Annals of Plant and Soil Research 20(3): 223–227 (2018)

Response of phenology and zinc on herbage, essential oil yield and its constituents in *Cymbopogon martinii* grown under Inceptisols of Jammu, (J&K)

***RENU GUPTA AND S.CHANDRA[1]**

Division of Soil Science and Agricultural Chemistry, FOA, SKUAST-J, Chatha, Jammu (J&K)

Received May, 2018; Revised accepted: August, 2018

ABSTRACT

An experiment was conducted to study the response of phenology and zinc on herbage, essential oil yield and its constituents in Cymbopogon martinii during kharif seasons of 2011 and 2012 at research farm of Indian Institute of Integrative Medicine Jammu. Results revealed the presence of geraniol % and geranyl acetate % as major constituents in the essential oil of Cymbopogon martinii wats(var. motia) through GLC technique. Leaf production was quantified as phyllochron which revealed that 786.01 degree days were required for production of mature single leaf irrespective of zinc application. The application of zinc as $ZnSO_4$ through soil application was optimized as 45 kg ha^{-1} for obtaining maximum biomass, oil yield and geraniol content. The total oil content of Cymbopogon martinii reached its maximum towards the senescence of older leaves with ≥ 95% flowering. The geraniol % was highest in the leaf, though geranyl acetate was highest in the inflorescence at this stage. The geraniol% is maximum in the leaf at ≥ 95% flowering,The herbage and oil yield increased by 5.53% and 32.65% respectively at optimized zinc dose. The geraniol % was increased by 3.93% whereas geranyl acetate increased by 24.35%. Thus, the crop should be harvested at the end of blooming (95% flowering) and senescence of older leaves to get the maximum oil yield and the highest % of total geraniol in the oil with application of zinc sulphate.

Key words: *Cymbopogon martini*, zinc, phyllochron, geraniol%, senescence, phenology

INTRODUCTION

Total geographical area of J&K is 101387 sq.km, out of which total wasteland area is 7375438sq. km (72.75%). Jammu district alone occupies 336.59 sq.km out of total geographical area of 3097 sq.km (10.87%). The only feasible alternative is to utilize these waste lands by growing other potential crops. Palmarosa is one among them, belongs to family Poaceae and has about 780 genera and 12,000 species (Christenhusz and Byng, 2016). It is important source of essential oils for the flavour and fragrance industries worldwide and is also noted forits medicinal potential (Prashar *et. al*., 2003). It is perennial densely tufted grass attaining height of 3 meter having 50 cm long and lanceolate leaf blade. Geraniol and geranyl acetate are the main constituents of palmarosa oil, constituting about 95% of the total oil. Yield of geraniol is about 65-90% in the wasteland including alkali soils (Akhila *et al.*, 1984 and Smitha and Rana, 2015). Efforts have been made to quantify phyllochron, and response of phenology and zinc on herbage, essential oil yield and its constituents in *Cymbopogon martinii* grown under inceptisols of Jammu, J&K.

MATERIALS AND METHODS

Plant material and study site

The germplasm of *Cymbopogon martinii* was collected from wastelands of subtropical regions of Jammu and planted vegetatively through tussocks at Research Farm of Indian Institute of Integrative Medicine. The experiment was laid out in randomized block design. The soil was sandy loam in texture with neutral pH 6.9 (1:2.5 soil to water); organic carbon 7.6g kg^{-1}; cation exchange capacity 10.3cmol (p+) kg^{-1}; available N, P and K 208, 15.2 and134 kg ha^{-1} respectively. The five doses of zinc as control, 15, 30,45 and 60 Kg $ZnSO_4$ ha^{-1} were tested through soil application. All doses of zinc, 40 kg P_2O_5 30 kg K_2O ha^{-1} were applied as basal dose and remaining 40 kg N ha^{-1} was applied after 30 days of planting. The treatments were replicated four times in randomized block design. The seedlings of palmarosa were planted in July, 2011 and 2012 at 45x 45 cm distance and irrigated with tube well water to establish them and later on treatments were given as and when needed. Ten plants per replication were harvested (treatments) at different phenophases for recording of morphoeconomic parameters

[1]*Indian Institute of Integrative Medicine, Canal Road, Jammu- 180001, J&K*
*Corresponding author: e-mail.*guptarenu_2001@yahoo.com*

along with determination of essential oil yield $plant^{-1}$ and essential oil quality as percent geraniol and geranyl acetate were optimized for various doses of zinc as $ZnSo_4$.

Isolation of essential oils: The essential oils were obtained from the aerial parts of the plant by hydrodistillation method using a Clevenger – type apparatus. Triplicate distillate was performed in succession for each sample of 500g of fresh herbage at each leafing stage / growth stage. Oils obtained at each growth stage were dried over anhydrous Na_2SO_4 and stored at 4 ° C for chemical analysis.

Analysis of essential oils: The chemical composition of the oil was analysed by GLC using a Perkin Elmer 3920 gas chromatograph equipped with TCD and a 2m × 1/8" S.S column packed with k-20 M. Hydrogen gas was used as carrier at a flow rate of 25 ml/ mt and the isothermal operation was performed at 145°. The peaks were compared with those produced by authentic samples.

Degree days (ºC days): Sum of average daily ambient temp. minus the base temp. 5ºC during the growth period. (Chakravarty and Sastry, 1983).

Phenology: Phenological stages were monitored throughout the growing season and final leaf counts based on the scale were made from 3 leaf to 6.1 leaf on the main culm (Haun, 1973).

Phyllochron: It was quantified as regression coefficient (b) between the leafing and degree days to describe the requirement of degree days to describe the requirement of degree days (Pedersen *et al.*, 1991) for the production of mature leaf during the successive growth stages. Validation of the model was done by calculating the correlation coefficient (r) value (Panse and Sukhatme, 1957) between estimated and calculated value of degree days during the phenophases and its significance was tested at 5% probability level.

RESULTS AND DISCUSSION

Phyllochron

Leaves are the main source of essential oil production. For quantification of phyllochron (degree days/leaf) a linear regression equation was made which exhibited that 776.01 degree days were required for the production of single leaf on the tiller(Table 1.) Validation of the model was done by correlating the predicted and estimated values of degree days as correlation coefficient r =0.97 which was significant at 5% probability level. Similar observations were quantified while studying the phyllochron of *Cymbopogon citratus* in the Jammu region of India (Shahi *et al.*, 2005).

Table 1: Linear descriptive statistics between leafing and degree days for quantification of Phyllochron* in *Cymbopogon martini*

Regression Coefficient(b	Regression constant(a)	Regression equation	Validation of predicted and estimated values
7.01	-925.656	YDD= -925.66+ L	0.97**

**Based on mean replicates of two years*
***Significant at 5% probability level, YDD =Degree days, L = Leafing (in numbers)*

Response essential oil yield and essential oil constituents: Essential oil yield was found maximum at senescence of older leaves with ≅ 95% flowering to get the maximum oil yield .This fact can be explained by the process of essential oil distribution from roots through the plant during the crop growth stage. Similar observations were made while studying *Eryngium glaciale Boiss* (Pala-Paul *et al.*, 2005) These observations are also attributed to vegetation phase of plant and location of the plant species (Hashemabadi and Kaviani, 2010). The remarkable increase in geraniol and constant drop of geranyl acetate content was observed in the stem, leaves and flowers from the initiation of flowering towards the senescence of older leaves with ≅ 95% flowering. Similar observations were made while studying *Cymbopogon martini* (Akhila *et al.*, 1984 and Rao *et al.*, 2010). The monoterpenes are unevenly distributed in stems, leaves and flowers. The essential oil glands are present only on the surface of the leaves and flowers. The very low percentage of oil was present in the stem at all phenophases. Leaves possessed more geraniol than flowers at any stage of plant growth (Table 2). It may be due to the glycosydation of geraniol which take place in flowers.

Table 2: Effect of phenophases on herbage, essential oil yield and major essential oil constituents in *Cymbopogon martini*

*Phenophase(s)	Plant Parts	Fresh herbage g/plant	Essential oil yield/plant (w.w%)fr.wt	Geraniol%	Geranyl acetate%
Initiation of flowering	Whole Plant	393	0.42	52.65	34.28
	Stem	170	0.13	42.92	40.92
	Leaf	223	0.68	55.62	30.98
Before Anthesis	Whole Plant	550	0.57	56.82	34.12
	Stem	310	0.18	64.23	27.13
	Leaf	205	0.75	64.98	23.92
	Infloresence	35	050	45.68	45.54
At full bloom	Whole Plant	515	0.88	74.21	18.48
	Stem	325	0.15	62.63	25.43
	Leaf	92	0.85	80.02	17.18
	Infloresence	98	1.60	65.62	25.03
Senescence of older leaves(≅95% flowering)	Whole Plant	524	0.98	78.82	7.02
	Stem	350	0.15	74.03	10.52
	Leaf	82	1.80	81.52	17.12
	Infloresence	92	1.60	70.10	13.02

**Based on mean replicates*

Optimization of zinc dose for maximum herbage, oil yield and oil constituents: The biomass and oil yield of the plant was maximum at the treatment where zinc was applied@ 45 kg ha^{-1}**.** Plant biomass and oil yield of the whole plant showed a remarkable increasing trend with different zinc doses (Table 3) indicating zinc response to Palmarosa crop. The herbage and oil yield increased by 5.53 and 32.65% respectively at optimized zinc dose. The geraniol % was increased by 3.93% whereas geranyl acetate increased by 24.35%. Nutrient available in the nutritional environment of plants are capable of changing yield and essential oil content in aromatic and medicinal plants. Similar results have been reported with foliar nutrition application on lemon verbena (Ibrahim *et al.*, 2015).

Table 3: Response of Zinc on herbage, essential oil yield and major essential oil constituents in *Cymbopogon martinii*

Zinc doses ($ZnSO_4$ kg $ha^{-1)}$)	Freshherbage g/plant	Essentialoil yield/ plant (w.w%) fr.wt.	Geraniol %	Geranyl acetate%
0	524	0.98	78.82	7.02
15	535	1.12	79.06	8.02
30	546	1.18	80.06	8.46
45	553	1.30	81.92	8.73
60	542	1.13	78.90	8.00
C.D (0.05)	3.23	0.15	0.86	0.98

Response of optimized zinc on herbage, essential oil yield and major essential oil constituents in *Cymbopogon martinii* at crop phenophases

Herbage and essential oil yield was found maximum at senescence of older leaves with ≅ 95% flowering at optimized zinc dose. Similar observations were made by other workers (Muller-Riebau *et al.*, 1997; Thiem *et al.*, 2011). The remarkable increase in geraniol and constant drop of geranyl acetate content was observed in the stem, leaves and flowers from the initiation of flowering towards the senescence of older leaves with ≅ 95% flowering at optimized dose of zinc application (Table 4). The effect of different zinc doses on essential oil and its constituents may be due to its effect on the enzyme activity and metabolism of essential oil production Further the zinc application has slightly improved the geraniol content (%) contributing towards total alcohol responsible for medicinal potential in the essential oil of *Cymbopogon martinii* at all crop phenophases as compared to control as also observed by (Ibrahim *et al.*, 2015).

Table 4: Response of optimized zinc dose on herbage, essential oil yield and major essential oil constituents in *Cymbopogon martinii* at crop phenophases

*Phenophase(s)	Plant Parts	Fresh herbage g/plant	Essential oil yield/plant (w.w%)fr.wt	Geraniol%	Geranyl acetate%
Initiation of flowering	Whole Plant	399	0.45	55.65	36.36
	Stem	172	0.13	43.93	41.98
	Leaf	227	0.70	56.92	32.06
Before Anthesis	Whole Plant	578	0.62	57.97	35.12
	Stem	315	0.22	64.27	27.42
	Leaf	226	0.77	65.42	24.26
	Infloresence	37	0.54	46.35	46.62
At full bloom	Whole Plant	540	1.12	74.34	19.23
	Stem	332	0.16	63.42	27.42
	Leaf	106	0.89	81.98	18.02
	Infloresence	102	1.62	66.85	25.04
Senescence of older leaves(≅95% flowering)	Whole Plant	553	1.30	81.92	8.73
	Stem	372	0.16	76.02	11.02
	Leaf	85	1.83	83.52	18.00
	Infloresence	96	1.62	73.48	13.68

**Based on mean replicates*

Thus, the crop should be harvested at the senescence of older leaves with ≅ 95% flowering to get the maximum oil yield and highest % of geraniol in the oil in the plantation raised on Inceptisols. The biomass of the plant was also maximum at this stage with optimized dose of 45 kg $ZnSO_4$ ha^{-1}.

REFERENCES

Akhila, A., Tyagi, B. R. and Naqvi, A. (1984) Variation of Essential oil Constituents in *Cymbopogon martinii* Wats. (var. Motia) at different stages of Plant Growth. *Indian Perfumer* **28**(3): 126-128.

Chakravarty, N.V.K. and Sastry, P.S.N. (1983) Phenology and accumulated heat unit relationships in wheat under different planting dates in the Delhi region. *Agricultural Science Progress* **1**, 32-42.

Christenhusz, M. J. M. and Byng, J. W. (2016) The number of known plants species in the world and its annual increase. *Phytotaxa* **261** (3): 201–217.

Hashemabadi, D. and Kaviani, B. (2010) Comparison of essential oil compositions of eryngo (*Eryngium caucasicum* Trautv.) at different growth phases by hydrodistillation method. *Plant Omics* **3**:135-139.

Haun, J. R. (1973) Visual quantification of wheat development. *Agronomy Journal* **65**,116-119.

Ibrahim Mohamed, E., Makarem A., Mohamed Makarem, A., Khalid, A. (2015) Growth and essential oil composition affected by foliar nutrition application on lemon verbena plant *Journal of Materials and Environment Science* **6** (7) 1824-1828

Muller-Riebau, F.J., Berger, B. M., Yegen. O. and Cakir, C. (1997) Seasonal variations in the Chemical Compositions of Essential Oils of Selected Aromatic Plants Growing Wild in Turkey. *Journal of Agricultural and Food Chemistry* **45** (12): 4821–4825.

Pala-Paul, J., Perez-Alonso, M. J., Velasco-Negueruela, A., Varade, J., Villa, A. M., Sanz, J. and Brophy, J. J. (2005) Analysis of the essential oil composition from the different parts of Eryngium glaciale Boiss. from Spain. *Journal of Chromatography* **1094**:179-182

Panse ,V.G. and Sukhatme, P.V.(1957) Statistical methods for Agricultural Workers. Indian Council Agricultural Research, New Delhi.

Pedersen, J.F., Moore, K. J. and Santen, E.V. (1991) Interpretive Analysis for Forage Yield Trial Data. *Agronomy Journal* **183**:774-776.

Prashar, A., Hili, P., Veness, R. and Evans, C. (2003) Antimicrobial action of palmarosa oil on Saccharomyces cerevisiae. *Phytochemistry* **63** (5): 569–575.

Rao, B.R., Rajput, D.K., Patel, R.P. and Purnanand, S. (2010) Essential oil yield and chemical composition changes during leaf ontogeny of palmarosa (*Cymbopogon martinii* var. *motia*). *Natural Product Communications* **5**(12) : 1947-50.

Shahi, A.K., Kaul, M.K., Gupta, R., Dutt, P, Chandra, S. and Qazi, G. N. (2005) Determination of essential oil quality index by using energy summation indices in an elite strain of *Cymbopogon citratus* (DC) Stapf. (RRL (J) CCA12. *Flavour and Fragrance Journal* **20**:118-121.

Smitha, G. R. and Rana, V.S. (2015) Variations in essential oil yield, geraniol and geranyl acetate contents in palmarosa (*Cymbopogon martinii*, Roxb. Wats. var. *motia*) influenced by inflorescence development *Industrial Crops & Products* **66**:1-318

Thiem, B., Kikowska, M., Kurowska, A. and Kalemba. D. (2011) Essential Oil Composition of the different Parts and In Vitro Shoot Culture of *Eryngium planum* L. *Molecules* 16: 7115-7124.