STATE OF THE ART OF IRRIGATION RESEARCH ON PROCESSING TOMATOES IN BRAZIL

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Abstract

Despite the importance of irrigation for processing tomato crops in Brazil, research contributions to this subject have been modest and considerable gaps in knowledge still exist. The objective of this paper is to present a survey of irrigation technology research on processing tomatoes in Brazil, emphasizing recent developments and trends, and pointing out the need of further work. It has been found that irrigation research has given little but significant contributions to the improvement of the crop in the last fifteen years. A whole lot of research, however, still remains to be carried out on irrigation and related fields, in order to define optimal parameters of the plant-water-nutrient system.

1. Introduction

Processing tomato is one of the most important vegetable crops cultivated in Brazil, especially in the Middle São Francisco river basin in the semi-arid Northeast region, in the "cerrados" of Central Brazil and in some parts of the state of São Paulo. It is estimated that 20,000 ha of processing tomatoes are cropped annually in the country (Argerich *et al.*, 1997) and the majority of this area is irrigated by sprinkle irrigation systems, primarily by center pivot machines.

Until the seventies and early eighties irrigation of processing tomato crops in Brazil used to be performed mostly by sloping furrows, even though most of the soils had high infiltration capacities, not appropriate for this irrigation system.

Changes have been happening in all aspects of the processing tomato cropping systems thanks to agricultural technologies evolution in the country. This is due greatly to the implementation of agricultural research centers and an ambitious researcher training program starting in the mid seventies, provided by the government through EMBRAPA (Brazilian Agricultural Research Agency).

Despite the importance of irrigation for processing tomatoes, research contributions to this subject have been modest. There is relatively small amount of published information related to irrigation systems, management and water requirements. Therefore, the objective of this work is to present and discuss the status of the irrigation technology research on processing tomatoes in Brazil, emphasizing recent developments and trends, and pointing out the need of further work.

2. Irrigation systems

In the early seventies, growers, extension agents, and researchers began to realize that they had to look for more efficient irrigation systems, mainly for the high infiltration capacity soils. Caixeta *et al.* (1977) compared furrow with drip irrigation for processing tomatoes in coarse textured soil, both applying the same depth of water on a daily basis. Although no significant differences between the evaluated methods were found, they

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noticed that furrow irrigation performed a little better in terms of crop yield. Nevertheless, low yields and emitter clogging were some of the problems faced during the experiments.

Soares and Faria (1983) studied the influence of irrigation systems on the production of processing tomatoes in an oxisoil. They found that marketable fruit yields were similar for both furrow and hand-move sprinkle systems. However, water use efficiency for sprinkle irrigation was almost twice as much as for furrow. Furthermore, sprinkle irrigation favored higher occurrence of rotten fruits and 2.5 times more fruits with blossom-end-rot. Sprinkle irrigation was recommended for the months of low precipitation and low relative humidity.

In the last ten years most of the processing tomatoes crops have been irrigated by sprinkle systems, especially center pivot, with yields of up to 75 t/ha. Because many problems such as lack of good water management, lack of efficient crop rotation schemes and severe occurrence of diseases, farmers have been looking for alternative irrigation systems. Exploratory work has shown that microirrigation, especially drip systems, are feasible (Silva and Marouelli, 1995). More recently it has been found that subsurface drip fertigation has favored high yields of several processing tomato cultivars and hybrids, up to 98 t/ha, associated with low occurrence of diseases and low rate of rotten fruits (Silva *et al.*, 1997a).

3. Water requirements

In spite of its importance it has been found only a couple of reports dealing specifically with crop water requirements. Millar *et al.* (1978) determined the crop evapotranspiration in the semi-arid region of Brazil, using the complete water balance approach. Cumulative crop evapotranspiration rate was found to be in the range of 626 to 451 mm as soil water tension increased from 300 kPa to 500 kPa, corresponding to 5.22 and 3.76 mm/day, respectively.

In Central Brazil, region with relatively low relative humidity and rather cool air temperatures during growing season, studies were carried out to estimate crop coefficient (Kc) for sprinkle irrigated processing tomatoes crop, using Class A pan evaporation data. Kc values were found to be 0.45, 0.65, 0.80 and 0.60 for initial, vegetative, fruit formation and fruit ripening phases, respectively (Marouelli *et al.*, 1996).

In terms of water consumption in Central Brazil, for an average growing period of 130 days and good fruit yields, net amounts of total applied irrigation water have ranged from about 300 mm (Marouelli *et al.*, 1991) to 400 mm (Silva and Marouelli, 1996). During the normal growing season in this region, rainfalls usually amount no more than 50 mm.

4. Irrigation scheduling and management

Studies on irrigation scheduling and management for processing tomatoes started in the early seventies. Lima *et al.* (1978) tested three levels of available soil water depletion (20, 40 and 60%) in a sandy soil. Best results were obtained when irrigations were performed as 40% of available water was depleted. Low yields and the large rate of non-marketable fruits were attributed to heavy rainfalls during fruit maturation period.

Choudhury *et al.* (1980a) compared three irrigation scheduling techniques for processing tomatoes growing in the semi-arid region of the country. The treatments consisted of irrigating at the intervals of 4, 7 and 14 days. These irrigation intervals corresponded to average soil water tensions of 70, 140 and 300 kPa, respectively. The 4-day interval treatment simulated a traditional irrigation frequency used by local farmers. Results showed that there were no significant differences in yields when irrigating the crop at 4- and 7-day interval. On the other hand, the 14-day irrigation interval caused a yield reduction of 32%.

Another work done by Choudhury *et al.* (1980b) had the objective of studying the crop response and root system distribution as function of five irrigation regimes.

Treatments consisted of irrigating the crop as soil water tension reached 30, 100, 200, 300 and 500 kPa during the entire growing season. It was found that irrigation for processing tomatoes crop can be managed between soil water tensions of 30 and 200 kPa, with best possibilities for lower irrigation frequency without affecting yield significantly. Furthermore, 85% of the crop root system was concentrated within the 0-35 cm soil layer.

A line-source experiment was carried out by Bezerra Neto and Almeida (1985) in the semi-arid state of Rio Grande do Norte, with the objective of verifying processing tomato crop response to different depths of applied water. Four depths of total applied water were distinguished: 1,032; 923; 796 and 584 mm. The water depths of 923 and 796 mm favored the highest yields: 68 and 72 t/ha, respectively. Optimization showed that maximum yield would be obtained for the depth of 864 mm.

In Central Brazil, Marouelli *et al.* (1991) studied several irrigation management regimes that resulted from the combination of soil water tensions (30, 100 and 460 kPa) with three plant growth phases. They found no significant differences in fruit marketable yields for soil tensions between 30 and 460 kPa during vegetative and fruit maturation growing periods. Yields decreased as soil water tension increased during the fruit formation but with no significant differences between 30 and 100 kPa. Soluble solids content and acidity were not affected by treatments.

Considering that soil water management during fruit maturation period has a great influence on processing characteristics, Marouelli and Silva (1993) carried out a two-year study in order to determine the right moment to suspend irrigation. It was found a parabolic tomato yield response, reaching a maximum of 90 t/ha as irrigation was terminated 86 days after blossom. Soluble solids contents decreased linearly with the delay of irrigation ending. Therefore, in order to obtain a maximum production of soluble solids, water applications should cease when about 50% of the plants present at least one fully red fruit.

More recently, also considering that many water management techniques are available and Brazilian processing tomatoes growers still manage irrigation empirically, Silva and Marouelli (1996) evaluated four irrigation scheduling techniques. Three of the studied techniques are based on crop evapotranspiration and soil water retention characteristics, and the fourth one was farmer's empirical method, based on irrigation frequency and depth of water application established previously. Crop yields were about 25% higher when irrigation was managed by any sound technique such as monitoring soil water content and/or estimating crop evapotranspiration. These techniques, however, require reliable, relatively precise and rather simple equipment like neutron probe and Class A pan.

5. Fertigation

Pinto *et al.* (1997) studied different rates and periods of nitrogen application through drip irrigation on processing tomatoes crop. Nitrogen total rates of 45, 90 and 135 kg/ha were applied in three different periods (up to 25, 50 and 75 days after transplanting). Levels of nitrogen smaller than 90 kg/ha applied before 50 days after transplanting reduced yield and fruit weight. Conventional side-dressing fertilization favored yield reduction of about 20% as compared with fertigation. Subsurface drip fertigation has also been used successfully in a study dealing with response of processing tomato cultivars to fertigation (Silva *et al.*, 1997a).

6. Irrigated crop rotation

The major problem associated with center pivot irrigated processing tomato crop in the main production regions of Brazil is not directly related to irrigation itself, but to the widespread occurrence of white mold caused *Sclerotinia sclerotiorum*. Structures of resistance of this fungus accumulates in the soil year after year, if processing tomato crop is grown without rotation with a non-susceptible crop.

A five-year study carried out with center pivot in Brasilia, has indicated that the crop sequence tomato-corn-wheat-corn-tomato corresponding to winter-summer-winter-summer-winter is adequate for obtaining good processing tomato yields (Silva *et al.*, 1997b). Furthermore, adequate soil and water management not allowing excessive water applications and/or water pond on soil surface contributes to delay of infection and keep pathogen population within tolerable level.

7. Concluding remarks

Until the mid seventies irrigation of processing tomatoes used to be realized by surface systems, primarily furrow irrigation, even in coarse textured soils. Since center pivots have predominated over other irrigation systems, problems related to lack of efficient crop rotation schemes has brought out many problems. Research has shown some measures to be taken in order to mitigate the problems. Recent studies have shown technical feasibility of drip irrigation for processing tomatoes crops in Brazil and that high yields associated with low occurrence of diseases can be obtained by using subsurface drip fertigation.

In relation to crop water requirements the situation is worse because only one paper has been found in the literature dealing specifically with this important problem. A couple of other papers presented estimates of water consumption as a by-product.

Most of the research done in Brazil is related to irrigation scheduling and water management. For the major tomato growing areas it has been found critical levels of soil water tension. The right moment to suspend irrigation in order to obtain best results has also been determined. No research has been done about processing tomatoes pestigation. Only timid experiences on fertigation have been reported.

As it could be seen, a whole lot of research still remains to be done on processing tomatoes irrigation and related fields. From the results showed here it could be depicted that research projects to be effective must include economical analysis besides incorporating a holistic approach.

References

Argerich, C.A., Melo, P.C.T. de and Valderrama, L.A., 1997. Update on the agro-industry situation of processing tomatoes in South American Countries. In: International Conference on the Processing Tomato, 1., 1996, Recife. Proceedings. Recife: IPA/ASHS. p.15.

Bezerra Neto, R. and Almeida, A.M., 1985. Efeito de lâminas de água e fertilizantes na cultura do tomate industrial, em Caicó, Rio Grande do Norte (*Lycopersicon esculentum*). Agropecuária Técnica, Areia, 6 (1): 1-7.

Caixeta, T.J., Marinato, R. and Fontes, P.C.R., 1977. Estudo comparativo de quatro lâminas de água em irrigação por sulcos e gotejamento em tomate industrial. Projeto Olericultura; Relatório Anual 1974/75, Belo Horizonte, p. 71-73.

Choudhury, E.N., Millar, A.A. and Silva, M.A., 1980a. Comparação de três sistemas de manejo de irrigação de tomate industrial em escala semicomercial. In: Congresso Nacional de Irrigação e Drenagem, 5., 1980. São Paulo. Anais...São Paulo: ABID. v.3: 231-249.

Choudhury, E.N., Millar, A.A., Choudhury, M.M. and Abreu, T.A.S., 1980b. Diferentes níveis de irrigação na produção e sistema radicular do tomate industrial. Pesquisa Agropecuária Brasileira, Brasília, 15 (4): 475-480.

Lima, C.A.S., Padua, J.G. and Purcino, J.R.C., 1978. Efeito de três níveis de umidade em solo aluvião na produção do tomate (*Lycopersicon esculentum* Mill.) industrial na região norte de Minas Gerais. Projeto Olericultura; Relatório 76/77, Belo Horizonte, p. 195-198.

Marouelli, W.A., Silva, H.R. and Oliveira, C.A.S., 1991. Produção de tomate industrial sob diferentes regimes de umidade no solo. Pesquisa Agropecuária. Brasileira, Brasília, 26 (9): 1531-37.
Marouelli, W.A. and Silva, W.L.C., 1993. Adequação da época de paralisação das irrigações em tomate industrial no Brasil Central. Horticultura Brasileira, Brasília, 11 (2): 218-221.
Marouelli, W.A., Silva, W.L.C. and Silva, H.R., 1996. Manejo da irrigação em hortaliças. Brasília: EMBRAPA-SPI/EMBRAPA-CNPH, 72p.
Millar, A.A., Choudhury, E.N. and Abreu, T.A.S., 1978. Determinação da evapotranspiração em tomate industrial através do balanço completo de água sob diferentes regimes de irrigação. In: Congresso Nacional de Irrigação e Drenagem, 4., 1978, Salvador. Anais... Salvador: ABID. v.2: 212-229.
Pinto, J.M, Soares, J.M., Costa, N.D., Faria, C.M.B., Brito, L.T.L. and Silva, D.J., 1997. Doses e períodos de aplicação de nitrogênio via água de irrigação na cultura do tomate. Horticultura Brasileira, Brasília, 15 (1): 15-18.
Silva, W.L.C., Giordano, L.B., Gornat, B., Marouelli, W.A. and Fontes, R.R., 1997a. Resposta de cultivares de tomateiro para processamento industrial à fertirrigação por gotejamento subterrâneo. Brasília: Embrapa Hortaliças, 7 p. (Embrapa Hortaliças. Pesquisa em Andamento, 6).
Silva, W.L.C. and Marouelli, W.A., 1995. Exploratory studies on microirrigation for processing tomatoes in Central Brazil. In: International Microirrigation Conference, 5., 1995, Orlando. Proceedings... Orlando: ASAE, p. 904-908.
Silva, W.L.C. and Marouelli, W.A., 1996. Evaluation of irrigation scheduling techniques for processing tomatoes in Brazil. In: International Conference on Evapotranspiration and Irrigation Scheduling, 1996, San Antonio. Proceedings... San Antonio: ASAE. p. 522-526.
Silva, W.L.C., Lopes, C.A., Pereira, W. and Fontes, R.R., 1997b. Crop rotation systems for irrigated processing tomatoes in Central Brazil. In: International Conference on the Processing Tomato, 1., 1996, Recife. Proceedings... Recife: IPA/ASHS. p. 80.
Soares, J.M. and Faria, C.M.B. de, 1983. Métodos de irrigação e adubação na cultura do tomate industrial. Pesquisa Agropecuária Brasileira, Brasília, 18 (3): 281-286.