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Influence of Plant Population Density on Growth and Yield of Lemon Grass (*Cymbopogon citratus L.)* at Wondo Genet, South Ethiopia

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Field experiment was conducted at Wondo Genet agricultural research center during 2013 to 2015 cropping season to determine optimum intra and inter row spacing on growth, biomass and oil yield of lemongrass. Four intra-row spacing (40cm, 50cm, 60cm and 70cm) and three inter-row spacing (40cm, 60cm and 80cm) would be laid out in factorial RCBD with three replications. The results of the study revealed that tiller number/hill, leaf number/hill, leaf dry weight, essential oil yield and oil content varied significantly by the main effects. The interaction effect of intra and inter row spacing gave significant higher leaf fresh weight and leaf number/hill. Lemongrass planted at the distance of 80 cm row to row and 70cm plant to plant spacing recorded significantly highest tiller number per plant and leaf number per hill. However, closer space between row and plant (40cmX40cm) produced maximum leaf dry weight, essential oil yield and essential oil content. Thus, it was concluded that Cymbopogon citratus should be planted at a closer inter row spacing of 40cm and intra row spacing of 40cm at Wondo Genet and other similar agro ecologies for maximum leaf dry weight and oil yield.

Key words: Essential oil yield, lemongrass and population density

INTRODUCTION

In the recent past, there is greater demand for medicinal and aromatic plants as they are the raw material for pharmaceutical, perfumery, cosmetics and confectionery industries (Karnataka, 2007). Medicinal and aromatic plants offer a wide range of safe, cost-effective, preventive and curative therapies, which are useful in achieving the goal of “health for all‟ (Rashi Mittal and Singh, 2007).

Lemon grass, a tufted perennial with numerous stiff leafy stems (EPOPA, 2005), is widely cultivated in the tropics and subtropics (Punam *et al.*, 2012). The grass has great benefit to mankind as it revitalizes the body and mind, helps with infections and act as muscle and skin toner. It is an essential oil bearing aromatic plant belonging to the genus Cymbopogon, family Poaceae with diverse medicinal and aromatic value (Rangari, 2009). From the many species of the genus, *Cymbopogon citrates* is the one considered economically important for the production of essential oils and aromatic herbs.

Oil from lemon grass is widely used for medicinal value (Vaibhav *et al.*, 2013) and fragrance in perfumes and cosmetics, such as soaps and creams (Punam *et al.*, 2012). However, the major use of oil is as a source of citral, which goes in perfumery, cosmetics, beverages and is a starting material for manufacture of ionone's which produces vitamin-A that reduces the risk of xerophthalmia and night blindness (Vaibhav *et al.*, 2013) and geraniol (Rangari, 2009) besides the use in perfumery soaps and cosmetics. The oil has strong lemon like odour due to high percentage (over 75%) of citral in the oil (Vaibhav *et al.*, 2013).

Cymbopogon citrates is the one which is used either in the herb form or in the essential oil form and used for flavouring, perfume production, and medicinal purposes (Rangari, 2009; Tamuli *et al.* 2012). Lemongrass is generally recognized as safe for human consumption as plant extract/essential oil.

There are many agronomic factors that influence agronomic characteristics, biomass and essential oil yield of lemongrass. Among these, crop density (Singh, 2002) deserves special attention. Moreover, the full yield potential and quality traits of lemongrass are determined as it is planted at its optimum intra and inter row spacing due to efficient utilization of natural resources such as sunlight for photosynthesis and different growth factors. Thus, Establishment of the ideal number of plant per unit area of the field is a crucial point to get maximum yield.

Although *Cymbopogon citratus* is an economically important essential oil yielding grass, it has been observed that detailed investigation on the agronomic practices of this valuable essential oil bearing crop has so far not been done elsewhere. Similarly, in the country Ethiopia, there is no research supported information on population density of lemongrass till the end of this investigation. Therefore, conducting research to establish optimum population per unit area is vital. In view of the above reasons, this research was done to determine the optimum intra and inter row spacing on growth, biomass and oil yield of lemongrass.

MATERIALS AND METHODS

The experiment was carried out under irrigated condition in the research field of Wondo Genet agricultural research center, southern Ethiopia during 2013 to 2015. The research center is located 270 km South of Addis Ababa and 14 km southeast of Shashemene. The geographical coordinate of the area is $7^0$19'N latitude and $38^0$38'E longitude with an altitude of 1780 meters above sea level (masl). The site receives mean annual rainfall of 1128 mm with minimum and maximum temperature of 11 and 26°c, respectively. Wondo Genet has a bimodal rainfall distribution with two rainy seasons with Short rains occur during March-May and the long rains in July-October.The experiment was conducted on lemon grass using four intra-row spacing (40cm, 50cm, 60cm and 70cm) and three inter-row spacing (40cm, 60cm and 80cm) that would be laid out in factorial RCBD with three replications. Each treatment would have a plot size of 4.20 m x 3.50 m and spaces between each plot and replication would be 1m and 1.5m respectively. The number of plant per row and the number of row per plot were determined by intra and inter-row spacing of the treatments respectively. Healthy slips from well grown clumps of lemon grass were used for planting in well tilt land. The test crop stayed in the actual field up to two years. Before actual data collection, the plant was engraved at ten centimeter above ground level to make uniform and good vigorous plant growth. Then, the first harvest was carried after four months whereas the next consecutive harvesting cycles were taken after two months. For each consecutive harvesting cycle, the grass was cut manually at 10cm above ground level with the help of sickle. The crop was chopped in to small pieces before it filled in to the distillation unit. Essential oil content was determined on dry weight basis from300 g of composite leaves. Laboratory analyses were executed at Wondo Genet agricultural research center using hydro-distillation. All required cultural practices were done as and when required.

Five plants were selected randomly from each plot by excluding the borders to collect yield and yield contributing characters such as plant height (cm), above ground fresh biomass (kg/ha), above ground dry biomass (kg/ha), number of tillers/hill, number of leaves/tiller, number of leaves /hill, essential oil content (w/w, dry based) and essential oil yield (kg/ha). The collected data was statistically analyzed using SAS computer software version (9.0) English and the difference between means were tested by LSD at 5% level of significant.

RESULTS AND DISCUSSION

Number of tiller per hill

The analysis of variance showed 70cm intra row spacing significantly ($p \le 0.001$) increased tiller number per hill in the two consecutive harvesting seasons and the pooled mean (Appendix 1, 2 and 3). Whereas the lowest tiller number was recorded at 40cm intra row spacing in both years and the pooled mean (Table 1). Inter row spacing, in the same way, revealed significant ($p \le 0.001$) variation of tiller number per hill except in the first harvesting seasons where tiller number was unaffected by row spacing (Appendix 1, 2 &3). The highest and lowest tiller number was found at wider (80cm) and closer (40cm) inter row spacing respectively (Table 1). Reduction of tiller number by 14.74% (28.69 vs. 24.46) and 13.47% (39.49vs. 34.17) was found as lemongrass was planted at narrower intra and inter row spacing respectively. Conversely, in both harvesting season and the pooled mean number of tiller per plant was not significantly ($p > 0.05$) influenced by their interaction. This indicate that,

Table 1: Means for tiller number per hill and leaf number per hill as affected by intra and inter-row spacing at Wondo Genet in the 2013/2014-2014/2015 harvesting seasons

Treatments	Number of tiller per hill			Number of leaves per hill		
	2014	2015	Pooled	2014	2015	Pooled
			Intra row spacing (cm)			
40cm	24.46[c]	42.99[c]	33.73[c]	172.51[b]	207.31[b]	189.91[b]
50 cm	25.51[bc]	47.34[b]	36.42[b]	180.47[ab]	209.97[b]	195.22[b]
60 cm	27.41[ab]	49.20[b]	38.31[b]	189.84[a]	224.69[a]	207.26[a]
70 cm	28.70[a]	53.05[a]	40.87[a]	194.51[a]	230.13[a]	212.32[a]
LSD	2.270	3.45	2.19	15.30	14.03	9.21
			Inter row spacing (cm)			
40cm	25.76	42.57[b]	34.17[b]	173.69[b]	199.96[c]	186.83[c]
60cm	26.76	49.91[a]	38.34[a]	189.44[a]	219.18[b]	204.31[b]
80cm	27.04	51.95[a]	39.49[a]	189.87[a]	234.94[a]	212.40[a]
LSD	ns	3.05	1.91	13.25	12.56	7.9745
Intra * Inter	ns	ns	ns	ns	ns	**
CV %	15.84	13.56	14.02	15.37	12.32	12.04

Means followed by the same letter within a column are statistically non-significant at p≤0.05 probability level; CM =centi meter; CV=Coefficient of Variance; LSD= Least Significant Difference

Table 2: Means for leaf fresh and dry weight as affected by intra and inter-row spacing at Wondo Genet in the 2013/2014-2014/2015 cropping season.

Treatments	Leaf fresh weight (kg/ha)			Leaf dry weight (kg/ha)		
	2014	2015	Pooled	2014	2015	Pooled
			Intra row spacing (cm)			
40cm	11314.8	12665.8	11990.3	4650.2[a]	4102.5[a]	4376.4[a]
50 cm	11455.7	12419.4	11937.6	4069.5[b]	3728.0[ab]	3898.8[b]
60 cm	12092.1	11762.9	11927.5	3465.1[c]	3285.7[b]	3375.4[c]
70 cm	12578.8	12088.8	12333.8	3351.4[c]	3440.0[b]	3395.7[c]
LSD	ns	ns	ns	383.2	534.13	296.46
			Inter row spacing (cm)			
40cm	11610.4	13733.6[a]	12672.0[a]	4860.5[a]	3670.3	4265.4[a]
60cm	12176.7	11827.3[b]	12002.0[ab]	3858.4[b]	3727.5	3792.9[b]
80cm	11794.1	11141.8[b]	11467.9[b]	2933.4[c]	3519.4	3226.4[c]
LSD	ns	1091	687.86	331.9	ns	256.75
Intra * Inter	ns	**	**	ns	ns	ns
CV %	21.15	19.06	17.34	18.26	26.92	20.73

Means followed by the same letter within a column are statistically non-significant at p≤0.05 probability level; CM =centi meter; CV=Coefficient of Variance; LSD= Least Significant Difference

the variation in intra-row spacing means may be attributed to the effect of the different levels of that factor and was not significantly affected the different levels of inter-row spacing. In general, as the plant to plant and row to row spacing gets narrower, the number of tillers per hill decreased linearly. These results agree with the previous findings of Oad *et al.* (2002) who concluded that growth parameters of safflower plant are significantly influenced by wider intra and inter row spacing. The reduction in tiller number per hill with deceasing intra and inter-row spacing may be due to superior plant competition for incident light, soil nutrient, soil moisture and mutual shading of each other at high plant density than at low plant density. Further, Blackshaw (1993) reported that plants sown at greater row and plant distance increased the biomass of the plant by producing healthy plant parts by receiving maximum sun light for the process of photosynthesis.

Number of leaves per hill

In the two consecutive harvesting seasons, significant (p≤0.05 and p≤0.01) higher leaves number per hill was observed at 70 cm and 80 cm intra and inter row spacing respectively (Appendix 1 and 2). In the separate cropping seasons, the interaction didn't show significant variation

Table 3: Means for essential oil yield and essential oil content as affected by intra and inter-row spacing at Wondo Genet in the 2014-2015 cropping season.

Treatments	Essential oil yield (kg/ha)			Essential oil content (w/w, dry based)		
	2014	2015	Pooled	2014	2015	Pooled
Intra row spacing (cm)						
40cm	62.60[a]	75.01	68.80[a]	0.545	0.650	0.597[a]
50 cm	44.79[b]	74.81	59.80[b]	0.520	0.606	0.563[b]
60 cm	43.08[b]	80.95	62.02[ab]	0.494	0.620	0.562[b]
70 cm	42.06[b]	81.88	61.97[ab]	0.511	0.597	0.554[b]
LSD	5.86	ns	7.42	ns	ns	0.030
Inter row spacing (cm)						
40cm	58.43[a]	74.33	66.38[a]	0.554[a]	0.615	0.584[a]
60cm	52.63[b]	78.68	65.66[a]	0.513[b]	0.643	0.578[a]
80cm	33.34[c]	81.48	57.41[b]	0.486[b]	0.604	0.545[b]
LSD	5.08	ns	4.13	0.034	ns	0.026
Intra * Inter	ns	ns	ns	ns	ns	ns
CV %	22.55	28.61	19.86	14.05	14.35	13.63

Means followed by the same letter within a column are statistically non-significant at p≤0.05 probability level; CM =centi meter; CV=Coefficient of Variance; LSD= Least Significant Difference

Table 4: Means for number of leaves per hill and leaf fresh weight as affected by the interaction effects of intra and inter-row spacing

Inter row spacing (cm)	Number of leaves per hill				Leaf fresh weight(kg/ha)			
	Intra row spacing(cm)				**Intra row spacing(cm)**			
	40	**50**	**60**	**70**	**40**	**50**	**60**	**70**
40	173.533[dc]	184.611[d]	181.722[dc]	207.722[dc]	11747.3[bc]	12730.4[ab]	11999.6bc	14210.6a
60	187.178[dc]	205.422[ab]	217.478[a]	207.156[ab]	12107.2[bc]	12189.4[bc]	11915.7bc	11795.5bc
80	209.022[ab]	195.633[bc]	222.589[a]	222.367[a]	12116.4[bc]	10892.9[c]	11867.19[bc]	10995.2c
LSD	17.69**				1624.9*			
CV (%)	13.38				20.52			

Means followed by the same letter within a column are statistically non-significant at p≤0.05 probability level; CM=Centi meter; CV=coefficient of variance; LSD=least significant difference

Table 5: Association among growth, yield and yield related characters of lemon grass tested under varying intra and inter-row spacing's

Traits	NTPH	NLPH	LFW	LDW	EOY	EOC
NTPH	1					
NLPH	0.69***	1				
LFW	0.43 ***	0.80 ***	1			
LDW	0.35***	0.70***	0.70***	1		
EOY	0.67 ***	0.65 ***	0.54 ***	0.59***	1	
EOC	0.34 ***	-0.04 ns	-0.18 **	-0.02[ns]	0.39***	1

*,**and ***= Significant at p ≤ 0.05; p ≤ 0.01; p ≤ 0.001; probability level; and ns= non significant at 0.05 probability level;
NTPP=numbers of tiller per hill, NLPP=number of leaves per hill, LFW= Leaf fresh weight, LDW= Leaf dry weight, EOY= Essential oil yield and EOC= Essential oil content.

(Appendix 3). Concomitantly, the pooled mean revealed significant (p≤0.001) higher leaf number (222.589) per hill at the interaction of 60cm x 80cm intra and inter row spacing though statistically at par with 70cm x 80cm intra and inter row spacing (222.367) respectively (Table 4). These revealed that the effects of different levels of intra-row spacing were affected by different levels of inter-row spacing. The values recorded in this study were comparable to the values reported for Cowpea (*Vigna unguiculata* L.) by Malami and Sama'ila (2012). In addition, similar reports were done by (Malami and Abdullahi, 2007; Malami and Sulaiman, 2007; Malami *et al*., 2010 on *Lablab purpureus* leaf number and Nigussie *et al.* (2015) on *Artemisia annua* branch number. The increased leaf number per hill at wider row spacing probably due to higher tiller number of lemongrass at larger intra and inter row spacing.

Leaf fresh weight (kg/ha)

In the first harvesting season (2013/2014), the main effects (intra row and inter row spacing) and the interaction didn't show significant ($p>0.05$) variation on leaf fresh weight (Appendix 1). Whereas in the 2014/2015 cropping season and pooled mean, the interaction between 40cm x 70cm row to row and plant to plant distance gave significantly ($p\leq0.01$) higher leaf fresh weight (14210.6 kg/ha) (Appendix 2& 3 and Table 4). The minimum leaf fresh weight (10995.2 kg/ha) was maintained at the interaction of 80cm x 70cm inter and intra row spacing. The increase in leaf fresh weight at wider plant spacing might be due to the contribution of highest tiller and leaf number which were high at wider plant to plant and row to row spacing. The result was substantiated by strong and significant correlation of leaf fresh weight with number of leaves per hill ($r=0.80$, $p\leq0.001$) and positive and significant correlation with tiller number per hill ($r=0.43$, $p\leq0.001$) (Table 5). Solomon and Beemnet (2011), in line with this finding, reported that a decreasing trend of fresh and dry leaf yield with increasing inter row spacing from 30cm to 60cm for Japanese mint. Blackshaw (1993) also reported that plants sown at greater row and plant distance increased the biomass of the plant by producing healthy plant parts by receiving maximum sun light for the process of photosynthesis. This finding was in agreement with with the result of Zewdinesh (2010) on *Artemisia annua* and Rao (2002) on rose scented geranium.

Leaf dry weight (kg/ha)

The analysis of variance for the two consecutive harvesting seasons and the pooled mean showed that significantly ($p\leq0.001$) higher leaf dry weight at 40cm intra row spacing (Appendix 1,2 and 3). Similarly, the inter row spacing at 40cm gave significantly ($p\leq0.001$) higher leaf dry weight in 2013/2014 harvesting season and the pooled mean while it was non-significant ($p>0.05$) in 2014/2015 harvesting season (Appendix 1,2 and 3). The maximum (4376.4kg/ha) and minimum (3395.7kg/ha (though statistically at par with 60cm intra row spacing) leaf dry weight was observed at 40cm and 70cm intra row spacing respectively (Table 2). This is due to the fact that both too narrow and too wide spacing do affect leaf dry weight through competition (for nutrients, moisture, radiation, etc.) and due to the effect of shading. In the latter case (too wide spacing), dry weight reduction can occur due to in efficient utilization of the growth factors. Increased leaf dry weight was further indicated by strong and significant correlation values between leaf dry weight and leaves number per hill ($r = 0.70$, $P\leq0.001$) and leaf fresh weight ($r=0.70$, $P\leq0.001$) (Table 5). An increase in biological yield with increasing plant population density was also reported by Nekonam and Razmjoo, 2007 and Najafi and Moghadam, 2002 on *Plantago ovata*. Correspondingly, Beemnet *et al.* (2011) also reported maximum above ground dry weight at lower spacing and decreased with increasing row spacing from 30cm to 60cm of peppermint. Solomon and Beemnet (2011) on Japanese mint also reported a similar trend. Additional research findings made by Board *et al.* (1990) reported that narrow-row spacing at normal and high densities had significantly higher yield than wide rows. The interaction, on the other hand, didn't show significant ($p>0.05$) variation on leaf dry weight in each harvesting season and the pooled mean (Appendix 1, 2 &3).

Essential oil yield (kg/ha)

In the first harvesting season and the pooled mean, essential oil yield significantly ($p\leq0.001$) varied at 40cm intra row spacing and 40cm ($p\leq0.05$) inter row spacing respectively (Appendix 1 & 3). In the second cropping season, inconsistent with this, both intra and inter row spacing didn't significantly ($p>0.05$) affect essential oil yield (Appendix 2). In the first harvesting season, oil yield was significantly reduced by 28.46, 31.18 and 32.81% as the intra row spacing increased from 40cm to 50, 60 and 70cm respectively. Consistent with this harvesting season, the pooled mean result revealed reduction of oil yield by 13.08, 9.86 and 9.93% as the intra row spacing increased from 40cm to 50, 60 and 70cm respectively. Correspondingly, oil yield reduction by 9.93% and 42.95% was observed as the inter row spacing increased from 40cm to 60cm and 40 to 80cm respectively in the first harvesting season. In agreement with the first harvesting season, the pooled mean analysis also showed reduction of oil yield by 13.52% as the inter row spacing increased from 40 cm to 80cm. In line to this finding, Rao (2002) in corn mint reported that highest biomass and maximum essential oil yield were produced due to the narrow spacing's. Besides to this, EL-Gandi *et al.* (2001) reported for sweet basil; Solomon and Beemnet (2011) for Japanese mint and Zewdinesh (2009) for Artemisia who reported higher total essential oil yield at narrower row spacing (higher plant density). The increasing in essential oil yield at higher densities may be due to the contribution of higher leaf dry biomass at narrower spacing (higher densities). This was supported by positive and significant correlation of essential oil yield with leaf fresh weight (r=0.54, p≤0.001) and leaf dry weight (r=0.59, p≤0.001) (Table5). Therefore, essential oil yield of lemongrass which is important for different aroma input and medicinal value can be improved through proper management of row and plant spacing.

Essential oil content (w/w, dry based (%))

Essential oil content is a fundamental decisive factor in determining the quality of lemongrass oil. In the separate harvesting seasons intra row spacing didn't show significant (p>0.05) variation on oil content of lemongrass (Appendix 1& 2). Inter row spacing in the first harvesting season revealed significant (p≤0.05) effect while it was not in the second season. The pooled mean analysis, on the other hand, revealed that planting of lemongrass at 40cm intra and 40cm inter row spacing gave significantly higher (p≤0.05) essential oil content (Appendix 3). Essential oil content in was decreased by 5.70, 5.86 and 7.37% as intra row spacing increased from 40 cm to 50, 60 and 70cm respectively and also, 6.90% reduction as the inter row spacing increased from 40 to 80cm (Table 3). The increasing in essential oil content at narrower spacing may be due to the contribution of higher leaf dry weight and essential oil yield at higher densities. This could be further justified by positive and significant correlation between essential oil content and essential oil yield (r=0.39, p≤0.001) (Table 5).

CONCLUSION

Empirical knowledge about intra and inter row spacing of lemongrass plays vital role in maximization of economic yield and efficient utilization of resources. The agronomic studies on plant population of lemongrass would be considerable significance in the identification of optimum intra and inter row spacing for yield maximization. The result verified that tiller number and leaves number per hill of *Cymbopogon citratus L.* were affected by wider spacing while narrower spacing increased dry leaf weight and essential oil yield. Therefore, it could be concluded that *Cymbopogon citratus* could be planted at optimum spacing of 40 x 40 cm in Wondo genet area and other similar agro ecologies to attain maximum economic yield.

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APPENDICES

Appendix1: Analysis of variance for influence of plant population on yield and component of lemongrass at Wondo Genet during 2013/2014 harvesting season

Mean square							
Source of variation	DF	NTPH	NLPH	LFW	LDW	EOY	EOC
Rep	2	34.98^{ns}	1640.33^{ns}	39664226**	3692436.1**	216.94^{ns}	0.006^{ns}
Intra RS	3	97.17***	2596.83*	9280385^{ns}	9725027.4***	2545.36***	0.012^{ns}
Inter RS	2	16.14^{ns}	3057.67*	3004834^{ns}	33438935.0***	6214.55***	0.041*
Inter*Intra	6	21.37 ^{ns}	1437.12^{ns}	8951030^{ns}	773238.5^{ns}	161.27^{ns}	0.009^{ns}
Error	179	17.42	760.91	6118054	485839.3	115.01	0.005

*, **, *** and ns significant at P≤0.05, p≤0.01 and p≤0.001 probability levels respectively; ns= not significant; DF= degree of freedom; Rep=replication; RS=Row spacing

NTPH=Number of tiller per hill; NLPH=number of leaves per hill; LFW=leaf fresh weight; LDW=leaf dry weight; EOY=essential oil yield and EOC= essential oil content

Appendix 2: Analysis of variance for influence of plant population on yield and component of lemongrass at Wondo Genet during 2014/2015 harvesting season

Mean square							
Source of variation	DF	NTPH	NLPH	LFW	LDW	EOY	EOC
Rep	2	31.19^{ns}	2079.72^{ns}	18927339*	1998232.99^{ns}	172.76^{ns}	0.04*
Intra RS	3	470.79***	3336.15**	4174289^{ns}	3484497.77*	385.02^{ns}	0.015^{ns}
Inter RS	2	874.87***	11046.83***	64927690***	415817.14^{ns}	467.56^{ns}	0.015^{ns}
Inter*Intra	6	69.91^{ns}	1447.61^{ns}	17366884**	704437.67^{ns}	612.34^{ns}	0.009^{ns}
Error	179	40.85	674.01	4658771	976407.2	492.77	0.0079

*, **, *** and ns significant at P≤0.05, p≤0.01 and p≤0.001 probability levels respectively; ns= not significant; DF= degree of freedom; Rep=replication; RS=Row spacing

NTPP=Number of tiller per hill; NLPH=number of leaves per hill; LFW=leaf fresh weight; LDW=leaf dry weight; EOY=essential oil yield and EOC= essential oil content

Appendix 3: Analysis of variance of the pooled means for influence of plant population on yield and yield component of lemongrass at Wondo Genet in 2013/2014 and 2014/2015 harvesting season

Mean square							
Source of variation	DF	NTPH	NLPH	LFW	LDW	EOY	EOC
Rep	2	60.50^{ns}	3308.07*	49202390**	3804009.5*	386.98^{ns}	0.037**
Intra RS	3	491.37***	5825.42***	883442376^{ns}	12235151.3***	825.22*	0.02*
Inter RS	2	564.34***	12302.05***	2011035^{ns}	19481545.7***	1788.76*	0.03**
Inter*Intra	6	39.16^{ns}	1901.35*	13719097*	990444.4^{ns}	220.03^{ns}	0.01^{ns}
Error	179	33.34	724.18	6109762	877629.0	382.46	0.0067

*, **, *** and ns significant at P≤0.05, p≤0.01 and p≤0.001 probability levels respectively; ns= not significant; DF= degree of Freedom; Rep=replication; RS=Row spacing

NTPP=Number of tiller per hill; NLPH=number of leaves per hill; LFW=leaf fresh weight; LDW=leaf dry weight; EOY=essential oil yield and EOC= essential oil content