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Quality Parameters of Java Citronella Oil as Influenced by Nutrient Management Under Inceptisols

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Abstract: *Field experiment was carried out at Nagarjun Medicinal and Aromatic Plants Garden, Dr. P.D.K.V., Akola (M.S.) during kharif 2009-10 and 2010-11. The experimental soil was calcareous in nature and moderately alkaline in reaction. The fertility status of the soil was moderate in organic carbon, low in available nitrogen and available phosphorus and very high in available potassium while the soil micronutrient contents (Zn, Fe, Mn, Cu) were above the critical level. Experiment comprised of thirteen treatments replicated thrice in randomized block design, involving control (no fertilizer/ manure), 5 t FYM ha^{-1}, 10 t FYM ha^{-1}, 80:20:40 kg NPK ha^{-1}, 100:30:60 kg NPK ha^{-1}, 140:40:80 kg NPK ha^{-1}, 5 t FYM + 80:20:40 kg NPK ha^{-1}, 5 t FYM + 100:30:60 kg NPK ha^{-1}, 5 t FYM + 140:40:80 kg NPK ha^{-1}, 10 t FYM + 80:20:40 kg NPK ha^{-1}, 10 t FYM + 100:30:60 kg NPK ha^{-1}, 10 t FYM + 140:40:80 kg NPK ha^{-1} and 100 kg N through FYM (based on FYM analysis).*

The results indicated that, alone application of organic manure, NPK graded doses and combination of both (FYM + NPK) had no significant influence on the physical (specific gravity, refractive index, optical rotation and solubility in alcohol) and chemical properties (acid value, ester value and saponification value) of Java citronella oil. It was observed as per the BIS standard.

In case of major constituents of Java citronella oil, the citronellol, geraniol and citronellal content were varied from 11.04 to 15.01%, 30.56 to 41.84% and 14.05 to 23.28%, respectively as influenced under the various treatments of nutrient management. However on the basis of mean values worked out with the various FYM and NPK graded doses and combination of FYM + NPK graded doses, the application of FYM doses in combination with graded doses of NPK improved the content of citronellol and geraniol, while the citronellal content was comparatively higher with the application of FYM doses alone.

Hence, it can be concluded that the conjunctive use of FYM along with chemical fertilizer (10 t FYM + 140:40:80 kg NPK ha^{-1}) was found beneficial way of nutrient management to improve the quality of Java citronella oil.

Keywords: *Quality parameters of oil, Inceptisols, Java citronella, Cymbopogon winterianus, Nutrient management.*

INTRODUCTION

Java citronella (*Cymbopogon winterianus*) belongs to Graminae family and it has a world production of 1600 tons per year and out of which 500 tones is produced in India on 9000 ha area. India stands 3rd position in essential oil production in the world. In Maharashtra the area is around 320 ha with the production of 25 ton of oil per annum. The area in Vidharbha under this crop is 56.4 ha and the major districts cultivated this crop are Nagpur, Yavatmal, Akola, Wardha, Chandrapur and Amravati. There is a large scope to cultivate this Aromatic crop. The

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market demand up to the year 2025 in the India is estimated to 3200 ha and 66000 ha in World. Presently, the oil and value added products of the oil has gaining price of ' 325-350 kg^{-1} and hydroxyl citronellol has ' 1150 kg^{-1} with the estimated demand of 120-130 tons per year (Anonymous, 2004).

Java citronella is rich in geraniol (36.0%) and citronellal (42.7%) and show repellant, antimycotic and acaricide activities. It is reported to be an air freshener (Guenther, 1992 and Matos, 2000). The main constituents of Java citronella oil are citronellol (13.4-15.7%), geraniol (14.3-34.3%) and citronellal (12.0-46.8%). Hydroxycitronellal can be prepared from citronellal and it is a key ingredient in compounding and used most frequently oil in floral perfume materials. It finds its way into almost every type of floral fragrance (Shiva *et al*., 2002).

The oil is used mostly in perfumery, both directly and indirectly in soaps, soap flakes, cosmetics, detergents, agarbatties, insecticides, *etc.* are often perfumed exclusively with this oil. Small quantity of citronellal is used in perfumery as an aromatic chemical. However, the greatest importance of citronellal lies in its role as a starting material for further derivatives. It is good mosquito repellant. The leftover of the citronella grass has been recommended to be utilized as source of raw material for cellulose pulp and paper production by using sulphate, sulphite and cold caustic soda.

Considering the importance of this crop every effort is made to improve the quality parameters of oil by using improved nutrients management practices. At present no information is available on nutrient management of Java citronella under agroclimatic condition of Vidarbha region that's why the present investigation was carried out.

MATERIAL AND METHODS

Study Sites

The experiment was conducted during *Kharif* seasons of 2009-10 and 2010-11 at Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (latitude of 22° 41′ N and longitude of 77°02′ E with an altitude 307.41 meters). The climate of experimental site is semi-arid and subtropical with extreme conditions having hot and dry summer and cold winter, where maximum temperature goes up to 42.6°C during summer and minimum as low as 10.3°C during winter. The annual average rainfall of area is 764.7 mm. The soil of the experimental field is medium black, Smectitic, clay loam in texture and classified as *Typic Haplustept* which comes under the soil order Inceptisol.

The experiment was laid out with randomized block design having three replication comprising of 13 treatments, *viz* Control (no fertilizer/manure), 5 t FYM ha^{-1}, 10 t FYM ha^{-1}, 80:20:40 kg NPK ha^{-1}, 100:30:60 kg NPK ha^{-1}, 140:40:80 kg NPK ha^{-11}, 5 t FYM + 80:20:40 kg NPK ha^{-1}, 5 t FYM + 100:30:60 kg NPK ha^{-1}, 5 t FYM + 140:40:80 kg NPK ha^{-1}, 10 t FYM + 80:20:40 kg NPK ha^{-1}, 10 t FYM + 100:30:60 kg NPK ha^{-1}, 10 t FYM + 140:40:80 kg NPK ha^{-1} and 100 kg N through FYM (based on FYM analysis). Treatment wise FYM was added on dry weight basis before planting of Java citronella during 2009-10 contain 0.67% N, 0.22% P and 0.49% K and in the month of April 2010 contain 0.64% N, 0.20% P and 0.51% K after 3rd cutting as per treatments. Treatment wise Nitrogen, Phosphorus and Potassium doses were applied in both the years (2009-10 and 2010-11). Nitrogen was applied through urea in three split doses as per treatment after each cutting. Full dose of Phosphorus and Potassium was applied as a basal dose at the time of planting through single super phosphate and muriate of potash as per the treatments. Java citronella 'Bio-13' was planted (rooted slips @ 16666 slips ha^{-11}) on 7th July 2009 at a spacing of 90 × 60 cm. The irrigation to the plantation was given immediate after transplanting and during the growing period, as and when required throughout the experimentation. Harvesting was done by cutting the grass close to their bases 10-12 cm above ground level. In the two years of field experimentation total six cuttings were undertaken.

Methods Adopted for Quality Parameters of Java Citronella Oil Analysis

Treatment wise plant samples were selected randomly from each net plot and cut near the ground surface at each cutting. After partial drying

of grass in shade for 8-12 hrs, the oil was extracted by using a small hydro steam distillation lab unit having capacity of 15 kg biomass per batch and quality parameters were determined as per the standard procedures (Anonymous, 2007).

Physical Properties of Oil

The specific gravity of an aroma chemical (or) essential oil at 27/27°C is the ratio of weight of a given volume of sample to an equal volume of water at 27/27°C. Specific gravity was measured by glass bottle (or) specific gravity bottle. Theoretically, the refractive index of a liquid is equal to the ratio of sine of the angle of incidence of the ray in air to the sine of angle of refraction in the liquid. Refractive index was measured by an Abbe type Refractometer. The refractometer allows direct reading of refractive indices between 1.3000 and 1.7000 with an accuracy of 0.0002. Refractive index is also dependent on temperature and as the temperature increases, refractive index decreases. Optical rotation is very useful for quality assessment of essential oils. Optical rotation was determined by polarimeter and measured in degree of rotation. Most of the essential oils and aroma-chemicals are slightly soluble in water and miscible with absolute alcohol. It is therefore possible to determine the number of volumes of dilute alcohol required for the complete solubility of one volume of oil. The solubility was estimated by standard procedure described in manual on quality assessment of essential oils using modern instrumental techniques, FFDC, Kannauj (UP) (Anonymous, 2007).

Chemical Properties of Oil

The acid value, ester value and saponification value of oil was determined by the procedure described in manual on quality assessment of essential oils using modern instrumental techniques, FFDC, Kannauj (UP) (Anonymous, 2007).

Major Constituents of Oil

The essential oil of Java citronella was analyzed in the laboratory at the Directorate of Medicinal and Aromatic Plants, Boriavi (Anand), Gujarat by using

Table 1
Physical properties of Java citronella oil as influenced by different treatments of nutrient management (2010-11)

Treatments	*Specific gravity at 27/27°C*	*Refractive index*	*Optical rotation (°)*	*Solubility in alcohol (%)*
T_1 – Control	0.8773	1.4690	–2.87	80% 2 to 3 volumes
Organic manure doses (t ha^{-1})				
T_2 - 5 t FYM ha^{-1}	0.8773	1.4692	–2.89	80% 1 to 2 volumes
T_3 - 10 t FYM ha^{-1}	0.8774	1.4691	–2.88	80% 2 to 3 volumes
NPK fertilizer doses (kg ha^{-1})				
T_4 - 80:20:40 kg NPK ha^{-1}	0.8773	1.4693	–2.90	80% 1 to 2 volumes
T_5 - 100:30:60 kg NPK ha^{-1}	0.8774	1.4692	–2.89	80% 1 to 2 volumes
T_6 - 140:40:80 kg NPK ha^{-1}	0.8772	1.4690	–2.87	80% 1 to 2 volumes
Combined doses (O. M. + NPK fertilizer)				
T_7 - 5 t FYM + 80:20:40 kg NPK ha^{-1}	0.8773	1.4692	–2.87	80% 1 to 2 volumes
T_8 - 5 t FYM + 100:30:60 kg NPK ha^{-1}	0.8774	1.4691	–2.89	80% 2 to 3 volumes
T_9 - 5 t FYM + 140:40:80 kg NPK ha^{-1}	0.8772	1.4694	–2.90	80% 1 to 2 volumes
T_{10} -10 t FYM + 80:20:40 kg NPK ha^{-1}	0.8773	1.4693	–2.89	80% 2 to 3 volumes
T_{11} -10 t FYM + 100:30:60 kg NPK ha^{-1}	0.8774	1.4694	–2.89	80% 1 to 2 volumes
T_{12} -10 t FYM + 140:40:80 kg NPK ha^{-1}	0.8773	1.4690	–2.87	80% 1 to 2 volumes
Organic manure dose equivalent to 100 kg N ha^{-1}				
T_{13} -100 kg N through FYM (based on FYM analysis)	0.8772	1.4692	–2.88	80% 1 to 2 volumes

Table 2
Chemical properties of Java citronella oil as influenced by different treatments of nutrient management (2010-11)

Treatments	*Acid value*	*Ester value*	*Saponification value*
T_1 – Control	1.22	21.30	22.52
Organic manure doses (t ha^{-1})			
T_2 - 5 t FYM ha^{-1-1}	1.20	23.12	24.32
T_3 - 10 t FYM ha^{-1}	1.22	22.25	23.47
NPK fertilizer doses (kg ha^{-1})			
T_4 - 80:20:40 kg NPK ha^{-1}	1.21	21.32	22.53
T_5 - 100:30:60 kg NPK ha^{-1}	1.23	23.11	24.34
T_6 - 140:40:80 kg NPK ha^{-1}	1.22	21.31	22.53
Combined doses (O. M. + NPK fertilizer)			
T_7 - 5 t FYM + 80:20:40 kg NPK ha^{-1}	1.20	21.38	22.58
T_8 - 5 t FYM + 100:30:60 kg NPK ha^{-1}	1.23	23.15	24.38
T_9 - 5 t FYM + 140:40:80 kg NPK ha^{-1}	1.22	22.21	23.43
T_{10} -10 t FYM + 80:20:40 kg NPK ha^{-1}	1.20	22.28	23.48
T_{11} -10 t FYM + 100:30:60 kg NPK ha^{-1}	1.21	23.13	24.34
T_{12} -10 t FYM + 140:40:80 kg NPK ha^{-1}	1.22	21.33	22.55
Organic manure dose equivalent to 100 kg N ha^{-1}			
T_{13} -100 kg N through FYM (based on FYM analysis)	1.20	21.31	22.51

GC-MS/MS instrument to find out the percentage of citronellal, geraniol and citronellol.

RESULTS AND DISCUSSION

Quality Parameters of oil

Physical properties of oil

The physical properties of oil *viz.*, specific gravity, refractive index, optical rotation and solubility in alcohol were determined and the data obtained is presented in table 1.

On the perusal of the data it is revealed that the physical properties were not influenced by the application various treatments of nutrient management under study. The specific gravity of the oil was in the range of 0.8772 to 0.8774. The refractive index was ranged between 1.4690 to 1.4694 and the optical rotation was in the range of (–) 2.87° to (–) 2.90°. The solubility in alcohol was noted from 80% in 1 to 2 volumes to 80% in 2 to 3. Pareek *et al*. (1981[a]) reported that the quality of essential oil of Palmarosa grass was neither deteriorated nor improved by nitrogen, phosphorus and potassium fertilizer application, both when applied singly as well as in combinations, physico-chemical properties of oil was within ISI range of specifications. As per the BIS standards for Java citronella oil (IS: 512-1988), the specific gravity of Java citronella oil at 27°C was in the range of 0.8743 to 0.8893. Refractive index was in the range of 1.4624 to 1.4714 at 27°C, optical rotation was in the range of (–) 0.5° to (–) 5.0° and solubility was 80% in 1 to 2 volumes (Akbar and Saxena, 2009).

The physical properties of oil observed in the present investigation are as per the BIS standard, and in general, being tested for any adulteration in the oil.

Chemical properties of oil

The chemical properties of oil *viz.*, acid value, ester value and saponification value were determined and the data obtained is presented in table 2.

The data revealed that the chemical properties of Java citronella oil were not influenced with the

application of various treatments of nutrient management. The results are in accordance with the findings of Chinnamma and Aiyer (1988) and Rao (2001). The acid value was in the range of 1.20 to 1.23 however, no particular trend of acid value was noticed as influenced by different treatments. Similar results were also observed with the ester value and saponification value. The acid value of oil was ranged from 0.5 to 3.5, ester value range was from 20 to 40 and the saponification value is equivalent to ester value plus acid value. These values were also found as per the standard specified to Java citronella oil.

Major constituents of oil

The major constituents of Java citronella oil citronellol, geraniol and citronellal were estimated by using GC-MS/MS instrument and the data obtained is presented in table 3.

The citronellol content was found in the range of 11.04 to 15.01%. The geraniol content was comparatively higher and the content was varied from 30.56 to 41.84% and the citronellal content was in the range of 14.05 to 23.28% as influenced by the various treatments of nutrient management to Java citronella.

No particular trend of these major constituents was noticed. However on the basis of mean values worked out with the various FYM doses, NPK graded doses and combination of FYM + NPK graded doses, the application of FYM doses in combination with graded doses of NPK improved the content of citronellol and geraniol, however the citronellal content was comparatively higher with the application of FYM doses alone. These results are supported by the findings of Chandra (1972) who has reported that the geraniol (18.03%) and citronellal (14.31%) content of the Java citronella oil was highly influenced due to application of potassium. Munsi and Mukherjee (1986) also reported improvement in geraniol content with the application of 120 kg N ha^{-11}.

In the present investigation, the application of combined dose of FYM + NPK graded doses might have provided optimum nutrient availability in the soil for better crop growth, resulted in higher herbage yield with higher oil content and better synthesis of secondary metabolism ultimately, improvement in main constituents of oil.

Table 3
Major constituents of Java citronella oil as influenced by different treatments of nutrient management (2010-11)

Treatments	*Citronellol (%)*	*Geraniol (%)*	*Citronellal (%)*
T_1 – Control	11.71	30.56	14.05
Mean	11.71	30.56	14.05
T_2 - 5 t FYM ha^{-1-1}	11.30	31.65	17.46
T_3 - 10 t FYM ha^{-1}	12.88	30.58	20.88
T_{13} -100 kg N through FYM (based on FYM analysis)	13.39	37.79	23.28
Mean	12.52	33.34	20.54
T_4 - 80:20:40 kg NPK ha^{-1}	12.92	39.04	17.08
T_5 - 100:30:60 kg NPK ha^{-1}	12.90	38.36	18.55
T_6 - 140:40:80 kg NPK ha^{-1}	11.04	37.03	18.39
Mean	12.29	38.14	18.01
T_7 - 5 t FYM + 80:20:40 kg NPK ha^{-1}	15.01	35.92	22.56
T_8 - 5 t FYM + 100:30:60 kg NPK ha^{-1}	13.14	41.84	19.22
T_9 - 5 t FYM + 140:40:80 kg NPK ha^{-1}	11.61	39.01	18.72
T_{10} -10 t FYM + 80:20:40 kg NPK ha^{-1}	13.99	38.84	15.99
T_{11} -10 t FYM + 100:30:60 kg NPK ha^{-1}	14.93	37.32	20.03
T_{12} -10 t FYM + 140:40:80 kg NPK ha^{-1}	13.72	38.08	22.56
Mean	13.73	38.50	19.85

CONCLUSION

From the results obtained, it can be concluded that the conjunctive use of FYM along with chemical fertilizer (10 t FYM + 140:40:80 kg NPK ha^{-1}) was found beneficial way of nutrient management to improve the oil quality parameters of Java citronella.

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