Universidade Federal Rural do Semi-Árido
Pró-Reitoria de Pesquisa e Pós-Graduação
http://periodicos.ufersa.edu.br/index.php/sistema

ISSN 0100-316X (impresso)
ISSN 1983-2125 (online)

CHAMOMILE PRODUCTION USING SUPPLEMENTARY IRRIGATION AND ORGANIC FERTILIZATION IN SANDY SOILS[1]

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ABSTRACT – The use of medicinal plants in the herbal medicine of Brazilian Health System has intensified production and the need for developing efficient agricultural techniques that promote greater productivity of these species. The objective of this work was to evaluate the chamomile production at field conditions as a function of irrigation depths and organic fertilizer rates. The experiment was conducted in the Universidade do Oeste Paulista (Campus II experimental area), in Presidente Prudente, São Paulo State, Brazil. A triple factorial experimental design was used, consisting of irrigation rates (150, 100, 75, 50, 25 and 0% of the reference evapotranspiration - ETo), organic manure types (poultry and cattle manure) and manure rates (0, 3 and 5 kg m^{-2}), with four replications. The capitula production per plant, capitula dry weight and *yield per water input (*water use efficiency) were evaluated. The supplementary irrigation combined with organic manure fertilization provided the highest capitula yield for chamomile crop in the Presidente Prudente region. The combination of poultry manure at rate of 5 kg m^{-2} with water depth equal to 150% of the ETo resulted in higher average values of capitula fresh and dry weight and water use efficiency.

Keywords: *Chamomilla recutita* (L.) Rauschert. Medicinal plant. Water stress. Irrigation management.

PRODUÇÃO DA CAMOMILA COM O USO DE IRRIGAÇÃO SUPLEMENTAR E ADUBAÇÃO ORGÂNICA EM SOLO ARENOSO

RESUMO – A utilização de plantas medicinais na fitoterapia do Sistema Único de Saúde no Brasil tem intensificado o cultivo e a necessidade de desenvolvimento de técnicas agronômicas eficientes para promover maior produtividade destas espécies. O objetivo do presente trabalho foi avaliar a produção da camomila a campo em função de lâminas de irrigação e doses de adubo orgânico. O ensaio foi conduzido em área experimental do campus II, da Universidade do Oeste Paulista, na cidade de Presidente Prudente – SP, Brasil. O delineamento experimental foi em esquema fatorial triplo, sendo composto por lâminas de irrigação (150, 100, 75, 50, 25 e 0% da evapotranspiração de referência - ETo), tipos de adubo orgânico (esterco de aves e esterco bovino curtido) e doses do adubo_(0, 3 e 5 kg m^{-2}), em quatro repetições. Foram avaliadas a produção de capítulos florais por planta, a massas seca dos capítulos florais e a produtividade da água. Para a região de Presidente Prudente, a irrigação suplementar combinada à adubação orgânica, proporcionaram maior produção de capítulos florais. A combinação de esterco de aves na dose de 5 kg m^{-2} à lâmina de 150% ETo resultou em maiores valores médios de massa fresca e seca de capítulos florais e produtividade da água.

Palavras-chave: *Chamomilla recutita* (L.) Rauschert. Planta medicinal. Estresse hídrico. Manejo de irrigação.

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[1]Received for publication in 09/15/2014; accepted in 03/07/2016.
Paper extracted from the Masters's thesis of the first author.
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INTRODUCTION

Chamomile (*Chamomilla recutita* (L.) Rauschert) is an herbaceous, annual and aromatic medicinal plant from the *Asteraceae* family (LORENZI; MATOS, 2002). This species has great economic importance in many countries. The world production of chamomile is over 4,000 Mg year^{-1} of capitula dried flowers (KAVANDI et al., 2011), which is mainly from Hungary, Russia, Argentina, Germany, Slovakia, Finland, Egypt and India (MOHAMMAD, 2011). The Brazilian chamomile production is mainly from the state of Paraná (PR), which had a dried flower production of 929.4 Mg in 2011. Mandirituba PR, is the largest producer county, which has average dried flower yield of 450 kg ha^{-1} (SEAB/DERAL, 2013). The flower capitula of chamomile have calming, analgesic, antispasmodic and cicatrizant properties, and is employed in the pharmaceutical and cosmetic industry (MAPELI et al., 2005).

The use of organic fertilizer for growing medicinal plants is widespread due its beneficial effects in the soil, providing organic matter, improving physical structure and directly influencing its water storage capacity and water availability for plants (MAPELI et al., 2005). Moreover, organic fertilizers contribute to greater stability of nutrients through mineralization process, is an energy source for soil microorganisms and provides macro and especially micronutrients for plants (ALVARENGA, 2004).

Ramos et al. (2004) found a significant increase in the production of capitula per plant in chamomile crops, and Bezerra et al. (2006) found a significant increase in total biomass of Chamba (*Justicia pectoralis* Jacq.) with the use of organic fertilizers.

Irrigated agriculture, singly or in combination with other agronomic practices such as fertilization, favors the metabolism of plants, noticed in the plant growth, development and production. It is important that these practices are in accordance with the regional soil and climatic conditions to favor the capitula production in chamomile crops (SANTOS; INNECCO, 2004).

Marques et al. (2011) evaluated various irrigation rates in Presidente Prudente, São Paulo State (SP) for marigold (*Calendula officinalis*) production based on class A evaporation tank (CAE) (0, 50, 100 and 150% of the CAE) and found that an intense precipitation period at pre-flowering resulted in a great flowering of plants kept under severe water stress (50% CAE). In a study on water stress in oregano, Marques et al. (2009) found that an increase in irrigation rates has a positive linear relationship with the variables fresh and dry weight of shoot and root, root-shoot ratio, essential oil content and yield.

A correct irrigation water depth combined with proper fertilization (rate and type of fertilizer) can result in a greater capitula production per plant, thus having better use of the water. Studies related to medicinal plants are scarce, denoting the need to intensify researches on agronomic management focused on these species and to form a standardized material with information on irrigation management for them (SILVA et al., 2002; BORBA et al.; 2012). Given the commercial importance of chamomile and the need to evaluate irrigation and organic fertilization in this crop, the objective of this work was to evaluate the chamomile production at field conditions as a function of irrigation depths and organic fertilizer rates in the soil and weather conditions of the western São Paulo State.

MATERIAL AND METHODS

The experiment was conducted between April and August 2011, in the Universidade do Oeste Paulista (Campus II experimental area), in Presidente Prudente, São Paulo State, Brazil. A triple factorial experimental design was used, consisting of six irrigation rates, two types of fertilizers and three rates of each fertilizer, with four replications, totaling 144 plots. The seedlings were prepared in 200-cell trays, with commercial seeds of chamomile (ISLA®), which were transplanted to the field 40 days after planting (DAP). The experimental area was divided into plant beds of 30 m long and 1 m wide, and each plot had 3 m x 1 m. Seedlings were transplanted spaced by 0,30 m and 0,40 m, totaling 15 plants per plot.

The plants had an irrigation water depth equal to 100% of the reference evapotranspiration (ETo) in the first seven days after transplantation. After this period, the treatments with different water depths were applied. The irrigation rates were 150, 100, 75, 50, 25 and 0% of the ETo daily applied based on the Penman-Monteith method. Meteorological data were collected daily from the Campbell scientific weather station located in the experimental area, which had temperature, relative humidity, wind speed, solar radiation and precipitation sensors.

The irrigation rates were applied in combination with organic fertilizers. The organic fertilization was performed at the day that the seedlings were transplanted to the experimental plots. The fertilizers used were cattle and poultry manure, both at rates of 0,3 and 5 kg m^{-2}. Chemical analysis of fertilizers was performed at the Soil and Plant Nutrition Laboratory of the Universidade do Oeste Paulista. The cattle manure results were: 38.2 g kg^{-1} total N, 9.9 g kg^{-1} P, 24.4 g kg^{-1} K, 33.7 g kg^{-1} Ca, 14.2 g kg^{-1} Mg, 0.7 g kg^{-1} S, 35.8 mg kg^{-1} B, 5.04 mg kg^{-1} Cu, 49.71 mg kg^{-1} Fe, 414 mg kg^{-1} Mn and 135 mg kg^{-1} Zn. The poultry manure results were: 20.6 g kg^{-1} total N, 12.8 g kg^{-1} P, 64.5 g kg^{-1} K, 173 g kg^{-1} Ca, 12 g kg^{-1} Mg, 7.9 g kg^{-1} S, 40 mg kg^{-1} B, 183 mg kg^{-1} Cu, 13.62 mg kg^{-1} Fe, 339 mg kg^{1} Mn and 489 mg kg^{-1} Zn.

The soil of the region was classified as eutrophic Red-Yellow Argisol (EMBRAPA, 1999). The physical-chemical analysis of soil of the experimental area had the following results: pH in $CaCl_2$ 6.2, SMP pH 6.9, organic matter 13 g dm^{-3}, H+AL 18 mmolc dm^{-3}, Ca^{+2} 41 mmolc dm^{-3}, Mg^{+2} 21 mmolc dm^{-3}, K^{+} 2.6 mmolc dm^{-3}, P 69 mg dm^{-3}, base saturation 27 mmolc dm^{-3}, CEC 57 mmolc dm^{-3}; V% 58, and particle size 79.5% sand, 14% clay and 6.5% silt, characterizing a sandy textural class. Soil acidity correction was performed 30 days before transplanting, using 627 kg ha^{-1} of dolomitic limestone with *total neutralizing power* of 90% to raise the base saturation to 70%, according to recommendations of Van Raij et al. (1997) for chamomile crops.

The total chamomile crop cycle was 128 days. The harvest of the center line started 100 days after transplanting (DAT), by the appearance of the first flowers, and performed daily until plant senescence (duration of 28 days). The number of capitula per plant was counted and the total number of capitula (NC ha^{-1}) was calculated at each harvest, considering a population of 83,333 plants per hectare. Subsequently, the capitula were cut with scissors, stored in kraft paper bags and air dried in an oven with air circulation at 60°C for 3 days for later weighing. The floral capitula were added to find their total dry weight (FCDW in kg ha^{-1}) at the end of the experiment. The *yield per water input* (water use efficiency) (WE) (PERRY et al, 2009) was assessed by considering the capitula yield relationship with the water consumption. The chamomile FCDW was considered because the chamomile is marketed using weight units (COSTA; DONI FILHO, 2002). This variable was calculated according to the equation:

$$WE = \frac{FCDW}{\left(P + L\right)} \quad (01)$$

in which WE is the water use efficiency (kg ha^{-1}), FCDW is the total dry weight of capitula (kg ha^{-1}), P is the effective precipitation in the experiment period (mm), L is the applied irrigation depth in the experiment period (mm).

Figure 1 shows the monthly water balance during the experimental period, and the periods of planting, transplanting and first harvest. The total accumulated water depths and the effective precipitation during the experiment are shown in Table 1. The total precipitation in the experiment period (Apr 18 to Aug 28) was 181 mm. Effective precipitation was found after removed loss of surplus water from the total precipitation (using only those greater than 10 mm), considering a humidity at field capacity of 20.9% and a humidity in permanent wilting point of 4.9% as soil water retention parameters, resulting in 45 mm of water storage capacity of the soil, considering an effective depth of the chamomile root system of 40 cm.

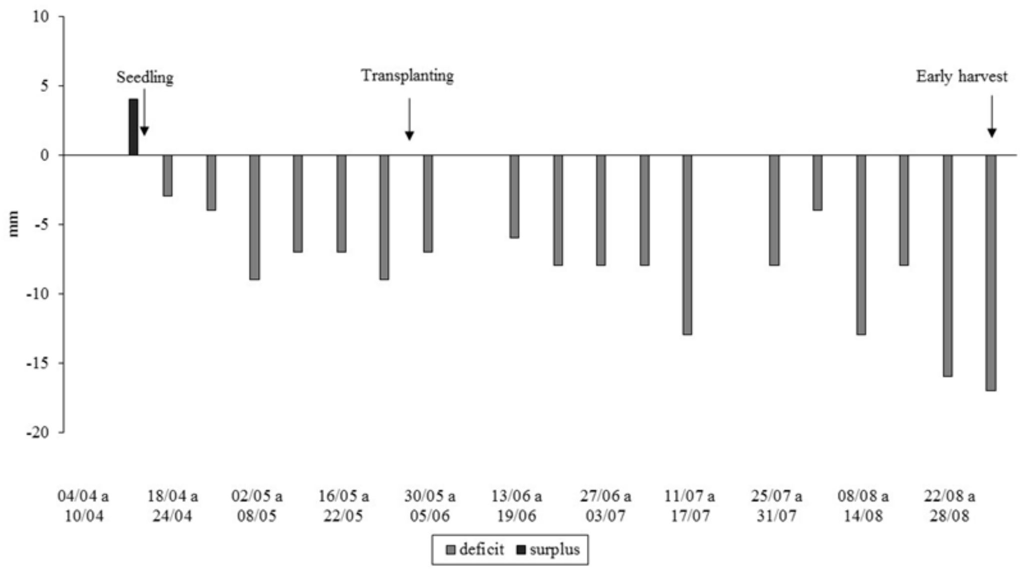

Figure 1. Water balance of the chamomile crop cycle during the experimental period.

Table 1. Effective precipitation and the total water depth applied in the experimental period from May 30 to August 8, 2011. Presidente Prudente SP.

Treatments % ETo	Effective precipitation (mm)	Irrigation (mm)	Total water depth (mm)
150%	0	135.5	135.5
100%	0	90.3	90.3
75%	19	67.7	86.7
50%	39	45.2	84.2
25%	58	22.5	80.5
0%	65	0	65.0

RESULTS AND DISCUSSION

According to the water balance shown in Figure 1, the periods with moderate drought favored the positive response of chamomile to irrigation management. The interaction irrigation rate x organic fertilizer type x fertilizer rate presented significant results. The F values found for this interaction were 23.995 (NC), 29.043 (FCDW) and 4.84 (WE) at 1% of significance.

Figure 2 shows that all the tested organic fertilizer had polynomial fit in relation to the water depth, i.e., the increase in water supply increased the capitula production per plant, considering the water depths tested in this experiment. The largest number of capitula were in the plots under irrigation with 150% of the ETo. Unfertilized plants presented capitula abortion, even when irrigated.

The experiment was conducted in sandy soil characterized by high infiltration rate and low water retention capacity, therefore, the largest water depth tested associated with organic fertilizer, which enables improvement in the physicochemical characteristics of the soil, provided the best results in capitula production of chamomile. Medicinal plants require soils with light texture that has availability of sufficient water for their growth and development. Sandy soils that have not been supplied with organic matter have low or absent floral capitula production, because the low water retention due to unfavorable texture conditions (NÓBREGA et al., 2012).

Azevedo et al. (2005) studied irrigation management through CAE for pepper crops (cv. Tabasco McIlheny) in Fortaleza, Ceara State, Brazil, using water depths equal to 40, 60, 80, 100 and 120% of the CAE. The authors found that each additional percentage used resulted in an average gain of 90 kg ha^{-1} in production. Similar results of positive responses with water depth equal to 150% ETo were found by Pizard *et al*. (2006) for chamomile and Silva et al. (2002) for *Melaleuca alternifolia*, in which the excessive water depth irrigation did not hindered the floral capitula production. These positive responses may be due to few studies related to crop coefficient (kc) to establish the water needs of medicinal crops.

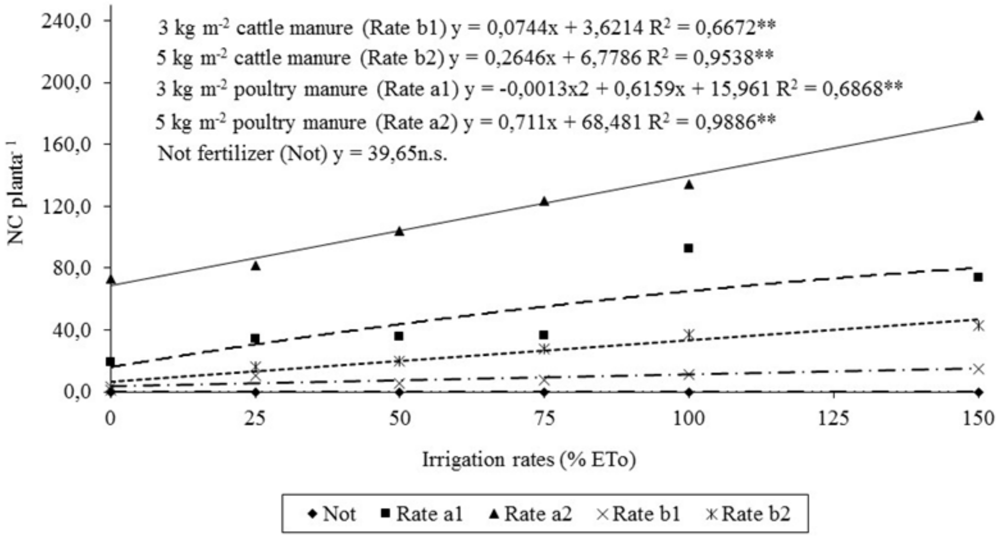

Figure 2. Number of floral capitula per plant (NC) of chamomile subjected to different irrigation rates (150, 100, 75, 50, 25 and 0% of the ETo), organic fertilizers (cattle and poultry manure) and fertilizer rates (3 kg m^{-2} - a1 and b1; and 5 kg m^{-2} - a2 and b2). Presidente Prudente SP, 2011.

The organic fertilizers cattle and poultry manure resulted in higher capitula production in the chamomile plants. This positive result can be explained by the fact that the organic fertilizers provide nutrients for plants, enabling a production increase favoring water retention in the soil (ALVARENGA, 2004; PEREIRA et al., 2013). Rosal et al. (2009) evaluated manure rates (0, 2.5, 5, 7.5 and 10 kg m^{-2}) for fertilization of *Plectranthus neochilus* Schlechter, and found that an increase in the manure rate positively influences biomass accumulation.

According to Amer et al. (2009), the water depth interaction with the use of different organic fertilizers (rabbit, poultry and cattle manure) favors the soil texture and soil organic matter and nutrients concentrations, contributing to increase water retention and consequently meeting the plant water needs.

Regarding the capitula dry weight (Figure 3), a polynomial fit was found for the interaction of fertilizer rates with the water depths, with the greatest capitula dry weight to the rate of 5 kg m^{-2} of poultry manure associated with increasing irrigation rates. The improvement in soil chemical and physical structures favors the progressive increases in water depths without hindering the plant by water stress. Nóbrega et al. (2012) also found a positive response for development of *Jatropha curcas* subjected to organic fertilization and irrigation rates established using the reference evapotranspiration of the Santa Luzia region, State of Paraiba.

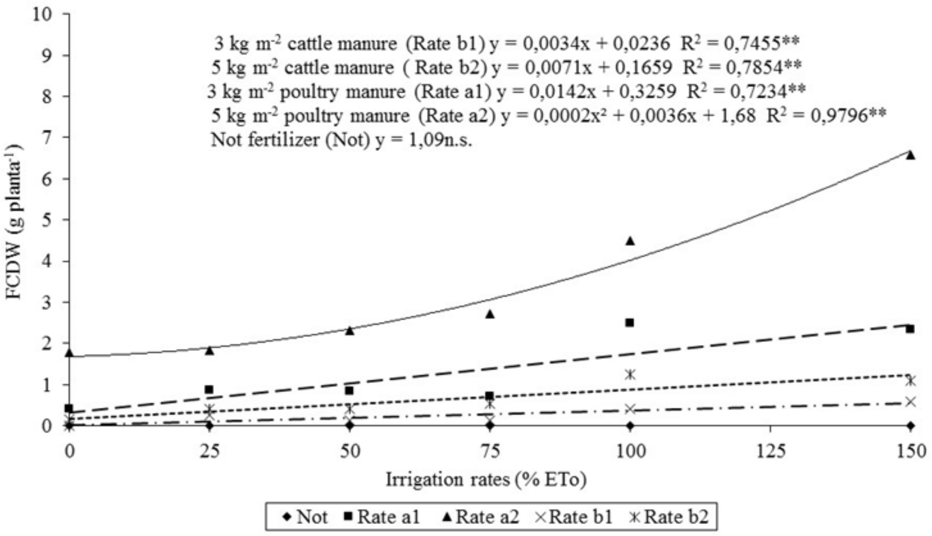

Figure 3. Capitula dry weight (FCDW) of chamomile subjected to different irrigation rates (150, 100, 75, 50, 25 and 0% of the ETo), organic fertilizers (cattle and poultry manure) and fertilizer rates (3 kg m^{-2} - a1 and b1; and 5 kg m^{-2} - a2 and b2).

Oliveira Júnior et al. (2006) studied the response of *Lychnophora ericoides* subjected to three different fertilizers (cattle manure; balanced mineral fertilizer with NPK, $S\text{-}SO_4$, B, Cu and Zn, and a mix of these two) and found that *Lychnophora ericoides* had higher dry matter accumulation of shoot for the treatment with organic fertilizer, due to soil condition improvements by this fertilizer.

The water use efficiency (WE) positively responded to the increase in irrigation rates and showed higher values for the fertilizer with poultry manure at rate of 5 kg m^{-2} (Figure 4). The WE relates the crop yield to water consumption by the plant, thus, the water consumption by the plant increases with irrigation rate increases. These results can be explained by the sandy texture of the soil. Sandy soils have high infiltration speed, total porosity lower than clayey soils and low organic matter contents, factors that together contribute to greater irrigation need.

There is a limit in the WE response to the amount of water used for irrigation. This limit is related to the increase in evapotranspiration and percolation of excess water resulting from the soil sandy texture. These results differ from those found by Sousa et al. (2008) for castor bean, Araújo et al. (2010) for lettuce and Nascimento et al. (2011) for sesame, in which the increase in the water depth applied decreased the water use efficiency by plants even in sandy soil conditions.

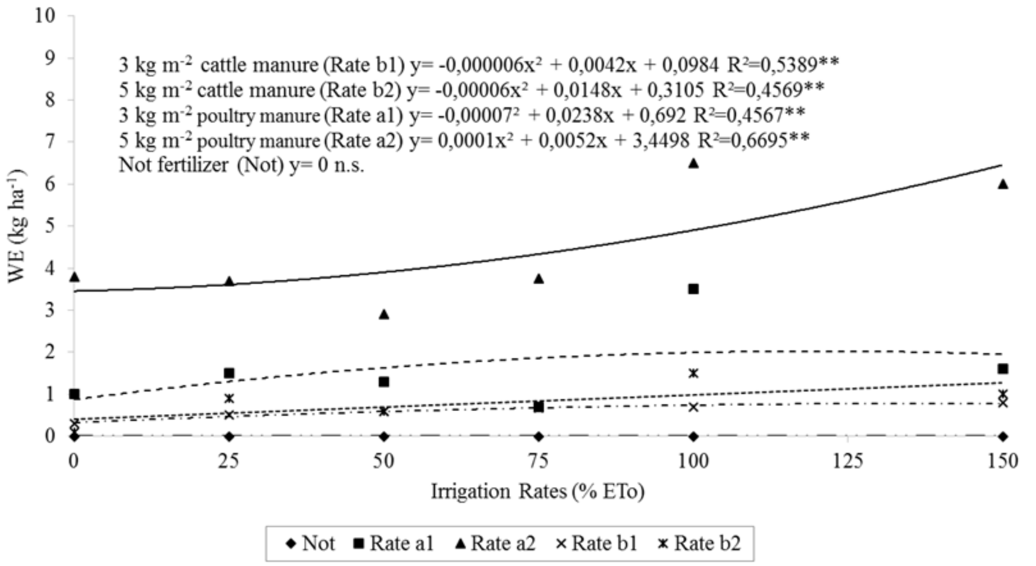

Figure 4. Water use efficiency (WE) of chamomile subjected to different irrigation rates (150, 100, 75, 50, 25 and 0% of the ETo), organic fertilizers (cattle and poultry manure) and fertilizer rates (3 kg m^{-2} - a1 and b1; and 5 kg m^{-2} - a2 and b2).

CONCLUSION

The supplementary irrigation combined with organic manure fertilization provided the highest capitula yield for chamomile crop in the Presidente Prudente region.

The irrigation with water depth equal to 150% of the ETo, associated with fertilization with poultry manure at rate of 5 kg m^{-2}, increased the production of capitula per plant and water use efficiency.

ACKNOWLEDGEMENTS

The authors thank the São Paulo Research Foundation (FAPESP) for granting Master's scholarship and partial funding this research.

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