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Original Scientific Paper

Effects of some growth regulators on oil yield, growth and hormonal content of lemon grass (*Cymbopogon citrates*)

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ABSTRACT: In field trails on lemongrass (*Cymbopogon citrates*), the effect of growth regulators, viz. indole butyric acid (IBA) and mepiquat chloride (MC), and their mode of application was studied to assess their effects on growth, oil yield and hormonal contents. The results suggested that application of growth regulators had no favourable effect on growth and oil yields in lemon grass. However, application of MC decreased endogenous GA and IAA concentrations while IBA increased them.

Key words: Lemongrass, indole butyric acid, mepiquat chloride, phytohormones, oil, yield.

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INTRODUCTION

It is known that oil of *Cymbopogon citrates* Stapf (lemongrass) is one of the most important essential oil-bearing herbaceous species of the Gramineae because of its high citral content of up to at least 75% of the oil (Jayasinha 1999). The oil and citral are both used in the perfumery and soap industries and in the manufacture of synthetic vitamin A.

There are several important aromatic grasses of the genus Cymbopogon, which are cultivated for their essential oils, i.e. lemongrass, palmarosa and citronella java. Aromatic grasses have great potential as agro and social forestry plants and for wasteland reclamation with their proven soil binding properties (Farooqi *et al*. 2000).

Changes in primary metabolic processes due to nutrient or external growth conditions may play an important role in the regulation of secondary metabolism (Singh Sangwan *et al.* 2001). Growth regulators can improve plant growth, development and yield and essential oil quality (Singh-Sangwan *et al.* 2001). Foliar application of triacontanol and mixtalol have been shown to significantly increase yield attributes of rose-scented geranium (Bhatacharya & Rao 1996). Plant growth regulators can also confer plant resistance to abiotic stresses such as drought and osmotic stress (Chatterjee 1995; Zhao & Ooserhuis 1997; Vardhini & Rao 2003). The responses of some aromatic grasses to plant growth regulators have been studied (Farooqi *et al.* 2000; Singh-Sangwan *et al.* 2001).

It is well known that essential oil is derived from mevalonic acid via the isoprene pathway in a manner similar to that for other terpenes. Thus, plant growth regulators that exert their effect at the level of gibberellin metabolism might increase the accumulation of essential oil in plants. Growth retardants such as phosphone D and chlormequat chloride (CCC) which influence gibberellin metabolism have been shown to increase terpene formation resulting in increased essential oil content of peppermint and sage (El-Keltawi & Croteau 1987).

Randhawa *et al.* (1985) reported that application of growth regulators (gibberellic acid or indole acetic acid) did not increase herb and oil yields in *Mentha piperita*. Foliar application of mepiquat chloride (MC) under field conditions reduced excessive vegetative growth of plants. It decreased plant height, leaf area and main stem

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Table 1. Effect of various nitrogen sources on lavender herb (*Lavandula officinalis*) (Mean value of two successive seasons).

Kg N/Fed		Plant height (cm)	Herb fresh wt.				Herb dry wt.			
			g/ clump	Ton/ fed	Relation total yield	Fertilizer efficiency	g/ clump	Ton/ fed	Relation total yield	Fertilizer efficiency
control		19.3	40.9	0.654	100	-	13.5	0.216	100	-
Ammonium sulphate	20	21	65.7	1.051	160.7	1.985	22.4	0.358	165.9	0.71
	40	21.2	43.6	0.698	106.7	0.11	14.9	0.238	110.4	0.055
Ammonium nitrate	20	20.2	58	0.928	141.8	1.37	18.5	0.296	137	0.4
	40	19.7	81.9	1.31	200.2	1.64	27.6	0.442	204.4	0.656
Ammonium cloride	20	20.8	84.9	1.358	207.6	3.52	27.8	0.445	205.9	1.145
	40	18.9	60.5	0.968	148	0.78	21.7	0.347	160.7	0.328
Urea	20	21	56.7	0.907	138.7	1.625	19.7	0.258	119.2	0.21
	40	22.3	91.5	1.464	223.8	2.025	32.5	0.52	240.7	0.76
L.S.Dat 0.05		1.3	5.6	0.183	NS	NS	3.2	0.031	NS	NS

node number (Stuart *et al.* 1984; Zhang *et al.* 1990). Growth responses, flowering quality and active chemical constituents of gladiolus plants were studied by Bedour *et al.* (2011) using some vitamins such as thiamin, ascorbic acid and their combination during two seasons. Plants which received the combined treatments of both vitamins recorded the highest growth, flower quality and cormlet induction.

The use of plant growth regulators is directed towards improving the yield, quality and/or quantity of many crops. Gibberellic acids (GA) are the most important natural growth regulators in use. They are used to induce major changes in the growth required to increase the quantity and quality of edible characters, chemical composition and yield criteria of *Hibiscus sabdariffa* L. plants (Rabie 1996). Balbaa *et al.* (2008) investigated the influence of foliar application of stigmasterol and nicotinamide and their combinations on growth, yield and chemical compositions of *Tagetes erecta* plants. Plant height, number of branches, herb fresh and dry weights, number of flowers and fresh and dry weight of flowers were significantly affected by the application of the two bio-regulators. The most pronounced increment was in vegetative growth as well as essential oil content. All treatments significantly increased total nitrogen %. Data also showed a significant increment in essential oil percentage and oil yield.

Consulting the available literature there was no available information concerning the effect of IBA or MC on the growth and oil yield of lemon grass. Therefore the aim of this work was studying the effect of these growth regulator treatments on the growth, oil yield and hormonal content of lemon grass.

MATERIAL AND METHODS

A field experiment was carried out during two successive seasonsat Kalubia Governorat. Uniform plants of lemongrass introduced from the Medicinal and Aromatic plant section, Ministry of Agriculture, ARE were planted. The transplants were individually placed at 50 cm spacings from each other in rows 70 cm apart.

The experimental trials included various treatments of indole butyric acid (IBA, 25, 50 and 100 ppm) and mepiquat chloride (MC, 125, 250 and 500 ppm) that were individually used as foliar spraying 15 and 30 days after transplanting.

The aerial growth parameterswere recorded after 3 and 6 months from transplanting. The essential oil content (%) was determined by the water distillation method on a fresh weight basis. The essential oil yield was obtained by multiplying the content by the harvested fresh weight (g/plant).

For determination of the endogenous hormones activity, samples were obtained three months from transplanting. The plant material was frozen in liquid nitrogen immediately after sampling and kept at -20° until extraction. The extraction procedure of indoles was similar to that described by Stow *et al.* (1968). The extraction procedure of GA was similar to that described by Hayashi *et al.* (1962).

Data were subjected to standard ANOVA and LSDs were determined according to Snedecor & Cochran (1973).

RESULTS AND DISCUSSION

Vegetative characters. Data presented in table 1 show that on both sampling occasions plant height was decreased

Table 2. Effect of various nitrogen sources on volatile oil of (*Lavandula officinalis*) (Mean value of two successive seasons).

Kg N/Fed		Oil% v/w	Oil yield (ml/clump)	Oil yield Kg/fed	Relation total oil yield
control		0.256	0.105	1.68	119.3
Ammonium sulphate	20	0.224	0.147	2.352	167
	40	0.222	0.097	1.552	110.2
Ammonium nitrate	20	0.151	0.088	1.408	100
	40	0.171	0.14	2.24	159.1
Ammonium cloride	20	0.225	0.191	3.056	217
	40	0.216	0.131	2.096	148.9
Urea	20	0.276	0.156	2.496	177.3
	40	0.191	0.175	2.800	198.9
L.S.Dat 0.0		0.031	0.053	0.103	-

Table 3. Effect of various nitrogen sources on macro and micronutrients of lavender herb (*Lavandula officinalis*) (Mean value of two successive seasons).

Kg N/Fed		Concentration							uptake						
		%			ppm				mg/plant			ug/plant			
		N	P	K	Fe	Mn	Zn	Cu	N	P	K	Fe	Mn	Zn	Cu
control		0.47	0.1	1.3	132.4	47.8	58	10.2	63.5	13.5	175.5	357.5	129.1	156.6	27.5
Ammonium sulphate	20	0.61	0.09	1.1	256	47.8	63.8	10.4	136.6	20.2	246.4	1147	214.1	285.8	46.6
	40	0.72	0.11	1.53	200	43.8	82.8	10.2	107.3	16.4	228	596	130.5	246.7	30.4
Ammonium nitrate	20	0.60	0.11	1.23	229.8	48	59.2	12.2	111	20.4	227.5	850.3	177.6	219	45.9
	40	0.58	0.11	1.30	286.8	44.8	50.2	13	160	30.4	358.8	1479	247.3	277.1	71.8
Ammonium cloride	20	0.55	0.14	1.47	143.8	41.2	54.4	16.2	152.9	38.9	408.7	799.5	229.1	302.5	90.1
	40	0.67	0.12	1.31	183.2	42.2	65.4	17.2	145.4	26	284.3	796.1	183.1	283.8	74.6

significantly as a result of IBA or MC treatments, except IBA at 100 ppm which increased significantly the plant height. Concerning the number of tillers per plant, low concentrations of IBA had no pronounced effect, while the highest one caused a significant increase compared with IBA at 50 ppm. On the other hand MC treatments increased the number of tillers/plant, with the maximum (significantly greater than the control) obtained with 250 ppm and 500 ppm during the 1^{st} and 2^{nd} cuts, respectively. The effect of IBA or MC on the number of leaves, shown in table 1, revealed generally that both growth regulators inhibited the number of leaves, especially IBA at 50 ppm compared with the control. Also herb fresh and dry weight/plant were reduced as a result of growth regulator applications. In this respect, IBA was more effective than MC. So, the total yield (1^{st} cut plus 2^{nd} cut) was reduced as a result of foliar application of growth regulators.

From the above results, it could be concluded that IBA or MC had no favourable effect on the growth of lemongrass. Concerning IBA, Krishnamoorthy (1981) and Nissen (1985) reported that the concentration of auxin optimal for stem growth was superoptimal for both lateral buds and roots and consequently the growth of these organs became inhibited at this concentration. Visually, the elongation of the plant organ was linearly proportional to the logarithm of the IAA concentration up to the optimum. Any further growth of plants was inhibited by the exogenous application of auxin as the auxin concentration in these plants was already optimal or near optimal owing to its biosynthesis. Also, Salisbury and Ross (1969) reported that auxin retarded the tillering of grasses to some extent.

The results of MC treatments agree with several investigators such as Cothren *et al.* (1983), Stuart *et al.* (1984) and Zhang *et al.* (1990) who found that MC treatments reduced vegetative growth. The inhibitory action of MC may have been due to reduced GA biosynthesis. So, MC may inhibit the formation of kaurene which is an intermediate in gibberellin biosynthesis from mevalonate.

Essential oil content (%) and yield. Data tabulated in table 2 show that foliar application of growth regulators produced significantly higher oil contents compared with the control except those treated with MC at 125 and 250 ppm during the 1st cut. The maximum level of oil content (%) was obtained at the 2nd cut. Oil content % during the 1st cut was higher than those obtained during the 2nd one. This may be due to the environmental conditions i.e., air temperature and light during the season.

Concerning the oil yield/plant, growth regulators had no favourable affect except for MC at 500 ppm during the 2nd cut which gave the maximum mean oil yield/plant compared with other treatments.

The results in table 1 and 2 demonstrate the negative correlation between fresh or dry weight and essential oil content (%). An inverse correlation between growth and secondary product formation was also shown clearly in cells of *Catharanthus roseus* where the alkaloids accumulated to the highest level in slow-growing, stationary phase cells. A similar inverse correlation was demonstrated for rosmarinic acid production in cells of *Anchusa officinalis* (De-Eknamkul & Ellis 1984), and by tropane alkaloid accumulation in a number of solanaceous species (Lindsey & Yeoman 1983a). In this connection, it was suggested that growth rate itself is the possible determining factor in secondary product formation, by allowing a diversion of precursors from primary pathways (associated with rapid growth) to secondary pathways (associated with slow growth) (Lindsey & Yeoman 1983b).

Endogenous hormonal content. GA and IAA concentrations in lemongrass plants treated with different levels of MC and IBA are shown in table 3. MC treatments decreased endogenous GA in plants. Decreases were 36% and 54% compared with the control for plants treated with 125 and 500 ppm MC, respectively. However, the content of IAA in plants treated with MC was slightly less than in control plants. Decreases were 9% and 15% for plants treated with 125 and 500 ppm MC, respectively.

Table 3 shows that IBA treatment increased endogenous GA concentrations in plants by 10% and 23% compared with the control for plants treated with 25 and 100 ppm, respectively. IAA concentrations in plants treated with IBA were also higher than those in the control by 6% and 15% for plants treated with 25 and 100 ppm IBA, respectively.

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REZIME

Uticaj nekih regulatora rastenja prinos ulja i hormonalni status *Cymbopogon citrates*

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Uticaj regulatora rastenja IBA i MC i načina njihove primene parćen je kod *Cymbopogon citrates*. Praćen je efekat na razvoj, sadržaj ulja i hormonalni status. Primena regulatora nije dala značajnije pozitivne rezultate na prinos. Ipak, primećeno je da primena MC snižava endogeni sadržaj GA i IAA, dok IBA utiče na povećanje endogenog GA i IAA kod *C. citrates*.

Ključne reči: *Cymbopogon citrates*, IBA, MC, fitohormoni, ulja, prinos