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Full Length Research Paper

Effects of vermicompost and amino acids on the flower yield and essential oil production from *Matricaria chamomile* L.

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The main objective of this study was to determine the effects of vermicompost and amino acids on the qualitative and quantitative yield of chamomile. The experiment was conducted during the growing season of 2010 at the Alborz Medical Research Center. The treatment groups consisted of vermicompost (0, 5, 10, 15 and 20 tons/ha) and the sprays of amino acids (budding stage, flowering stage, and budding + flowering stage). The experimental design was a factorial experiment based on randomized complete block design (RCBD) with three replications. The present results have shown that the highest plant height, flower head diameter, fresh and dry flower yield and significant essential oil content were obtained by using 20-ton vermicompost per hectare. Effects of amino acids were similar to those seen in vermicompost treatment and all measured traits were seen to be significant after the spray of amino acids at the budding + flowering stage.

Key words: Vermicompost, amino acids, chamomile, yield.

INTRODUCTION

Chamomile (*Matricaria chamomilla* L.) is an annual plant belonging to the Asteraceae family (Salmon, 2007). Its height varies from 20 to 60 cm, depending on the location and the soil. The root system in this plant is short but quite widespread (Applequist, 2002). Chamomile may be considered as an economic substitute of the field crops, irrigated with fresh water since it has adaptability to a wide range of soil and climatic conditions. Nowadays, chamomile is among the widely used medicinal plants throughout the world (Baghalian, 2000).

Many medical properties of chamomile are attributed to its essential oil. Therefore, the improvement of oil quality and quantity is among the major objectives in chamomile breeding programs (Wagner et al., 2005). Over 120 components have been identified in chamomile essential oil, while α-bisabolol, chamazulene, α- and β-bisabolol oxides, farnesene and α-bisabolonoxide A, are the most important ones. Chamomile is known to be anti-inflammatory, anti-spasmodic, anti-bacterial, and anti-septic (Franke and Schilcher, 2007).

Chamomile is an herb and native to Iran and Europe that grows as a wild plant (Reichinger, 1977). Chamomile is naturally widespread in west, northwest and south of Iran and its consumption has a long history in Iranian folklore medicine (Reichinger, 1977).

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 (Baghalian, 2000).

The form, structure and morphological characteristics of chamomile plants, their essential oil content and quality are affected by genetic background, ecological

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and agronomical conditions (Salmon, 2007). In this respect, the management of nutritional aspects of chamomile is very important in agro-ecosystems (Hadj Seyed et al., 2004).

Sustainability of agricultural systems has become an important issue throughout the world. Many of the sustainability issues are related to the quality and time-dependent changes of the soil (Karlen et al., 1997). It is well known that intensive cultivation has led to a rapid decline in organic matter and nutrient levels besides affecting the physical properties of soil. Conversely, the management practices with organic materials influence agricultural sustainability by improving physical, chemical and biological properties of soils (Saha et al., 2008).

The use of organic amendments has long been recognized as an effective means of improving the structure and fertility of the soil, increasing the microbial diversity, activity and population, improving the moisture-holding capacity of soils and crop yield (Frederickson et al., 1997).

Vermicompost contains most nutrients in plant-available forms such as nitrates, phosphates, and exchangeable calcium and soluble potassium (Edwards, 1998). Vermicompost has large particulate surface area that provides many microsites for the microbial activity and strong retention of nutrients. It is rich in microbial population and diversity, particularly fungi, bacteria and actinomycetes (Edwards, 1988). It contains plant growth regulators and other growth-influencing materials produced by microorganisms (Atyieh et al., 2002). Vermicompost also contains large amounts of humic substances and some of the effects of these substances on plant growth have been shown to be very similar to those of soil-applied plant growth regulators or hormones (Muscolo et al., 1999).

As a result, most nutrients are easily available such as; nitrates, phosphates, and exchangeable calcium and soluble potassium (Edwards, 1998), which are responsible for increased plant growth and crop yield. Vermicompost has been shown to increase the dry weight (Edwards, 1995) and nitrogen uptake efficiency of plants (Tomati et al., 1994). The beneficial effects of vermicompost have been observed in horticultural (Goswami et al., 2001; Atiyeh et al., 2000a) and agronomic crops (Pashanasi et al., 1996; Roy et al., 2010). The use of vermicompost on onion increased growth and yield from 2.72 to 38.05 g/plant (Thanunathan et al., 1997). In other vegetables, such as cucumber and lettuce, adding 20% of pig manure vermicompost increased the above ground dry weight of seedlings and in tomato resulted in 12.4% increase in fruit weight (Atiyeh et al., 2000b and 2001).

Most of research on the use of vermicompost has been on the horticultural crops and a few workers have reported on the use and effects of vermicompost on the field crops and medicinal plants. However, Several studies have reported that vermicompost can increase the growth and yield of some medicinal plants such as basil (Anwar et al., 2005), garlic (Arguello et al., 2006), fennel (Darzi et al., 2008) and chamomile (Azizi et al., 2009). Vermicopmpost had a positive effect on flower yield and essential oil of roman chamomile (Liuc and Pank, 2005).

The use of amino acid leaf sprayings, are becoming more frequent but its function is still not very well defined. The asparagine and glutamine connect the two important metabolic cycles of the plant, the carbon and nitrogen cycles, and they have an influence both on sugars and on proteins. The glycine is an amino acid that inhibits the apparent photorespiration done by C3 (Taiz and Zeiger, 2002).

The methionine is the ethylene precursor, it regulates the flowering and fruit ripening; the asparagine and the glutamine help in the nutrient transport and as reserve of nitrogen, besides being important in the pollination and fruit set. The tryptophan inhibits the precocious flower and fruit fall and it is important in the process of production of enzyme that catalyses synthesis reaction of auxin. The glutamic acid is important for the synthesis of the auxin and fruit set and the alanine for the germination and the pollen grains fertility (Taiz and Zeiger, 2002).

Studies have proved that amino acids can directly or indirectly influence the physiological activities in the growth and development of plants. According to several studies, the foliar application of amino acids causes an enhancement in plant growth and fruit yield while the maintenance of protein component is also regulated in cucumber (El-Shabasi et al., 2005), garlic (Awad et al., 2007) and sweet pepper (Kamar and Omar, 1987). Neeraja et al. (2005) found that amino acids application increased the number of flowers, fruit setting and fruit yield of tomatoes. On the contrary, shoot and root fresh weights were not affected by addition of amino acids (Cerdan et al., 2006). Shehata et al. (2011) indicated that spraying amino acids is effective on growth and yield of strawberry.

The main objective of this study was to assess the effects of vermicompost and amino acids on the flower yield and essential oil content of chamomile.

MATERIALS AND METHODS

Field experiment

The present study was conducted during the growing season of 2010 at the Alborz Medical Research Center of Research Institute of Forests and Rangelands (Latitude: 35° 38´ N; Longitude: 51° E; Altitude: 1321 m). The soil of the experimental region was loamy with pH 7.36 (Table 1).

The experimental design was a factorial study, based on randomized complete block design (RCBD) with three replications. Treatments consisted of vermicompost with five concentration levels (V1 = zero, V2 = 5, V3 = 10, V4 = 15 and V5 = 20 ton ha^{-1}) and amino acid spraying at three levels (spraying at the

Table 1. Chemical and physical characteristics for soil of experimental field (at the soil depth of 0 to 30 cm).

Texture	Clay	Silt	Sand	ECe (dS/m)	pH	TNV %	OC %	SP %	Total N %	Available P (ppm)	Available K (ppm)
Loamy	16	40	44	1.33	7.36	10.1	0.79	24	63	14.4	178.4

Table 2. Chemical analysis of fosnutren for its amino acid constitution.

Aminogram	Distribution (%)
Glycine	1.80
Valine	5.10
Proline	8.40
Alanine	13.21
Aspartic acid	4.50
Arginine	8.40
Glutamic acid	0.90
Lysine	5.10
Leucine	16.51
Isoleucine	4.50
Phenilalanine	5.10
Methionine	4.20
Serine	3.90
Theronine	3.00
Histidine	3.00
Glycocoll	9.60
Tyrocine	1.50
Glutamine	0.90
Cystine	0.30
Other	0.08

F1 = budding stag, F2 = at flowering stage, and F3 = at budding + flowering stage).

The amino acid treatment, used in this experiment, was Fosnutren, which consists of several amino acids, as described in Table 2.

The vermicompost was prepared from cow dung by employing epigeic species of *Eisena foetida*. Vermicompost was analyzed for major nutrients, as shown in Table 3. Vermicompost was applied and incorporated to the top 10 cm layer of soil in experimental beds. At the end of March and before the planting time (14th of April), the field was ploughed and harrowed thoroughly up to the depth of 30 cm and leveled. Each experimental plot was 4 m long and 3 m wide with the total area of 12 m^2. Chamomile seeds (Esfahan ecotype: a diploid ecotype belonging to chemotype A (prevailing content of α (–)-bisabolol oxide A with a high content of chamazulene) were obtained from the Research Center of Medicinal Plants, Isfahan, Iran. Sowing was done manually, and three weeks after sowing, the seedlings were thinned up to 33.3-plant m^{-2} (30 × 10 cm distances). The experimental plots were irrigated weekly and the weeds were controlled manually. All necessary cultural practices and plant protection measures were followed uniformly for all the plots during the entire period of experimentation.

Measurements

Data of the plant height (cm), flower head diameter (mm), number of flowers per plant, fresh and dry flower yield (kg ha^{-1}), and essential oil content were recorded from each treatment. Measurements and samplings were done on the inner eight rows in each plot, discarding 50 cm from both ends to avoid edge effects. Twenty plants were randomly selected for measuring the traits.

Chamomile had a continuous flowering period, which starts from the end of May and lasted to the end of July 2010. Therefore, for all plants in each plot, several harvests were done with the interval of 7 to 10 days. Cumulative measurements for the number of flowers per plant and flower weights were used for the analysis.

At the beginning of the flowering period, plant height was measured for each plot using a ruler (±0.1 cm) from the base to the tip of plant. Flower diameters were measured with a vernier caliper (±0.01 cm). Dry weight of the flowers was calculated in each plot after drying the flowers at room temperature (25°C for 120 h) using a digital balance (Sartorius B310S) (±0.01 g) (Azizi et al., 2009).

To determine the amount of essential oil, a sample of 100 g of flowers from the second harvest time were mixed with 500 ml of tap water in a flask and the water was distilled for 3 h using a Clevenger-type apparatus. The oil content was measured by following the protocol of Letchamo and Marquard (1993), based on ml oil per 100 g dry matter of flower.

Statistical analysis

All data were subjected to the statistical analysis (one-way ANOVA) using SAS software (SAS Institute Inc, 2002). Means of comparisons were performed by Duncan's Multiple Range Test (DMRT) at 5% probability level. Data were transformed when necessary before analysis to satisfy the assumptions of normality. However, any values mentioned in this section refer to the original data of present experiment.

RESULTS

The results have indicated that all measured traits were significantly affected by using vermicompost and the spray of amino acids, except for the values of flower head diameter after the amino acid spray (Table 4). Interactions were significant only for the dried flower yield.

Chamomile plant height

After the application of vermicompost, the chamomile plant height was increased significantly. Regression analysis showed that by increasing the vermicompost amount from V1 to V5, the plant height increased linearly.

Table 3. Chemical analysis of vermicompost used in the experiment.

pH	ECe ds/m	Total N %	K %	P %	OC %	OM %	Moisture %	Fe (ppm)	Zn (ppm)	Mn (ppm)
7	1.1	4.92	3.19	0.61	37.7	65	25	36-50	27-40	15-25

Table 4. Effects of vermicompost and fosnutren on some traits of chamomile (*Matricaria chamomilla* L.).

Treatment	Height (cm)	Flower head diameter (mm)	No. flowers/plant	Fresh flower yield (kg/ha)	Dry flower yield (kg/ha)	Essential oil (%)
Vermicompost						
V1	25.3^{d}	18.5^{b}	65.42^{d}	1800.77^{d}	352.95^{e}	0.34^{d}
V2	31.2^{c}	18.6^{b}	89.21^{c}	2311.23^{c}	462.42^{d}	0.37^{c}
V3	34.1^{bc}	18.9^{b}	95.76^{bc}	2733.5^{b}	535.77^{c}	0.38^{c}
V4	37.2^{b}	19.4^{b}	107.5^{ab}	3172.54^{a}	592.63^{b}	0.43^{b}
V5	41.8^{a}	21.5^{a}	110.23^{a}	3335.7^{a}	653.81^{a}	0.49^{a}
Fosnutren						
F1	33.2^{b}	18.4^{b}	105.11^{a}	2528.48^{b}	510.18^{b}	0.35^{b}
F2	31.9^{b}	18.2^{b}	105.92^{a}	2315.68^{c}	493.07^{b}	0.36^{b}
F3	38.7^{a}	20.8^{a}	104.41^{a}	2868.09^{a}	572.15^{a}	0.39^{a}

Vermicompost levels: V1, 0 ton/ha (control); V2, 5 ton/ha; V3, 10 ton/ha; V4, 15 ton/ha; V5, 20 ton /ha. Fosfutren spraying F1, at budding stage; F2, at flowering stage; F3, at budding stage + at flowering stage. Mean values followed by the same letter are not significantly different at $P \leq 0.05$.

The highest plant height (41.8 cm) was recorded by using 20-ton vermicompost per hectare.

Mean comparison showed significant differences between various levels of fosnutren spraying. Foliar application of fosnutren at F3, caused the plant to reach the highest height (38.7 cm). Amino acids are the fundamental ingredients of the process of protein synthesis because of their nitrogen content.

Flower head diameter

During the present experiment, the flower head diameter was significantly influenced by vermicompost treatment. Use of the vermicompost from V1 to V3 did not cause major differences in flower head diameter (Table 4). Flower head diameter was greater ($P \leq 0.05$) after the V5 treatment.

Mean comparison has shown significant differences between various levels of fosnutren treatments. Spraying the fosnutren twice (F3) caused increased flower head diameter (20.8 mm). However, there were no significant differences in flower head diameter between the plants in plots sprayed with fosnutren at F1 and F2 (Table 4).

Fresh and dry flower yield

Vermicompost had positive effects on the fresh and dry flower yield of chamomile. Plants grown in the plots, treated with V5, had significantly greater flower yield ($P \leq 0.05$).

As shown in Figures 1 and 2, by increasing the vermicompost amounts, the flower yield increased nonlinearly. The highest fresh and dry flower yields (3335.7 and 653.8 kg/ha, respectively) were recorded by using V5 treatment (Figure 1).

The high flower yield of chamomile under V5 might be due to higher number of flowers per plant and an increased flower head diameter (Table 4).

Mean comparison showed significant differences between various levels of fosnutren spraying. Foliar application of amino acids at F3 phase (Budding + Flowering stage) caused the greatest fresh and dry flower yield (Table 4). Significant differences in flower yield were also recorded for the plants sprayed with fosnutren at the budding (F1) and flowering stage (F2).

Essential oil content

Analysis of variance showed that vermicompost and fosnutren had significant effects on the essential oil content. Mean comparison showed significant differences among various levels of vermicompost treatments (Table 4). Total essential oil content varied between 0.34 and 0.49% (Table 4), which was obtained from control (V1) and V5, respectively. There were significant differences in essential oil content between the plants sprayed with

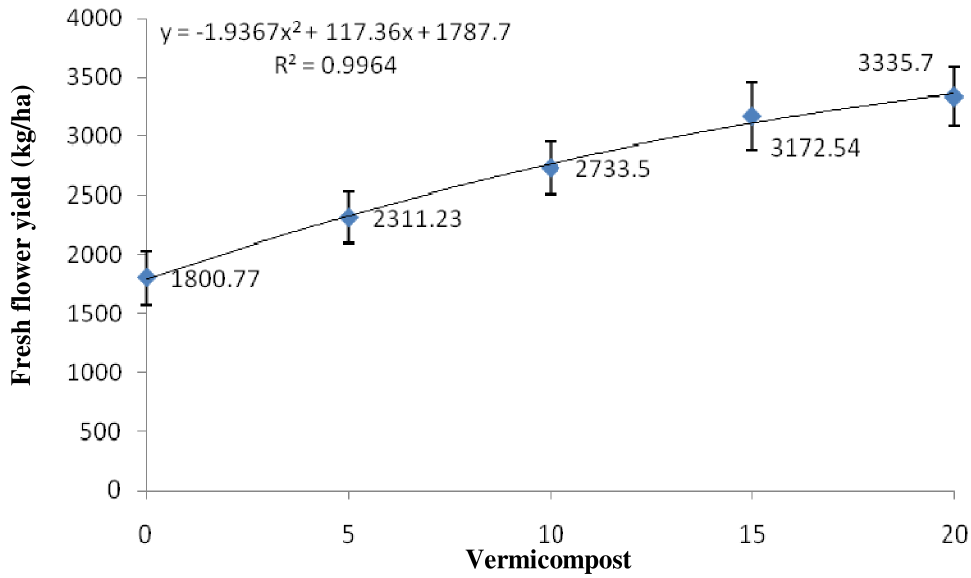

Figure 1. Effects of vermicompost on fresh flower yield.

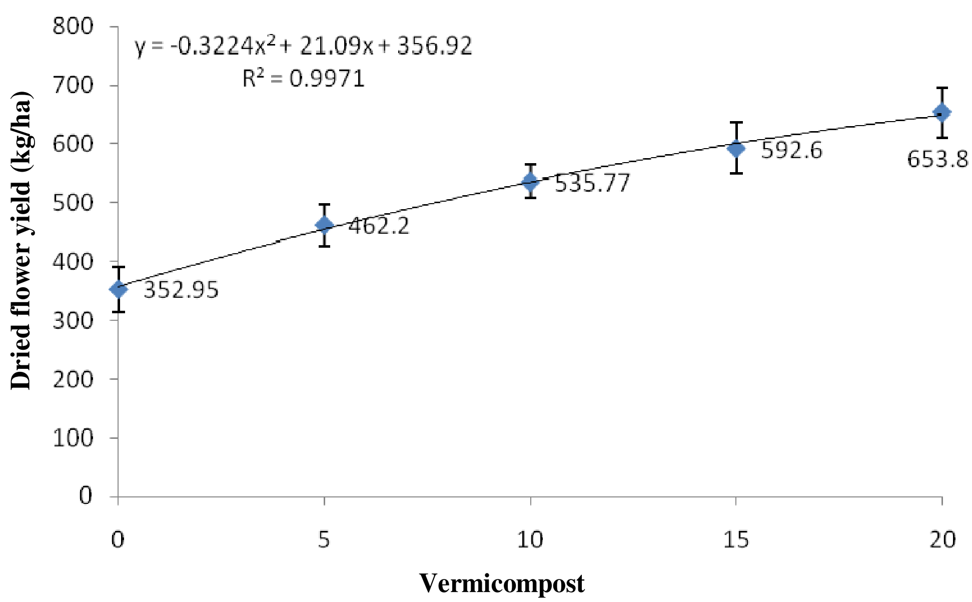

Figure 2. Effects of vermicompost on dry flower yield.

various levels of fosnutren treatments. Foliar application of fosnutren at F3 (Budding + flowering stage) resulted in the greatest essential oil content (Table 4).

DISCUSSION

Vermicompost contains most of the plant nutrients such as; nitrate, phosphates, exchangeable calcium and soluble potassium (Edwards, 1998), and microelements which result in improved plant growth and development and is responsible for increased qualitative and quantitative yield of many crops (Atiyeh et al., 2002; Roy et al., 2010). Azizi et al. (2009) have found the positive influence of vermicompost on the essential oil and chamazulene contents of chamomile. Other studies have indicated the same results on some medicinal plants (Darzi et al*.,* 2007; Hadj et al*.,* 2004). Vermicompost has been shown to increase chamomile height, flower yield and flower head diameter (Azizi et al., 2009).

Studies on the field crops have also shown that the vermicompost has a positive influence on flower yield by improving the biological activities in soil and the absorption of mineral elements (Atiyeh et al., 2002; Roy et al., 2010).This finding of this investigation is in accordance with the previous observations on the *Fragaria ananasa* and *Foeniculum vulgare* (Arancon et al., 2004; Darzi et al., 2007).

Amino acids are the fundamental ingredients of the process of protein synthesis because of their nitrogen content. The importance of nitrogen or amino acids came from their increased application for the biosynthesis of a large variety of non-nitrogenous materials that is, pigments, vitamins, coenzymes, purine and pyrimidine bases (Kamar and Omar, 1987).

Many studies have reported that foliar application of amino acids caused an increase in the growth and development of plants (Awad et al., 2007; Kamar and Omar, 1987; Alaa et al., 2009; Faten et al., 2010). Neeraja et al. (2005) found that amino acid treatment increased the number of flowers, fruit setting and fruit yield in tomato.

The present results suggest that not only purely physical and chemical properties of vermicompost stimulate the plant growth but there is also the possibility that its indirect effects, via the inhibition of plant pathogen infection (Edwards, 1998), nitrate uptake kinetics (Muscolo et al., 1999), effects on beneficial microorganisms and plant growth regulators (Tomati et al., 1994) might override pure nutrient effects. In addition, amino acid spraying on chamomile has stimulating effects on the flower yield and could be substitution for chemical fertilizers. Clearly, more experimental research, aiming to specifically address vermicompost application and amino acid spraying and their consequences for medicinal plants, seems necessary.

Conclusion

In conclusion, the results of current experiment show that vermicompost and amino acids have no detrimental but rather stimulatory effects on the growth, flower yield and essential oil content of chamomile and have thus considerable potential for providing nutritional elements in chamomile production, especially for the sustainable production systems.

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