Advances in Crop Science and Technology

Tadesse and Chala, Adv Crop Sci Tech 2017, 5:6
DOI: 10.4172/2329-8863.1000318

Research Article Open Access

Influence of Plant Population Density on Growth and Yield of Chamomile (*Matricaria chamomilla* L.) at Wondo Genet, South Ethiopia

Nebret Tadesse* **and Midhekisa Chala**

Wondo Genet Agricultural Research Center, EIAR, Shashemene, Ethiopia

***Corresponding author:** Nebret Tadesse, Wondo Genet Agricultural Research Center, EIAR, PO Box 198, Shashemene, Ethiopia, Tel: +251921582397; E-mail: nibrettadesse@gmail.com

Received date: October 26, 2017; **Accepted date:** November 10, 2017; **Published date:** November 17, 2017

Abstract

An experiment was conducted at Wondo Genet Agricultural Research Center in the production season of 2016 and 2017 with the objective of identifying the best combination of intra and inter-row spacing for optimum plant population density of chamomile. The experiment was conducted using four intra-row spacing (40 cm, 50 cm, 60 cm and 70 cm) and three inter-row spacing (40 cm, 60 cm and 80 cm) with a total treatment combination of twelve that were laid out in factorial RCBD design with three replications. The main effect of intra-row and inter-row spacing had a significant influence on a number of flowers per plant, the weight of fresh flower per plant in both cropping seasons. In 2016 cropping season significantly higher number of flowers per plant was obtained from the interaction spacing of 60 cm × 60 cm and In 2017 cropping season weight of fresh flower per plant was affected by the interaction spacing of 60 cm × 80 cm. Significantly maximum fresh flower weight per hectare and dry flower weight per hectare was obtained from the main effect of 40 cm intra-row and 40 cm inter-row spacing in both cropping seasons and in 2017 cropping season their interaction was significantly influenced by the weight of fresh flower per hectare.

The pooled mean analysis showed that the maximum fresh flower weight per hectare (3779 kg ha^{-1}), dry flower weight per hectare (517.2 kg ha^{-1}) and (586.7 kg ha^{-1}) were obtained from the treatment combination of 40 cm intra-row with 40 cm inter-row spacing. In 2016 cropping season maximum oil yield (5.6 kg ha^{-1}) was obtained from the treatments combination of 40 cm intra-row with 40 cm inter-row spacing. Therefore we suggest that the best-combined intra-row and inter-row spacing for chamomile is 40 cm × 40 cm to attain maximum yield under appropriate management conditions at Wondo genet and similar agroecology zones.

Keywords: Chamomile; Intra-row; Inter-row; Spacing and plant; Population density

Introduction

Chamomile (*Matricaria chamomilla* L.) is an annual plant belonging to the Asteraceae family. Its height varies from 20 to 60 cm, depending on the location and the soil [1]. Chamomile may be considered as an economic substitute of the field crops, irrigated with fresh water since it has the adaptability to a wide range of soil and climatic conditions. Nowadays, chamomile is among the widely used medicinal plants throughout the world [2]. Chamomile is a herb and native to Iran and Europe that grows as a wild plant [3,4]. Chamomile is known to be anti-inflammatory, anti-spasmodic, anti-bacterial, antiseptic and antispasmodic [5]. Its consumption as a folklore medicine has a long history. Medicinal importance of this species is also on the rise and at present, seven pharmaceutical products have been manufactured from chamomile in Iran under the license of the Ministry of Health. Its cultivation has been increased steadily in recent years [2]. Stand density affects plant architecture, alters growth and developmental patterns and influences carbohydrate production [6]. Flower and oil yield of chamomile can be maximized by adjusting the seedling population to match the moisture conditions of the environment, that is, densely populated stands utilize moisture and nutrients more quickly than sparsely populated stands.

Therefore, optimum densities for each crop and each environment should be determined by research. However, there is a limitation of information on the plant population density of chamomile in Wondo Genet Research Center Southern Region, Ethiopia.

Materials and Methods

The research was conducted at Wondo Genet Agricultural Research Center's fields, in Southern Ethiopia during 2016-2017 growing seasons to evaluate the influence of plant population density on growth and flower yield of chamomile (*Matricaria chamomilla* L.). Wondo Genet is located at 7°19'N latitude and 38°38'E longitude with an altitude of 1760-1920 m.a.s.l. The site receives a mean annual rainfall of 1372 mm with minimum and maximum temperature of 11.5°C and 26.2°C, respectively. The soil is a sandy clay loam with an average pH of 7.2. The experiment was conducted using five intra-row spacing (40 cm, 50 cm, 60 cm and 70 cm) and three inter-row spacing (40 cm, 60 cm and 80 cm) with a total treatment combination of twelve that were laid out in factorial RCBD design with three replications.

Seedlings were raised in the nursery for 35 days in polyethylene pots. Transplanting was done in October 2016 and in September 2016 for two consecutive years. Plots were 3.5 m × 3.0 m and final harvest was taken from central rows. There was space 1 m between plots and 1.5 m replication. Weed control was done by hand. Plots were irrigated at 7 days intervals. Harvesting of flowers started when 50% of the flowers matured and continued at two-week intervals by using hand

pick. Data on plant height, the number of primary branch per plant, number of flowers per plant, the weight of flowers per plant and fresh and dried flowers yield per hectare, oil yield and oil content percentage were recorded. The extraction of the essential oil content per unit dry flower weight was based on steam distillation using Clevenger apparatus. The collected data were statistically analyzed using SAS computer software version 9.0 English and differences between means were assessed using the least significant difference (LSD) test at $P<0.05$.

Results and Discussion

Number of primary branch per plant and plant height

There were significant differences in a number of primary branch per plant between the various intra-row spacing in 2017 cropping season and the pooled mean, however, the main effect of the inter-row was not significant. In 2016 cropping season the main effect of intra-row and inter-row spacing and their interaction was not significant. From the pooled mean analysis the highest number of primary branches per plant (27) was recorded from 70 cm intra- row spacing and the lowest number of primary branch per plant (24) was recorded at the close spacing of 40 cm. Generally, an increase in intra-row spacing led to significantly higher branching. Similarly, the result was reported on Rose Scented Geranium (Pelargonium graveolens) [7]. The data presented in Table 1 show that the plant height chamomile was not affected by intra-row and inter-row spacing in both years and the pooled mean.

Treatment	Number of primary branch per plant			Plant height(cm)			Number of flowers per plant			Weight of fresh flower per plant		
Intra-row(cm)	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
40	25	23	24.2	48.3	54	51.1	297c	667.5c	482b	42.7bc	70.6b	56.7
50	29	25	27	48.4	56	52	370ab	755.2b	562.8a	34c	94a	64.4
60	27	24	25.8	46.6	51	48	390a	709.4bc	549.7a	57a	85.9a	71.9
70	26	28	27.2	46.7	54.5	50	333bc	836.5a	584.8a	49b	90.1a	69.6
LSD	ns	Ns	Ns	ns	Ns	Ns	48.2 *	73.0*	53.5*	8.3 *	10.5*	ns
Inter-row (cm)												
40	29 a	25	26.8	49.1	55.3	52.2a	316b	665.1b	490.8b	49	76.0b	62.6
60	27ab	27	26.3	47.7	54.4	51.2a	352ab	792.9a	570.9a	45.6	91.9a	68.7
80	25b	26	25.1	45.6	51.4	48.5b	373a	768.3a	571.9a	43.5	87.6a	65.6
LSD	3.3*	Ns	Ns	ns	Ns	2.6	41.7 *	63.2*	46.4*	Ns	9.1*	Ns
Intra*Inter	Ns	Ns	Ns	Ns	Ns	Ns	*	Ns	Ns	ns	*	*
CV	13.9	17.2	15.7	10	9.5	8.7	13.5	10.1	14.7	17.5	12.5	19
LSD: Least Significant Difference; CV: Coefficient of Variation; Ns: Non-significant.												

Table 1: Main effects of intra-row and inter-row spacing on yield and yield components of chamomile for two consecutive cropping seasons (2016 to 2017). Means within the same column followed by the same letter are not significantly different.

Number of flowers per plant and weight of fresh flowers per plant

The number of flowers per plant was significantly affected by the main effect of intra-row and inter-row spacing in both years and their interaction in 2016 cropping season and the pooled mean.

The pooled mean analysis revealed that the maximum number of flowers per plant (585) and (572) were recorded from 70 cm intra-row and 80 cm inter-row spacing. The lowest number of flower per plant (482) and (490) were recorded from 40 cm intra-row and 40 cm inter-row spacing respectively. Fresh flower weight per plant was significantly influenced by the main effect of intra-row and inter-row spacing and their interaction of pooled mean. The pooled mean analysis revealed that the maximum fresh flowers weight per plant (62.1 g/p) was obtained from the treatment combination of 60 cm intra-row with 60 inter-row spacing which was statistically similar to the value obtained at the combined spacing of 50 cm × 60 cm, 60 cm × 40 cm and 60 × 80 cm (Table 2). At wider spacing, there is less inter-row and intra-row plant competition for available resources and the plant have a chance to develop more number of branches and leaf that could be the reason for a maximum number of fresh flowers per plant and weight of fresh flowers per plant obtained than in closer spacing. The increase in a number of flowers and weight of flowers per plant in wider spacing might be also due to the availability of more resources to plants on account of low population density per unit area. This was consistent with the findings who reported that low density resulted in an increased number of flowers per plant in chamomile [8]. These result also in accordance with previous studies [9-11].

Treatment	Weight of fresh flower per hectare			Weight of dry flowers (kg/ha)			Oil yield kg/ha			Oil content (dry based)		
Intra-row(cm)	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean	2016	2017	Pooled mean
40	2013.9a	3202.2a	2608.1a	318.8a	715.6a	517.2a	3.2a	1.91a	2.6a	0.97	0.27	0.62
50	1769.9a	3183.2a	2476.5a	282a	682.32a	482.6a	2.4b	1.70ab	2.1a	0.86	0.25	0.55
60	1731.5a	2437.6b	2084.6b	280.1a	537.6b	392.3b	2.7ab	1.42b	2.1a	1.01	0.39	0.7
70	922.2b	2435.5b	1678.8c	146b	504.4b	392.3b	1.2c	1.41b	1.3b	0.84	0.27	0.55
LSD	358.3 *	360.5***	256.6***	58.8 *	125.1*	71.7***	0.5*	0.32*	0.5*	Ns	Ns	Ns
Inter-row (cm)												
40	2344.9a	3556.9a	2950.9a	371a	801.9a	586.7a	3.82a	1.99a	2.9a	1	0.2	0.63
60	1464.9b	2860.4b	2162.6b	231.3b	590.3b	410.8b	2.0b	1.67b	1.8b	0.9	0.37	0.61
80	1018.3c	2026.6c	1522.5c	168.6c	437.57c	303.1c	1.6c	1.16c	1.3c	0.8	0.26	0.58
LSD	310.3 ***	312.2***	222.2***	50.9 ***	108.4***	62.1***	0.4***	0.28***	0.4***	0.16	Ns	ns
Intra *Inter	Ns	*	*	Ns	Ns	Ns	*	Ns	Ns	Ns	Ns	ns
CV%	21.7	13.1	17.4	22.3	20.9	24.7	19.9	20.5	30	20.2	28	31.9
LSD: Least Significant Difference; CV: Coefficient of Variation; Ns: Non-significant.												

Table 2: Main effects of intra-row and inter-row spacing on yield and yield components of chamomile for two consecutive cropping seasons (2016 to 2017). Means within the same column followed by the same letter are not significantly different.

Weight fresh flowers per hectare and dry flower per hectare

The analysis of variance showed that the main effect of inter and intra-row spacing showed very highly significant ($P<0.001$) differences in fresh flowers weight per hectare in both years and pooled mean and significantly ($P<0.05$) influenced by the interaction effect of inter and intra-row spacing in 2017 cropping season and polled mean (Tables 3 and 4). In 2016 cropping season maximum fresh flower weight (2013.9 kg ha^{-1}) and (2344.9 kg ha^{-1}) were recorded at 40 cm intra-row and 40 cm inter-row spacing respectively. The lowest fresh flowers weight (922.2 kg ha^{-1}) and (1018.3 kg ha^{-1}) were obtained at 70 cm inter-row and 80 cm inter-row spacing respectively. In 2017 cropping season maximum fresh flowers weight (4387.9 kg ha^{-1}) was obtained from the combined spacing of 40 cm intra × 40 cm inter-row spacing flowed by fresh flowers weight (3939 kg ha^{-1}) obtained from the combined spacing of 50 cm intra × 40 cm inter-row spacing. The lowest fresh flower weight (1651 kg ha^{-1}) was recorded at the combined spacing of 70 cm intra × 80 cm inter-row spacing which was statistically similar to the value obtained at the combined spacing of 70 cm intra × 60 cm inter-row, 50 cm intra × 80 cm inter-row and 60 cm intra × 80 cm inter-row spacing (Table 4). The pooled mean analysis also showed that the maximum fresh flower weight (3779 kg ha^{-1}) was obtained from the treatment combination of 40 cm intra-row with 40 cm inter-row spacing. The highest fresh flower yield at the narrow spacing was due to a high number of plants per unit area. This study clearly indicated that fresh flowers yield increased their yield potential at narrow spacing as compared to wider interims of population number per unit area. This was consistent with the findings who reported that high density resulted in an increased weight of chamomile fresh flowers per hectare [8]. These result also in accordance with previous studies [9,10].

Dry flower weight was very highly significantly affected by the main effect of inter-row spacing and significantly influenced by intra-row spacing in both year and the pooled mean, however, their interaction was not significant. The maximum pooled mean analysis of dry flower weight (517.2 kg ha^{-1}) and (586.7 kg ha^{-1}) was recorded from 40 cm intra-row and 40 cm inter-row spacing. The minimum dry flower weight (392.3 kg ha^{-1}) and (303.1 kg ha^{-1}) were recorded from 70 cm intra-row and 80 cm inter-row spacing respectively (Table 2). Similar to fresh flower weight dry flower weight also at the narrow spacing was due to a high number of plants per unit area. This was consistent with the findings who reported that high density resulted in an increased weight of chamomile dry flowers per hectare [11]. There are some reports on producing the same yield in narrow ranges of densities [12]. The optimal plant densities for German chamomile were reported for 10 to 80 cm spaces between rows in different condition [13,14]. Flower yield per hectare increases to a degree, by which the row distance gets smaller.

	Number of fresh flowers per plant in 2016 g.c cropping season	The weight of fresh flowers per plant in 2017g.c cropping season	Weight of fresh flowers per plant (pooled mean)

Intra-row spacing (cm)	Inter-row spacing(cm)			Inter-row spacing(cm)			Inter-row spacing(cm)		
	40 cm	60 cm	80 cm	40 cm	60 cm	80 cm	40 cm	60 cm	80 cm
40	309de	234e	347bcd	70de	75.7cde	65.9de	48.7bc	43.2cd	34.2ed
50	338bcd	358 abcd	414abc	78.8bcd	98.3a	93.3abc	47.9bcd	52.2abc	46.7bcd
60	295de	452a	424ab	60.4e	98.5a	98.9a	54.7abc	62.1a	57.2ab
70	324cde	367abcd	308de	94.8ab	95ab	92.5abc	42.9cd	24.8e	36de
LSD	94.3			18.1			13.9		
CV%	16			12.6			17.81		
LSD: Least Significant Difference; CV: Coefficient of Variation.									

Table 3: The interaction effect of intra-row and inter-row spacing on pooled mean value of chamomile number of flowers per plant, fresh flowers weight per plant and the pooled mean. Means within the same column followed by the same letter are not significantly different.

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

Oil yield was significantly affected by the main effect of intra-row spacing and very highly significantly influenced by inter-row spacing in each year and the pooled mean. In 2016 cropping season oil yield was significantly affected by the interaction of intra-row with inter-row spacing however in 2017 and the pooled mean did not interact. Maximum oil yield (5.6 kg ha^{-1}) was obtained from the treatments combination of 40 cm intra-row with 40 cm inter-row spacing, followed by 60 cm intra-row and 40 cm inter-row and 50 cm intra-row and 40 cm inter-row spacing respectively. On the other hand, the lowest oil yield (0.6 kg ha^{-1}) was recorded from the combination of 70 cm intra-row and 60 cm inter-row spacing which is statistically at par with the value obtained from the combined spacing of 40 cm × 80 cm, 50 cm × 80 cm and 70 cm × 80 cm intra and inter-row spacing respectively (Table 4). The result indicated that the closer spacing accommodates more plant number per unit area than wider spacing that may contribute to more number and weight of flower led to significantly higher oil yield. This was consistent with the findings who reported that high density resulted in an increased number and weight of flowers per hectare in chamomile [8]. The data presented in Table 2 show that the oil content of chamomile was not affected by intra-row and inter-row spacing in both years and the pooled mean.

	Fresh flowers weight per hectare(kg/ha) in 2017 cropping season			**Fresh flowers weight per hectare(kg/ha) (pooled mean)**			**Oil yield kg ha^{-1}in 2016 cropping season**		
Intra-row spacing (cm)	Inter-row spacing(cm)			Inter-row spacing(cm)			Inter-row spacing(cm)		
	40 cm	60 cm	80 cm	40 cm	60 cm	80 cm	40 cm	60 cm	80 cm
40		3158cde	2061gh	3779a	2479.8c	1565d	5.6a	2.3cd	1.7def
50		3278cd	2333fgh	3167.9b	2510.2c	1751d	3.6b	2.0cde	1.7def
60		2737def	2061gh	2396.7c	2231.1c	1626d	3.7b	2.9bc	1.9cde
70		2269fgh	1651h	2459.8c	1429.5de	1147e	2.2cd	0.6f	0.9ef
LSD	663.2*			395.7***			1.2*		
CV	13.6			15.4			27.7		
LSD: Least Significant Difference; CV: Coefficient of Variation.									

Table 4: The interaction effect of intra-row and inter-row spacing on chamomile fresh flowers weight per hectare and oil yield and the pooled mean value. Means within the same column followed by the same letter are not significantly different.

Conclusion and Recommendation

The two consecutive study years result showed that the highest economic fresh flower weight (3779 kg ha^{-1}) and oil yield (5.6 kg ha^{-1}) was recorded from the combined spacing of 40 cm intra-row and 40 cm inter-row spacing. Therefore we, recommend that the best-combined intra-row and inter-row spacing for Chamomile (*Matricaria chamomilla* L.) are 40 cm × 40 cm to attain maximum yield under appropriate management conditions for Wondo genet and similar agroecology.

Acknowledgments

The authors would like to acknowledge Wondo Genet agricultural research center and crop research process for providing the necessary facilities and support during the entire experimentation. Our special thanks to Gizachewu Atinafu, Alemitu Teka, Chrenet Tefera, Abdela Befalo and Beriso Mi'eso for their direct and indirect contribution in field and laboratory work.

References

1. Salmon I (2007) Effect of the internal and external factors on yield and qualitative-quantitative characteristics of chamomile essential oil. In: Proceedings of the First International Symposium on Chamomile Research, Development, and Production. Presov, Slovakia, pp: 45-64.
2. Baghalian K (2000) Recent advances of medicinal and aromatic plants in Iran. Chronica Hortic 40: 13-14.
3. Reichinger KH (1977) Flora Iranica. Akademische Verlagsgesellschaft 22: 82-88.
4. Pourohit SS, Vyas SP (2004) Medicinal Plants Cultivation. Agrobios, India.
5. Franke R, Schilcher H (2007) Relevance and use of chamomile (Matricaria recutita L.). Acta Hort 749: 29-43.
6. Sangoi L (2000) Understanding plant density effects on maize growth and development: an important issue to maximise grain yield. Ciênc Rural 31: 159-168.
7. Beemnet M, Zewdinesh D, Zinash T, Solomon A, Biniyam Y, et al. (2012) Yield and yield components of rose-scented geranium (Pelargonium graveolens) as influenced by plant population density in Ethiopia. Medicinal and Aromatic Plant Science and Biotechnology 2: 60-68.
8. Hadi MH, Noormohammadi G, Sinaki MJ, Khodabandeh N, Yasa N, et al. (2004) Effects of planting time and plant density on flower yield and active substance of chamomile (Matricaria chamomilla L.). In: Fourth International Crop Science Congress, Brisbane, Australia.
9. Zalecki R (1972) The cultivation and manuring of tetraploid chamomile Part III: Row width and sowing density. Herba Polonica 18: 70-78.
10. Leto C, Carrubba A, Cibella R (1997) Results of a four-year trial period of chamomile cultivation in a semi-arid Sicilian environment. Horticultural Abstracts 53: 25.