in that category gave the total leaf area.

3. Results and Discussion

3.1 Weed persistence in crop field

Weed infestation is one of the major constraints in kalmegh cultivation. The weeds were collected from the experimental area and identified and classified into broad leaved, grassy and sedge. The details regarding the botanical name, English name, local name, family and duration of life cycle of these weeds are presented here Upadhyay *et al.* (2011) [5]. Out of various weed group identified, sedge weeds were most predominant at 30 DAT accounting about 44.03 per cent of total weed population, but broad leaved weeds were most predominant under weedy check treatment accounting for 40.10 and 39.65 per cent of total weed population at 60 and 90 DAT (harvest), respectively.

Table 3.1: Weed flora of the experimental field during *Kharif* season, 2015

Botanical name	English name	Local name	Family	Life cycle
Grassy weeds				
Cynodon dactylon (L.)	Bermuda grass	Dub ghas	Poaceae	Perennial
Dactyloctenium aegyptium (L.)	Crowfoot grass	Makra	Poaceae	Annual
Digitaria sanguinalis (L.)	Crab grass	Tackri ghas	Poaceae	Annual
Eleusine indica (L.)	Goose grass	Mandua ghas	Poaceae	Annual
Broad leaved weeds				
Cleome viscosa (L.)	Tick weed	Hulhul/bagra	Capparaceae	Annual
Celosia argentea (l.)	Cock's comb	Murga	Amaranthaceae	Annual
Parthenium hysterophorus (L.)	Congress grass	Gajar ghas	Asteraceae	Perennial
Ageratum conyzoides (L.)	Bill goat weed	Mahakaua	Asteraceae	Annual
Trianthema monogyna (L.)	Carpet grass	Patharchatta	Aizoaceae	Annual
Sedge weeds				
Cyperus rotundus (L.)	Purple nutsedge	Motha	Cyperaceae	Perennial

3.2 Plant height

Plant height increased with increasing crop age and reached maximum at harvest. Plant height varied significantly due to different weed management treatments at various stages of crop growth. Initially, up to 30 DAT, the plant height increased at slower rate, thereafter, the rate increased and reached its peak between 30 to 60 DAT. Growth rates decreased gradually between 60 to 90 DAT. At all stages of crop growth maximum plant height was recorded in weedy check treatment Yucel (2013) [6]. Plant height increase with

increasing in plant population due to competition for light, resulted in taller plants. Statistically no significant difference was observed in plant height if increased straw mulch from 3 t/ha to 5 t/ha.

3.3 Number of leaves and branches per plant

In general, the number of leaves and branches per plant increased as the advanced stage of crop growth. The significant difference was obtained in number of leaves and branches per plant due to different weed management treatments. At all stages of growth maximum number of leaves and branches per plant was obtained under weed free treatment which was significantly higher than all other treatments, except T_8 (Three hand weeding). It was mainly due to less weed population in these treatments, which provide more space for spread of plants resulted in increased number of branches per plant. Similar results were also found by Wagner and Nadasy (2006). The weeds were effectively controlled through mechanical weeding than herbicide. If increasing straw mulch from 3 t/ha to 5 t/ha then increase number of leaves and branches per plant. It was mainly due to mulch had positive effect on weed control where weed was amply present.

3.4 Leaf area per plant

Leaf area per plant increased with advanced stage of crop growth and maximum leaf area per plant was observed at 90 DAT. Maximum leaf area per plant was observed in weed free treatment than all other treatments. It was mainly due to weeds were effectively controlled by repeated hand weedings in this treatment, resulted in favourable environment provided for plant growth, that leads to increasing the leaf area per plant.

Table 3.2: Plant height (cm), Number of leaves per plant and Leaf area pre plant (cm^2) as influenced by different weed management treatments at various stages of crop growth

Treatments	Plant height (cm)			Number of leaves per plant			Leaf area per plant (cm^2)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1	24.327	41.000	45.997	98.66	218.66	359.00	589.66	934.66	2,147.66
T_2	17.663	33.667	41.440	85.33	211.33	336.33	540.33	788.00	2,001.00
T_3	32.443	52.330	50.663	77.66	115.66	291.66	501.66	710.33	1,412.66
T_4	34.327	54.330	58.217	102.33	245.00	371.33	824.33	1,881.33	3,525.33
T_5	29.333	41.333	51.997	79.00	117.33	290.66	501.33	753.00	1,624.00
T_6	29.443	45.440	55.887	81.66	130.00	292.00	531.66	973.66	2,006.66
T_7	30.220	50.773	57.107	101.66	225.00	369.66	698.66	1,481.33	2,407.00
T_8	35.107	51.660	59.107	107.33	265.33	379.33	831.66	2,512.00	3,673.00
T_9	41.327	56.550	65.220	77.33	105.33	254.00	497.00	625.00	1,347.66
T_{10}	36.550	53.217	61.997	110.66	312.00	385.33	876.33	4,069.66	4,733.66
SE(m)±	1.686	2.870	3.045	4.34	9.917	50.74	33.03	106.01	129.11
CD (P=0.05)	5.047	8.595	9.118	13.01	29.69	N/A	98.91	317.43	386.57

T1-Pendimethalin PE @ 1 kg a.i. ha-1 + mechanical weeding at 30-35 DAT, T2-Quizalofop ethyl PoE @ 50 g a.i. ha-1 + mechanical weeding at 30-35 DAT, T3- Pendimethalin PE @ 1 kg a.i. ha-1 + Quizalofop ethyl PoE @ 50 g a.i. ha-1, T4-Pendimethalin PE @ 1 kg a.i. ha-1 + Quizalofop ethyl PoE @ 50 g a.i. ha-1 + mechanical weeding at 30-35 DAT, T5-Pendimethalin PE @ 1 kg a.i. ha-1 + straw mulch @ 3 t ha-1, T6-Pendimethalin PE @ 1 kg a.i. ha-1 + straw mulch @ 5 t ha-1, T7- Two hand weeding at 15-20 and 30-35 DAT, T8-Three hand weeding at 15-20, 30-35 and 45-50 DAT, T9- Weedy check, T10- Weed free

3.5 Dry matter accumulation per plant

Dry matter accumulation per plant increased habitually with advanced of crop age and reached maximum at 90 DAT. Maximum dry matter accumulation per plant was observed in weed free treatment. It was mainly due to effective control of weeds which created favourable environment for plant growth that leads to increased dry matter accumulation per plant. Lowest dry matter accumulation per plant was recorded in weedy check treatment. It was mainly due to unrestrained situation for weeds which created competition for nutrient, solar radiation and space among crop plants and weeds that leads to reduction in dry matter accumulation per plant. Dry matter accumulation per plant was significantly higher in T_8 (Three hand weeding) treatment than T_7 (Two hand weeding) treatment.

Table 3.3: Number of branches per plant and Dry accumulation pre plant (g/plant) as influenced by different weed management treatments at various stages of crop growth

Treatment	Number of branches per plant			Dry matter accumulation per plant (g/plant)		
	30 DAT	60 DAT	90 DAT (harvest)	30 DAT	60 DAT	90 DAT (harvest)
T_1	13.667	27.000	43.333	4.99	27.663	34.69
T_2	12.000	25.333	35.000	3.98	16.000	23.85
T_3	9.333	20.333	30.000	3.54	13.923	22.44
T_4	15.333	32.000	44.667	5.25	31.067	40.18
T_5	10.667	20.000	29.667	2.92	18.000	24.68
T_6	11.333	24.667	33.333	3.38	19.000	29.56
T_7	13.667	28.667	38.667	5.49	24.000	28.34
T_8	15.667	34.333	46.000	5.30	34.500	52.81
T_9	9.000	17.667	22.333	2.60	7.000	10.54
T_{10}	17.333	39.333	51.667	5.72	36.440	59.18
SE(m)±	0.623	1.294	5.430	0.252	0.707	2.40
CD (P=0.05)	1.864	3.874	1.814	0.75	2.116	7.21

T1-Pendimethalin PE @ 1 kg a.i. ha-1 + mechanical weeding at 30-35 DAT, T2-Quizalofop ethyl PoE @ 50 g a.i. ha-1 + mechanical weeding at 30-35 DAT, T3- Pendimethalin PE @ 1 kg a.i. ha-1 + Quizalofop ethyl PoE @ 50 g a.i. ha-1, T4-Pendimethalin PE @ 1 kg

a.i. ha-1 + Quizalofop ethyl PoE @ 50 g a.i. ha-1 + mechanical weeding at 30-35 DAT, T5-Pendimethalin PE @ 1 kg a.i. ha-1 + straw mulch @ 3 t ha-1, T6-Pendimethalin PE @ 1 kg a.i. ha-1 + straw mulch @ 5 t ha-1, T7- Two hand weeding at 15-20 and 30-35 DAT, T8-Three hand weeding at 15-20, 30-35 and 45-50 DAT, T9- Weedy check, T10- Weed free

4. Conclusion

Conclusion of this study suggested that all treatments were found promising in weed control which also showed superior effect on yield contributing characters of crop over unweeded control. Hand weeding give best results to control weeds than herbicides and mulching methods. No significant effect was observed if increase straw mulch from 3 t/ha to 5 t/ha.

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