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RESPONSE OF WATERMELON TO NITROGEN FERTIGATION

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1 ABSTRACT

A 2-year study was carried out during 2004-2005 at the Meio-Norte Agropecuary Brazilian Agency experimental area, located in Parnaíba, State of Piauí, Brazil, to investigate the effect of nitrogen (N) fertigation on the watermelon yield and fruit quality. The 'Crimson Sweet' watermelon was planted in a 2 x 1 m spacing and drip irrigated with a row of pressure-compensated drippers. Treatments consisted of five N levels (0, 40, 80, 120 and 160 kg ha^{-1}). The statistical design had randomized blocks with four replications. The total yield and marketable fruit increased with levels of N at a maximum of 66.1 and 58.4 t ha^{-1} with N levels of 114.6 and 112.3 kg of N ha^{-1}, respectively. Fruit quality, represented by the total soluble solids (SST) and pH, was not affected by nitrogen levels.

KEYWORDS: *Citullus lanatus*, drip irrigation, irrigation management

ANDRADE JÚNIOR, A. S. de; SILVA, C. R. da; DIAS, N. da S.; RODRIGUES, B. H. N.; RIBEIRO, V. Q. RESPOSTA DA MELANCIEIRA A FERTIRRIGAÇÃO NITROGENADA

2 RESUMO

Para investigar o efeito da aplicação de nitrogênio via fertirrigação sobre a produtividade e qualidade de frutos de melancieira irrigada por gotejamento, um experimento foi conduzido durante dois anos (2004 e 2005) na área experimental da Empresa Brasileira de Agropecuária Meio-Norte, localizada em Parnaíba, Piauí. A melancia 'Crimson Sweet' foi plantada no espaçamento de 2 x 1 m e irrigadas por uma linha de gotejadores autocompensantes. Os tratamentos consistiram de 5 níveis de nitrogênio aplicados via fertirrigação (0, 40, 80, 120 e 160 kg ha^{-1}). O delineamento experimental utilizado foi o de blocos ao acaso com quatro repetições. A produtividade total e comercial aumentou com os níveis de N até um máximo de 66,1 e 58,4 t ha^{-1} com os níveis de 114,6 e 112,3 kg of N ha^{-1}, respectivamente. A qualidade dos frutos, representada pelo teor de Sólidos Solúveis Totais (SST) e pH, não foi afetada pelos níveis de nitrogênio.

UNITERMOS: *Citullus lanatus*, irrigação por gotejamento, manejo de irrigação.

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3 INTRODUCTION

The watermelon (*Citullus lanatus*) is cultivated throughout most of Brazil, especially in Northwest States. The hot and dry climate there allied with irrigation provides excellent conditions to obtain high yield and fruit quality (Pedrosa, 1997).

In 2002, around 28.0% of the total of fruit produced in country was obtained in Northwest States, being Pernambuco and Bahia responsible by 65.9% (IBGE, 2003). The watermelon was the fourth summer vegetable produced in Brazil with an annual production of 12.5 million of tons and fruit exportation by 1.8 million of dollars, in 1999. The main importers were the countries of MERCOSUL (Chabaribery & Alves, 2001; Camargo Filho & Mazzei, 2002).

In Piauí State, watermelon is a good alternative for irrigation growers and the cultivated area has increased annually. Since watermelon is widely spaced crop, large quantities of water are wasted whether conventional irrigation methods as furrow or sprinkler were used, especially in the early stage of crop development. (Srinivas et al., 1989).

Evaluating the watermelon response to drip and sprinkler irrigation, Elmstron et al. (1981) concluded that about 40% less water was used with the drip system than with overhead irrigation. Another advantage is that the leaves are not wetted with drip irrigation and it can help in the control of the diseases. Thus, drip irrigation has become a first choice of the watermelon growers in Piauí State.

Nitrogen (N) fertigation offers the most expressive results due to the large plant nutrient requirements as well as the great role of N on vegetative development, which increases the photosynthetic activity determining the crop yields (Pizarro, 1996). However, the response to N is greatly influenced by local fertility and moistures status. This second influences the mineralization of soil organic matter and its availability and consequently its uptake could be expected with increased soil moisture (Hedge, 1987).

Drip irrigation allows applying fertilizer through the irrigation, a technique called fertigation (Bernardo et al., 2005). The advantages of fertigation is the lower fertilizer lost, better soil distribution and assimilation nutrient by plants and by allowing an adequate nutrient supply throughout phenological cycle of development (Pizarro, 1996).

Although there are some researches about N fertilization and soil moisture on watermelon (Headge, 1987; Garcia, 1988; Pier & Doerge,1995; Garcia & Souza, 2002 and Soares et al. 2002), there is little information about levels of nitrogen in drip fertigation. Because of this, irrigation growers have unused the fertigation technique in the State.

The main purpose of this work was the determination of optimum level of N applied by drip fertigation for high yield and fruit quality of watermelon cultivated in Piauí, Brazil.

4 MATERIAL AND METHODS

The work was performed from September to November of 2004 and 2005 in the 1.0-ha plot of experimental area of Brazilian Agency of Agropecuary, Embrapa Meio-Norte, localized at 20 km from Parnaiba city, PI, (02° 54’S, 41° 47’W; altitude 46 m). The local climate is rainy tropical (Bastos et al., 2000).

The watermelon plants ‘Crimson Sweet’ were planted in a sandy soil with particle size distribution of 846.4 g kg^{-1} of sand, 58.2 g kg^{-1} of silt and 95.4 g kg^{-1} of clay. The soil water content for the 0-1.0 m depth was 0.18 m^{3} m^{-3} at field capacity and 0.06 m^{3} m^{-3} for the permanent wilting point. Some chemical properties of soil are presented in Table 1.

Table 1. Selected chemical properties from a sandy soil before the beginning of experiments of 2004 and 2005. Parnaíba, Brazil.

Year	pH	M.O.[1]	P	S	K^+	Ca^{2+}	Mg^{2+}	H^++Al^{3+}	CTC[2]	V[3]
		g kg^{-1}	mg dm^{-3}	------------------$cmol_c$ dm^{-3}--------------------						----%---
2004	6.17	-	16.7	17.2	0.07	0.96	0.66	0.91	2.62	65.1
2005	5.78	10.81	7.45	14.0	0.10	1.08	0.17	2.12	3.53	39.7

[1] Organic Matter.
[2] Cation Exchange capacity.
[3] Bases sum.

Before planting, the soil pH was corrected and fertilized with 30-80-30 kg ha^{-1} ($N-P_2O_5-K_2O$) and 12 kg ha^{-1} of fritted micro-nutrients (FTE BR-12). Fertilizations were made in according to recommendations of Andrade Júnior et al (2004). The fertilizer sources were urea, single super phosphate and potassium chloride, respectively.

The plants population was planted (2.0 m between rows and 4 seeds for meter) on days 23 Sept. 2004 and 01 Sept. 2005. This cultivar has globulose fruits, 6 to 12 kg weight, 60 to 70 days to harvest and good local market acceptation (Andrade Júnior et al., 1997). The seedlings were later thinned to leave a single plant in each basin (5,000 plants ha^{-1}). Ordinary pest control practices were performed routinely and no weeds were allowed to develop at field throughout the experiment.

Each row of plants was drip irrigated with a row of pressure-compensated drippers spaced each 0.5 m and giving a flow rate of 2 l h^{-1}. Emission uniformity was measured as described by Pizarro (1996) and maintained at high levels (>90%) for two crop cycles.

After planting and before the beginning of the treatments, were made 10 daily irrigations with objective to uniformize the soil water content and to support the crop establishment. After, irrigations were managed to every two days. Fertigation was made using a TMB pump.

Daily irrigation water requirement was calculated as:

$$NI = \frac{ET \times Kc \times S_1 \times S_2 \times Am}{Ef} \quad \text{.......} \quad (1)$$

Where:

NI – Irrigation water requirement (L $plant^{-1}$ day^{-1});
ET – Reference evapotranspiration of previous day (mm day^{-1});
Kc – Crop coefficient;
S_1 – Space between rows (m);
S_2 –Space between plants (m);
Am – Fraction of wetted area or covered by canopy of plants in relation to the total area;
Ef –Efficiency of the irrigation system.

The reference evapotranspiration (ET) was estimated with a class A pan evaporation method in 2004 and Penman-Monteith model with standardization of Allen et al. (1998) in 2005 using the climatic data from an automatic weather station present near to the plot.

The values of crop coefficient (Kc) were that suggested by Miranda et al. (2004) ranged from 0.3 (initial) to 1.15 (fruit maturation). The wetted bulbs produced a long wetted narrow band on a soil surface, which in a combination with the area covered by canopy of plants resulted in 0.3 (initial), 0.5 (intermediate) and 0.8 (maturation phase) fraction of total area.

After the beginning of treatments, the soil matric potential (Ψs) was monitored every two days in all irrigated treatments using tensiometers installed at 0.2 and 0.4 m depth in three replications per treatment.

Treatments consisted of five nitrogen levels (N0 = 0 kg ha^{-1}; N1 = 40 kg ha^{-1}; N2 = 80 kg ha^{-1}; N3 = 120 kg ha^{-1}; N4 = 160 kg ha^{-1}) applied using urea as source fertilizer. The statistical design was a randomized block with four replicates per treatment. Each replicate unit consisted of three rows of 12 plants, with 10 plants in the center of row serving as experimental control plants and the others serving as buffers. All treatments received the same amount of potassium: 80 kg K_2O ha^{-1} (potassium chloride), which was supplied through the irrigation system.

The variables evaluated were the total number of fruits per plant, fruit weight and the total fruit yield. In addiction, the commercial fruit yield was obtained discounting fruits smaller than 6 kg or with fruit damage. Fruit quality variables, total soluble solids (TSS) determined by refractometry, and pH by standard potentiometric method were assessed in samples of two representative fruits per replicate.

Analysis of variance and regression (linear, quadratic and cubic models) were performed using the SAS computer program (version 9; SAS Institute, Cary, North Caroline, USA). Models with the highest level of significance and best fit (higher determination coefficient, R^2) were chosen.

5 RESULTS AND DISCUSSION

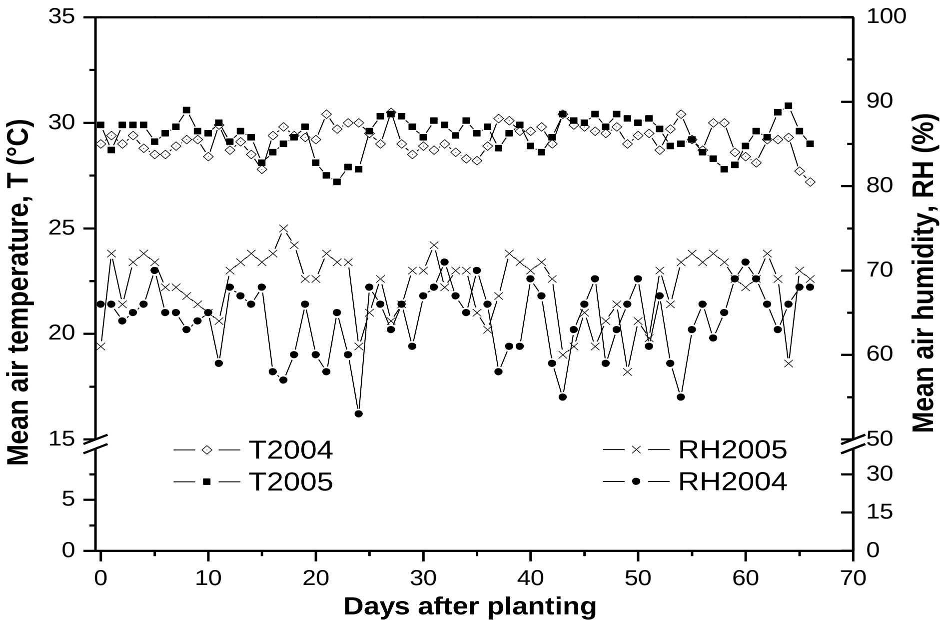

Figure 1. Daily mean air temperature and humidity measured at Parnaiba in 2004 and 2005 during the watermelon cycle.

The climate was very similar in both years (Figure 1A) resulting in the same number of days from planting to harvest (67 days). There was no rainfall. Total irrigation depths applied was 167.5 mm (5.0 L $plant^{-1}$ day^{-1}) and 185.6 mm (5.5 L $plant^{-1}$ day^{-1}) for 2004 and 2005 (Table 2). Since there were no differences of the soil matric potential (Ψs) among the treatments (P>0.05) a mean value for each year was determined (Table 2). The mean Ψs at

0.2-0.4 m was lower as compared to 0-0.2 m depth due to the reduction of wetted bulb depth as well as the higher soil water extraction by roots. In general, the Ψs values were higher (-7.5 kPa) which led a high moisture soil throughout the crop cycle in both years.

Table 2. Weather data of mean air temperature (T), relative humidity (RH), total evapotranspiration (ET), and irrigation depth applied (I) and the mean soil matric potential (Ψs) at 0.2 and 0.4 m depth recorded during cropping years. Parnaíba, Brazil.

Year	T	RH	ET	I	Ψ_s (kPa)‡	
	(°C)	(%)	(mm)	(mm)	0,2m	0,4m
2004	29,2 ± 0,7†	64,3 ± 4,1	452,0	167,5	-6,6±2,4	-10,6±4,2
2005	29,4 ± 0,8	68,1 ± 3,9	423,4	185,6	-6,7±2,1	-8,4±1,9

† Standard deviations.

‡ Mean values among the treatments.

As the analysis of variance of 2004-2005 did not revealed significant interactions between years and nitrogen levels, only the pooled analysis of the data were presented. There were significant effect of nitrogen levels for number of fruit, total and commercial fruit yield, but no differences were obtained for fruit weight. Therefore, fruit yield was more influenced by number than by weight of fruits which contrasted with Hegde (1987) that verified increase in both of them with nitrogen levels. Faria et al. (2000) verified similar results with melon crop. Probably, fruit weight was not affect due to the low plant densities used as compared with these researchers.

The lowest total fruit yield (38.24 t ha^{-1}) obtained in non-fertigated plants was higher than the national mean (22.56 t ha^{-1}) reported by FAO (2005). This fact stands out the potential climate and soil of Piauí State with irrigation supply. Previous researches (Hegde, 1987; Srinivas et al., 1989; Andrade Júnior et al., 1997) had reported the watermelon irrigation benefits.

Commercial fruit yield corresponded to 87% of total fruit yield. The reduction was caused by fruit lower than 6 kg. The regressions for total and commercial fruit yields are presented in Figure 2. The best fit curve was a cubic polynomial with maximum points at 66.1 and 58.4 t ha^{-1} for total and commercial fruit yields that were obtained with 114.6 and 112.3 kg $ha^{-1}$of N, respectively. Minimum points were reached with lower levels of N that proved the importance of N supply for adequate yield of watermelon crop.

The strong response to N, especially from 40 to 120 kg ha^{-1}, could be due to low fertility status of soil in the experiment as observed by Hedge (1987). Up to 120 kg ha^{-1}, there was a decreasing in fruit yield that indicated an excess level on plant metabolism.

Maximum fruit yields were higher than that obtained by Garcia & Souza (2002) with 54.47 and 46.60 t ha^{-1}, in the same site but with sprinkler irrigation system and conventional fertilization. In this experiment, simulating use a sprinkler system led to 247.2 mm of water depth which could represent 30% more in water volume. In this case, choosing drip fertigation besides the increased in the fruit yields resulted in savings of water. In addition to benefits of drip irrigation, Elmstron et al. (1981) reported that weed growth was much greater with sprinkler irrigation.

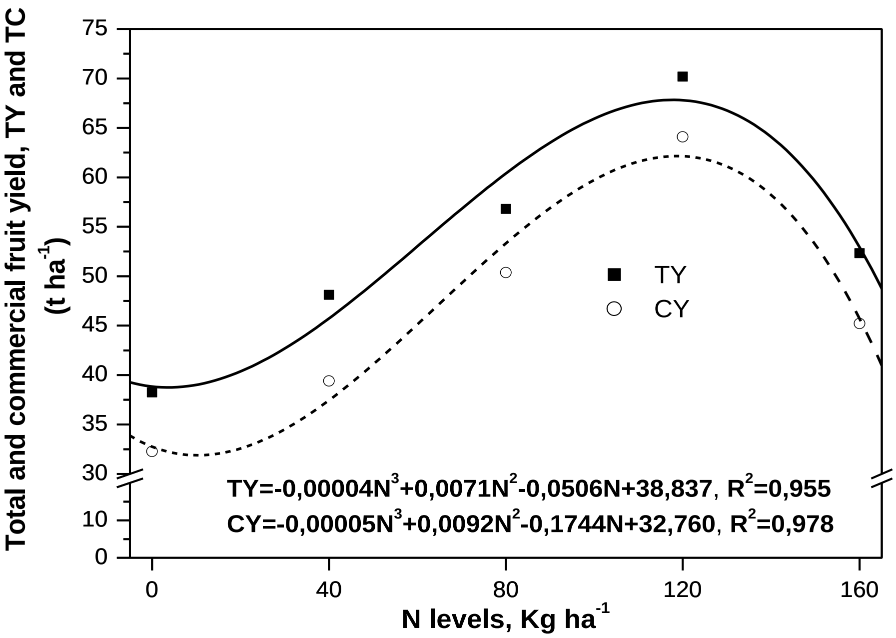

Figure 2. Total (TY) and commercial fruit yield (CY) regressed against levels of N. Parnaiba, Brazil.

No differences in SST and pH were observed. Singh & Naik (1998), El-Beheidi et al. (1990) and Garcia & Souza (2002) also did not found effect of levels of N on these variables. Greater values of SST are desirable and it is an important parameter of fruit quality, being 10% the minimal acceptable value for commercialization (Bleinroth, 1994). In this work, the mean SST values were 10.6% and 5.43 for pH. These values are similar to verified by Andrade Júnior et al. (1997) with the same cultivar (Table 3).

Table 3. Number of fruits per plant (NFP), fruit weight, total fruit yield (TY), commercial fruit yield (CY), total soluble solids (SST) and pH. Analyses of mean data of 2004 and 2005. Parnaíba, Brazil.

Factor	NFP	FW	TY	CY	SST	pH
			Means			
	Unit pl^{-1}	*kg* $fruit^{-1}$	*t* ha^{-1}	*t* ha^{-1}	*%*	
$N_0 = 0$	1.0	7.39	38.24	32.27	11.0	5.44
$N_1 = 40$	1.2	8.08	48.11	39.41	10.3	5.42
$N_2 = 80$	1.4	8.02	56.80	50.37	10.6	5.47
$N_3 = 120$	1.7	8.08	70.19	64.10	10.4	5.37
$N_4 = 160$	1.3	7.89	52.32	45.20	10.5	5.43
Mean	1.3	7.89	53.13	46.27	10.6	5.43
			Test F			
Linear	21.52**	-	20.56**	18.43**	-	-
Quadratic	14.32**	-	15.00**	12.52**	-	-
Cubic	7.51*	-	7.37*	9.58**	-	-
VC (%)[1]	16.1	7.9	18.6	22.8	5.3	1.42

*, ** significant by F test at 5% and 1% of probability, respectively.
[1] Variation coefficient.

6 CONCLUSIONS

1. In Piauí State, the yield crop watermelon responds to levels of N applied by fertigation with the maximum total yield and marketable fruit at 114.6 and 112.3 kg of N ha^{-1}, respectively;
2. The fertigation nitrogen levels do not affect pH and total soluble solids of the fruits.

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8 REFERENCES

ALLEN, R.G.; PEREIRA, L.S.; RAES, D.; SMITH, M. **Crop evapotranspiration: guidelines for computing crop water requirements**. Vol. 56. Food and Agriculture Organization of the United Nations, Rome. (FAO. Irrigation and Drainage Paper, 56), 1998. 300p.

ANDRADE JÚNIOR, A.S.; RODRIGUES, B.H.N.; ATHAYDE SOBRINHO, C.; MELO, F.B.; BASTOS, E.A.; CARDOSO, M.J.; RIBEIRO, V.Q. Produtividade e qualidade de frutos de melancia em função de diferentes níveis de irrigação. **Horticultura Brasileira**, v. 15, p.43-46, 1997.

ANDRADE JÚNIOR, A.S.; RODRIGUES, B.H.N.; ATHAYDE SOBRINHO, C.; MELO, F.B.; CARDOSO, M.J.; SILVA, P.H.S.; DUARTE, R.L.R. **A cultura da melancia**. Brasília: Embrapa Informação Tecnológica, 2004. 86p. (Coleção Plantar, 34).

BASTOS, E.A.; NUNES, B.H.; ANDRADE JUNIOR, A.S. **Dados agrometeorológicos para o município de Parnaíba, PI**. Embrapa Meio Norte, Teresina. 2000. 27p.

BERNARDO, S.; SOARES, A.A.; MANTOVANI, E.C. **Manual de irrigação**. UFV, Viçosa. 2005. 611p.

BLEINROTH, E.W. Determinação do ponto de colheita. In: Netto, A.G. (ed) Melão para exportação: procedimentos de colheita e pós-colheita. MAARA/FRUPEX, Brasília, 1994. p.11-21.

CAMARGO FILHO, W.P.; MAZZEI, A.R. O mercado de melancia no Mercosul. **Informações Econômicas**, v.32, n.2, 2002.

CHABARIBERY, D.; ALVES, H.S. Produção e comercialização de limão, mamão, maracujá e melancia em São Paulo. **Informações Econômicas**, v.31, n.8, p.43-50, 2001.

EL-BEHEIDI. M.A.; EL-SHERBEING, A.A.; EL-SAWAH, M.H. Watermelon growth and yield as influenced by nutrition and irrigation methods in new reclaimed sandy soils. **Egyptian Journal Horticulture**, v.17, p.447-456, 1990.

ELMSTRON, G.W.; LOCASCIO, S.J.; MYERS, J.M. Watermelon response to drip and sprinkler irrigation. **Proceedings of Florida State Horticultural Society**, v.94, p.161-163, 1981.

FOOD AND AGRICULTURE ORGANIZATION. 2005. FAOSTAT statistical database. http://www.fao.org.com. Data retrieved on 09 may of 2006. FAO, Rome, Italy.

FARIA, C.M.B.; COSTA, N.D.; PINTO, J.M.; BRITO, L.T.L.; SOARES, J.M. Níveis de nitrogênio por fertirrigação e densidade de plantio na cultura do melão em um vertissolo. **Pesquisa Agropecuária Brasileira**, v.35, p.491-495, 2000.

GARCIA, L.F. **Influência do espaçamento e da adubação nitrogenada sobre a produtividade da melancia no Baixo Parnaíba Piauiense**. Teresina: Embrapa Meio-Norte, 1998. 5p. Comunicado Técnico, 79.

GARCIA, L.F.; SOUZA, V.A.B. Influência do espaçamento e da adubação nitrogenada sobre a produção da melancia. **Revista de la Facultad de Agronomia**, v.28, p.59-70, 2002.

HEDGE, D.M. Effect of irrigation and fertilization on dry matter production, fruit yield, mineral uptake and field water use efficiency of watermelon. **International Journal of Tropical Agriculture**, v.5, p.3-4, 1987.

MIRANDA, F.R.; OLIVEIRA, J.J.G.; SOUZA, F. Evapotranspiração máxima e coeficiente de cultivo para a cultura da melancia. **Revista Ciência Agronômica**, v.35, p.36-43, 2004.

PEDROSA, J.F. **Cultivo da melancieira**. ESAM, Mossoró, 1997. 50p.

PIER, J.W., DOERGE, T.A. Nitrogen and water interactions in trickle-irrigated watermelon. **Soil Science Society of America Journal**, v.59, p.145-150, 1995.

PIZARRO, F. **Riegos localizados de alta frecuencia (RLAF) - goteo - microaspersion – exudacion**. 3o ed. Mundi, Madri, 1996. 513pp.

SINGH, R.V.; NAIK, L.B. Response of the watermelon (*Citrullus lanatus* Thumbs. Mansf.) to plant density, nitrogen and phosphorus fertilization. **Indian Journal of Horticulture**, v.46, p.80-83, 1998.

SOARES, J.I.; COSTA, R.N.T.; SILVA, A.C.DA; GONDIM, R.S. Função de resposta da melancia aos níveis de água e adubação nitrogenada, no Vale do Curu, CE. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.6, p.219-224, 2002.

SRINIVAS, K.; HEDGE, D.M.; HAVANAGI, G.V. Irrigation studies on watermelon (C*itrillus lanatus* (Thunb) Matsum et Nakai). **Irrigation Science**, v.10, p.293-301, 1989.