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Full Length Research Paper

The interaction effect of water stress and manure on yield components, essential oil and chemical compositions of cumin (*Cuminum cyminum*)

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Water stress enhances essential oils content in medicinal plants. Manure in soil prepares essential elements and increase quality and quantity of plant products. To study the effects of water stress and manure application on yield components, oil percentage and its main constituents on *Cuminum cyminum*, this experiment was conducted at the Agricultural Research Station of Zahak, Zabol, south east of Iran in a complete randomized block in factorial design with four replications. Treatments including irrigation intervals (I_1: two times irrigation, I_2: three times irrigation and I_3: four times irrigation that are irrigation in germination, seedling, flowering and seed filing stages) and manure application (F_1: without manure application, F_2: 20 t/ha manure application). The chemical composition of the essential oil was examined by GC and GC-MS and they were significantly affected by water stress and manure ($P<0.05$). Three irrigation times with manure treatment produced the highest number of umbrella per plant, seed and biological yield and the lowest 1000 – seed weight and number of seed per umbrella. The effect of water stress and manure were significant on essential oil and its constituents. Three irrigation times with manure treatment caused the highest amount of cumin aldehyde and ρ-cymene and the lowest of β-pinene, γ-terpinene and α-pinene. Results showed that a relationship exist between the main constituents of cumin essential oil under water and manure application.

Key words: *Cuminum cyminum*, manure, irrigation, oil, oil constituents.

INTRODUCTION

Quality in medicinal plants is more important than other plant products. Environmental factors have an important role on plant growth. Some of these factors such as irrigation and manure can be controlled by human. Both of them are essential to increase yield and quality of plants (Singh and Goswami, 2000). Water deficit is the major limiting factor in agricultural production (Aminpoor and Musavi, 1995). Drought stress may change the mineral elements absorption from soil (El-Fouly, 1983). Therefore, we can control accessibility of water and minerals in roots medium in order to increase the quality of medicinal plants produced in these soils.

Usage of manure is more important and beneficial than chemical fertilizers (Loecke, 2004). Chemical fertilizers just provide one or some essential elements for plants, while organic fertilizer provides more micro and macro nutrients (Saboor bilandi 2004). Furthermore, it can be improved by the physiochemical property of soil and yield quality (Loecke, 2004). Essential oil in medicinal plants is affects by some nutrimental elements (Shaath and Azzo, 1993). Therefore, using manure could be a reliable method for growing medicinal plants.

Cumin (*Cuminum cyminum L.*) is a member of Umbelliferae and annual a plant which is widely cultivated in arid and semi-arid regions (Tuncturk and Tuncturk, 2006). Iran is one of the main producers of this plant (Kafi, 2002).

Plant essential oils have many applications such as changing the smell of some medicines, equipping the product antiseptic associated with the mouth, sterilization

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of surgical operation fiber, product of some veterinary and agricultural medicine, industry perfumery, coloring, soap, detergent and plastic (Yilmaz and Arslan, 1991).

Leaf shape, short leaves, color and surface cover of plant parts are representative adaptation of cumin to drought conditions (Kizil et al., 2003). Furthermore, the plant is relatively salt resistant and has no much needs of soil fertility (El-Fouly, 1983).

Researches that were conducted on water and fertilizer requirements on cumin show that there are low requirements of fertilizers which are much lesser than the other crop plants (Kafi, 2002).

Tavoosi (2000) studied the effects of irrigation regimes on cumin yield and reported that moisture potential of soil on cumin reached 30 bar in last growing period but not any sign of wiltness was observed. These indicate that cumin is able to absorb water even in very low water potential. In that study, it was cleared that there is no significant difference between seed yield, number of umbrella per plant and number of seeds per umbrella in irrigation regimes.

Tatari (2004) reported that increasing irrigation times enhanced biological yield and decrease seed yield and harvest index significantly. The best treatment was obtained with 2 irrigation after flowering.

Farahza et al. (2002) in evaluating the effect of drought stress on yield components of cumin, using moisture treatments of FC, ½ FC, $^2/_3$ FC (field capacity) observed that FC treatment showed the highest seed yield, 1000 seed weight, number of umbrella per plant and biological yield. But other treatments have no significant difference in such properties.

Until now some investigators extracted the essential oil of different varieties of cumin. Li and Jiang (2004) reported that essential oil of cumin include cumin aldehyde, cuminic alcohol, γ terpinene, safranal, paracymene and β pinene. Nevertheless, Jirovets and Buchbouer (2005) reported the presence of cumin aldehyde, β pinene, paracymene, γ terpinene in this plant. Iacobellis et al. (2005) stated that the main fractions of cumin oil are 1-4-paramentadin-7-al, cumin aldehyde, γ terpinene, β pinene. According to the results there are some constituents in all varieties and cumin aldehyde is the major constituent of cumin (Shaath and Azzo, 1993; Borges and Pino, 1993; Behera et al., 2004).

In this study, the effect of irrigation times and manure application on cumin yield, yield components, essential investigated.

MATERIALS AND METHODS

The experiment was conducted in Zahak Agricultural Research Station in Sistan, South east of Iran in 2005. During this experiment, accumulated rainfall during the crop seasons (November to April) was 40 mm, and this value was lower than the long-rainfall average, which is 50 mm.

The soil texture was sandy-loam, having 1.1% organic matter. Soil chemical analysis was as follows: pH = 7.7; ECdS/m) = 2.4; cations (meq/L): Ca^{+2} = 2.43, Mg^{+2} = 2.5, Na^+ = 6.46, K^+ = 2.74; anions (meq/L): CO_3^{-2} = zero, HCO_3^- = 3.6, Cl^- = 2.4, SO_4^{2-} = 5.6 (Jackson, 1973).

Seeds were planted on 22 November, 2004 in 20 cm row distance, 1.5 cm sowing depth in 2.2×2.4 m plots. Before planting the decomposed cattle manure added to those plots that was supposed to receive manure at the range of 20 t/ha.

The lay-out of the experiment was a complete randomized block in factorial design of four replicates for each treatment. Treatments including irrigation times (I_1: two times irrigation, I_2: three times irrigation and I_3: four times irrigation, that are irrigation in germination, seedling, flowering and seed filing stages) and manure (F_1: without manure application, F_2: with 20 t/ha manure application).

Number of umbrella per plant, number of seed per umbrella, plant height (cm), number of seed per plant, 1000-seed weight (g), seed and biological yield (kg/ha) were determined.

All agricultural practices were performed in the same manner, as it is usually done in the cumin production areas in Iran.

Plants of 2 m^2 in each plot were harvested, dried and winnowed. The dry cumin seed powdered sample (50 g), and distilled water (500 ml) were placed in a round bottom flask and connected to the Clevenger distillation unit and distilled for 3 h.

The gas chromatography (GC) characteristic was: a FID Hewlett-Packard 5890 was used using a fused silica capillary SE54 (30 m × 0.25 mm id.) column. Temperature program was: 2 min at 60°C, 60 to 100°C (2°C/min) and 100 to 250 °C (5°C/min), then isothermal for 20 min; carrier gas was helium at a flow rate of 1.0 ml/min in Khorasan Science and Technology Park.

The gas chromatography–mass spectrometry (GC–MS) characteristic was: a Hewlett Packard 5989A GC-MS system, equipped with library software, Wiley 138 and NBS75, was used. Capillary GC conditions, as above were employed for the fused silica capillary column SE54. Injection volume was 1.0 ul at 1:50 split. Significant MS operating parameters: ionization voltage 70 eV, and scan mass range from 40 to 350 u.

Compounds were identified by matching of their mass spectra with those recorded in the MS library and further confirmed by injecting the authentic samples of different compounds with the volatile oil and by comparison of the mass spectra with those of reference compounds or with published data.

All data were averaged and statistically analyzed using analysis of variance (ANOVA) by MSTATC analytical software. The Duncan's multiple range test level was used to compare means.

RESULTS

Yield components

Table 1 shows the effects of irrigation times and manure on cumin growth. Manure had no significant effects on the number of seed per umbrella, 1000 seed weight (g) oil percentage and chemical compounds of oil was and plant height (cm), however enhanced number of seed and number of umbrella per plant.

Irrigation times imposed a positive effect on the number of seed and number of umbrella per plant, and it had negative effect on seed weight, but no effects on number of seed per umbrella and plant height (cm). There were no significant differences between 3 and 4 irrigation times in all yield components.

The highest number of umbrella per plant and number of seed per plant resulted from 3 irrigations with manure

Table 1. Effect of manure and irrigation times on cumin yield components (mean of two seasons).

Treatment	Number of seed per plant	Number of umbrella per plant	Number of seed per umbrella	Thousand– seed weight (g)	Plant height (cm)
Without manure	296 b	21.89 b	13.39 a	2.87 a	26.09 a
With manure (20t/ha)	364 a	27.43 a	13.32 a	2.65 a	28.54 a
LSD 5%	41.6	2.72	1.03	0.286	2.75
2Irrigations	287 b	21.18 b	13.56 a	3.16 a	25.83 a
3 Irrigations	357 a	27.28 a	13.13 a	2.51 b	28.58 a
4 Irrigations	347 a	25.53 a	13.38 a	2.61 b	27.55a
LSD 5%	51	3.33	1.26	0.35	3.37
2 Irrigations without manure	261 c	19.06 c	13.58 a	3.29 a	25 b
2 Irrigations with manure	313 bc	23.3 bc	13.55 a	3.04 ab	26.65 ab
3 Irrigations without manure	320 abc	23.5 bc	13.6 a	2.68 bc	26.8 ab
3 Irrigations with manure	394 a	31.05 a	12.65 a	2.34 c	30.35 a
4 Irrigations without manure	308 bc	23.13 bc	13 a	2.65 bc	26.48 ab
4 Irrigations with manure	386 ab	27.93 ab	13.57 a	2.57 bc	28.63 ab
LSD 5%	72.1	4.7	1.78	0.495	4.76

There were no statistical differences among the means shown by the same letters at 5 % probability level.

application treatment. The effects of manure and irrigation times were not found statistically significant on the number of seed per umbrella. The decrease in the thousand– seed weight (g) is due to the higher number of seed and number of umbrella per plant in 3 irrigations with manure application treatment. Plant height in 3 irrigations with manure treatment was significantly more than plant height in 2 irrigations without manure treatment. These results are in agreement with those obtained by Tuncturk and Tuncturk (2006) and Singh and Goswami (2000).

Yield

Table 2 demonstrates that no marked changes were obtained in the herb yield due to irrigation and manure. Manure and further irrigation enhance seed and biological yield. The increase in the biological yield is due to the higher seed yield. The highest seed yield (493 kg/ha) resulted from 3 irrigations with manure treatment. Similar effects of fertilizers and irrigation on cumin yield were reported by several investigators such as Jangir and Singh (1996) Tuncturk and Tuncturk (2006) and Saboor Bilandi (2004).

Oil constituents of cumin seeds

Table 3 shows the square means of oil constituents affected by manure and irrigation times. All treatments had significant effect on oil and its constituents.

Figure 1 shows that increasing irrigation times, significantly ($p<0.05$) decreased the oil percentage. However application of manure, significantly ($p<0.05$) enhanced cumin essential oils. The maximum oil percentage resulted from 2 irrigation times without manure application, 2 and 3 irrigations times with manure treatments (Figure 1). Drought stress is a primary factor in increasing oil percentage of medicinal plants.

Using the manure increased the two major constituents, cumin aldehyde and paracymene (Figure 3). A positive effect was also observed with paramentadyne. Also, the application of manure decreased other constituents of cumin oil compounds. This effect was obvious with β - pinene.

Increasing irrigation from 2 to 3 times led to significantly increase ($p<0.05$) cumin aldehyde, paracymene and 1-4-paramentadyne-7-al and

Table 2. Effect of manure and irrigation and their interaction on seed, biological and herb yield. (mean of two seasons).

Treatment	Seed yield (kg/ ha)	Biological yield (kg/ ha)	Herb yield (kg/ ha)
Without manure	383b	715b	332a
With manure (20t/ha)	449a	852a	403a
LSD 5%	32.7	93	79
2irrigations	374b	686b	312a
3irrigations	448a	850a	403a
4irrigations	427a	817a	390a
LSD 5%	40	113.9	96.8
2 Irrigations without manure	349c	624c	275b
2 Irrigations with manure	400bc	748bc	349ab
3 Irrigations without manure	402bc	775abc	373ab
3 Irrigations with manure	493a	926a	433a
4 Irrigations without manure	397bc	744bc	347ab
4 Irrigations with manure	456ab	891ab	435a
LSD 5%	56.6	161	136.7

There were no statistical differences among the means shown by the same letters at 5 % probability level.

Table 3. Square means of oil constituents affected by manure and irrigation.

S.O.V	df	Means of square						
		α Pinene	γ Terpinene	β Pinene	Cumin aldehyde	Paracymene	Paramentadyne	Miresen
Replication	2	0.002 ns	0.001 ns	0.004 ns	0.009 ns	0.02 ns	0.0001 ns	0.001 ns
Irrigation	2	0.29 **	4.2 **	27.82 **	22.74 **	12.89 **	0.175 **	0.17 **
manure	1	0.08 **	0.66 **	0.781 **	1.67 **	0.64 **	0.029 **	0.008 *
Interaction A&I	2	0.01**	0.016 ns	0.091 **	0.07 ns	0.04 ns	0.002 ns	0.001 ns
Error	10	0.001	0.009	0.01	0.04	0.011	0.001	0.001
CV %	-	2.62	0.61	0.69	0.45	0.49	1.47	2.68

** , * statistical significant on 0.01 and 0.05 ns : not significant.

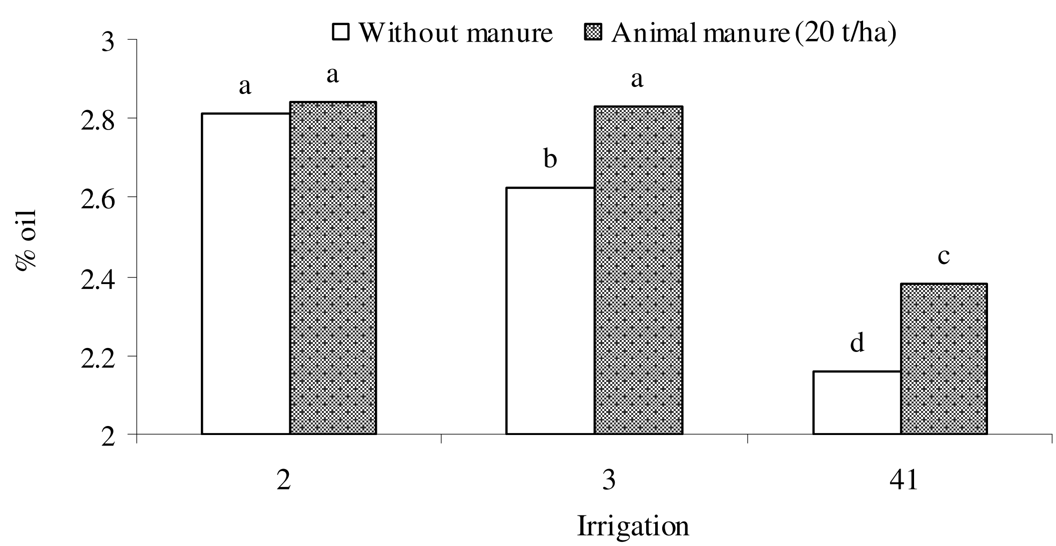

Figure 1. The effect of irrigation times and animal manure on cumin oil (%).

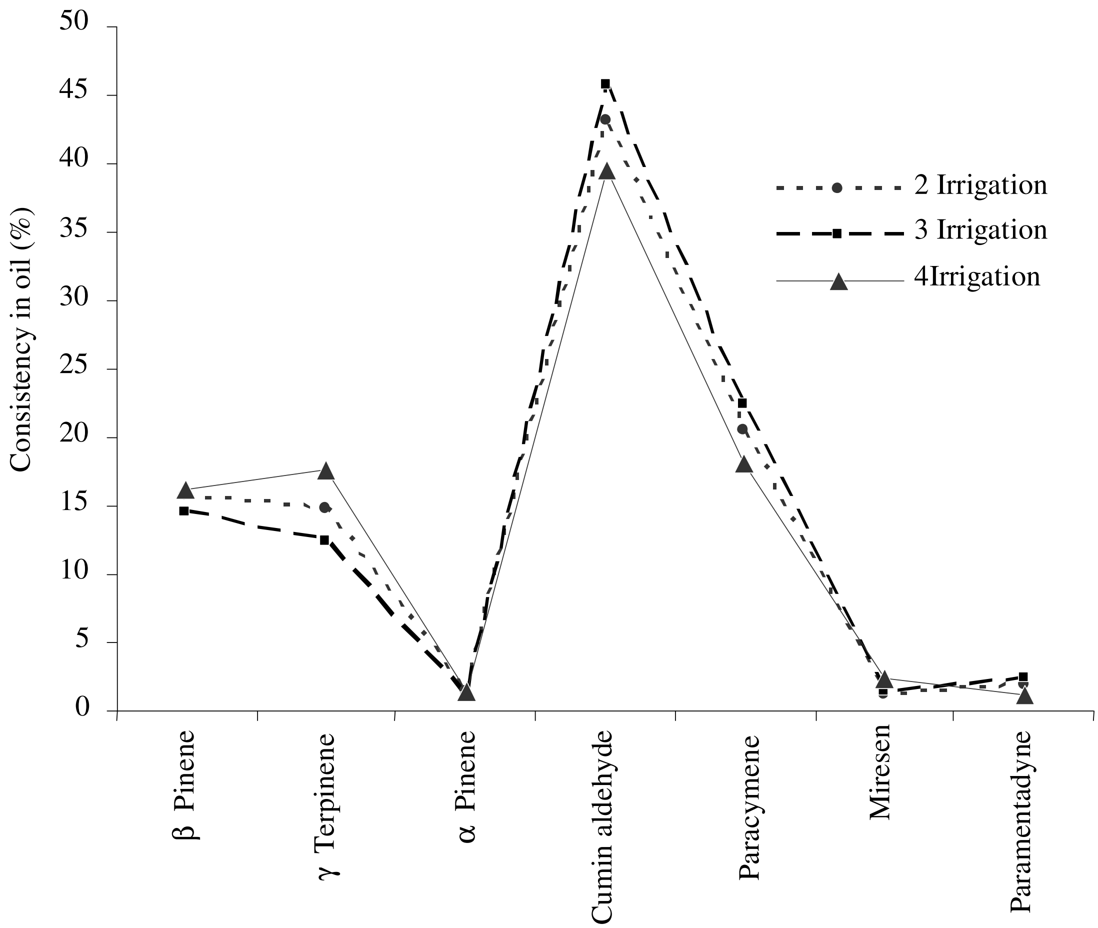

Figure 2. The effect of irrigation times on oil components.

significantly decrease other concentrations of cumin oil compounds, while the increase of irrigation from 3 to 4 times increased β pinene, α pinene ,γ terpinene and miresen and decreased cumin aldehyde, parasimene, 1-4-paramentadyne -7-al, respectively (Table 4).

Highest and lowest levels of miresen, β pinene and γ terpinene were obtained in 4 irrigations without manure and 3 irrigations with manure treatments, respectively (Figure 2).

Cumin aldehyde, the most important constituent of cumin, (Kafi, 2004; Li and Jiang, 2004) was at highest level with 3 irrigations and manure treatment but it was in lowest level with 4 irrigations without manure treatment (Figure 2).

DISCUSSION

Tables 1 and 2 demonstrate that manure has significant effect on number of seed and umbrella per plant, seed and biological yield. It is also indicated that manure has no significant effect on number of seed per umbrella, 1000 seeds weight, plant height and herb yield. Manure application improves the soil structure and soil moisture content, provides plant with essential elements, increase growth, number of umbrella per plant and biological yield and finally led to increase seed yield. Saboor Bilandi (2004) also reported that manure application increases cumin yield.

Decrease of yield and some of its components by 4 irrigation times indicate that irrigation in last stage of plant growth cannot increase yield and probably decrease it. Water stress and high temperature of the region in seed filling period led to decrease yield and its components. Aminpoor and Musavi (1995) and Tatari (2004) also reported that water deficit decreases cumin yield and irrigation in seed filling period has not positive effects and even may have adverse effects on cumin yield and growth.

The interesting issue is that 4 irrigation times with manure application treatment partly decreases the number of umbrella per plant, biological and seed yield compared with 3 irrigations with manure treatment. This is because of plant sensitivity to water stress and disruption in physiological growth.

Water stress has no significant effect on number of

Table 4. effect of irrigation times on chemical compositions of oil in cumin seed (%).

Treatment	β-Pinene	γ-Terpinene	α-pinene	Cuminaldehyde	ρ-Cymene	Mirecene	1-4-P-mentadyne-7-al
2 Irrigations	14.8 b	15.67 b	1.31 b	43.95 b	20.39 b	1.14 c	2.19 a
3 Irrigations	12.44 c	14.60 c	1.04 c	45.75 a	22.46 a	1.21 b	1.99 b
4 Irrigations	16.74 a	16.25 a	1.48 a	41.86 c	19.62 c	1.46 a	1.85 c

There were no statistical differences among the means shown by the same letters at 5 % probability level.

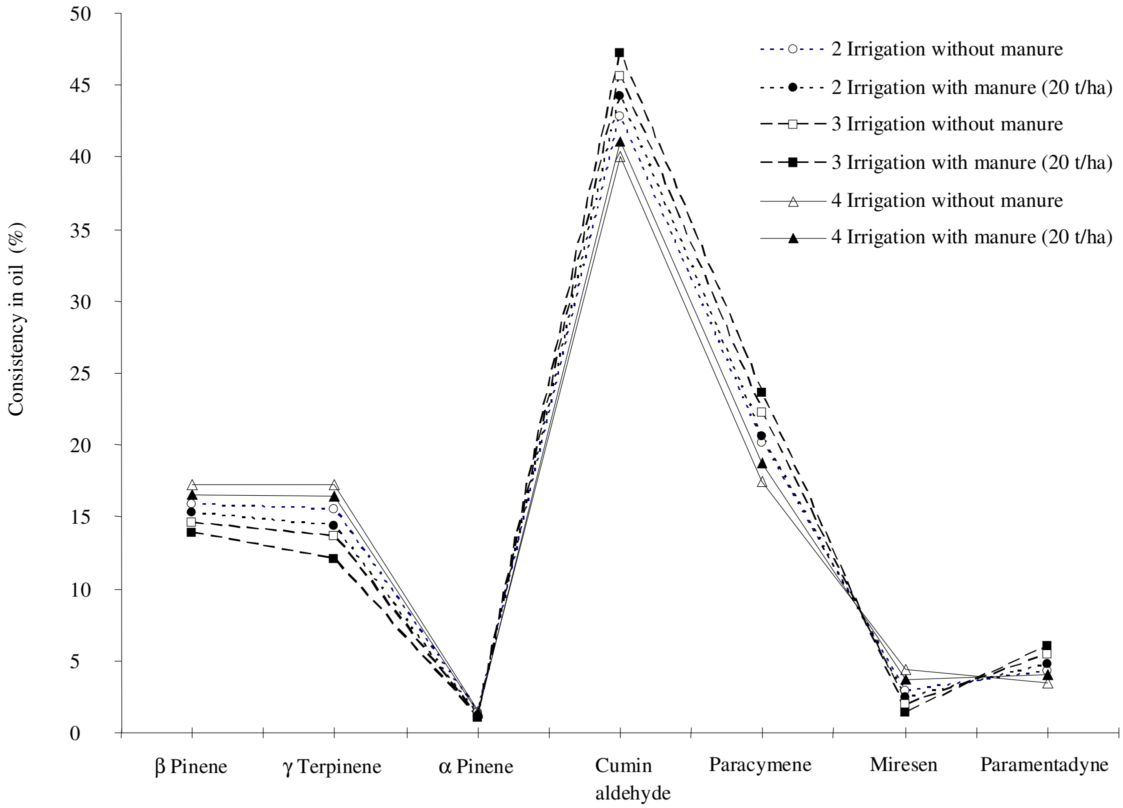

Figure 3. The interaction effect of irrigation times and animal manure on oil components.

seed per umbrella and herb yield. However, growth and productivity of seeds per umbrellas may be prevented by water stress. Furthermore, result show that number of seeds per umbrella in cumin is constant whereas number of productive umbrellas per plant is changeable with environmental stresses (Aminpoor and Musavi, 1995; Kafi, 2004).

Table 4 shows that irrigation in flowering period (in 3 irrigation times treatment) led to increase cumin aldehyde while irrigation in seed filling period (in 4 irrigations times treatment) decrease cumin aldehyde. In this figure, it can be found that cumin aldehyde contact has direct relationship with paracymene and paramentadyne content, whereas it has inverse relationship with β pinene, α pinene and γ terpinene.

Figure 2 demonstrates that there is a regular relationship among oil constituents with application of manure. Studies on the effects of nutrition on the constituents of the essential oil have been reported by El-Sawi and Mohamed (2002) on cumin seed and herb. It was found that the concentrations of different oil constituents were affected by the application of fertilizers. Essential oil biosynthesis is strongly influenced by several intrinsic (genotype, ontogeny) and extrinsic (environmental) factors (Lawrence, 1986).

Amount of the main components are not affected by manure and irrigation times. In fact, the differences between the main oil components of cumin arise from their concentration percentage. On the other hand if some constituents of oil are decreased, the other constituents will be increased. This is in agreement with those obtained by several investigators such as El-Sawi and Mohamed (2002) and Behera et al. (2004).

Conclusion

Irrigation times and application of manure has effect on the yield, yield components, oil percentage and its chemical compounds concentration. It also appears that three times irrigation with manure application led to achieve the best yield and quality of cumin. It is also found that there is probably a regular relationship among oil constituents of cumin.

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