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Phenology of German Chamomile and its Changes under Different Irrigation Regimes and Plant Densities

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Abstract

In order to definite growth stages of *Matricaria chamomilla* L., 40 plants were planted with 200 × 200 cm distance from each other. To determine the phenology under different water stress condition and plant densities, an experiment was conducted in factorial based on randomized complete block design with two factors including irrigation at 4 levels (25, 50, 75, and 100 mm evaporation from pan class A), and plant density at 5 levels (cultivation in 30 cm rows with 5, 10, 15, 20 and 25 cm intra-row spaces) with three replications. Definition of growth stages including the maximum number of nodes, sub stems and tillers were 21, 20 and 14 that were occurred at 970, 1088 and 1088 °C growth degree-days, respectively. The numbers of nodes were 28.6, 30.0, 30.2 and 27.8, of sub stem were 19.2, 18.4, 19.8 and 18.4; and of tillers were 14.8, 14.0, 15.0 and 14.4 that were obtained from irrigation at 25, 50, 75, and 100 mm evaporation from pan, respectively. In the other hand, the number of nodes as follow 28.25, 29.00, 29.75, 29.75 and 29.00; sub stem as 17.50, 20.00, 20.75, 19.00 and 17.50; and tillers were 15.00, 13.50, 14.75, 14.00 and 15.50 that were obtained from 5, 10, 15, 20 and 25 cm intra-row spacing, respectively. Differences by irrigation on GDDs values were observed at the second harvest. However the earliest observation of flower and seed receiving at the first harvest occurred on 5 cm intra-row spacing. These changes were identical by GDDs for second harvest of flower, but with mild slope of reduction. There were no differences in number of leaves and tillers among irrigation levels and plant densities.

Keywords: intra-row spacing, growth degree-days, growth stage, *Matricaria chamomilla*, water stress

Introduction

Prior to any serious consideration of the chemical composition of chamomile, the botanical and taxonomical identity needs to be understand (Mann and Staba, 1992). Chamomile (*Matricaria chamomilla* L.), family *Asteraceae*, there so called German, Hungarian or small chamomilla is a native of Europe and is cultivated extensively in Hungary, Germany, Russia and Yugoslavia. In India *M. chamomilla* (Persian chamomilla, locally called 'Baboonaj') has been reported to grow in the plains. *Matricaria* has a wide domestic use, especially among the Germans (Singh, 1982). Chamomile is an annual with an erect or spreading height and usually attains a height of 50 to 65 cm and in some cases about 85 cm. The stem is glabrous, branched; leaves very green and smooth, 2-3 perinatiseet with segments short and very linear, giving the leaf finely dissected appearance. Head solitary, long peduncled, with white ray and yellow disc florets. Receptacle conic, elongated during fruiting (Singh, 1982; Salamon, 1992). The world market currently has German chamomile drug of various origin and therapeutically values. In the 1970s, plant material was evaluated by the content of essential oil and the content of chamazulene (Salamon, 1998).

The changes in the soil moisture regime can alter the root morphology and anatomy, the pore size distribution, and the angle of roots penetration, which affect root proliferation. The major types of stresses which potentially affect plant growth on a global basis are water (flooding and drought) stress (Pessarakli, 1999). In waterlogged soils, slowing down of shoot and root growth was more closely related to the declining O_2 concentration in the soil solution than to the concentration of dissolved inorganic nitrogen (Trought and Drew, 1980). Flooding is the saturation of the soil root zone with water. Flooding (water logging) occurs when inundation persists as a result of inadequate surface and/or subsurface drainage and the aeration status of the soil system decreases below critical

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limits. Water stress (drought) is also an important limitation to crop production. Reduction in photosynthetic activity and increases in leaf senescence are symptomatic of water stress and adversely affect crop growth. Water stress also reduces the net CO_2 assimilation (Pessarakli, 1999).

Plant density is invariably linked with yield, the more plant stands there are up to a certain limit, the higher the expected yield (Bertoia *et al.*, 1998). The dominant production practice is for farmers to plant crops (cereals) at spacing in the range of 30-35 cm, which on average gives about 44.000 to 38.000 plants per hectare. In addition, in most irrigation schemes, water is not a limiting factor, what tends to happen is rather over-irrigation because of the abundance of water. Research has also shown that farmers apply on average twice the moisture consumptive use requirements of crops on each irrigation level. This is deleterious to crops and retards proper growth and subsequent yield. Farmers thus face the problem of knowing the correct plant density to sow and also the exact amount (or optimum amount) of water to apply, which amount to apply in areas of abundance and areas of scarcity (Sani *et al.*, 2008).

Materials and methods

This research was conducted between May and August for two seasons (2003 and 2004) at the field of Dept. Agronomy and Plant Breeding of Faculty of Agriculture of Urmia University (latitude 37.53°N, 45.08°E, 1320 m above sea level) Urmia, Iran. Mean of air temperature (15.6, 16.6, 23.4, 23.4°C), evaporation (191.1, 200.2, 272.0, 296.9 mm), rainfall (9, 5.9, 0, 0 mm) and relative humidity (55.7, 52.2, 51.7, 51.3%) for May, June, July and August 2003, respectively. However, mean of air temperature (14.8, 19.9, 22.1, 23.2°C), evaporation (165.1, 230.1, 227.3, 271.8 mm), rainfall (60, 3.3, 16.3, 0 mm) and relative humidity (62.7, 52.1, 56.8, 49.9%) for May, June, July and August 2004, respectively. The soil texture of experiment site was clay-loam (28% silt, 33% clay, 40% sand) with 22.5% field capacity, 1.54 g cm^{-3} soil density, 1.98% organic mater, pH=7.6.

This communication, based on a 2-year (2003 and 2004) field study, describes the drought susceptibility of 5 plant density of German chamomile, expressed in terms of plant phenology. The seeds of *Matricaria chamomilla* L. c.v. 'Bodegold', a tetraploide variety were planted on 1 May both two year. Experiments carried out in factorial based on Randomized Complete Block Design with two factors, Irrigation and plant density. Irrigation regimes (I_1, I_2, I_3 and I_4) irrigation at 25, 50, 75 and 100 mm evaporation from class A pan, respectively) and plant density (D_1, D_2, D_3, D_4 and D_5, cultivation in 30 cm rows with 5, 10, 15, 20 and 25 cm intra-row spaces, respectively) treatments have done at rosette stage. Plant growth was continuously monitored during the whole experimental period by mechanical control of weeds. However, to determine a complete phenology of German chamomile, 40 plants were planted with 200 cm distance from each other in 2003 and 2004.

Statistical evaluation was performed using MSTATC software (Michigan State University, 1988). The effects of Irrigation regimes (I) and Plant density (D) as well as the interactions of these two factors were analyzed with the analysis of variance. The results of statistical analysis are expressed by F-values; asterisks indicate p-values: $p^{*}<0.05$ and $p^{**}<0.01$. The comparison of means carried out with SNK (Student-Neuman Keul's test).

Results and discussion

Definition of growth stages of *Matricaria chamomilla* L. at the experiment site in 2003 and 2004, showed in Tab. 2. In this study, the maximum number of nodes (V_n), sub stems (S_n) and tillers (T_n) were 21, 20 and 14 at the GDDs of 970, 1088 and 1088°C, respectively (Tab. 1).

Means of vegetative and generative growth stages of German chamomile under irrigation regimes and plant distances on constant rows (plant density) showed on Tab. 2 and 3. Vegetative stages: V_e, V_c, V_1, V_2 and V_3 were same in all treatments, after that and carrying out of irrigation and plant density treatments differences were showed. The numbers of node were 28.6, 30.0, 30.2 and 27.8 at the irrigation at 25, 50, 75 and 100 mm evaporation from class A pan, respectively. It seems excess water on I_1 and water deficit on I_4 lead to reduce number of nodes. Means of the number of sub stem were 19.2, 18.4, 19.8 and 18.4; and the number of tillers were 14.8, 14.0, 15.0 and 14.4 obtained from I_1, I_2, I_3 and I_4, respectively. R_1 stage was 73 days after planting at I_1 and I_2, but 66 days after planting at I_3 and I_4. However, R_2 stage was 87 days after planting in I_1 and I_2 and 80days after planting in I_3 and I_4. R_{3a} were occurred 87 days after planting in all irrigation regimes, but R_3b were 113 days after planting for I_3 and I_4 and 111 days after planting for I_1 and I_2. R_{4a} were occurred 105 days after planting in all irrigation regimes, but R_{4b} were 122 days after planting for I_1, I_2 and I_3 that were 7 days later than I_4. These results, any differences at the first harvest and differences at the second harvest, are due to ending a growth stage at the second stage while at the first one we cut the growth and harvest its flowers and seeds. Rs, flowering of sub stems occurred 80 days after planting at the I_4, while it occurred 87 days after planting at the I_1, I_2 and I_3 (Tab. 2). It seems the strength stresses led to early observation on generative stages.

The number of nodes 28.25, 29.00, 29.75, 29.75 and 29.00; sub stem 17.50, 20.00, 20.75, 19.00 and 17.50; and tillers were 15.00, 13.50, 14.75, 14.00 and 15.50 obtained from D_1, D_2, D_3, D_4 and D_5, respectively. Initial of generative stage, R_1 was occurred 66 days after planting at the D_1 and D_5 that were 7 days earlier than D_2, D_3 and D_4. However occurrence of R_2 was 73 days after planting at the D_1 and D_5 like R_1 in comparison with D_2, D_3 and D_4. R_{3a} were occurred 84, 86, 87, 88 and 89 days after planting and R_{4a}

Tab. 1. Definition of growth stages of *Matricaria chamomilla* L. at the experiment site in 2003 and 2004

Growth Stage	Symbol	Definition	GDDs (mean 2 year)
Vegetative	V_e	Emerging (Cotyledons are top of the Soil)	195
	V_c	Appearance of Cotyledons leaves (simple leaf fully opened)	219
	V_1	Appearance of First node on stem (2 leaves)	274
	V_2	Appearance of Second node on stem (2 leaves)	364
	V_3	Appearance of third node on stem (5th leaf)	407
	V_4	Appearance of 4th node on stem (6th leaf)	437
	V_5	Appearance of 5th node on stem (7th leaf)	484
	V_6	Appearance of 6th node on stem (8th leaf)	531
	V_7	Appearance of 7th node on stem (9th leaf)	580
	V_8	Appearance of 8th node on stem (10th leaf)	600
	V_9	Appearance of 9th node on stem (11th leaf)	620
	V_{10}	Appearance of 10th node on stem (12th leaf)	641
	V_{11}	Appearance of 11th node on stem (13th leaf)	662
	V_{12}	Appearance of 12th node on stem (14th leaf)	681
	V_n	Appearance of Nth node on stem (N-2th leaf)	N
	S_1	Appearance of First Sub stem	650
	S_2	Appearance of Second Sub stem	680
	S_3	Appearance of Third Sub stem	710
	S_4	Appearance of Forth Sub stem	748
	S_5	Appearance of 5th Sub stem	788
	S_6	Appearance of 6th Sub stem	910
	S_7	Appearance of 7th Sub stem	970
	S_8	Appearance of 8th Sub stem	990
	S_9	Appearance of 9th Sub stem	1000
	S_{10}	Appearance of 10th Sub stem	1015
	S_{11}	Appearance of 11th Sub stem	1023
	S_{12}	Appearance of 12th Sub stem	1032
	S_n	Appearance of Nth Sub stem	N
	T_1	Appearance of First Tiller	680
	T_2	Appearance of Second Tiller	690
	T_3	Appearance of Third Tiller	707
	T_4	Appearance of Forth Tiller	725
	T_5	Appearance of 5th Tiller	743
	T_6	Appearance of 6th Tiller	760
	T_7	Appearance of 7th Tiller	788
	T_8	Appearance of 8th Tiller	838
	T_9	Appearance of 9th Tiller	938
	T_{10}	Appearance of 10th Tiller	970
	T_{11}	Appearance of 11th Tiller	1010
	T_{12}	Appearance of 12th Tiller	1088
	T_n	Appearance of Nth Tiller	N
	TT	Appearance of Sub Tiller	1043
	SS	Appearance of Sub Stem from Sn	1184

Tab. 1. Definition of Growth stages of *Matricaria chamomilla* L. at the experiment site in 2003 and 2004 (Continue)

Growth Stage	Symbol	Definition	GDDs (mean 2 year)
Generative	R_1	Flowering initialize	970
	R_2	Flowers are fully opened, ligulae petals horizontal, Smooth Receptacle, yellowish florets with pollen grain on it	1029
	R_S	Flowering initialize on Sub stem	1026
	R_3	Receptacle is conic and swollen (cone-shape capitulum, hollow bottom), ligulae petals are swept and their color changed and grain is formed but soft, flowers in optimal condition for essential bearing. In harvested condition there are 2 harvests as: R_{3a} first harvest and R_{3b} the second harvest.	1120-1680
	R_4	Ligulae petals are vertical and up down, florets completely ripened except of mid florets, grains darken and hard. In harvested condition there are 2 harvests as: R_{4a} first harvest and R_{4b} the second harvest.	1338-1705
	D	Plant drying initialize, defoliate 2-3 downiest leaves, a few numbers of small flowers appears at the end of stem and substem.	1305

were occurred 102, 103, 104, 105 and 108 days after planting in D_1, D_2, D_3, D_4 and D_5, respectively. But R_{3b} were 113 days for D_1 and D_2, 114 days for D_3 and D_4, and 115 days for D_5, while R_{4b} for D_1, D_2 and D_3 were 119 days and for D_4 and D_5 were 120 days after planting. Rs Stage was 87 days for D_1, D_3, D_4 and D_5, and 94 days after planting for D_2 (Tab. 3). Accumulative Growth Degree Days for German chamomile during growth season of experiment site was shown on Fig. 1. Results of ANOVA showed that GDDs for first harvests of flower and seed were not affected by irrigation regimes, but plant density had significant effect on them ($P<0.01$). Significant interaction between year and plant density showed different procedure of GDDs for first harvest of flower and seed (Tab. 4). Despite of these significances, GDDs for first harvest of flower and seed have same trends, increasing with reducing plant density in both 2 years (Fig. 2). We found the maximum amounts of GDDs at the first harvest of flower (1075) and seed (1409) belonged to D5 in which declined with reducing intra-row distances and received the minimum amounts for flower (1011) and seed (1300) harvest in D1 (Fig. 3). At the second harvest, GDDs for harvest of flower affected by irrigation regime and plant density ($P<0.01$), But the effect of plant density was non-significant for seed harvest (Tab. 4). Maximum amounts of GDDs at the second harvest of flower belonged to I_1 and I_2 and the minimum amount obtained from I_3 and I_4. These values obtained at I_3 and I_4 for maximum and minimum, respectively. Comparisons of means showed the same procedures on GDDs like one of the first harvest of flowers affected by different plant density (Fig. 2). Overall differences by irrigation on GDDs values observed at the second harvest. Water stress at the strength level led to earlier occurrence of receiving both flower and seed. However the earliest observation of flower and seed receiving at the first harvest occurred on the highest density of plant. It seems that increasing the distances between plants provide a condition to branching and great vegetative growth. These changes were the same with GDDs for second harvest of flower, but with mild

Tab. 2. Growth stages of *Matricaria chamomilla* L. under irrigation regimes

Days after Planting	GDDs		Irrigation regimes (irrigation after evaporation from class A pan)			
	2003	2004	I_1(25 mm)	I_2(50 mm)	I_3(75 mm)	I_4(100 mm)
0	0	0	Planting	Planting	Planting	Planting
26	227	205	V_e	V_e	V_e	V_e
28	247	229	V_c	V_c	V_c	V_c
33	290	280	V_1	V_1	V_1	V_1
42	354	388	V_2	V_2	V_2	V_2
45	383	423	V_3	V_3	V_3	V_3
52	454	522	$V_{5.4}$	V_7	$V_{7.4}$	$V_{9.4}$
59	552	636	$V_{7.2}$	$V_{10.2}$	$V_{10.2}$	$V_{14.2}$
66	664	729	$V_{8.8}$ $S_{3.4}$ $T_{4.6}$	V_{12} $S_{2.6}$ $T_{5.4}$	$R_1V_{12.6}$ $S_{5.2}$ $T_{6.4}$	R_1V_{18} S_6 $T_{5.8}$
73	788	827	$R_1V_{16.2}$ $S_{5.6}$ $T_{8.4}$	$R_1V_{17.2}$ $S_{5.2}$ $T_{7.6}$	$R_2V_{18.6}$ $S_{8.6}$ T_{10}	$R_2V_{22.2}$ $S_{9.6}$ $T_{9.8}$
80	915	945	R_2 $V_{21.8}$ $S_{8.8}$ $T_{11.2}$	R_2 $V_{20.6}$ S_9 $T_{9.2}$	$V_{22.4}$ S_{13} $T_{12.6}$	$RsV_{24.8}$ $S_{14.4}$ T_{12}
84	981	1010				
86	1012	1040				
87	1029	1055	R_{3a} Rs $V_{25.4}$ $S_{13.8}T_{13.6}$	R_{3a} $RsV_{26.2}$ $S_{13.2}$ T_{12}	R_{3a} RsV_{27} $S_{16.2}$ T_{14}	$R_{3a}V_{26.6}$ $S_{16.2}T_{13.6}$
88	1043	1073				
89	1060	1090				
94	1138	1179	$V_{28.6}$ $S_{19.2}T_{14.8}$	V_{30} $S_{18.4}$ T_{14}	$V_{30.2}$ $S_{19.8}$ T_{15}	$V_{27.8}$ $S_{18.4}$ $T_{14.4}$
101	1262	1298				
102	1282	1316				
103	1304	1332				
104	1324	1348				
105	1340	1362	R_{4a}	R_{4a}	R_{4a}	R_{4a}
108	1387	1412				
113	1468	1502			R_{3b}	R_{3b}
114	1484	1516				
115	1500	1530	R_{3b}	R_{3b}		R_{4b}
119	1562	1594				
12	1578	1610				
122	1612	1643	R_{4b}	R_{4b}	R_{4b}	

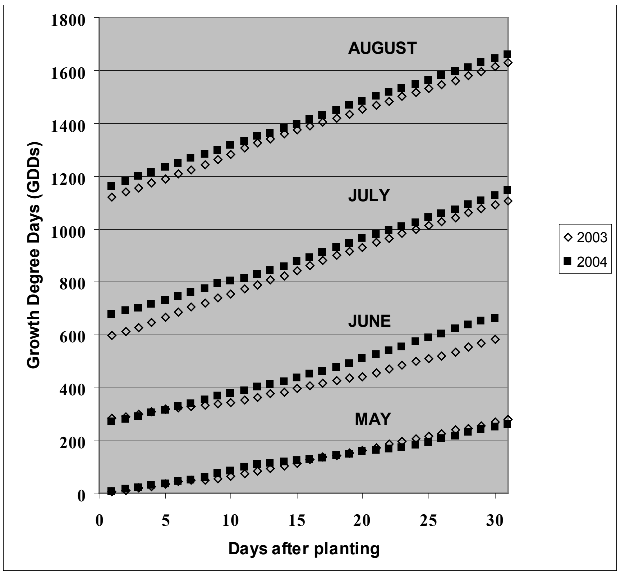

Fig. 1. Growth Degree Days (GDDs) of *Matricaria chamomilla* L. at the experiment site

slope of reduction. At last, this slope got zero for second harvest of seed because of ending growth season on this stage.

Results showed no differences of the number of leaves and tillers among irrigation levels with means 27.377 and 12.683, respectively. But, plant density had significant ($P<0.05$) and non-significant effect on the numbers of leaves and tillers. Despite of this significance all levels of plant densities had same numbers of leaves and tillers under among plant densities. However, there were significant interaction between irrigation and plant density on the numbers of sub stem (Tab. 4). Results indicated that levels of each factor in other factor had a same trend of the numbers of sub stem (Tab. 5).

Acknowledgments

I dedicate this paper to the late Prof. Houshang Alyari.

Tab. 3. Growth stages of *Matricaria chamomilla* L. under plant densities

Days after Planting	GDDs		Intra row spacing by 30 cm inter row spacing (cm)				
	2003	2004	D_1(5 cm)	D_2(10 cm)	D_3(15 cm)	D_4(20 cm)	D_5(25 cm)
0	0	0	Planting	Planting	Planting	Planting	Planting
26	227	205	V_e	V_e	V_e	V_e	V_e
28	247	229	V_c	V_c	V_c	V_c	V_c
33	290	280	V_1	V_1	V_1	V_1	V_1
42	354	388	V_2	V_2	V_2	V_2	V_2
45	383	423	V_3	V_3	V_3	V_3	V_3
52	454	522	V_8	$V_{7.5}$	$V_{6.25}$	$V_{7.75}$	V_7
59	552	636	$V_{11.5}$	$V_{10.25}$	V_9	$V_{11.25}$	$V_{10.25}$
66	664	729	$R_1 V_{13.75}\ S_{4.25}\ T_5$	$V_{12.75}\ S_{2.75} T_{4.25}$	$V_{11.25}\ S_{4.25} T_{6.25}$	$V_{13.75}\ S_{3.75} T_{5.75}$	$R_1 V_{12.75}\ S_{6.5}\ T_{6.5}$
73	788	827	$R_2 V_{18}\ S_{6.5}\ T_{8.5}$	$R_1 V_{18}\ S_6\ T_{8.25}$	$R_1 V_{19}\ S_{6.5}\ T_9$	$R_1 V_{19}\ S_{7.75}\ T_{9.5}$	$R_2 V_{18.75}\ S_{9.5} T_{9.5}$
80	915	945	$V_{20.75} S_{9.25}\ T_{11}$	$R_2 V_{21.5}\ S_{11}\ T_{11.25}$	$R_2 V_{24.5}\ S_{9.5}\ T_{10.75}$	$R_2 V_{23.25} S_{13.25}\ T_{11.5}$	$V_{22}\ S_{13.5} T_{11.75}$
84	981	1010	R_{3a}				
86	1012	1040		R_{3a}			
87	1029	1055	$V_{25.25}\ S_{13.25} T_{13.5}$	$V_{25.75}\ S_{15} T_{12.75}$	$R_{3a}\ \ R_s V_{27.5}\ S_{14.75} T_{13.25}$	$R_s V_{26.75}\ S_{16}\ T_{13}$	$R_s V_{26.25}\ S_{15.25}\ T_{14}$
88	1043	1073				R_{3a}	
89	1060	1090					R_{3a}
94	1138	1179	$V_{28.25}\ S_{17.5} T_{15}$	$R_s V_{29}\ S_{20}\ T_{13.5}$	$V_{29.75}\ S_{20.75} T_{14.75}$	$V_{29.75} S_{19} T_{14}$	$V_{29}\ S_{17.5}\ T_{15.5}$
101	1262	1298					
102	1282	1316	R_{4a}				
103	1304	1332		R_{4a}			
104	1324	1348			R_{4a}		
105	1340	1362				R_{4a}	
108	1387	1412					R_{4a}
113	1468	1502	R_{3b}	R_{3b}			
114	1484	1516			R_{3b}	R_{3b}	
115	1500	1530					R_{3b}
119	1562	1594	R_{4b}	R_{4b}	R_{4b}		
12	1578	1610				R_{4b}	R_{4b}
122	1612	1643					

Tab. 4. Combined Analysis of variance of GDDs for flower and seed at two harvest of German chamomile affected by different irrigation regimes and plant densities

Source of Variation	d.f.	GDDs				Maximum numbers		
		Flower		seed		Leaf per plant	Sub stem per plant	Tiller per plant
		First harvest	Second harvest	First harvest	Second harvest			
Year	1	24168.41^{**}	42112.53^{ns}	$42.865.20^{**}$	75300.30^{ns}	1930.25^{**}	10.716^{**}	8.431^{**}
E1 (r/Y)	4	0.01	362399.43	73.20	16677.24	1.31	0.058	0.116
Irrigation (A)	3	0.01^{ns}	15195.34^{**}	0.0001^{ns}	26650.68^{**}	14.70^{ns}	0.138^{ns}	0.059^{ns}
A×Y	3	0.01^{ns}	46.07^{ns}	0.0001^{ns}	879.17^{ns}	0.21^{ns}	0.0003^{ns}	0.001^{ns}
Plant Density (B)	4	15262.21^{**}	2122.00^{**}	41386.20^{**}	635.55^{ns}	23.34^{*}	0.373^{*}	0.563^{ns}
B×Y	4	7.91^{**}	6.53^{ns}	202.20^{**}	25.57^{ns}	0.64^{ns}	0.002^{ns}	0.006^{ns}
A×B	12	0.01^{ns}	2.84^{ns}	0.0003^{ns}	168.56^{ns}	11.11^{ns}	0.375^{**}	0.368^{ns}
A×B×Y	12	0.01^{ns}	2.84^{ns}	0.0003^{ns}	8.08^{ns}	0.24^{ns}	0.002^{ns}	0.004^{ns}
Error	76	0.01	516.11	15.41	769.01	8.85	0.141	0.272
Coefficient of Variance		0.01	1.52	0.29	1.74	10.87	9.36	14.83

Note: ns, *, ** non-significant, significant at P<0.05 and P<0.01, respectively; df, degree of freedom

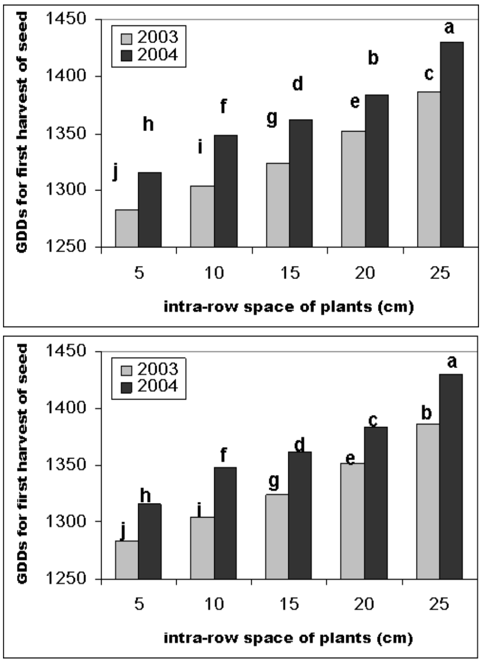

Fig. 2. Means of interaction between year and plant density on GDDs of first harvest of flower and seed. The same letters show non-significant differences

Tab. 5. Means of interaction between irrigation regimes and plant density on the maximum numbers of sub stem per plant

Intra-row space of plants (cm)	Irrigation regimes (mm evaporation from class A pan)			
	25	50	75	100
	Maximum numbers of sub stem per plant			
5	13.833ab	16.000ab	16.000ab	18.333ab
10	16.333ab	16.000ab	16.667ab	15.000ab
15	19.167a	16.000ab	18.833ab	16.833ab
20	14.167ab	18.167ab	19.500a	14.833ab
25	17.667ab	12.500b	14.500ab	15.667ab

Note: The same letters show non-significant differences.

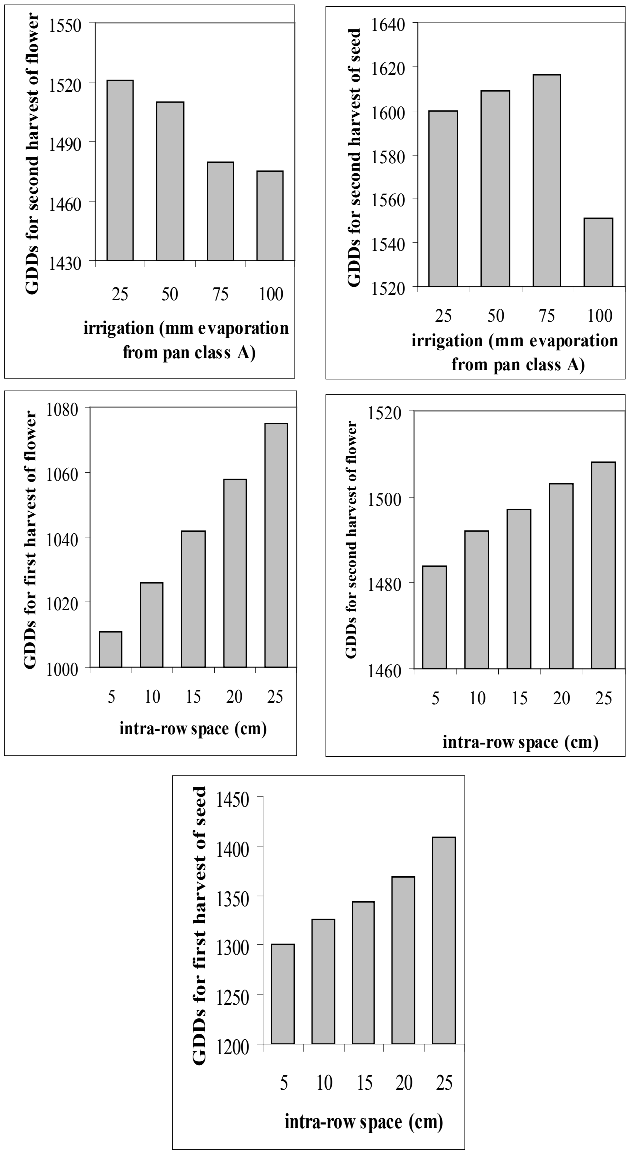

Fig. 3. Means of GDDs for flower and seed harvest under different irrigation regimes and plant densities. The same letters show non-significant differences

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