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Influence of plant population density on growth and yield of Rosemary (*Rosmarinus officinalis* L.) at Wondo Genet South Ethiopia

Nebret Tadesse

Wondo Genet Agricultural Research Center, EIAR. P. O. Box: 198-Shashemene, Ethiopia.

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A field experiment was conducted at Wondo Genet Agricultural Research Center in the production season of 2013/2014 and 2014/2015 with the objective of identifying the best combination of intra and inter-row spacing for optimum plant population density of rosemary. The treatments consisted of five intra-row spacing (50, 60, 70, 80, and 90 cm) and three inter-row spacing (60, 80 and 100 cm) with a total treatment combination of fifteen that were laid out in factorial randomized completely block design with three replications. Data on plant height, fresh leaf weight per plant, fresh aboveground biomass and dry leaf weight were collected and analyzed. The main effect of intra-row and inter-row spacing had a significant influence on the number of branch per plant, fresh leaf weight per plant, dry leaf weight per hectare and oil yield per hectare in each year and pooled mean. The interaction effect of intra-row and inter-row spacing caused significant variations in the number of branch per plant, fresh leaf weight per hectare and aboveground biomass per hectare in the pooled mean analysis. Plant height and oil content were not influenced by the main effect of intra-row and inter-row spacing and their interaction in each year and pooled mean. Significantly maximum fresh leaf yield (23777 kg ha^{-1}) and fresh aboveground biomass (33746 kg ha^{-1}) were obtained from the combined of 50 cm intra-row and 60 cm inter-row spacing. Significantly higher dry leaf yield (7081.1 kg ha^{-1}) and (6333.4 mkg ha^{-1}) and oil yield (174.6 kg ha^{-1}) and (154.7 kg ha^{-1}) were obtained from the main effect of 50 cm intra-row and 60 cm inter-row spacing respectively. It may, therefore, be concluded that spacing combination of 50 cm intra-row x 60 cm inter-row responded favorably in attaining higher leaf yield and oil yield of Rosemary in the area.

Key words: Rosemary inter-row, intra- row, spacing, plant population.

INTRODUCTION

Rosemary (*Rosmarinus officinalis* L.) is one of the most effective spices among the Lamiaceae family commercially available for use as a natural source of antioxidant (Yanishlieva et al., 2006; Okoh et al., 2011). The leaves of Rosemary also used for the culinary purpose and are reported to possess antioxidant properties. This plant grows in the dry, warm regions of southern Europe, especially the Mediterranean area. It has been described as a medicinal plant and wonder-drug in various medieval drug monographs and literature (Sanchetti and Goyal, 2007). Rosemary which is used in traditional Turkish folk medicine for the treatment of hyperglycemia, has a long history of medicinal use (Hanafy and Hassan, 2010). The dried leaf material and essential oil of rosemary are obtained from the leaves and flowering twigs. The leaves are used as a culinary herb and essential oil is extensively used in food, flavor and fragrance industries (Beemnet et al., 2010; 2012). The essential oil is also used almost wholly in perfumery industry for the production of soaps, detergents, household sprays and other products (Joy et al., 2001). Oiye and Muroki (2002) on their review spices reported to exhibit antioxidant and antimicrobial proporeties which includes rosemary.

Plant spacing is agronomical practice that determine the spatial distribution of plants which affects canopy structure, light interception and radiation use efficiency and, consequently, biomass production of plants. Optimum plant density of variety considerably depending upon the climatic condition of the growing area and fertility status of the soil is important. Plant distant is an important factor in higher production and gives equal opportunity to plants for their survival and best use of other inputs. Spacing has critical effects on quantitative and qualitative characters of plants (Badi et al., 2004). To achieve the highest yield of economic production per unit area, crops should intercept solar radiation fully during the growing stage, in which photosynthesis provides carbohydrate for the economic products (Hall, 1990). In general, increasing a plant population produce a greater biological yield per unit area for most crops up to some upper limit or threshold density, after which further increase in plant density either maintain the same yield or cause yield decline. Land holding per house hold is shirking due to the increased population density of human demand for food crop cultivation and there is minimum land allocation for spices production. There is need to use land efficiently to increase productivity. Hence it seems that plant geometry could be used as a management tool for maximizing crop growth and yield, so it is advisable to carry out the trial in each plant to establish adequate plant population density. Since in Ethiopia optimum plant population density of growth and oil yield of rosemary have not been yet reported. Therefore, this investigation was initiated with the objective of to determine optimum plant population density of growth,leaf and oil yield of Rosemary in Ethiopia condition.

MATERIALS AND METHODS

The research was conducted at Wondo Genet Agricultural Research Center's fields, in Southern Ethiopia during 2013/2014 and 2014/2015 growing seasons. Wondo Genet is located 270 km South of Addis Abeba and 14 km Southeast of Shashemene. The geographical coordination of the area is 7°19' N latitude and 38° 38' E longitude with an altitude of 1780 m above sea level (masl). The site receives a mean annual rainfall of 1128 mm with minimum and maximum temperature of 11 and 26°C, respectively. The soil is a sandy clay loam with an average pH of 7.2. The experiment was conductedon rosemary using five intra-row spacing (50, 60, 70, 80 and 90 cm) and three inter-row spacing (60cm, 80cm and 100cm) with a total treatment combination of fifteen that were laid out in factorial randomized completely block design (RCBD) with three replications.Each treatment would have a plot size of 4.4 m x 4 m and spaces between each plot and replication would be 1m and 1.5m respectively. The number of plants per row and thenumber of row per plot was determined by intra and inter-row spacing of the treatments respectively. For seedling preparation, soft stem cutting of 15 cm length was taken from a one-year-old disease free Rosemary (*R. officinalis* L.) mother plants maintained at Wondo Genet Agricultural Research Center botanical garden. Seedlings were raised in the nursery for three months in polyethylene pots. Transplanting was done in October 2013, The test crop stayed in the actual field up to two years. After transplanting, harvesting was done in nine-month intervals for two consecutive years.

Five plants were selected randomly from each plot by excluding the borders to collect yield and yield contributing characters such as plant height (cm), number of branches /plant, fresh leaf yiled per plant (g p^{-1}), above ground fresh biomass (kg/ha), essential oil content (w/w, dry based) and essential oil yield (kg/ha). The collected data were statistically analyzed using statistical analysis system (SAS) computer software version (9.0) English and the difference between means were tested by Least Significant Difference (LSD) at the 5% level of significance.

RESULTS AND DISCUSSION

Plant height

In both years, neither main effect of intra-row spacing nor the interactions of inter and intra-row spacing significantly (P>0.05) affected plant height of rosemary. However, it was significantly (P < 0.05) affected by the main effects of inter-row spacing and its pooled mean (Appendix Tables 1, 2 and 3). The narrow inter-row spacing of 60 cm gave significantly taller plants (84.2 cm) than the wider inter-row spacing of 80 and 100 cm. Plant heights were consistently decreased as the spacing of inter-rows increased from 60 to 100 cm (Table 1).

The increase in plant height at narrow inter-row spacing might be due to comparatively low solar interception through the plant canopy at a narrow spacing (high plant density). Competition for light might be responsible for the increase in height due to closer intra-row spacing and this might have resulted in longer internodes. In conformity with the result Zigene et al. (2012) who reported an increase in rosemary height with an increase in plant density. An increase in plant height with decreasing plant spacing was also reported by Khorshidi et al. (2009) in fennel.

Number of branches per plant

The main effect of intra-row and inter-row spacing and the pooled mean on numbers of branches per plant was

E-mail: nibrettadesse@gmail.com. Tel. +251 913687489.

Table 1. The main effect of intra and inter-row spacing on plant height, number of branches per plant and fresh leaf weight per plant of rosemary in 2013/2014 and 2014/2015 cropping season.

Treatments	Plant height (cm)			Number of branches per plant			Fresh leaf weight kg P-1		
Intra-row (cm)	2013/2014	2014/2015	Pooled Mean	2013/2014	2014/2015	Pooled Mean	2013/2014	2014/2015	Pooled mean
50	82.2	65.2	73.7	114[b]	242[b]	182[c]	911.2[c]	736.42d	824[c]
60	81.3	66.4	73.8	128[a]	250[ab]	185[bc]	1056.4[ab]	754.42[c]d	905[bc]
70	80.4	66.5	73.5	133[a]	257[a]	195[ab]	1104.1[ab]	855.16[b]	980[b]
80	79.0	66.1	72.5	132[ab]	257[a]	195[ab]	1021.1[bc]	831.89[bc]	926[bc]
90	78.6	67.2	72.9	138[a]	264[a]	200.9[a]	1224.2[a]	958.75[a]	1091[a]
LSD	NS	NS	NS	14.71	15.0	10.14	192.9	87.6	104.4
Inter-row(cm)									
60	84.2[a]	66.4	75.32[a]	122[b]	247[b]	184.8[b]	951.27[b]	723.81[c]	838[b]
80	79.2[b]	65.8	72.53[b]	122[b]	255[ab]	188.3[b]	1020.75[b]	808.21[b]	914[b]
100	77.4[b]	66.7	71.99[b]	143[a]	260[a]	201.7[a]	1218.20[a]	949.96[a]	1084[a]
LSD5%	3.0	NS	1.6	11.3	11.6	7.85	149.4	67.9	80.9
CV	5.09	6	8.6	11.8	10.5	7.9	18.78	10.9	16.6

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.

significant (P<0.05) while the interaction effect was not significant in both harvesting season (Appendix Table 1, 2 and 3). In 2014 croppingseason the highest number of branches per plant (138) and (143) were recorded at intra- row and inter-row spacing of 90 and 100 cm, respectively. While the lowest number of branches per plants (114) and (122) were obtained at intra- row and inter-row spacing of 50 and 60 cm respectively. A similar trend was observed during the 2015 harvesting season,the highest number of branches per plant (264) and (260) were recorded at intra-row and inter-row spacing of 90 and 100 cm respectively. The lowest number of branches per plant (122) and (247) was recorded at 60 and 50 cm respectively (Table 1). As the distance between plant to plant increased from 50 cm to the 90 cm number of branch per plant was increased by 21.1 and 9.1% in 2014 and 2015 respectively and the same trend was observed on inter-row spacing. Thevalues recorded in this study were comparable to the values reported for rosemary by Mishra et al. (2009).

In addition, similar reports were done by Nigussie et al. (2015) on Artemisia annua branch number, Sigaye et al. (2016) on the Vernonia number of branches per plant. The higher number of branches per plant in the wider intra-row and inter-row spacing might be due to more availability of growth factors and better penetration of light, consequently, increasing the number of leaves and branch production at wider row spacing. The reduction in branch number per plants with deceasing intra and inter-row spacing may be due to greater inter-plant competition for incident light, soilnutrition, soil moisture and mutual shading of each other at a high plant density than at low plant density.

Fresh leaf weight g p^{-1}

The analysis of variance indicated that in both years; the main effects of inter and intra-row spacing and their pooled mean had highly significant (P<0.01) effect on fresh leaf weight per plant (Appendix Tables 1, 2 and 3). However, in both years their interaction was not significant. Maximum pooled mean fresh leaf weight per plant (1091g p^{-1}) was obtained at 90 cm intra-row spacing and minimum fresh leaf weight per plant (824g p^{-1}) was recorded at 50 cm intra-row spacing. When the space between plants increased from 50 to 90 cm distant fresh leaf weight per plant was showed 32.4% of increments. Maximum pooled mean fresh leaf weight per plant (1084 gp^{-1}) was recorded at 100 cm inter-row and minimum fresh leaf weight per plant (838 g p^{-1}) was observed at a 60 cm inter-row spacing (Table 1).

This variation might be due to the fact that wider spacing facilitated the plant to get more opportunity of spreading and growth resulting in higher fresh leaf weight per plant. However, fresh leaf weight per hectare was lower in wider spacing due to the accommodation of least number of plants in the one-hectare land. The result of this study in agreement with Mishra et al. (2009) who report that increasing plant population reduced that herbage yield of individual plants but increased herbage yield per unit area of rosemary. This result was also in line with Beemnt et al. (2012) who obtained decreased leaf per plat under narrower spacing on rose scented

Table 2. Pooled means comparison of fresh aboveground biomass and Leaf fresh weight of rosemary as affected by the interaction effects of intra and inter-row spacing.

Treatments	Fresh aboveground biomass (kg ha^{-1})				Fresh leaf weight (kg ha^{-1})			
	Inter-row spacing (cm)				Inter-row spacing(cm)			
Intra-row spacing (cm)	60	80	100	Mean	60	80	100	Mean
50	33746^{a}	30649^{ab}	31243^{ab}	31259	23777^{a}	22003^{a}	22961^{a}	22465
60	31886^{ab}	22125^{cd}	25123^{c}	26998	22431^{a}	15974^{cde}	18224^{bc}	19325
70	29333^{b}	23078^{c}	22116^{cd}	24842	20740^{ab}	16582^{cd}	16276^{cd}	17866
80	24314^{c}	18760^{d}	18065^{d}	20370	17340^{c}	13504de	13537de	14794
90	24834^{c}	21716^{cd}	18036^{d}	21538	17693^{bc}	15732^{cde}	13181^{e}	15535
Mean	28822.6	23265.6	22916.6		20396.2	16759	16835.8	
LSD		4134.6				3080.8		
CV		14.3				16.7		

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.

Geranium, Zewdinesh (2010) on Artemisia.

Fresh leaf weight (kg ha^{-1})

Pooled mean analysis result showed that the main effect of intra-row and inter-row spacing were very highly significant (P<0.01)and their interaction significantly (P<0.05) affected on fresh leaf weight per hectare (Appendix Table 3). Higher fresh leaf weight (23777 kg ha^{-1}) was obtained from the combination spacing of 50 × 60 cm intra-row and inter-row spacing respectively. This result was statistically similar to the value obtained at the combination spacing of 60 × 60 cm, 50 × 80 cm, 70 × 60 cm and 50 × 100 cm. The lowest fresh leaf weight (13181 kg ha^{-1}) was recorded from the combination spacing of 90 × 100 cm (Table 3). Increasing the spacing between plants and rows from 50 × 60 cm to 90 × 100 cm resulted in a 44.5% decreased in fresh leaf weight per hectare of rosemary. Increasing fresh leaf yield per hectare was attributed to the accommodation of a number of plants at a closer spacing than in the wider spacing.In agreement with this result, Zigene et al. (2012) and Mishra et al. (2009) reported that rosemary fresh leaf yield ha^{-1} was lower in wider spacing due to the accommodation of least number of plants in the one-hectare land. Singh (2004) also reported that closer spacing of 45 × 30 cm higher herbage yield of rosemary. Similar findings were also done by Zewdinesh (2010) on Artemisia annua; Lulie and Chala (2016) on Lemongrass; Nigussie et al. (2015) on Artemisia annua.

Fresh aboveground biomass (kg ha^{-1})

Pooled mean analysis result showed that the main effect of intra-row and inter-row spacing were very highly significant (P<0.01) and their interaction significantly (P<0.05) affected on fresh aboveground biomass per hectare (Appendix Table 3). The highest fresh above ground (33746 kg ha^{-1}) was obtained at 50 × 60cm the resultwas statistically similar with the value obtained from 60 × 60 cm, 50 × 80 cm and 50 × 100 cm spacing (Table 2). The lowest fresh aboveground biomass (18036kg ha^{-1}) was recorded at the wider combination spacing of 90 × 100 cm. In general, at all intra-row spacing, fresh aboveground biomass decreased with increase in inter-rowspacing. The decreased population density at the wider spacing could be attributed to the lower fresh aboveground biomass per hectare. The increasing fresh aboveground biomass at the closer spacing on this study in a line with the report of Nigussie et al. (2015) on Artemisia annua. Maximum biomass was reported at highest density by Beemnet et al. (2001) on peppermint. A similar pattern also reported for Japanese mint (Solomon and Beemnet, 2011) (Table 3).

Dry leaf weight kg ha^{-1}

Dry leaf weight was significantly (P<0.05) affected by the main effect of intra-row and inter-row spacing in each year and in pooled mean, however, their interaction did not affect this parameter (Appendix Tables 1, 2 and 3). Maximum dry leaf weight (7081.1 kgha^{-1}) and (6333.4 kg ha^{-1}) were obtained from 50 cm intra-row spacing and 60 cm inter-row spacing respectively. Minimum dry leaf weight (4734.4 kg ha^{-1}) and (5125.6 kg ha^{-1}) was obtained from 90 cm intra-row and 100 cm inter-row spacing respectively. Increasing plant spacing from 50 to 90 cm intra-row and from 60 to 100 cm inter-row spacing fresh leaf yield was decreased by 33.1 and 19.1% respectively (Table 3). In a line with this finding minimum, dry leaf yield /ha at wider spacing werereported by Zigene et al. (2012) and Mishra et al. (2009) for the same crop.A similar pattern was also reported by Tadesse et al. (2016)

Table 3. The main effect of intra-row and inter-row spacing on dry leaf weight, oil yield and oil content of rosemary in 2013/2014 and 2014/2015 cropping season.

Treatments	Dry leaf weight kg ha-1			Oil yield kg ha-1			Oil content(w/w, dry based)		
Intra-row(cm)	2013/2014	2014/2015	Pooled Mean	2013/2014	2014/2015	Pooled Mean	2013/2014	2014/2015	Pooled Mean
50	6295.7[a]	7866.5[a]	7081.1[a]	131.78[a]	174.56[a]	153.17[a]	2.32	2.21	2.17
60	5729.9[ab]	6053.3[b]	5991.6[b]	121.82[ab]	142.02[b]	131.9[b]	2.18	2.37	2.27
70	4882.3[bc]	6032.1[b]	5457.2[b]	103.92[bc]	126.4[bc]	115.17[c]	2.16	2.08	2.12
80	4082.2[c]	5069.5[c]	4575.85[c]	91.44[c]	110.48[c]	100.95[c]	2.13	2.16	2.24
90	4349.4[c]	5119.3[c]	4734.4[c]	90.24[c]	117.01[bc]	103.62[c]	2.08	2.30	2.19
LSD	1034.4	996.86	648.67	19.82	27.94	15.49	NS	NS	NS
Inter-row(cm)									
60	5864.7[a]	6802.2[a]	6333.4[a]	122.8[a]	154.71[a]	138.7[a]	2.17	2.29	2.23
80	4710.8[b]	5659.4[b]	5185.1[b]	100.6[b]	123.25[b]	111[b]	2.17	2.23	2.15
100	4628.3[b]	5622.9[b]	5125.6[b]	100.18[b]	124.33[b]	112.5[b]	2.15	2.22	2.21
LSD5%	801.23	772.16	502.46	15.2	21.6	12.00	NS	NS	NS
CV	21.1	12.2		19.0	18.03	18.4	13.0	11.4	12.1

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.

on stevia, Zewdinesh (2010) in Artemisia, Nigussie et al. (2015) on Artemisia

Oil yield kg ha^{-1} and oil content

The pooled mean analysis of variance showed that the main effect of inter and intra-row spacing showed significant (P<0.05) differences in oil yield (kg ha-^{1}). However, their interaction had no significant (P>0.05) effect on oil yield (Appendix Table 3). The significantly higher oil yield was recorded from 50 cm intra-row and 60 cm inter-row spacing. These were followed by the oil yield obtained from 60 cm intra-row and 80 cm inter-row spacing. The lowest oil yield was recorded from 80cm intra-row and 80 cm inter-row spacing; which was statistically similar to the value of oil yield obtained from 70 cm intra-row, 90 cm intra-row and 100 cm inter-row spacing. Decreasing the distance between the plant from 60 to 50 cm and between rows from 80 to 60 cm oil yield increased by 16.1 and 24.9% respectively (Table 3). In harmony with this finding Zigene et al. (2012) and Mishra et al. (2009) reported that closer spacing yields higher EO/ha than wider spacing in rosemary. An increase of oil yield/ha with increasing plant density was also reported for peppermint (Beemnet et al., 2001), Japanese mint (Solomon and Beemnet, 2011), Artemisia (Zewdinesh, 2010). Oil content was not influenced by the main effect of intra-row and inter-row spacing or by their interaction.

Conclusion

The two consecutive study years showed that the highest economic fresh leaf weight (23,777kg ha^{-1}) was recorded from the combined spacing of 50 cm intra-row and 60 cm inter-row spacing. Significantly higher dry leaf yield (7081.1 kg ha^{-1}) and (6333.4 kg ha^{-1}) and oil yield (174.6 kg ha^{-1}) and (154.7 kg ha^{-1}) were obtained from the main effect of 50 cm intra-row and 60 cm inter-row spacing respectively Thus; we recommend that the best-combined intra-row and inter-row spacing for Rosemary (*Rosmarinus officinalis* L.) 50 cm × 60 cm to attain maximum yield under appropriate management conditions for Wondo Genet and similar agroecology.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix Table 1. Analysis of variance for the influence of plant population on yield and yield component of rosemary at Wondo Genet during 2013/2014 harvesting season.

Source of variation	DF	PH	NBPP	LFWPP	LFWPH	AGFBM	DLW	OY	OC
Replication	2	41.4	686.8	73557.4NS	16391916.9	41986082.7	1227118.68NS	876.3	0.011
Intra-row	4	20NS	704.5*	118151.7*	109940196.6***	234253018.9***	7802856.81*	2803.4*	0.0019NS
Inter-row	2	187.4*	2320.4*	287671.7*	95153811.8*	249138458.9*	7167413.97*	2152.6*	0.00039NS
Intra*Inter	8	142NS	370.1NS	27227.4NS	13529852.1NS	26403481.4NS	1076298.25NS	596.6	0.0020NS
Error	28	16.75	232.05	39902.0	9266714	16305633	1147480.1	413.0	0.0047

DF= Degree of freedom, PH= Plant height, NBPP= Number of Branch per Plant, LFWPP= Leaf fresh weight per plant, LFWPH= Leaf fresh weight per hectare, FAGBM = Fresh aboveground biomass, DLW= Dry leaf weight, OY=Oil yield per hectare, OC= Oil content, NS = not significant, *= statistically significant at P>0.05 probability level, ***= statistically significant at p>0.001 probability level.

Appendix Table 2. Analysis of variance for the influence of plant population on yield and component of rosemary at Wondo Genet during 2014/2015 harvesting season.

Mean square	DF	PH	NBPP	LFWPP	LFWPH	FAGBM	DLW	OY	OC
Replication	2	15.7	243.3	49038	20851496.4	34198275.0	151174.8	1333.0	0.0041
Intra-row	4	5.11NS	640.07*	71202.4*	67380868.3***	124917727.1***	15324297.3***	7788.8***	0.0088NS
Inter-row	2	2.29NS	589.4NS	195897.6*	40853416*	98146838.8*	9988459.18***	6733.6*	0.0071NS
Intra*Inter	8	2.91NS	256.8NS	15548.6NS	7117250NS	13581990.8NS	891498.3NS	553.7NS	0.0190NS
Error	28	2.72	241.7	8243.8	4771095.2	9238389	556924.6	601.6	0.0093

DF= Degree of freedom, PH= Plant height, NBPP= Number of Branch per Plant, LFWPP= Leaf fresh weight per plant, LFWPH= Leaf fresh weight per hectare, FAGBM = Fresh aboveground biomass, DLW= Dry leaf weight, OY=Oil yield per hectare, OC= Oil content, NS = not significant, *= statistically significant at p>0.05 probability level, ***= statistically significant at p>0.001 probability level.

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

Mean square	DF	PH	NBPP	LFWPP	LFWPH	AGFBM	DLW	OY	OC
Replication	2	46.06	870.2	86568.4	27696880.8	62622561	640855.4	1886.3	0.009
Years	1	4412.8	351125.1***	1253983.7***	467117039.7***	1145041836***	24536420.2***	19013.4***	2.34
Intra-row	4	5.36NS	1080.5*	176622.6***	171288581.6***	344784031***	21393154.88***	9580***	0.007NS
Inter-row	2	95.61NS	2389***	477332.7***	129556183.2***	329399066***	170332113.6***	8250.28***	0.003NS
Intra*Inter	8	5.57NS	460*	29335.9NS	16451754.9*	30762350*	1333405.34NS	722.6NS	0.01NS
Error	28	10.0	223.05	23146.4	6753250	12365776	82232.3	492NS	0.0072

DF= Degree of freedom, PH= Plant height, NBPP= Number of Branch per Plant, LFWPP= Leaf fresh weight per plant, LFWPH= Leaf fresh weight per hectare, FAGBM = Fresh aboveground biomass, DLW= Dry leaf weight, OY=Oil yield per hectare, OC= Oil content, NS = not significant, *= statistically significant at p>0.05 probability level, ***= statistically significant at p>0.001 probability level.