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Evaluation of Yield and Land Equivalent Ratio in Saffron and Chamomile Mixed Culture

Mohammadreza Naderidarbaghshahi[+], Alireza Jalalizand and Mehdi Karimi

Agronomy and Plant Breeding Department, Khorasgan (Isfahan) Branch, Islamic Azad University, Isfahan, Iran, P.O. 81582-158.

Abstract. Mix culture is simultaneous culture of two or more plants in one field and has many advantages that yield increasing is the most important one of them. This study was conducted to possibility evaluation of chamomile mix culture between Saffron (*Crocus sativus* L.) rows during 2008-2010. The mixed culture of three chamomile kind (*Matricaria chamomilla, Tanacetum parthenium , Anthemis nobilis*) at two sowing dates (autumn and spring) were examined in a three years old Saffron farm. The experimental layout was split Factorial in a randomized complete block design in four replicates. Saffron and pure chamomile plots were two main plots and Factorial of two sowing dates (November 2008, after Saffron flower harvest as autumnal and late February 2008 as spring sowing date) and three kind of chamomile (*M. Chamomilla , A. nobilis , T. parthenium*) were six sub-plots. According to results, any competition was no seen between saffron and chamomile in all mix culture treatment. All treatments no had significant differences in Saffron yield as well as in the best treatment (Saffron and autumnal *M. Chamomilla*), 1.83kg/ha Saffron flower and 1354kg/ha chamomile dried flower was produced with a Land equivalent Ratio equal 1.69, also there was no any significant difference between yield of chamomile in mix culture and the yield of *M. Chamomilla* in pure chamomile cultivation. Chamomile cultivation significantly reduced soil electrical conductivity (EC).

Keywords: Mix Culture, Saffron, Chamomile, Land equivalent Ratio, Soil Electrical Conductivity

1. Introduction

Following the increase of world population, loss of balance and destruction of agro ecosystems will be continued, so it is necessary to raise crop production while protect environment too. Many strategies like biotechnology, plant breeding , chemical fertilizers, and pesticides have been used up to this time to increase agricultural and horticultural crops yield, but these strategies have been useful only in regional scale and provide part of our need and some these are not compatible with natural environment. Thus, food providing together with protection of natural environment must be researcher's main goal. One way to this goal is "mixed culturing" because it has been seen that mixed culture has higher yield than monoculture, also land is used better in mixed culture and upper ground parts(shoot) and underground parts of plants(root) cover more parts of soil, then erosion of soil will minimize (Mazaheri, 1994). Another advantage of mixed culturing is that the soil is used more efficiently. A mixture of various crops will often give a better coverage of the soil leaving less space for the development of weeds. If legumes are used in intercropping, they will contribute to improved soil fertility. Of course in mix culture maximum yield will be gained when selection of accompaniment plant there is according to main plant needs to water and nutrition and they to have similar ecological and agronomical needs (Farhoodi and Esmaeilzadeh, 2003). Saffron is a crop that is dormant in summer and part of spring, and it no have any vegetative organ in this time, so, Culturing the plants with similar needs can be a good option for better use of field in Saffron dormancy period (Farhoodi and Esmaeilzadeh, 2003) but because Saffron has a small water need and large amounts of water will certainly

[+] Corresponding author. Fax :0098-311-5224556 .Tel .0098-311-5230640.
E-mail address: (mnaderi@khuisf.ac.ir)

damage it, selecting crops with similar need to water is very important (Farhoodi and Esmaeilzadeh, 2003).Chamomile is a crop with shallow root system that has many horizontal roots (Omidbeigi, 2002) . This plant has a simple growth and prefers cool climates. evaluation of Chamomile ecological characteristics indicates that mixed culture of Saffron and chamomile must be possible (Azizi, 2006). Although there are no any scientific and practical record of Saffron and chamomile mixed culture, but because of similarities in their ecological characteristics, study of their mixed culture can be a good idea that was our reason of this study.

2. Materials and Methods

The experiment was conducted from October 2008 to July 2010 at the Research Station of Islamic Azad University of Isfahan (Khorasgan) Branch (32o 40' N, 51o 48' E) at is located in east of Isfahan (10 km) at an altitude of 1555m. The long mean annual rainfall and temperature are 120mm and16˚C, respectively. The regional climate is dry, very warm with dry summers (Bwhs), according to Koppen method. Soil texture was silty loam and 3.5 ds/m electrical conductivity and 7.8 acidity. In this study, mixed culture of three kind of chamomile (*M. Chamomilla, A. nobilis and T. parthenium*) at two sowing dates (autumn and spring) in a three years old Saffron farm were examined. The experimental layout was split factorial in a randomized complete block design with four replicates. Pure saffron and Without Saffron plots were as main plots and factorial of two sowing dates (November 2003, after Saffron flower harvesting and late February) and three kind of chamomile (*Matricaria chamomilla, Tanacetum parthenium , Anthemis nobilis*) were as sub- plots. Every plot of Saffron had five rows with 5 meters length with a 30cm and 20cm inter-row and inter plant distance respectively. Chamomile seeds were sown between Saffron rows with 1 cm depth and 5 cm distance. In “Without Saffron” plots, chamomile were sown in rows with a 30cm inter row distance and also in pure Saffron plot, chamomile were not sown. The method of irrigation was floating and weeds were controlled by handing. Samples were taken (harvested) from three middle rows of five Saffron rows for avoiding of margin effects. The yield of Saffron(dry stigma) in 2009 autumn, dry weight of Saffron shoot in 2010 spring, yield of chamomile dry flower in spring 2009 were measurement. Soil EC was measuring after chamomile harvesting for pure Saffron and all mixed plots. LER was calculated from the follow equation (Koocheki et al., 2009):

$$\text{equation 1:} \quad LER = \Sigma Yi / Yij$$

where Yi is the yield of every crop per unit area in mixed culture and Yij is the yield of same crop in monoculture.

A split factorial design was used to data analysis but Saffron properties data were analyzed according to completely randomized blocks design. Analysis of data was performed using S.A.S program and where f-value was found to be significant; Duncan's multiple range tests was used to compare means at $P \leq 0.05$. Excel 2009 software was used to graph drawing.

3. Results and Discussion

3.1. Total Dry Matter of Saffron Shoots

The Saffron shoots total dry matter in all treatments was located in one statistical group with a range of 86.30 g/m2 in SAMc to 127.90 g/m2 in pure Saffron (Table.1). On the whole the results show that although mixed culture reduced the dry matter of Saffron in both sowing dates and all of chamomile species, but this reduction was not significant. It seems that more ecological and agronomical conformity of all three kinds chamomile with saffron caused There were no significant differences between means of Corm numbers per area unit in all treatments and it's caused there were no significant differences between means of The saffron shoots total dry matter in all treatments.

3.2. Saffron yield

There was no significant difference between Saffron yield of mixed culture treatments (with a range of 1.16kg/ha in SAAn to 1.83kg/ha mix of SAMc) with pure Saffron treatment (1.93kg/ha) (Table1). This result shows that the existence of chamomile plants adjacent saffron plants no have any badness effect on growth of Saffron and dry matter accumulation in corms. Also chamomile's roots existence beside Saffron corms

and extra moisture of soil (because of additional irrigations for chamomile) didn't cause any trouble to corms in summer, because if additional irrigations of mix treatments had bad effects to corms, rottenness of corms would reduce next year yield of Saffron, certainly. General results of before studies about mixed culture of saffron and other plants (Banitaba et al. 2008 ; Koocheki et al.2009) shows that closer needs (agronomical and ecological) of companion plant will reduce bad effects of these on Saffron yield.

In our study, it seems that non-existence of negative effects of chamomile in both sowing dates and all three kinds is the appropriate conformity of its ecological and agronomical needs in both sowing dates. Chamomile plants have only a primary growth and are in rosette stage when Saffron has great need to water, light and nutrients in winter so there is no any light competition also competition on water and nutrients is little. On the other hand, from late march that chamomile starts to quick growth, growth of Saffron is slow and about end, and there is no noteworthy competition between them. The lack of growth interference and competition was more obvious in late February sowing that chamomile growth started from late April also, considering that chamomile ripening stage is from June first to July first depend on species and sowing date, while growth period of saffron end in is late of April and chamomile need to water in this time, it seems that water need interference in this period no have any considerable loss on Saffron yield. This interference was less in autumnal sowing and specifically in *M. Chamomilla* that was more early matured and harvestable in late May but in late February sowing and specifically in T. parthenium that was late matured than two other species was more obvious .In general, the reason of no existence significant difference between two sowing dates and also between three kind is probably that earlier competitive effect of chamomile in autumnal sowing and interference effect of longer irrigation in spring sowing acted against each other and counteracted the negative effects of another one.

3.3. Chamomile Yield

There was no any significant difference between means of chamomile yield in pure chamomile treatment and mixed culture treatment (617kg/ha and 603kg/ha, respectively) and they were located in one statistical group but chamomile yield in autumnal sowing (821 kg/ha) was significantly higher than spring sowing (399 kg/ha) (Table 2). Mean comparing of interactions between sowing date and chamomile kind showed that in autumnal sowing, *M. Chamomilla* significantly ranked higher than the other two kind but it didn't have any superiority in spring sowing date where *M. Chamomilla* and *A. nobilis* had equal yields (Figure 1).

3.4. Land equivalent Ratio (LER)

All treatments had significantly higher LER than pure Saffron and SAAn had the greatest one (1.95). Also, all of mixed culture treatments had LER more than 1 without any significant difference (Table1). Considering that all of mixed treatments had LER more than 1 in this study, it seems that the mixed culture of saffron and chamomile has better operation of soil and the other agricultural inputs. Banitaba et al. (2009)., Farhoodi and Esmaeilzadeh (2003); Kaafi et al. (2002); Koocheki et al. (2009) reported similar results.

3.5. Soil Electrical Conductivity (EC)

According to results (Table1), cultivation of all chamomile types in both sowing dates significantly had been decrease EC in proportion to pure Saffron and SSMc had significantly less EC (1.93ds/m) than pure Saffron (2.6ds/m). It seems that chamomile has been absorb a great deal of soil salt (salamon, 1994) and decreased EC that is a good feature of chamomile and Saffron mixed culture and considering relative sensitivity of Saffron to saltiness (Ait–aubahou and Ei-otmani, 1999), it can play a useful role in Saffron sowing in salty soils.

4. Conclusion

Considering the results of this study, the our hypothesis (possibility of chamomile sowing in Saffron farm) is proven and it can be frankly announced that cultivation of all three chamomile types in Saffron farm is possible in all similar regions of world, immediately after flower harvesting of Saffron in late November, or in early March. That this can to be creation a great evolution in world saffron farmers economy.

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Table 1. Results of means comparison effects of experimental treatments on saffron traits

Treatments	Saffron yield (kg/ha)	Saffron dry matter (g/m2)	Soil EC Ds/m	LER
Saffron + Autumnal Matricaria chamomilla	1.83 a	86.30 a	2.06 bc	1.69 a
Saffron + Autumnal Tanacetum parthenium	1.16 a	92.77 a	2.16 bc	1.98 a
Saffron + Autumnal Anthemis nobilis	1.76 a	98.47 a	2.03 bc	1.78 a
Saffron + Spring Matricaria chamomilla	1.20 a	106.20 a	1.93 c	1.77 a
Saffron + Spring Tanacetum parthenium	1.43 a	82.04 a	2.30 b	1.85 a
Saffron + Spring Anthemis nobilis	1.76 a	101.40 a	2.26 b	1.89 a
Pure Saffron	1.93 a	127.90 a	2.60 a	1.00 b

Means with similar letters in each column are not significant difference at the 5% level of probability according to MRT.

Table 2. Means comparison effect of experimental treatments on chamomile yield

Treatment	Yield (kg/ha)
Cultivation Method	
Chamomile +Saffron	603.00 a
Pure Chamomile	617.00 a
Sowing Date	
Autumnal	821.00 a
Spring	399.00 b
Kind chamomile	
M.c	1027.00 a
T.p	473.00 b
A.n	329.00 b

Means with similar letters in each column are not significant difference at the 5% level of probability according to DMRT.

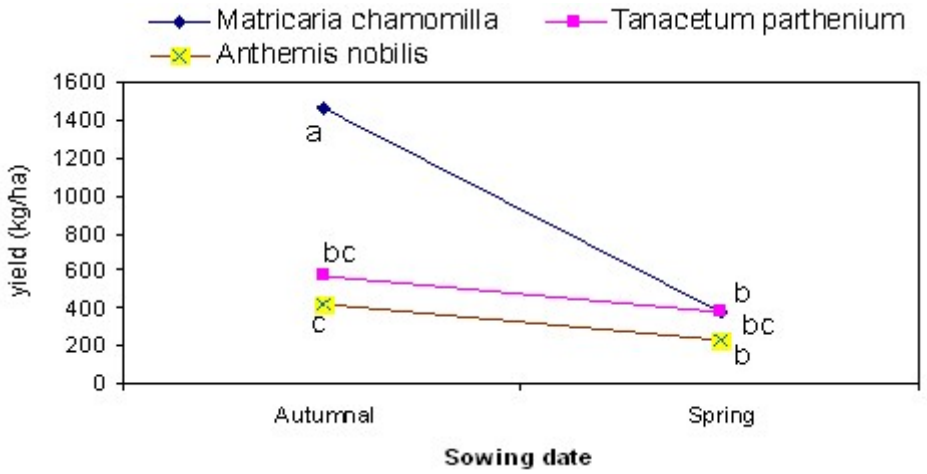

Fig. 2: Intraction effects of Sowing Date and Cahmomile type on chamomile yield