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Full Length Research Paper

Study of Chamomile's yield and its components under drought stress and organic and inorganic fertilizers using and their residue

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Management of organic and inorganic fertilizer application and residual of them are very important in their effect on environment and plant yield in order to determine the effect of drought stress and different amendments on flower, essential oil and chamazulene yield and yield components of *Chamomilla recutita* (L.). Rauschert, this study was conducted in split plot design with three replications during 2007 to 2009 at University of Zabol. Treatment included W_1 (non stress), W_2 (75% FC) and W_3 (50% FC) as main plot and three kind of residual's fertilizers: F_1 (non fertilizer), F_2 (chemical fertilizer), F_3 (manure fertilizer) and F_4 (compost) as sub plot that is used in the first year. Results showed that water stress at W_3 treatment reduced dry and fresh flower yield at both years. Low drought stress increased essential oil and chamazulene yield however high drought stress decreased these variable. Chemical fertilizer caused to make the highest yield and essential oil in the first year, but in the second year that had no difference with control treatment (without fertilizer). The residue of animal manure and compost enhanced flower, oil and chamazulene yield at the second year. In addition, animal manure and compost under drought stress in the first year and under all water conditions in the second year reach the best quantitative and qualitative yield and application of them was recommendable.

Key words: *Chamomilla recutita*, essential oil, chamazulene, animal manure.

INTRODUCTION

Arid and semi arid regions of the world are generally noted for their low primary productivity which is due to a combination of low, unpredictable water supply and low soil nutrient concentrations (Hooper and Johnson, 1999; Peek and Forseth, 2003). How to improve the efficiency of using finite resources and restore the degraded vegetation is always the problem facing ecosystem managers. James et al. (2005) suggested that the change of finite nutrient availability would have the largest impact in altering community and ecosystem properties rather than changes in water availability or efficiency of water utilization. Fertilization increases the availability of limited nutrient, and then could alter system properties, which might be a potentially practical way to stimulate plant growth, enhance stress tolerance, and improve the efficiency in using finite resources in infertile and dry environment (Baligar et al., 2001; Singh et al., 2005; Dang et al., 2006). In general, plant adaptation to dry conditions has been documented with high degree of drought tolerance, highly efficient utilization of water, and greater biomass allocation to roots (Patterson et al., 1997).

The use of natural organic manure and biofertilizers are recommended by several investigators to substitute the chemical fertilizers as they improve physical and chemical properties of soil and they are the way of clean agriculture with minimum pollution effects and reduce agricultural cost (El-Akabawy, 2000). Cook et al. (2006) stated that application of organic amendment to the soil surface is widely used in order to ameliorate top soil

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Table 1. Physical and chemical properties of the soil, 0 to 30 cm depth.

EC	pH	OM	N	P	K	Fe	Zn	Mn	Silt	Clay	Sand	Texture
		%			(ppm)					%		
1.8	7.7	1.45	0.06	12	185	2.2	4.8	3.1	27	32	41	Sandy loam

physical conditions, especially with respect to temperature, evaporation and water content. Shen and Shen (2001) reported that organic material is a good source of plant nutrients and has a positive effect on improvement of the soil physical structure. Aggrawel et al. (1997) maintaining that crop residues and manure on pearl millet improved soil water storage, soil nutrient availability and crop yield.

Medicinal and aromatic plants are of prime economic importance because of the continuous and increasing demand for their products by local and foreign markets (Khalid, 2006). German chamomile (*Chamomilla recutita* (L) Rauschert is one of the most important plants in this regards (Salamon, 1992). Nowadays, in phytotherapy, flower anthodia are mainly used. Pharmacological properties include anti-inflammatory, antiseptic, carminative, healing, sedative and spasmolytic activity (Salamon, 1992). According to Yanive and Palevitch (1982) and Bernath (1986), essential oil content and composition of essential oil in plant varies and is due to the genetic and environment factors, such as water stress and nutrient fertilizers. It means that the production of essential oil not only depends upon the metabolic state of the source tissues, but also may be integrated with the stress factors (Sangwan et al., 2001).

Water stress resulted in significant reduction of fresh and dry matter, nutrient content, and essential oil yield of Japanese mint plants (Misra and Strivastava, 2000). Fertilization management and their residual effect especially in arid and semi arid land are very important. Our objective in this study was to characterize and to identify the effect of organic and inorganic fertilizers in the first year and their residual in the second year on chamomile under water deficit.

MATERIALS AND METHODS

This study was conducted in split plot design with three replications, during two successive seasons, 2007 to 2009, at University of Zabol, Iran. Annual rain and temperature means of resign is 63 mm/year and 23°C respectively. Physical and chemical properties of soil used in this study are presented in Table 1. Treatment included W_1 (non water stress), W_2 (75% FC) and W_3 (50% FC) as main plot and three kind of residual's fertilizers: F_1 (non fertilizer), F_2 (chemical fertilizer), F3 (manure amendment) and F4 (compost) as sub plot that using in the first year. Each plot was 2 × 2 m. Chamomile seeds were cultured in the first year of experiment (2007). There wasn't done any cultivation practical in the second year. The residual seed of chamomile germinated in the second year as self-growing. Weeding was done before beginning of plant speed growth. Thinning scattering practices for obtaining optimum density (100.000 plant/ha) was done in two stages (20th of March and April). Seeds of chamomile (Bodegold Varity) were provided by the Institute of Medicinal and Aromatic Plants, Karaj, Iran. Drought stress treatments were exercised before beginning of plant speed growth. Soil moisture was measured by TDR and irrigations were done on the basis of experiment treatment. Chamomile flowers were harvested each 4 to 5 days because they matured daily. 10 plants in each plot were selected for harvesting of flower heads and determining of fresh flower head yield, yield components (no. flower/plant, no. main stem/plant, height, Anthodia diameter and Stem diameter). After harvesting, flower heads remained under sunlight to drying and to determining of dry flower head yield.

Essential oil yield was extracted by Clevenger set in the Central Analysis, University of Zabol. Chamazulene yield was extracted by spectrophotometer way (Arazmjoo, 2000). The averages of data from each season were statistically analysed using analysis of variance (ANOVA) by using the SAS system for windows, version 9 (1) (SAS Inst., 2001) and means were compared by using Duncan Multiple Range Test at 0.05% probability.

RESULTS

The first year

Mean comparison of data (Table 2) showed that the highest number of flower per plant, number of main stem per plant and biomass were in irrigation at 90% field water capacity (control treatment) in the first year. With increasing of drought stress level, anthodia and stem diameter were enhanced (Table 2). Chemical fertilizer treatment had the highest number of flower per plant, number of main stem per plant and biomass. The difference between animal manure and compost using was non-significant. The interaction of treatments had significantly effected on height, fresh flower head yield, dry flower head yield, oil and kamazolene yield (Table 3).

In the control treatment of irrigation (90% FC) chemical fertilizer had the highest fresh flower head yield, dry flower head yield, oil and chamazulene yield, while in the high level of water stress (50% FC) difference among fertilizer treatments was non-significant (Table 3). Dry flower head had positive and significant (at 1% level) correlation with number of flower per plant, number of main stem per plant, height, fresh flower head yield, biomass and had negative correlation with stem and anthodia diameter (Table 4). The correlation between dry flower head yield and oil yield was positive and significant (0.74), while dry flower head yield and chamazulene yield had non-significant correlation. The correlation between anthodia and stem diameter with other variables in this experiment was negative (Table 4).

Table 2. Biomass and yield components of chamomile under irrigation and different fertilizers in the first year.

Treatment	Number of flower in plant	Number of main stem	Anthodia diameter	Stem diameter	Biomass
			(mm)		(kg/ha)
Irrigation (%)					
50field capacity	90.83c	9.1b	6.54a	3.22a	750.05c
70field capacity	139.93b	10.3ab	6.06b	3.03b	871.92b
90field capacity	152.60a	11.7a	5.94b	2.59c	994.03a
Fertilizer					
control*	117.65c	9.1c	6.59a	3.11a	820.94b
chemical	136.24a	12.3a	6.01b	2.81b	916.08a
animal	133.5ab	10.8b	6.0b	2.90ab	884.57ab
compost	123.8bc	9.3c	6.12b	2.97ab	866.41ab

Means followed by similar letters in each column are not significantly different at p≤ 0,05 Duncan Test. * Without fertilizer.

Table 3. Means of flower, oil and kamazolene yield of chamomile under irrigation and different fertilizers in the first year.

Treatments (%)		Fresh flower Y	Dry flower Y	Oil yield	Chamazulene yield	Height
		(kg/ha)		(gr/ha)		(cm)
50 field capacity	Control	872.7f	137.97f	745.23e	64.45g	30.70h
	Chemical	973.9de	178.00e	1108.47c	94.31.de	34.32g
	Animal	999.5d	187.60de	1094.83c	103.61cd	40.25ef
	Compost	971.1de	180.73e	1057.2cd	101.36cd	38.14f
70 field capacity	Control	939.0e	173.62e	1020.1cd	114.14c	37.25fg
	Chemical	1135.2b	221.84b	1556.6a	167.02a	46.21bc
	Animal	1088.9bc	202.86cd	1340.73b	151.82b	45.79c
	Compost	1085.2bc	H98.89cd	1303.07b	154.47ab	44.80cd
90 field capacity	Control	1056.7c	199.35cd	944.13d	67.47g	42.01de
	Chemical	1267.8a	247.14a	1343.43b	90.14def	56.49a
	Animal	1131b	210.15bc	1070.9cd	78.02fg	53.91a
	Compost	1116.9b	206.77bc	1050.6cd	82.11ef	49.56b

Means followed by similar letters in each column are not significantly different at p≤ 0,05 Duncan Test.

The second year

Similar to the first year, in the second year increase of drought stress level (90% to 50% FC) made number of flower per plant, number of main stem per plant and height to be significantly decreased (Table 5). The highest of these variables were obtained from residual of animal manure treatment. The difference between chemical fertilizers residue and control treatment was non-significant (Table 5). Drought stress had significantly effected on fresh flower head yield, dry flower head yield, oil and kamazolene yield, and biomass of German chamomile (Table 6). Maximum fresh flower head yield, dry flower head yield and biomass were obtained from control treatment (90% FC). While the highest oil and kamazolene yield were in 70% FC. High level of drought stress significantly decreased yield and biomass of chamomile (Table 6).

Animal manure and compost residue significantly enhanced fresh and dry flower head yield, oil and kamazolene yield and biomass in the second year (Table 6). While the difference between chemical fertilizer residue and control treatment about oil and kamazolene yield and biomass was non-significant (Table 6). The highest of kamazolene yield was obtained from animal manure residue treatment. Correlation between dry flower head yield with other variable in this experiment was significant (except chamazulene yield) (Table 7).

Table 4. Correlation coefficients between yield and its components in the first year.

Variable	Dry flower yield	Oil yield	Kamazolene Yield	Flower number in plant	Fresh flower yield	Height	Stem number in plant	Anthodia diameter	Stem diameter
Oil Yield	0.74**								
Kamazolene Y.	0.29ns	0.82**							
No. flower in plant	0.86**	0.56ns	0.24ns						
Fresh flower Y.	0.98**	0.65*	0.22ns	0.88**					
height	0.92**	0.55ns	0.13ns	0.90**	0.95**				
No. stem in plant	0.85**	0.59*	0.08ns	0.78ns	0.88**	0.85**			
Anthodia diameter	-0.90**	-0.74**	-0.39ns	-0.85**	-0.94**	-0.94**	-0.80**		
Stem diameter	-0.89**	-0.38ns	0.14ns	-0.85**	-0.90**	-0.90**	-0.81**	0.76**	
biomass	0.89**	0.46ns	0.01ns	0.94**	0.93**	0.95**	0.83**	-0.85**	-0.95**

* , ** and ^{ns} are significant at 5 % and 1 % levels and non-significant, respectively

Table 5. Yield components of chamomile under irrigation and different fertilizers in the second year.

Treatment	Number of flower in plant	Number of main stem	Anthodia diameter (mm)	Stem diameter (mm)	Height (cm)
		Irrigation (%)			
50 field capacity	99.77c	9.30c	6.48a	3.51a	36.88c
70 field capacity	146.60b	11.41b	6.08b	3.11b	44.68b
90 field capacity	158.91a	12.57a	5.82b	2.71c	52.04a
		Fertilizer residue			
Control*	123.68c	10.48b	6.57a	3.28a	40.43c
Chemical	127.11c	10.86ab	6.13b	3.21ab	42.67b
Animal	148.01a	11.83a	5.78c	2.92c	48.24a
Compost	141.57b	11.21ab	6.03b	3.04bc	46.79a

Means followed by similar letters in each column are not significantly different at p≤ 0,05 Duncan Test. * Without fertilizer.

There were significant correlation among most variable in this research in the second year (similar to the first year) (Tables 4 and 7).

DISCUSSION

Result of two years showed that although stem and anthodia diameter enhanced with increasing of drought stress levels, number of flower per plant, number of main stem per plant, biomass and flower head yield decreased significantly (see Tables 2, 3, 5 and 6). Oil yield and kamazolene yield in 70% FC treatment are more than low (90% FC) and high (50% FC) levels of drought stress treatments because of having higher oil percentage and kamazolene percentage per oil respectively (data did not shown). Production of extra stem under water stress is an undesirable property (Arazmjoo, 2009) because of their low water use efficiency. Ogbonnaya et al. (1998) recorded that water stress condition limiting production of extra stem is an adaptation mechanism for water saving in flowering stage. Therefore decreasing of number of stem per plant probably is an adaptation mechanism to water shortage condition in chamomile. Decreasing of biomass and flower head yield under water stress have connection with decrease of height, number of flower per plant, number of main stem per plant, leaf area and shoot/root. Under water shortage conditions, nutrient absorption and water uptake are limited, that led to decrease growth, leaf expansion, light absorption and photosynthetic potential of plant. And as a result, plant yield was being restricted (Ashraf and Foolad, 2007). These results are in accordance with those obtained by Ahmadian et al. (2009) and Arazmjoo (2009).

Table 6. Flower, oil and kamazolene yield and biomass of chamomile under irrigation and different fertilizers in the second year

Treatment	Fresh flower Y	Dry flower Y	Oil yield	Chamazulene yield	Biomass
	(kg/ha)		(gr/ha)		(kg/ha)
Irrigation (%)					
50 field capacity	972.1c	178.63c	1010.92c	92.23b	744.4c
70 field capacity	1063.1b	206.71b	1309.98a	154.45a	853.3b
90 field capacity	1127.9a	233.28a	1187.44b	95.36b	987.6a
Fertilizer					
Control*	983.4c	185.59c	990.9b	92.43c	819.0c
Chemical	1039.3b	200.0b	1084.5b	100.32c	838.6c
Animal	1105.4a	223.96a	1343.6a	137.18a	918.6a
Compost	1089.5a	215.27a	1258.8a	126.13b	870.8b

Means followed by similar letters in each column are not significantly different at p≤ 0,05 Duncan Test.
* Without fertilizer.

Table 7. Correlation coefficients between yield and its components in the second year

Variable	Dry flower Y.	Oil Yield	Kamazolene Y.	Flower number in plant	Fresh flower Y.	Height	Stem number in plant	Anthodia diameter	Stem diameter
Oil Yield	0.75**								
Kamazolene Y.	0.36ns	0.87**							
Flower number in plant	0.90**	0.73**	0.46ns						
Fresh Flower Y.	0.98**	0.78**	0.42ns	0.91**					
Height	0.95**	0.64*	0.26ns	0.95**	0.95**				
Stem number in plant	0.92**	0.65*	0.32ns	0.97**	0.92**	0.97**			
Anthodia diameter	-0.84**	-0.71**	-0.40ns	-0.84**	-0.90**	-0.88**	-0.85**		
Stem diameter	-0.96**	-0.62*	-0.24ns	-0.92**	-0.93**	-0.96**	-0.96**	0.81**	
Biomass	0.93**	0.56ns	0.17ns	0.93**	0.92**	0.97**	0.96**	-0.84**	-0.96**

* , ** and ns are significant at 5 and 1% levels and non-significant, respectively.

Results showed that fertilizer consumption and their residue enhanced yield and improved yield components of chamomile. Chemical fertilizers consumption caused high yield in the first year while its residual had non-significant effected on yield in the second year. Probably, leaching of N, P and K that consumed in the first year is the reason of yield decreasing. Animal manure and compost application and their residue enhanced flower head, oil and kamazolene yield in two years. Organic fertilizers improve physical, chemical and microbiological characteristics of soil (Atiyeh et al., 2000; Ahmadian et al., 2009) and increased hold capacity of soil. Their residual also have the same effect (Eghbal et al., 2004). In the first year under normal water condition (control treatment) chemical fertilizer consumption lead to enhance yield and oil of chamomile. While under water stress condition there was non-significant difference between chemical and organic amendments. On the other hand it is better that we consume organic fertilizers under water shortage conditions instead of chemical fertilizers. In addition to residual effect of organic amendments have positive influence on plant yield and quality in the next years of application. In general animal manure and compost using under drought stress (50% field capacity according to the first year result) and under all water regimes (according to the second year result) reach to the best quantitative and qualitative yield and application of them was recommendable.

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