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The effects of mist irrigation on biological and productive behaviour of globe artichoke

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Abstract. Globe artichoke [*Cynara cardunculus* L. var. *scolymus* (L.) Fiori] is an important Mediterranean crop, producing edible immature inflorescences (heads or capitula). In Southern Italy, it plays a pivotal economic role, given its early ripening and potential to provide employment almost all the year-round. However, the critical summer conditions experienced by plantlets, often negatively affect crop establishment, yield and earliness. The goal of our study was to evaluate the opportunity to mitigate these drawbacks by means of mist irrigation, on three early-producing artichoke cultivars ('Spinoso di Palermo', 'Tema 2000' and 'Violet de Provence'). Mist irrigation reduced the maximum air temperature and increased the maximum R.H. within the crop. Such modifications had positive effects on crop establishment and yield, while reducing the production of unmarketable heads at the same time. This was positively reflected on final yield per unit area. Significant "genotype x mist irrigation" interactions were observed.

Keywords. Globe artichoke – Mist irrigation – Head atrophy – Earliness – Yield.

Effets de la nébulisation sur le comportement biologique et productif de l'artichaut

***Résumé**. L'artichaut [Cynara cardunculus L. var. scolymus (L.) Fiori] est une importante culture méditerranéenne, produisant des inflorescences immatures comestibles (capitules). L'artichaut joue un rôle crucial dans l'économie du sud de l'Italie, vues sa maturité précoce et sa capacité de fournir des emplois presque toute l'année. Toutefois, les conditions critiques auxquelles les plantules sont exposées l'été, ont souvent un effet négatif sur l'accroissement, le rendement et la précocité de la culture. L'objectif de notre étude était d'évaluer la possibilité de limiter ces inconvénients sur trois cultivars d'artichaut précoce ('Spinoso di Palermo', 'Tema 2000' et 'Violet de Provence') par la nébulisation. La nébulisation a réduit la température maximale et a augmenté la H.R. maximale au sein de la plante. Ces modifications ont eu des effets positifs sur l'accroissement et sur le rendement de la culture, tout en réduisant la production de capitules invendables. Cela a influé positivement le rendement final par unité de surface. Des interactions significatives "génotype x nébulisation" ont été observées.*

***Mots-clés**. Artichaut – Nébulisation – Atrophie du capitule – Précocité – Rendement.*

I – Introduction

Globe artichoke [*Cynara cardunculus* L. var. *scolymus* (L.) Fiori] is a perennial, Mediterranean crop, belonging to the Asteraceae family. The main product consists of immature inflorescences (heads or capitula), traditionally eaten in a multitude of Mediterranean dishes. Each plant produces several heads, with the earliest and most appreciated ones (the main capitula) formed at the apex of the central stem. Several smaller heads are formed later on the lateral branches. Currently, Southern Italian regions are the main artichoke producers worldwide, especially Apulia (17 Kha), Sicily (15 Kha) and Sardinia (13 Kha) (ISTAT, 2008), where this crop represents one of most important agricultural resources (Mauromicale 1984; 1988). This is due to the possibility of achieving early head productions (from early autumn), so markedly anticipating those coming from other Italian regions, i.e. in spring. This results from the interaction between mild winters and the characteristics of the locally grown germplasm, best adapted to forcing (summer implantation by "ovoli", followed by frequent irrigations) and with little chilling requirements (e.g. 'Violetto di Sicilia', 'Spinoso di Palermo', 'Violet de Provence' etc.) (Mauromicale and Ierna, 2000;

Mauromicale *et al.*, 2004). Nonetheless, as a consequence of such a crop scheduling, artichoke plantlets experience unfavourable summer climatic conditions (high temperatures and low air R.H.) in the juvenile stages, which frequently cause a significant reduction of crop establishment, as well as inducing head atrophy. These are the outcome of the alteration of both the water balance and the calcium allocation in the plant (Morone Fortunato *et al.*, 1981; Mauromicale, 1984; Magnifico *et al.*, 1984; 1985; Saure, 1998). All these phenomena have significant effects on the yield and earliness of marketable production, often persuading growers to shift the period of artichoke plantation. On the other hand, it has repeatedly been shown that mist irrigation is a suitable technique to modify the microclimatic conditions (temperature and R.H.) over the crop, so positively influencing the biological behaviour and yield components of several horticultural species (Mauromicale and Restuccia, 1987; 1989; Restuccia *et al.*, 1995). The aim of this study was to evaluate the opportunity to limit these drawbacks and to improve the earliness of heads production through mist irrigation on early-producing globe artichoke cultivars.

II – Materials and methods

The experiment was carried out during the 2005-2006 season, in a representative area for globe artichoke cultivation in Sicily, South-East of Palermo (37°58' N, 13°49' E), on a clay soil. A randomized split-plot experimental design with four replications was adopted to test the effects of mist irrigation (as main plot), compared with an untreated test, on three early-producing globe artichoke cultivars ('Spinoso di Palermo', 'Tema 2000' and 'Violet de Provence') as subplots. The 'ovoli' were transplanted on August 1, 2005, 0.80 m apart within row, with an inter-row spacing of 1.25 m (1.0 plant m^{-2}). Crop management (fertilization, weed and pest control) was ensured by following standard commercial practices. Drip irrigation was effected by supplying 100% of maximum evapotranspiration (ETM). The mist system consisted of sprinklers placed at 1.4 m above the soil at 6.5 m intervals (12 l h^{-1} at 4.0 atm). Five minute periods of mist irrigation were carried out three times per day between 12.00 and 14.00, from September, 1 (31 Days After Planting, DAP) until November, 15 (106 DAP). On the whole, 281 m^3 ha^{-1} of water were delivered with mist irrigation. Each net subplot consisted of 40 plants. Within the crop, meteorological measurements (daily maximum and minimum air temperatures, RH) were done through thermo-hygrometers Salmoiraghi® (Milano, Italy). The following parameters were measured: percentage of established plantlets, percentage of atrophic heads produced (until 151 DAP), fortnight's cumulative yield of heads $plant^{-1}$ and fortnight's cumulative yield of marketable heads ha^{-1} (from 118 until 268 DAP).

Data were submitted to Bartlett's test to check the homoscedasticity, then they were subjected to the ANOVA. When *F*-test was significant, means were separated through Fisher's LSD test. Percentage data were Bliss' transformed before the ANOVA (untransformed data are reported and discussed).

III – Results and discussion

Mist irrigation was able to modify the microclimatic parameters within the crop (Table 1). On average, an appreciable reduction was recorded for the daily maximum temperature, ranging from 1.5°C (1-30 September) to 2.2°C (1-31 October), i.e. during the transition of the apical bud and the initial growth of the head. Moreover, a reduction of the daily minimum temperature, from 0.8°C (1-15 November) to 2.6°C (1-30 September) was recorded and a contextual increase of the R.H., particularly during the 1-30 September period (+2%) (Table 1).

Table 1. Mean values of maximum temperature, minimum temperature and maximum R.H. recorded inside the globe artichoke crop during the mis t irrigation period.

	Maximum temperature		Minimum temperature		Maximum R.H.	
	℃				%	
	Test	*Mist*	*Test*	*Mist*	*Test*	*Mist*
September, 1 - 30	32.4	30.9	21.5	18.9	90	92
October, 1 - 31	26.9	24.7	17.8	16.7	94	95
November, 1 - 15	25.8	23.9	16.5	15.7	94	95

The microclimatic conditions determined by mist irrigation, compared with those of the untreated test, significantly increased the percentage of plantlets established, most of all in 'Violet de Provence' (+22%), followed by 'Spinoso di Palermo' (+10%) (Table 2). This was evident notwithstanding the treatment was started 1 month after planting. Our result is corroborated by the observation of Mauromicale (1984), who noted that dramatic decreases of crop establishment occur when plants must cope with high evapotranspiration rates at the 4-6th leaf stage (about 50 days old plants). He explained this with the initial slow growth of the radical apparatus, which is still unable to compensate the water loss of the well-developed epigeal apparatus. Moreover, the mist irrigation significantly reduced the number of atrophic heads. Its effectiveness in reducing head atrophy was directly proportional to the susceptibility of the cultivar.

Table 2. The effect of mist irrigation on some bio-agronomical variables of three globe artichoke cultivars.

Cultivar	Established Plantlets		Atrophic Heads (at 151 DAP)		N heads plant^{-1}		Marketable Yield	
	%						(000 heads ha^{-1})	
	Test	*Mist*	*Test*	*Mist*	*Test*	*Mist*	*Test*	*Mist*
Spinoso di Palermo	76	86	31	14	7.2	8.3	54.3	71.2
Tema 2000	75	78	13	7	7.9	8.4	57.8	64.9
Violet de Provence	66	88	17	12	5.6	5.9	36.5	51.4
	LSD $P \leq 0.05$							
Cultivar	NS		4.6		0.4		6.8	
Treatment	5.7		3.0		0.5		5.5	
Interaction	9.9		8.9		NS		NS	

Indeed, in 'Spinoso di Palermo', the most sensitive cultivar to head atrophy, the highest control of this physiological disorder by mist irrigation was recorded (-17%) as compared with 'Tema 2000' (-6%) and 'Violet de Provence' (-5%) (Table 2). A genotype-dependent response to mist irrigation was recorded for the final accumulated yield of heads per plant too (Table 2). Indeed, while no statistical differences were recorded in 'Violet de Provence' (5.9 *versus* 5.6 heads plant^{-1}), significant increases were recorded in 'Spinoso di Palermo' (8.3 *versus* 7.2 heads plant^{-1}), and in 'Tema 2000' (8.4 *versus* 7.9 heads plant^{-1}) (Table 2). Such increases, could be explicated by an appreciable improvement of the physiological response of the plants, such as the photosynthetic rate, the chlorophyll fluorescence parameters, or even by the level of endogenous growth-regulators, as in other vegetable crops (Saure, 1998). Nevertheless, further in-depth studies are needed to highlight the nature of this response.

The positive influence of mist irrigation on plantlets establishment, head atrophy and plant yield, was favourably reflected in the accumulated yield per unit area, as shown in Figure 1. Compared with untreated test, mist irrigation significantly improved the marketable earliness of the crop, particularly in 'Tema 2000' (9,745 *versus* 6,818 heads ha^{-1}, at 133 DAP), followed by 'Violet de Provence' (7,549 *versus* 4,018 heads ha^{-1}, at 163 DAP) and 'Spinoso di Palermo' (8,221 *versus* 6,789 heads ha^{-1}, at 163 DAP) (Figure 1). At the end of crop cycle (268 DAP), such differences among treatments reached their maximum values, since the marketable yield was increased, in response to mist irrigation, by 41, 31 and 12% in 'Violet de Provence', 'Spinoso di Palermo' and 'Tema 2000', respectively (Table 2).

IV – Conclusions

Although limited to one productive cycle, our results show the suitability of mist irrigation to regulate microclimatic conditions in the field crop, so positively influencing the agronomical behaviour of the globe artichoke. The main results obtained concerned the increase of the plantlets establishment and the partial control of heads atrophy, which together significantly increased the earliness and yield of marketable heads. The first aspect appears of key importance, since the implementation of mist irrigation might avoid the replacing of wilted plantlets, which is an expensive technique that, in any case, had no effects on the loss of earliness of the yields. With reference to the second aspect, according to Magnifico *et al.* (1985), mist irrigation did not totally prevent the onset of head atrophy. However, the containment of the phenomenon we recorded, suggests that this technique, by means of a better calibration, could be successfully implemented in the field, with the aim of improving the artichoke yields and expanding the locally grown germplasm, through an easier introduction of cultivars selected abroad (such as 'Tema 2000') (Mauromicale, 1984; Foti and Mauromicale, 1994). Moreover, the increase in the number of heads per plant, suggests the need for an in-depth understanding of the effects of mist irrigation on the photosynthetic machinery (e.g. gas exchanges, chlorophyll content and fluorescence, net photosynthesis), as well as on the level of endogenous growth-regulator substances, in order to better calibrate the technique in terms of crop management and water requirements.

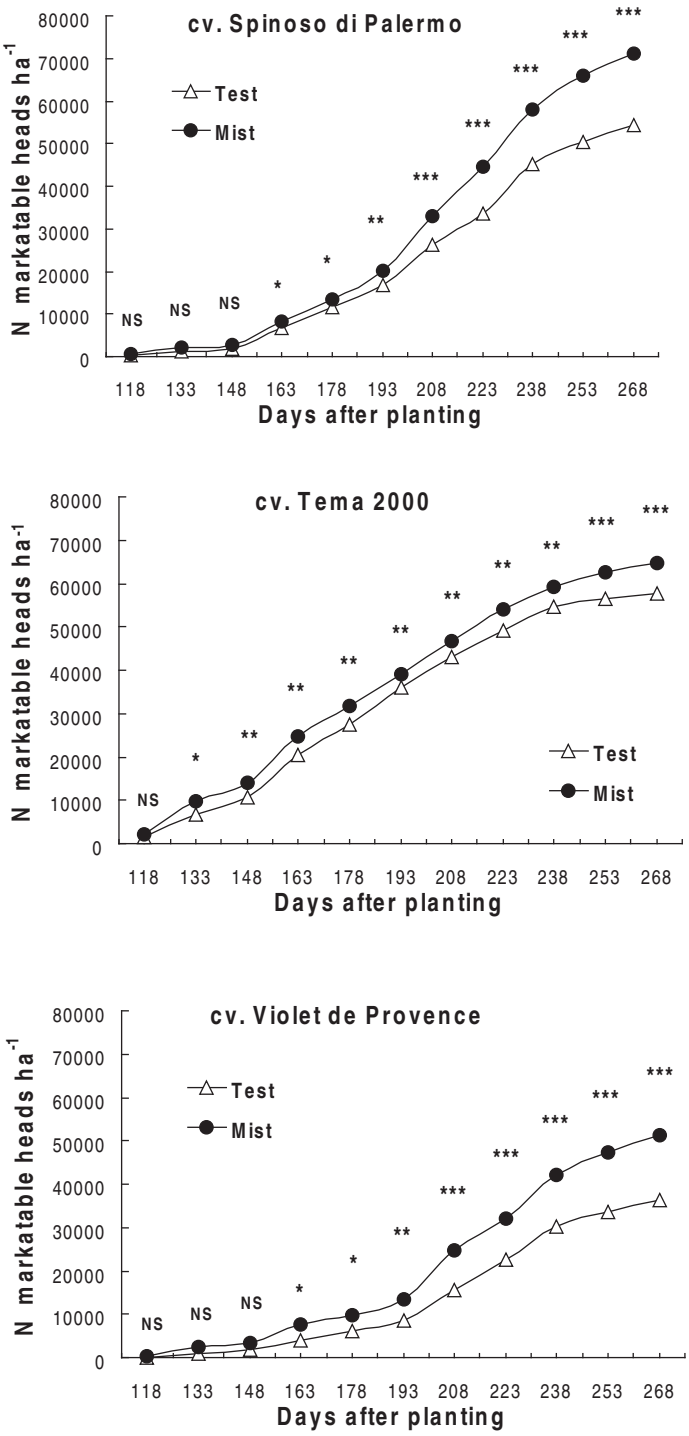

Figure 1. The effect of mist irrigation on the accumulated yield of three globe artichoke cultivars [NS = not significant; *, **, * significant at P ≤ 0.05, 0.01 and 0.001, respectively].**

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