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Effect of amount and time of potassium application on herbage yield, oil yield, oil content and quality of lemongrass (*Cymbopogon flexuosus*) under semi arid tropical conditions

M Singh*, N Guleria & H P Singh[1]

Central Institute of Medicinal & Aromatic Plants (Council of Scientific & Industrial Research) Research Centre, Allalasandra, GKVK Post, Bengaluru-560 065, Karnataka.
**E-mail: munnusingh10@gmail.com*

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Abstract

A field experiment on lemongrass (*Cymbopogon flexuosus*) comprising 12 treatments of four levels of K_2O (0, 40, 80 and 120 kg ha^{1} year^{-1}) and three time of applications (Full basal at the time of planting, ½ basal + ½ after six months and 1/3rd basal +1/3rd after six months and 1/3rd after first harvest) were tested during 2006–2008. Results showed that application of 40 kg K_2O ha^{1} year^{-1} in three splits i.e. 1/3rd basal +1/3rd after six months and 1/3rd after first harvest produced maximum herbage and oil yield which was at par with 80 kg K_2O ha^{1} year^{-1} applied as a basal.

Keywords: herbage yield, lemongrass, oil quality, potassium

Introduction

Lemongrass (*Cymbopogon flexuosus* Nees ex. Steud Wats) is a perennial multiharvest aromatic grass, belonging to *Poaceae* family. The essential oil of lemongrass is used in aromatherapy (Rande 1959). Lemongrass oil, obtained by distillation of lemongrass, is a widely used essential oil in perfumery and cosmetics. Citral, the chief constituent of the oil, is the starting material for the synthesis of ionones, which are used in the production of several aromatic compounds found in soaps, cosmetic and perfumes. β-ionone, which is obtained from citral, is used in the production of vitamin A. Lemongrass leaves are used in herbal tea (Husain 1995) in different countries. Owing to its tropical origin lemongrass responds well to nitrogen as well as other fertilizers (Beech 1990; Singh *et al.* 2005). Long term fertilizer experiments have shown that in high intensity, continuous cropping situation, the application of N, P and K failed to maintain yield levels (Singh 2001). There is however, very little information on the effects of K application on lemongrass (Rao *et al.* 1985; Singh *et al.* 2005). Red soils are deficient in available N and low to medium in K content. K may turn into limiting factor in cultivation of some essential

[1]Central Institute of Medicinal and Aromatic Plants (Council of Scientific & Industrial Research), CIMAP PO, Kukrail Picnic Spot Road, Lucknow-226 015, Uttar Pradesh.

oil bearing plants in red soils (Rao *et al.* 1996). Therefore, this field experiment was conducted to study the influence of level and application time of K on herbage and oil yield, and essential oil quality of lemongrass under semi-arid tropical conditions.

A field experiment was conducted during July 2006 to September 2008 at the research farm of the Central Institute of Medicinal and Aromatic Plants, Research Centre, Bengaluru, India, located at 13° 5′ N, 77° 35' E and 930 m above MSL. This area receives a mean annual rainfall of 870 mm, mostly between May and October. Minimum and maximum temperature fluctuate between 12°C (January) and 37°C (May), respectively. Temperature is lowest during January and highest during May. The soil of the experimental field was red sandy loam with a pH of 6.5. The soil had 0.30% organic carbon, alkaline $KMnO_4$ extractable N 190.5 kg ha^{-1}, 0.5 M $NaHCO_3$ extractable P 10.5 kg ha^{-1} and 1M NH_4-acetate extractable K 80.5 kg ha^{-1}.

Twelve treatment combinations consisting of four levels of K_2O (0, 40, 80 and 120 kg ha^{-1} $year^{-1}$) and three time of application (Full basal at the time of planting, ½ basal + ½ after six months of planting and 1/3rd basal + 1/3rd after six month and 1/3rd after first harvest) were tested in a factorial randomised block design with three replications. Lemongrass (cv.'*Krishna*') was planted in plots of 12.96 m^2 (3.6 m × 3.6 m) at a spacing of 45 cm × 45 cm in mid July, 2006. Nitrogen was applied at 200 kg ha^{-1} $year^{-1}$ in six equal splits at 60 days interval in each year, P in the form of single super phosphate at the rate of 17.5 kg ha^{-1} and basal dose of K_2O in the form of muriate of potash were applied before planting in 5 cm deep furrows. The remaining K_2O was applied along the side of rows of crop in 5 cm deep furrows. Irrigation was done depending upon climatic conditions. Weeds were removed by manually. Five harvests of lemongrass were taken during the two year period. The harvest schedule was March and July 2007, and March, July and September 2008. Plants were harvested 20 cm above ground level. At each harvest, the fresh herbage yield (kg ha^{-1}) and essential oil content (% w/w) of lemongrass plants were determined by hydro-distillation using a Clevenger type apparatus. Oil yield was estimated by multiplying the oil content with herbage yield. Standard procedures for data recording on different growth and yield parameter were applied and statistical analysis was carried out as described by Cochran & Cox (1957).

The essential oil samples from each harvest were analysed for their citral and geraniol content by gas chromatography (GC) on Perkin Elmer 8500 gas chromatograph fitted with flame ionization detector and an electronic integrator, using a 25 m × 0.25 mm bonded phase fused silica capillary column (BP-1, 25 mm i.d., film thickness, 0.22 µM made by SGE, Australia). The column was initially held at 120°C for 3 min, then heated to 230°C at 5°C min^{-1}. Injector and detector temperature were kept at 250°C and 300°C, respectively. The peaks of different chemical constituents were identified by their retention times, as previously determined with pure chemical standards (Sandra & Bicchi 1987). Soil samples (0-15 cm depth) were collected before planting and at the end of the study and analysed for the estimation of 1M NH_4Ac extractable K (Jackson 1958).

Data presented in Table 1 revealed that application of 40 kg K_2O ha^{-1} in three splits (1/3rd basal + 1/3rd after six month and 1/3rd after first harvest) produced 43.2% and 52.8% higher herbage and oil yield, respectively as compared to control (no K) closely followed by application of 80 kg K_2O ha^{-1} applied as basal. Thus, 40 kg K_2O ha^{-1} $year^{-1}$ can be saved through split application. The low available K status of the soil, and its red sandy loam texture, which encourage leaching, may explain the observed the crop response to added K. This is a unique observation, indicating the need for application of high doses of K in perennial irrigated lemongrass crops.

Oil content was not influenced by doses of K_2O and method of application. Oil content ranged from 1.12-1.83% in different harvests, lowest (1.12-1.18%) in fourth (July 2008) harvest and highest (1.77-1.85%) in fifth (September 2008) harvest. Oil quality in terms of citral was also not influenced by doses of K_2O and method of

Table 1. Effect of amount and time of K application on herbage yield of lemongrass (t ha^{-1}) (pooled value of 5 harvests)

Treatment	Herbage yield (t ha^{-1})			
	Time of K Application			
Doses of K_2O (kg ha^{-1})	Basal	2 Splits	3 Splits	Mean
0	12.2	13.3	13.6	13.03
40	15.0	16.1	17.5	16.20
80	17.2	15.0	16.7	16.30
120	16.1	15.2	16.1	15.80
Mean	15.13	14.90	15.98	-
LSD (P<0.05)	2.45			

LSD=Least Significant Difference; Dose=1.41; T=1.22; D × T=2.45

Table 2. Effect of amount and time of K application on oil yield (kg ha^{-1}) of lemongrass (Pooled value of five harvests)

Treatment	Oil yield (kg ha^{-1})			
	Time of K Application			
Doses of K_2O (kg ha^{-1})	Basal	2 Splits	3 Splits	Mean
0	174.5	187.5	196.9	186.3
40	225.2	248.1	266.7	246.7
80	206.9	208.1	229.6	214.9
120	211.9	223.4	225.8	220.4
Mean	204.6	216.8	229.8	-
LSD (P<0.05)		34.9		

LSD=Least Significant Difference; Dose 20.15; Treatment 17.45; D × T 34.9

Table 3. Effect of amount and times of K application on citral (%) and available K_2O (kg ha^{-1}) of lemongrass

Treatment	Citral (%) in essential oil					Available K_2O (kg ha^{-1})
	Harvest Number					
	1	2	3	4	5	
Doses of K_2O (kg ha^{-1})						
0	82.8	83.3	83.2	80.2	83.7	72.4
40	82.0	82.8	83.0	81.2	83.5	86.3
80	82.1	84.2	83.3	82.5	83.9	86.9
120	83.2	85.2	84.1	81.8	83.9	83.8
LSD (P<0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Time of K application						
Basal	82.7	83.5	83.5	80.2	83.3	78.8
2 Splits	82.0	83.4	83.4	81.5	84.1	87.9
3 Splits	82.8	84.8	83.5	80.6	84.0	79.5
LSD (P<0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

LSD=Least Significant Difference; NS=Not Significant

K application (Table 3). These findings were in conformity with those of Singh *et al.* (2005).

The application of K_2O in the soil maintained fertility status of the soil compared with control (no K). Split application of K_2O had no effect on available K_2O in the soil (Table 3).

On the basis of results obtained in this study, application of 40 kg K_2O ha^{-1} $year^{-1}$ in three splits $year^{-1}$ ($1/3^{rd}$ basal + $1/3^{rd}$ after six months and $1/3^{rd}$ after first harvest) is recommended for production of maximum essential oil yield of lemongrass under sandy loam (alfisol) of semi-arid tropical climate of Karnataka.

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