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Response of Lemongrass (*Cymbopogon Citratus* L) Varieties for Different Intra and Inter row spacing at Wondo genet, Southern Ethiopia

Getachew Jimayu[1*] Aynalem Gebre[1] and Beemnet Mengesha[1]

[1]Wondo Genet Agricultural Research Center, EIAR, P.O. Box: 198, Shashemene, Ethiopia.
Corresponding authors email: getachewjimayu@gmail.com

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The experiment was conducted at Wondo genet agricultural research center, southern Ethiopia from 2014 to 2016 cropping season to determine the optimum intra and inter row spacing of lemongrass varieties for maximize essential oil yield. Spacing of (30cmx30cm, 30cmx60cm, 30cmx90cm, 60cmx60cm, 60cmx90cm and 90cmx90cm) and two varieties of lemongrass (upper awash and java lemongrass) were arranged in RCBD design with three replications. The study showed that population density had a very highly significant (p≤0.001) influence on number of tillers/hill, longest leaf length, fresh biomass/hill and essential oil yield/ha; highly significant (p≤0.01) influence on fresh herbage yield/ha and a significant (p≤0.05) influence on number of leaves/plant, dry herbage yield/ha and essential oil content. Variety was exerted a significant (p≤0.05) influence on essential oil content and a highly significant (p≤0.01) influence on essential oil yield; whereas, it had a very highly significant (p≤0.001) influence on number of tillers/hill, number of leaves/tiller, longest leaf length, fresh biomass/hill, fresh herbage yield/ha and dry herbage yield/ha. The interaction of population density and variety had a significant influence on numbers of tillers/hill, longest leaf length, fresh herbage yield/ha and essential oil yield/ha. The highest essential oil yield (89.26 and 58.1 kg/ha) were obtained from java lemongrass and upper awash lemongrass, respectively at spacing of 30cm x 30cm.

Key words: Oil yield, lemongrass, spacing.

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INTRODUCTION

Lemongrass is an aromatic grass belonging to the family Gramineae and genus *Cymbopogon,* which consist of about 80 species (Puraima, 1999). It is a tall, clumped perennial grass growing to a height of 1 m (Vaibhav *et al*., (2013). Lemongrass is well known for its oil and it is one of the world's best known essential oils. The name lemongrass has been given because of its typical strong lemon - like dour, which it due to the high citral content.

Cymbopogon Citratus a fast growing, perennial aromatic grass is native to South India and Sri Lanka, now widely cultivated in the tropical areas of America and Asia. Freshly cut and partially dried leaves are used medicinally and are the source of the essential oil. *Cymbopogon Citratus* possesses various

pharmacological activities such as anti-amoebic, anti-bacterial, anti-diarrheal, anti filarial, anti-fungal and anti-inflammatory properties (Karkala *et al*., 2013).

The essential oil is also used in perfumery and cosmetic. In East India and Sri Lanka, where it is called "fever tea," lemon grass leaves are combined with other herbs to treat fevers, irregular menstruation and stomachaches. Lemon grass is one of the most popular herbs in Brazil and the Caribbean for nervous and digestive problems. The Chinese use lemon grass in a similar fashion, to treat headaches, stomachaches, colds, and rheumatic pains. The essential oil is used straight in India to treat ringworm or in a paste with buttermilk to rub on ringworm and bruises. Many studies show it does destroy many types of biomaterial and fungi and is a deodorant. *Traditional Uses:* Take as a tea for fevers, coughs, colds, and as a pleasant tonic or beverage. Promotes perspiration and excretion of phlegm, and eases stomach cramps.

There are many factors that influence on agronomic traits and essential oil yield of aromatic crops (Yasin *et al*. 2003; Khazie *et al*. 2007). The influence of spacing was reported by Lulie and Chala (2016) for lemongrass (Cymbopogon Citratus), Zewdinesh and Beemnet (2012) for palmarosa (Cymbopogon martini), Solomon and Beemnet (2011) for spearmint (*Mentha spicata L*).

Despite, plant population density influence agronomic and chemical characteristics of aromatic plants, there is gaps of information on the effects of population density on agronomic and chemical traits of those lemongrass varieties, in Ethiopia. Thus, the experiment was designed to determine the optimum intra and inter row spacing, for maximize essential oil yield of lemongrass varieties.

MATERIAL AND METHOD

This study was conducted on experimental field of Wondo genet agricultural research center, southern Ethiopia under irrigated condition in 2014 to 2016 cropping season. The research center was located 270 km South of Addis Ababa and 14 km southeast of Shashemene. The experimental site was geographically located at 07° 19.1' North latitude, 38° 30’ East longitude and an altitude of 1780m.a.s.l. The site receives mean annual rainfall of 1128 mm with minimum and maximum temperature of 11 and 26°c, respectively. The soil texture of testing location was sandy clay loam with soil PH of 8.84.

Two varieties of lemon grass (V1= Upper awash lemongrass and V2= Java lemongrass) and six population densities (30cmx30cm, 30cmx60cm, 30cmx90cm, 60cmx60cm, 60cmx90cm and 90cmx90cm) spacing were arranged in a Factorial Randomized Complete Block Design (RCBD) with three replications. To have sufficient biomass for essential oil physico-chemical analysis, each plot had 3.6 m length and width. Respective spacing 2m and 1m were maintained between replication and plots. Seedlings (slips) of lemongrass taken from Wondo Genet Agricultural Research Center were transplanted to the experimental plots on the commencement of main rainy season. Slips were prepared by cutting tops of clumps 20-25 cm above the ground. The lower sheath was removed to expose young roots and the old roots were clipped off keeping the slip 25-30 cm long. Three slips were planted into each hole, about 5-8 cm deep.

During planting and after subsequent harvesting, 20 kg N/ha were applied in the form of urea. During experimentation, all field horticultural practices were performed as required. For facilitation of good growth and tiller development, leaves were cut from the whole field two months after planting. Following this, normal harvesting were started three months after leaf removal and subsequent harvestings were also made 60 days after the preceding harvest. Harvesting was done by cutting the plant 10 cm above the ground level with the help of sickles.

Data on number of tillers/hill, number of leaves/tiller, longest leaf length, fresh herbage biomass (g)/hill, fresh herbage yield (kg/plot), dry herbage yield (kg/plot), fresh herbage yield(kg/ha), essential oil content(%) and essential oil yield (kg/ha) were recorded critically.

EO content was determined on fresh weight basis from 300 g of herbage biomass that are going to be harvested from the middle rows of a plot. The laboratory analysis will be performed at Wondo Genet Agricultural Research Center. EO will be determined by hydro-distillation as illustrated by Guenther (1972).

To statically analyze the differences in agronomic and chemical characteristics caused by the different plant spacing, five samples were taken from the central rows of each plot. Statistical analysis of experimental data was performed by analysis of variance (ANOVA) using SAS PROC GLM (2002) at $P < 0.05$. Differences between means were assessed by using of the least significance difference (LSD) test at $P < 0.05$.

RESULT AND DISCUSSION

Agronomic and chemical traits of lemongrass as affected by spacing and variety

Analysis of variance showed that variety exerted a very highly significant ($p \leq 0.001$) influence on number of tillers/hill, number of leaves/tiller, longest leaf length, fresh biomass/hill, fresh herbage yield/ha and dry herbage yield/ha; a highly significant ($p \leq 0.01$) influence on essential oil content and essential yield (Table 1).

Likewise, spacing exerted a very highly significant ($p \leq 0.001$) influence on number of tillers/hill, longest leaf

Table 1. Mean square of agronomic and chemical traits of lemongrass as affected by spacing and varieties

Source of variation	Df	NTPP	NLPT	LLL	FB	FHYPH	DB	DHYPH	EOC	EOY
Rep	2	95.13*	0.17*	4.44^{ns}	8908.69***	20024756^{ns}	10.88^{ns}	2776276.25^{ns}	0.0015^{ns}	304.2^{ns}
Var	1	616.2***	0.59***	17409.7***	118034.47***	109091311.1***	89.93***	22938422.25***	0.0037*	844.5**
Spa	5	2466.04***	0.14*	173.52***	167711.57***	36170334.5**	12.67*	3231499.06*	0.002*	840.78***
VarXSpa	5	145.09***	0.08^{ns}	18.86*	1498.78^{ns}	21299211.1*	4.70^{ns}	1198857.03^{ns}	0.0009^{ns}	311.30*
Error	22	23.44	0.03	6.90	678.15	7028338.8	3.59	1768701.1	0.0005	105.78
CV		8.02	4.24	3.22	6.89	20.35	25.95	25.95	5.47	19.39

*** = Significant at *P* ≤0.001; ** = Significant at *P* ≤ 0.01; * = Significant at *P* ≤ 0.05; ns = Non significant at *P* ≤ 0.05, NTPP = Number of tillers/hill, NLPT=number of leaves/tiller, LLL=longest leaf length, FBPH = fresh biomass/hill, FHYPP=fresh herbage yield/plot, FHYPH= fresh herbage yield/ha, DHYPH=dry herbage yield/ha, EOC=essential oil content and EOY=essential oil yield.

length, fresh biomass/hill, fresh herbage yield/ha, essential oil content and essential oil yield/ha; a highly significant (p≤0.01) influence on dry biomass/plant and dry biomass yield/ha; had a significant influence (p≤0.05) on number of leaves/tiller (Table 1).

Interaction of spacing and variety had a very highly significant (p≤0.001) influence on number of tillers/hill and a significant (p≤0.05) influence on fresh herbage yield/ha, essential oil content and essential oil yield/ha (Table 1).

Number of tillers/hill

The recorded numbers of tillers/hill were varied from (33.59 to 100.54) and (39.78 to 83.9) for upper awash and java lemongrass, respectively. The lowest number of tillers/hill was obtained at spacing of 30cmx30cm (Table 3)**.** When spacing increases from 30cmx30cm to 90cm x 90cm, number of tillers/hill increased by 199.32 % and 110.91 % for upper awash and java lemongrass, respectively (Table 3). The increment of number of tillers/hill was might be due to low population density resulted by low competitions for soil nutrient, soil moisture, sunlight etc. This in line with the previous study, Lulie *et.al* (2016), concluded that as the plant to plant and row to row spacing gets wider, the number of tillers per hill increased linearly for lemongrass.

Longest leaf length

The recorded values of longest leaf length was varied from (52.91 to 64.22 cm) and (94.22 to 114.17 cm) for upper awash and java lemongrass, respectively (Table 3). The maximum value (64.22cm) of longest leaf length of upper awash lemongrass was obtained at spacing of 60cm x 90cm; whereas, the minimum value (52.91cm) was recorded at spacing of 30cm x 30cm. When the plant spacing increased, the longest leaf length was also increased for both lemongrass varieties. When spacing increased from 30cm x 30cm to 90cmx 90cm and from 30cm x 30cmx 30cm to 60cm x 90cm the value recorded for longest leaf length increased by 21.17% and 21.37% for java lemongrass and upper awash lemongrass, respectively (Table 3). It was might be due to at low populated plants /area, there is low competition for nutrients, water, sun light and other resources, which contribute on the growth and developments of leaves.

Fresh herbage yield

The highest value of fresh herbage yield of 22.1 ton/ha and 13.23 ton/ha was recorded at spacing of 30cm x 30cm and 60cm x 60cm for java lemongrass and upper awash lemongrass respectively (Table 4). However, the lowest value of fresh herbage yield 10.64 ton/ha and 10.57 ton/ha were recorded at 60cmx90cm spacing for upper-awash and lomisar-java respectively (Table 4). When spacing increased from 30cm x 30cm to 60cm x 90cm, fresh herbage yield of java lemongrass was decreased by 47.85 %(Table 4). This might be due to areas occupied by low plant populations, which determine amounts of biomass.

This study supported by A. Nigussie *et al*., (2015) who found higher herbage yield at the highest plant density on *A. annua*. Similar ideas

Table 2. Performance of agronomic and chemical traits of lemongrass as affected by spacing and varieties

Variety	NTPP	NLPT	LLL	FB	FHYPH	DBPP	DBPH	EOC	EOY
V1	64.51^{a}	4.52^{a}	59.45^{b}	320.48^{b}	11284.3^{b}	5.72^{b}	2889.4^{b}	0.44^{a}	48.21^{b}
V2	56.24^{b}	4.27^{b}	103.44^{a}	435^{a}	14765.9^{a}	8.88^{a}	4485.9^{a}	0.42^{b}	57.90^{a}
LSD@0.05	4.46	0.15	2.22	27.01	1831.5	1.24	627.71	0.01	622.60
Spacing(cm)									
30X30	36.69^{e}	4.43^{ab}	73.57^{ab}	185.98^{f}	17205^{a}	9.63^{a}	4865.2^{a}	0.45^{a}	73.69^{a}
30X60	45.66^{d}	4.47^{ab}	77.75^{d}	249.11^{e}	14200^{ab}	7.93^{ab}	4003.1^{ab}	0.45^{a}	59.32^{b}
30X90	51.73^{d}	4.61^{a}	81.96^{bc}	325.45^{d}	11201^{bc}	5.98^{b}	3022^{b}	0.42^{b}	45.16^{c}
60X60	61.92^{c}	4.40^{abc}	8.029^{cd}	377.75^{c}	13333^{bc}	7.89^{b}	3984^{ab}	0.42^{b}	52.51^{bc}
60X90	74.03^{b}	4.31^{bc}	85.38^{ab}	479.58^{b}	10608^{c}	5.90^{b}	2976.6^{b}	0.41^{b}	42.67^{c}
90X90	92.22^{a}	4.16^{c}	88.73^{a}	648.55^{a}	11604^{bc}	6.49^{b}	3275^{b}	0.41^{b}	44.98^{c}
LSD@0.05	7.73	0.25	3.84	46.79	3172.2	2.15	1087.2	0.02	12.0
Cv	8.02	4.24	3.22	6.89	20.35	25.95	25.95	5.47	19.39

Means followed by the same letter with in a column are statistically non-significant at p≤0.05 probability level; V1=upper awash lemongrass; V2=java lemongrass CV=Coefficient of Variance; LSD= Least Significant Difference.

Table 3 Number of tillers/plant and Longest leaf length of lemongrass as affected by plant spacing and varieties interaction

	Number of tiller/plant		Longest leaf length (cm)	
	V1	V2	V1	V2
		Spacing (cm)		
30X30	33.59^{g}	39.78^{fg}	52.91^{h}	94.22^{d}
30X60	49.42^{de}	41.9^{ef}	56.75^{hg}	98.78^{c}
30X90	51.45^{d}	52.02^{d}	60.5^{efg}	103.42^{b}
60X60	70.54^{c}	53.31^{d}	59.05^{fg}	103.54^{b}
60X90	81.53^{b}	66.53^{c}	64.22^{e}	106.54^{b}
90X90	100.54^{a}	83.90^{b}	63.29^{ef}	114.17^{a}
LSD@0.05	8.20		4.45	
CV %	8.02		3.22	

Table 4. Fresh herbage yield/ha and essential oil yield/ha of lemongrass as affected by plant spacing and varieties interaction

	Fresh herbage yield kg/ha		Essential oil yield kg/ha	
	V1	V2	V1	V2
		Spacing (cm)		
30X30	12311^{bcd}	22100^{a}	58.1^{bc}	89.26^{a}
30X60	12475^{bcd}	15925^{b}	52.09^{bcde}	66.55^{b}
30X90	8339^{d}	14063^{bc}	35.56^{e}	54.75^{bcd}
60X60	13231^{bc}	13435^{bc}	54.92^{bcd}	50.09^{bcde}
60X90	10639^{cd}	10576^{cd}	44.98^{cde}	40.35^{de}
90X90	10710^{cd}	12497^{bcd}	43.6^{cde}	46.36^{cde}
LSD@0.05	4489.1		17.42	
CV%	20.35		19.39	

Means followed by the same letter with in a column are statistically non-significant at p≤0.05 probability level; V1=upper awash lemongrass; V2=java lemongrass CV=Coefficient of Variance; LSD= Least Significant Difference

reported by Beemnet *et al.* (2011) on peppermint; Solomon and Beemnet (2011) on Japanese mint; Zewdinesh and Beemnet,(2011) on palmarosa; Nekonam and Razmjoo, 2007 and Najafi and Moghadam, 2002 on *Plantago ovata.*

Essential oil yield kg/ha

Essential oil yield was very highly significantly influenced (p≤0.001) by varieties, highly significantly influenced (p≤0.01) by spacing and significantly (p<0.05) influenced by the interaction of variety and spacing (Table 1)**.** Essential oil yield increased with increasing of population density. The yield was varied from 35.5 to 58.1 kg/ha and from 40.35 to 89.26 kg/ha for upper awash lemongrass and java lemongrass, respectively (Table 4). The maximum value of essential oil yield 58.1 kg/ha and 89.26 kg/ha maintained from narrower spacing of 30cmx30cm for upper awash and java lemongrass respectively (Table 4). Increasing spacing of java lemongrass from 30cm x 30cm to 60cm x 90cm, decreased the essential yield by 45.2%. The increasing in essential oil yield at higher densities might be due to the contribution of higher above ground biomass, fresh leaf yield and dry leaf yield at higher densities. The present study in line with the study of Lulie and chala (2016), who reported that the closer plant population produced maximum amount of essential oil yield. This also supported with the result of Beemnet *et. al*., 2012 who found the highest value of plant EO yield /ha recorded at higher density of geranium. Similar findings were also reported by Zewdinesh *et al*., 2011 on *A. annua*; Yasin *et al.,* 2003 and Saeed *et al.,* 1996 on *Mott Elephant grass;* Nekonam and Razmjoo, 2007 and Najafi and Moghadam, 2002 on *Plantago ovate.*

CONCLUSION

The analysis variance table revealed that population density and varieties exerted a significant influence on all parameters. Interactions of population density and varieties had a very significant (p≤0.001) influence on number of tillers/hill; significant (p≤0.05) influence on longest leaf length, fresh herbage yield/ha and essential oil yield/ha. Maximum value of essential oil yield (89.26 kg/ha) and (58.1kg/ha) were obtained from spacing of 30cm x 30cm for java lemongrass and upper awash lemongrass respectively. Thus, it could be concluded that spacing of 30cm x 30cm can optimize essential oil yield for both lemongrass varieties at wondo genet and similar agro-ecologies.

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