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EFFECT OF DIFFERENT SPACINGS AND NITROGEN RATES ON GROWTH AND YIELD OF WATER MELON GROWN ON POLYETHYLENE MULCH

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ABSTRACT

Worldwide, a significant increase in watermelon (*Citrullus lanatus* [Thunb.] Matsum. & Nakai) growing areas has been registered in the last few years. Though it is a potential vegetable crop, there is not much standardized scientific cultivation technology available for improving the yield. Agro techniques like nutrition and spacing play an important role in commercial production, specially N rates and planting densities vary on a large scale, indicating that there is insufficient knowledge about their effects. Therefore, the objective of this study was to evaluate the effects of N rate and planting density on growth and yield of watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] grown on black polyethylene mulch. The field experiments with 'Aaliya' F1 hybrid (Bayer Crop Science) was planted during January, 2017. The treatments were factorial combinations of three paired row plant spacings (0.45, 0.60, and 0.75 m) and four N rates (75, 100, 125 and 150 kg·ha^{-1}). Part of the N (35 kg·ha^{-1}) was applied preplant and the remainder was fertigated. Vine length increased linearly as N rate increased from 75 to 150 kg·ha^{-1}, and also with plant spacing increased from 0.45 m to 0.75 m. Total yields per ha or per plant and Average fruit weight did not increase with N rates above 100 kg·ha^{-1}. Total yields per acre and number of fruits per plot were linearly decreased with an increase in plant spacing from 0.45 to 0.75 m. With increased plant spacing average fruit weight increased and fruit size distribution shifted to larger categories.

KEYWORDS: Polyetrylene mulch, Watermelon, Nitrogen

INTRODUCTION

The global consumption of watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] is greater than that of any other cucurbit (Robinson and Decker-Walters, 1997). It is a popular cash crop grown by farmers during summer due to its high returns in investment, especially in the regions of Ananthapur, Kadapa and Kurnool districts of Andhra Pradesh in an area of 5615 ha. Watermelon contains Vitamin C and A in form of the disease fighting *beta-carotene*. Potassium is also available in it, which is believed to help in the control of blood pressure and possibly prevent stroke .Enhanced earliness and yield in watermelon crop has been achieved through improvement of cultural practices (Lu *et al*., 2003; Soltani *et al*., 1995). Many commercial vegetable producers use mulching and drip irrigation as a common practice. Both technologies have been developed to enhance crop growth and improve water use efficiency (Brinen *et al*., 1979; Elmstrom *et al.,* 1981). Specially mulching was used now a days as mulch as it conserves soil moisture, retains heat as well as it suppresses weed growth. Improved N fertigation efficiency (Hochmuth, 2003) and decreased N leaching have also been noted (Pier and Doerge, 1995a; Romic *et al*., 2003).

Nitrogen has been frequently recognized as a major factor affecting watermelon yield. However, the suggested rates varied considerably. Srinivas *et al.* (1989) found that N up to 120 kg·ha^{-1} increased fruit yield, whereas Hochmuth and Cordasco (1999) who reviewed watermelon response to N, found that in majority of trials optimum yields were achieved with N rates from 134 to 145 kg·ha^{-1}.

Competition for water and nutrients in dense plant stands might be responsible for the decrease in plant growth and yield (Knavel, 1988). Generally, in watermelon the yield and number of fruit per unit area increase with increased crop density, whereas the yield and number of fruits per plant decrease (Brinen *et al.,* 1979; Duthie *et al*., 1999; Motsenbocker and Arancibia, 2002; NeSmith, 1993; Sanders *et al.,* 1999; Srinivas *et al.,* 1989). The increased number of fruit per area is probably the yield component mostly contributing to a

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greater yield under high planting density (Duthie *et al*., 1999; NeSmith, 1993). However, some studies showed that average fruit weight decreases with increasing plant density (Brinen *et al.,* 1979; Motsenbocker and Arancibia, 2002; Sanders *et al.,* 1999).

The impact of both N rate and plant density on watermelon yield has been reported in the literature frequently, yet there is insufficient knowledge about their interaction, especially when N fertigation is used. It is likely that optimal N rate would differ for different watermelon planting densities. Therefore, the objective of this study was to evaluate the effects of N rate and planting density on growth and yield of watermelon.

MATERIALS AND METHODS

The field experiments was conducted at Horticultural Research Station, Anantharajupeta, Kadapa district of Andhra Pradesh, India during summer season…..year?. The F1 hybrid used was "Aaliya " belongs to Bayer crop science which is popularly called as Icebox type "watermelons, with duration 60-65 days. Seeds were sown during January 2017 on black polyethylene mulch (thickness 25 mm; width 100 cm). Drip tape was placed beneath the black PE film, and with emitter spacing at 40 cm (capacity of 4 L h^{-1}) and plants were irrigated as needed. Weeds between rows were removed by hand if necessary, while pests and disease were controlled according to common practices.

The treatments were factorial combinations of three paired row plant spacings (0.45, 0.60, and 0.75 m) and four N rates (75, 100, 125 and 150 kg·ha^{-1}). The rows were 2.0 m apart, and in-row paired plant spacing was 0.45, 0.60, or 0.75 m. Part of the N (35 kg·ha^{-1}) was applied preplant and the remainder was fertigated. Remaining N for the four N treatments was fertigated in the form of ammonium-nitrate (35%N) in four applications. The first application (I) was 7 to 10 days after planting, second (II) at the early runner phase, third (III) when the diameter of fruit was about 50 mm, and fourth (IV) when 10 per cent of fruit reached the full size. To achieve targeted levels of N, the fertigation was scheduled as 1: 3: 1: 1 ratio in the I, II, III and IV stages of the crop respectively. All measurements were taken on a subsample of five plants per plot. Melons were harvested as fruit ripened, and each fruit from all plants was weighed. The total soluble solids content was determined from juice obtained from the fruit heart section using a hand refractometer , one representative melon was measured per plot in the main harvest. The observations on growth, yield and quality parameters were recorded and subjected to statistical analysis of variance.

RESULTS AND DISCUSSION

Paired row plant spacing and N fertigation influenced watermelon vegetative growth, and interactions among variables were not observed (Table 1 to 14). Paired row plant spacing had a significant effect on the main vine length. In general, early watermelon cultivars have a shorter vegetative period and less vegetative growth than late cultivars. In the present study, an early watermelon cultivar was planted. The length of the vine was more (207.67 cm) in spacing 0.75 m as it was less (173.21 cm) in Spacing 0.45 m (Table 1). This might be due to the fact that as the row space was more, plants were able to intercept more solar radiation during the growth stage and this impact on the photosynthesis activity. The fact that during the growth stage the plant did not compete for nutrient, water and light has impacted on the increase in the growth of the vine and this explain the reason why the longest vine was observed on plant under spacing of 0.75 m. The above results were in consonance with Efediyi and Samson (2009) who reported that in-row spacing has positive effect on plant height. The present results were also supported by Ban *et al.* (2011) who found that in-row plant spacing had a significant effect on the growth and yield of watermelon. Sabo *et al.* (2013) also reported an increase in watermelon vine length by increasing in-row plant spacing. Vine length was increased with increasing N fertigation. Vine length was highest (202.67 cm) at N fertigation at the rate of 150 kg ha^{-1}. But regarding the other growth parameters Leaf length, Leaf width, number of branches there was no significant difference observed in different spacings and different N fertigation rates (Table 2, 3, 4).

Yield, yield components and fruit quality

The yields per acre were significantly increased with an increase in N rate from 75 to 100 kg·ha^{-1} whereas the yields were not increased later by increasing N Rates. Highest fruit yield per acre (17.35 t ha^{-1}) was found with N rate 100 kg ha^{-1} (Table 15).

In contrast to earlier findings (Hochmuth and Cordasco, 1999; Pier and Doerge, 1995b; Srinivas *et al.,* 1989) in our study fruit yield did not increase with N rates above 100 kg·ha^{-1}. We assume that total yields

Table 1. Effect of different spacings and nitrogen levels on vine length (cm) of Water melon

	N1	N2	N3	N4	Mean
S1	157.39	158.89	186.55	190.00	173.21
S2	190.67	207.00	193.00	205.67	199.08
S3	194.67	215.00	208.67	212.33	207.67
Mean	180.91	193.63	196.07	202.67	
	S	19.19		6.54	
	N	NS	S.Em±	7.56	
	S*N	NS		13.09	

Table 2. Effect of different spacings and nitrogen levels on Leaf length (cm) of Water melon

	N1	N2	N3	N4	Mean
S1	15.50	15.95	14.00	15.77	15.30
S2	15.17	16.10	16.73	15.00	15.75
S3	15.13	14.77	16.37	16.20	15.62
Mean	15.27	15.60	15.70	15.66	
	S	NS		0.32	
	N	NS	S.Em±	0.37	
	S*N	NS		0.64	

Table 3. Effect of different spacings and nitrogen levels on Leaf width (cm) of Water melon

	N1	N2	N3	N4	Mean
S1	12.49	12.10	11.39	12.47	12.11
S2	11.60	13.20	15.00	11.67	12.87
S3	12.60	12.33	13.60	12.80	12.83
Mean	12.23	12.54	13.33	12.31	
	S	NS		0.48	
	N	NS	S.Em±	0.55	
	S*N	NS		0.95	

Table 4. Effect of different spacings and nitrogen levels on number of branches of Water melon

	N1	N2	N3	N4	Mean
S1	4.00	4.33	4.22	4.00	4.14
S2	4.00	4.67	4.00	4.00	4.17
S3	4.00	4.67	4.00	4.00	4.17
Mean	4.00	4.55	4.07	4.00	
	S	NS		0.17	
	N	NS	S.Em±	0.19	
	S*N	NS		0.33	

Table 5. Effect of different spacings and nitrogen levels on Average Fruit weight (in g) of Water melon

	N1	N2	N3	N4	Mean
S1	1137.87	1417.94	1564.33	1376.28	1374.11
S2	1581.83	2228.50	2079.08	2109.00	1999.60
S3	1659.83	2334.50	2200.67	2402.17	2149.29
Mean	1459.84	1993.65	1948.03	1962.48	
	S	336.97		114.89	
	N	389.09	S.Em±	132.67	
	S*N	NS		229.78	

Table 6. Effect of different spacings and nitrogen levels on Fruit length (in cm) of Water melon

	N1	N2	N3	N4	Mean
S1	15.69	19.66	19.61	19.05	18.50
S2	17.97	23.03	21.32	22.83	21.29
S3	21.55	22.90	21.80	21.95	22.05
Mean	18.40	21.87	20.91	21.28	
	S	2.13	S.Em±	0.73	
	N	2.46		0.84	
	S*N	NS		1.45	

Table 7. Effect of different spacings and nitrogen levels on Fruit width (in cm) of Water melon

	N1	N2	N3	N4	Mean
S1	10.37	12.99	12.50	10.57	11.61
S2	13.20	13.98	13.70	13.65	13.63
S3	13.47	13.67	15.12	13.63	13.97
Mean	12.34	13.55	13.77	12.62	
	S	1.71		0.58	
	N	NS	S.Em±	0.67	
	S*N	NS		1.17	

Table 8. Effect of different spacings and nitrogen levels on length of Pulp (in cm) of Water melon

	N1	N2	N3	N4	Mean
S1	17.29	17.22	16.79	16.98	17.07
S2	19.53	21.10	18.68	20.22	19.88
S3	19.00	18.90	19.37	19.23	19.13
Mean	18.61	19.07	18.28	18.81	
	S	1.71		0.58	
	N	NS	S.Em±	0.67	
	S*N	NS		1.17	

Table 9. Effect of different spacings and nitrogen levels on Width of pulp (in cm) of Water melon

	N1	N2	N3	N4	Mean
S1	10.20	10.68	9.75	10.56	10.30
S2	10.65	11.73	11.10	10.87	11.09
S3	10.65	10.75	11.00	10.68	10.77
Mean	10.50	11.05	10.62	10.70	
	S	0.58		0.20	
	N	NS	S.Em±	0.23	
	S*N	NS		0.40	

Table 10. Effect of different spacings and nitrogen levels on pulp weight (in gm) of Water melon

	N1	N2	N3	N4	Mean
S1	666.33	888.67	961.22	860.02	844.06
S2	753.08	1071.25	1005.50	1025.75	963.90
S3	827.67	1154.33	1102.00	1165.00	1062.25
Mean	749.03	1038.08	1022.91	1016.92	
	S	153.98		52.50	
	N	177.81	S.Em±	60.62	
	S*N	NS		105.00	

Table 11. Effect of different spacings and nitrogen levels on TSS (°Brix) of Water melon

	N1	N2	N3	N4	Mean
S1	10.39	10.05	9.09	9.91	9.86
S2	10.62	10.40	10.30	10.70	10.50
S3	10.70	9.60	10.53	9.75	10.15
Mean	10.57	10.02	9.97	10.12	
	S	NS		0.22	
	N	NS	S.Em±	0.25	
	S*N	NS		0.44	

Table 12. Effect of different spacings and nitrogen levels on Number of fruits of per vine Water melon

	N1	N2	N3	N4	Mean
S1	1.67	1.33	1.44	2.00	1.61
S2	1.67	2.00	2.00	1.33	1.75
S3	1.33	1.67	1.67	2.33	1.75
Mean	1.56	1.67	1.70	1.56	
	S	NS		0.12	
	N	NS	S.Em±	0.14	
	S*N	NS		0.25	

Table 13. Effect of different spacings and nitrogen levels on Fruit yield per plot (48 sq.m) of Water melon

	N1	N2	N3	N4	Mean
S1	172.60	242.76	228.84	249.79	223.50
S2	157.76	196.59	216.89	190.81	190.51
S3	131.59	185.38	172.95	175.44	166.34
Mean	153.98	208.24	206.23	205.35	
	S	32.16		10.97	
	N	37.14	S.Em±	12.66	
	S*N	NS		21.93	

Table 14. Effect of different spacings and nitrogen levels on Number of fruits per plot (48 sq.m) of Water melon

	N1	N2	N3	N4	Mean
S1	158	151	150	133.5	148.125
S2	111.1	85	108.3	88.88	98.32
S3	56.88	99.54	71.1	99.54	81.765
Mean	108.66	111.8467	109.8	107.3067	
	S	19.73		6.73	
	N	NS	S.Em±	7.77	
	S*N	NS		13.45	

Table 15. Effect of different spacings and nitrogen levels on Fruit yield per Acre (in Tonnes) of Water melon

	N1	N2	N3	N4	Mean
S1	14.38	20.23	19.07	20.82	18.63
S2	13.15	16.38	18.07	15.90	15.88
S3	10.97	15.45	14.41	14.62	13.86
Mean	12.83	17.35	17.19	17.11	
	S	2.68		0.91	
	N	3.10	S.Em±	1.06	
	S*N	NS		1.83	

achieved at the N rate 100 kg·ha^{-1} in the present study were partly the result of splitting N application, which may have enabled better use of the given N rate as it was found on tomato (Locascio *et al.,* 1997) and strawberry (Hochmuth *et al.,* 1996). We suppose that water and N distribution pattern as well as watermelon root development under drippers are factors strongly affecting those findings. As in the case of different parameters, there was no interaction between N and plant spacings on yield and yield components.

Paired row plant spacing had a stronger effect on the total yield. The total yields per acre were linearly decreased with an increase in plant spacing from 0.45 to 0.75 m. The yields per acre was highest (18.63 t/ha) with spacing of 0.45 m (Table 15). On contrary with an increase in plant density the yield and number of fruit per plot linearly increased. Our results confirmed the findings of other studies, which suggest that fruit yield increases with an increase in plant density due to an increase in the number of fruits per plot (Brinen *et al.,* 1979; NeSmith, 1993; Duthie *et al.,* 1999; Sanders *et al.,* 1999; Motsenbocker and Arancibia, 2002; Goreta *et al.,* 2005). The Average size of the fruit was increased with increased plant spacing. Highest size of the fruit (2149.29 g) was observed with S3 spacing (0.75 m) whereas it was lowest (1374.11 g) with S1 spacing (0.45 m). Frequently, the average fruit weight decreases with an increase in the plant density (Brinen *et al.,* 1979; Sanders *et al.,* 1999;

Motsenbocker and Arancibia, 2002; Goreta *et al.,* 2005). Regarding the quality parameters soluble solid content was relatively high and unaffected by the spacing or N rate applied.

The lack of interactions between N and plant spacing is somewhat surprising because we expected such interaction to occur at least under high planting densities. However, the threshold density above which watermelon yield per area starts to decline was not reached in our study. Similarly, Srinivas *et al.* (1989) did not report the significant interaction between plant spacing and N fertilization on watermelon yield.

CONCLUSIONS

Based on our data, it can be concluded that higher yield per acre (18.63 t ha^{-1}) was obtained with plant spacing of 0.45m, whereas average fruit weight (2149.29 g) was higher with spacing of 0.75m. Higher fruit yield per acre (17.35 t ha^{-1}) was obtained with N rate of 100 kg ha^{-1}. So, it is recommended to follow the spacing based on the consumer preference of the fruit size in the area.

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