Influence of Stand Deficiencies and Replanting on 'Athena' Muskmelon Yields

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SUMMARY. Two field studies were conducted in 1997 (Clinton, N.C.) and 1998 (Carbondale, Ill.) to determine if replanting (at 1, 2, 3, or 4 weeks after the initial seeding) into stand deficiencies of 10%, 30%, and 50% affected 'Athena' muskmelon (*Cucumis melo* L. var. *reticulatis*) melon size and yield. Muskmelon numbers were higher for 1997, but there was no interaction of treatment by year for any of the melon sizes (small, medium, or large) or total melon number. Based on the two experiments conducted, 'Athena' muskmelons stand deficiencies up to 30% do not reduce total or marketable numbers compared to a complete stand. Replanting into 10%, 30%, and 50% stand deficiencies increases early-season melon numbers regardless of the replant times. For main-season and total-season harvests, there was no advantage of replanting into 10% deficient stands and in most cases, replanting reduced total and marketable melon numbers. In the 1997 experiment, replanting into 30% and

50% stand deficiencies improved yields but this did not occur in the 1998 experiment. Based on this information, 'Athena' muskmelon should be replanted only if a field has a stand reduction of more than 30%. Melon numbers were generally higher if replanted in 1 or 2 weeks after the initial seeding compared to 3 or 4 weeks. However, the timing of replanting does not appear to have significant influence on total or marketable melon numbers.

Seedling losses shortly after emergence can reduce yields and grower profits, especially with high value crops like vegetables. Growers will usually make some visual determination if the seedling reductions in a field appear high enough to warrant replanting. However, growers could benefit if guidelines were developed for various vegetable crops as to which stand deficiencies should be replanted to potentially increase yields/profitability.

A few studies have been concerned with evaluating the effects on vegetable yields by replanting stand deficient vegetables to a complete stand. 'Jupiter' bell pepper (*Capsicum annuum* L.) yields were not improved when stands were reduced up to 30% and replanted 2 or 3 weeks after the initial planting date compared with plantings that had 100% plant stands and did not need to be replanted (Bracy, 1997). Replanting 'Sunny' tomato (*Lycopersicon esculentum* Mill.) in which stands were reduced by at least 30% improved marketable yields but only under unfavorable environmental and growth conditions (Stoffella and Maynard, 1988). These studies on solanaceous vegetables suggest that replanting may not be beneficial to the grower when plant stands have been reduced 30% or less. However, cucurbit vegetables have a vining growth habit compared to many other vegetables that have an upright growth habit; so, cucurbits may respond differently to replanting in response to inferior plant stands.

Two recent studies have shown the importance of plant populations on muskmelon yields. 'Superstar' (Maynard and Scott, 1998) and 'Athena' (Thornton et al., 1998) muskmelon yields were shown to be influenced by plant spacing. This indicates that seedling losses in muskmelon fields

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might increase the spacings between plants and have a direct influence on yields.

Stand reduction in muskmelon sometimes occurs because of environmental stress, poor cultural management decisions, and/or high incidence of insects or diseases, especially if the crop is planted later in the season (Schultheis, 1995). The objectives of this study were to determine if a yield reduction is associated with reduced muskmelon stands and how time of replanting over a 4-week period affects melon size and yield.

Materials and methods

Two experiments were conducted; the first in 1997 at the Horticultural Crops Research Station, Clinton, N.C., and the second in 1998 at the Horticultural Research Center, Carbondale, Ill. Sixteen treatments were evaluated to study the effects of stand reduction in 'Athena' muskmelon, and certain treatments were replanted to complete (or 100% stands) at certain times: 1) 100% stand, 2) 10% stand reduction, 3) 30% stand reduction, 4) 50% stand reduction, 5) 10% stand reduction-replanted 1 week later, 6) 30% stand reduction-replanted 1 week later, 7) 50% stand reduction-replanted 1 week later, 8) 10% stand reduction-replanted 2 weeks later, 9) 30% stand reduction-replanted 2 weeks later, 10) 50% stand reduction-replanted 2 weeks later, 11) 10% stand reduction-replanted 3 weeks later, 12) 30% stand reduction-replanted 3 weeks later, 13) 50% stand reduction-replanted 3 weeks later, 14) 10% stand reduction-replanted 4 weeks later, 15) 30% stand reduction-replanted 4 weeks later, and 16) 50% stand reduction-replanted 4 weeks later. Muskmelon stands were randomly reduced. The statistical design was a randomized

complete-block design with four replications. Plots were 20 ft (6.1 m) long with a 5 ft (1.5 m) alley between plots. Center-to-center row spacing was 5 ft (1.5 m) and in-row spacing was 2 ft (0.6 m). Ten plants were grown per plot. In both tests, all replants and those initially planted survived; so, complete stands were obtained with respect to a specific treatment. One honeybee (*Apis mellifera* L.) hive was placed at both locations a few days after the onset of flowering to insure proper pollination.

For the North Carolina test, 'Athena' muskmelon seeds were directly sown into raised beds covered with 1.25-mil [0.00125-inch (0.03175-mm)] black plastic mulch. Black plastic (polyethylene) mulch offers several advantages to muskmelon growers (Kemble, 1997) and is widely used in eastern North Carolina muskmelon production. The initial sowing date was 18 Apr. and continued weekly in those plots that were replanted until 16 May. Trickle fertigation was utilized under the black plastic to supply the water and nutrients necessary for plant growth and development (Sanders et al., 1995). Over the growing season, 92 lb/acre (103 kg·ha⁻¹) of N and 159 lb/acre (178 kg·ha⁻¹) of P were applied through the irrigation system. Recommended pest control practices and rates were followed (College of Agriculture and Life Sciences, 1997). Ethalfuralin was applied between the rows to control emerging weeds; whereas carbaryl and chlorothalonil were used several times throughout the growing season to provide control of spotted cucumber beetles (*Diabrotica undecimpunctata howardi* Barber), striped cucumber beetles (*Acalymma vittatum* Fabricius), and fungal diseases, respectively.

Melons were hand-harvested ev-

ery 2 to 4 d starting 7 July and ending with the ninth harvest on 5 Aug. Melons from each harvest were graded into small [<3.0 lb (1.35 kg)], medium [3.0–4.5 lb (1.35–2.03 kg)], large [>4.5 lb (2.03 kg)], and cull (misshapen or decaying). Muskmelon vines overlapped plots; so at harvest, melons were traced back to the plant in the plot from which they were growing. Harvests were analyzed based on early-season (first three harvests), main-season (harvests 4–9), and all harvests.

For the Illinois test, 'Athena' muskmelon plants were grown in strip tillage following corn (without plastic mulch). Strips were about 1 ft (0.3 m) wide in which seed were planted. The initial seeding was 13 May and replanting continued at weekly intervals until 6 June. Before the initial planting, 50 lb/acre (56 kg·ha⁻¹) of N, 28 lb/acre (31 kg·ha⁻¹) of P, and 54 lb/acre (60 kg·ha⁻¹) of K were broadcast in a 1 ft (0.3 m) wide strip in the row where seed were to be planted. Six weeks after the initial planting, plants were sidedressed with the same rates used at the initial planting. Plants received about 1 inch (25.4 mm) of water on a weekly basis throughout the growing season via natural rainfall or sprinkler irrigation. No herbicides were used for weed control, only hand weeding was used. Recommended application rates of carbaryl and chlorothalonil were mixed and sprayed 6 to 8 times throughout the growing season to provide control of cucumber beetles and fungal diseases, respectively (Foster et al., 1998). Melons were hand-harvested every 2 to 4 d starting 24 July and ending 24 Aug., with a total of nine harvests. Melons were harvested in the same manner and graded into the same categories as discussed previously.

Data were subjected to analysis of

Table 1. Combined analysis over years for number of melons per acre to show significance (P values) of main effects and interactions.^z

Main effects and interaction	Early season (harvests 1–3)				Main season (harvests 4–9)				Total (all harvests)			
	MED	LRG	TOT	MKT	MED	LRG	TOT	MKT	MED	LRG	TOT	MKT
Treatment	0.0601	0.6550	0.4101	0.3207	0.5487	0.1198	0.0359	0.0493	0.3546	0.4600	0.1706	0.2449
Year	0.1114	0.0001	0.0021	0.0019	0.3768	0.0001	0.0001	0.0001	0.1581	0.0001	0.0001	0.0001
Season	---	---	---	---	---	---	---	---	0.0001	0.0001	0.0001	0.0001
Treatment × year	0.6523	0.5393	0.6394	0.3922	0.8266	0.6203	0.4998	0.3767	0.8515	0.9471	0.9954	0.9445
Treatment × season	---	---	---	---	---	---	---	---	0.5256	0.2863	0.2695	0.2728
Year × season	---	---	---	---	---	---	---	---	0.8396	0.0001	0.0001	0.0001

^zMED = medium-sized melons, LRG = large-sized melons, TOT = total melon number, and MKT = marketable melon number. Total melon number is the sum of small [<3.0 lb (1.35 kg)], medium [3.0–4.5 lb (1.35–2.03 kg)], large [>4.5 lb (2.03 kg)], and cull (misshapen or decaying) melons. Marketable melon number is the sum of small, medium, and large melons.

variance using SAS (SAS Inst., Cary, N.C.). Orthogonal contrasts were used to make comparisons between the control (100% stand at initial sowing) and stand deficient treatments that were not replanted; comparisons were also made among the stand deficient control treatments (those not replanted) and those that were replanted at specific intervals. Trend analyses were also conducted.

Results

The data were combined over the two years and analyzed (Table 1). Generally, there were few or no significant differences between the two experiments for the variables studied. Medium size melons did not differ among the various treatments tested or between the two years; large, total, and marketable melon number differed among years ($P \leq 0.0001$), but the various treatments did not differ, except for main-season harvests of total and marketable melon numbers. Greater fruit numbers were obtained in the 1997 experiment compared to the 1998 experiment. Although the

years were significantly different in many instances, there was no interaction of treatment by year for any of the melon sizes or total melon number. Even though the melons were grown at two different locations utilizing two different growing systems, the treatment responses were similar. Muskmelon fruit size was also greater in 1997 than in 1998; but the treatments did not differ between years and there was no year by treatment interaction. There was also no stand deficiency by replant date interaction in either year that the study was conducted (data not shown). For both 1997 and 1998, trend analyses indicated no significant ($P \leq 0.05$) trends in the data for stand reduction and/or replant timing for early (harvests 1–3), main (harvests 4–9), or total season production, with respect to small, medium, large, marketable, and total melon numbers (data not shown).

1997 EXPERIMENT. Marketable fruit numbers over all treatments averaged 1484/acre (594/ha), 7181/acre (2872/ha), and 8665/acre (3466/ha) for early, main, and total season

production, respectively. Early-season and total-season muskmelon numbers were similar for the 0%, 10%, and 30% reduced stands. Stand deficiencies up to 30% for the entire growing season did not affect medium, large, total, or marketable muskmelon numbers compared to 100% plant stands (Table 2). However, stand deficiencies of 50% for the growing season reduced large, total, and marketable numbers for both early and total-season production. No differences were detected for muskmelon numbers comparing the 10%, 30%, and 50% reduced stands at the different replant dates in most cases. It appears that plants grown at lower plant populations compensated by producing more melons per plant. Generally, for main-season melon production (harvests 4–9), medium, large, total and marketable muskmelon numbers were similar for the 0%, 10%, 30%, and 50% reduced stands (Table 2), regardless of replanting time.

Large melon numbers for main and total-season harvests were decreased in the 10% stand deficiency treatment when replanted at 2, 3, or 4

Table 2. Yield (number of melons per acre) as affected by stand deficiencies and replanting at Clinton, N.C., Summer 1997.^z

Treatment	Replant time ^y	Early season (harvests 1–3)				Main season (harvests 4–9)				Total (all harvests)			
		MED	LRG	TOT	MKT	MED	LRG	TOT	MKT	MED	LRG	TOT	MKT
1) 0% reduction	Control	109	1851	1960	1960	1198	5990	7732	7296	1307	7841	9692	9257
2) 10% reduction	Control	0	1089	1198	1089	980	7950	9148	8930	980	9039	10345	10019
3) 30% reduction	Control	109	980	1089	1089	653	6207	7079	6861	762	7187	8168	7950
4) 50% reduction	Control	109	653	762	762	653	5772	6643	6425	762	6425	7405	7187
5) 10% reduction	1	109	1525	1634	1634	1089	6970	8494	8168	1198	8494	10128	9801
6) 30% reduction	1	109	1416	1634	1525	762	7079	8276	7950	871	8494	9910	9474
7) 50% reduction	1	0	1307	1525	1307	980	5445	7405	6643	980	6752	8930	7950
8) 10% reduction	2	327	2178	2614	2505	1525	5663	7405	7187	1851	7841	10019	9692
9) 30% reduction	2	109	980	1089	1089	1416	5554	7841	7296	1525	6534	8930	8385
10) 50% reduction	2	545	980	2178	1525	871	5663	6861	6534	1416	6643	9039	8059
11) 10% reduction	3	436	1634	2069	2069	1416	5554	8168	7079	1851	7187	10236	9148
12) 30% reduction	3	218	1742	2069	1960	871	5772	7079	6643	1089	7514	9148	8603
13) 50% reduction	3	109	1089	1198	1198	653	6207	6861	6861	762	7296	8059	8059
14) 10% reduction	4	218	980	1198	1198	1525	6534	9148	8168	1742	7514	10346	9365
15) 30% reduction	4	109	1416	1525	1525	1198	6316	7950	7732	1307	7732	9474	9257
16) 50% reduction	4	109	1198	1634	1307	545	4574	5554	5118	653	5772	7187	6425
Contrasts^x													
1 vs. 4		NS	*	*	*	NS	NS	NS	NS	NS	*	*	*
2 vs. 8		NS	NS	NS	*	NS	*	*	NS	NS	*	NS	NS
2 vs. 11		*	NS	NS	NS	NS	*	NS	NS	NS	*	NS	NS
2 vs. 14		NS	NS	NS	NS	NS	*	NS	NS	NS	*	NS	NS
4 vs. 10		*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

^zData are means of four replications. MED = medium-sized melons, LRG = large-sized melons, TOT = total melon number, and MKT = marketable melon number. Total melon number is the sum of small [<3.0 lb (1.35 kg)], medium [3.0–4.5 lb (1.35–2.03 kg)], large [>4.5 lb (2.03 kg)], and cull (misshapen or decaying) melons. Marketable melon number is the sum of small, medium, and large melons; 1 melon/acre = 0.4 melon/ha.

^yReplant time is the number of weeks after the initial planting.

^xOther contrasts evaluated that were found to be nonsignificant for all variables listed were 1 vs. 2, 1 vs. 3, 2 vs. 5, 3 vs. 6, 3 vs. 9, 3 vs. 12, 3 vs. 15, 4 vs. 7, 4 vs. 13, and 4 vs. 16.

NS, *Nonsignificant or significant at $P \leq 0.05$, respectively.

weeks after the initial planting (Table 2). The later developing plants (from replanting) were several weeks behind in their development and occupied space that competed with plants from the initial planting. This appeared to reduce melon numbers due to the competition between the early and late developing plants in the 10% stand reduction, while the 30% and 50% stand deficiencies were not affected in this manner.

The 10% stand deficiency and those replanted at 1 and 2 weeks tended to yield 400 to 800 more total marketable melons per acre (160 to 320 melons/ha) than the complete stand (0% stand reduction) (Table 2). The 10% stand deficiency when replanted at 3 and 4 weeks after the initial planting had similar yields [within 110 melons/acre (44 melons/ha)] to the complete stand treatment (0% stand reduction).

The size of the muskmelon is an important characteristic since most are sold by piece rather than weight with larger sizes warranting a greater monetary return. Considering all harvests, the average melon size was 5.6 lb (2.5 kg). This test indicated that melon size

was not affected by stand reduction or replant date (data not shown). Even with drastically reduced stands, 'Athena' muskmelon plants did not overcompensate by producing larger melons but by producing more melons per plant.

1998 EXPERIMENT. Marketable melon production numbers were lower compared to the 1997 experiment with numbers over all treatments averaging 880/acre (352/ha), 4102/acre (1641/ha), 4982/acre (1993/ha) for early, main, and total season production, respectively.

For early-season and main-season, large, total, and marketable muskmelon numbers were not different among the 0%, 10%, 30%, and 50% stand deficiency controls (Table 3). However, the 50% stand deficiency tended to produce fewer melons compared to the 0%, 10%, and 30% stand deficiencies. For main and total season harvests, total and marketable fruit numbers were similar among the 10%, 30%, and 50% stand deficiencies that were replanted 1 or 2 weeks after the initial planting. When seed were replanted at 3 or 4 weeks after the initial seeding, melon numbers in the 50%

stand deficiency tended to be lower compared to the 10% or 30% stand deficiency. Replanting did not improve early, total and marketable muskmelon numbers in most stand deficiencies with the slightly greater yields obtained being nonsignificant ($P \leq 0.05$). This trend can also be seen for the 1997 experiment (Table 2). The only significant increase was for the 4-week replant date into the 50% plant stand for early yields of large, total, and marketable melon numbers (Table 3); but for the main-season harvest, this treatment did not differ from the 50% plant stand control.

For the cumulative harvests, stand deficiencies of 50% reduced large, total, and marketable numbers compared to the 0% stand deficiency control treatment. Stand deficiencies up to 30% did not reduce melon numbers compared with the control treatment. Replanting into reduced stands did not influence total-season muskmelon yields.

This test again indicated that the size of melons was not affected by stand reduction or replant date (data not shown). Over all harvests, the average melon size was 4.8 lb (2.2 kg). In plots with reduced stands, 'Athena'

Table 3. Yield (number of melons per acre) as affected by stand deficiencies and replanting at Carbondale, Ill., Summer 1998.^z

Treatment	Replant time ^y	Early season (harvests 1-3)				Main season (harvests 4-9)				Total (all harvests)			
		MED	LRG	TOT	MKT	MED	LRG	TOT	MKT	MED	LRG	TOT	MKT
1) 0% reduction	Control	0	436	436	436	2178	2759	5227	5082	2178	3194	5663	5518
2) 10% reduction	Control	290	436	871	871	1307	3630	5227	5227	1597	4066	6098	6098
3) 30% reduction	Control	0	581	871	581	1307	2904	4356	4356	1307	3485	5227	4937
4) 50% reduction	Control	145	145	290	290	1307	2178	3775	3775	1452	2323	4066	4066
5) 10% reduction	1	290	581	1016	1016	871	2614	3630	3630	1162	3194	4646	4646
6) 30% reduction	1	290	290	581	581	871	2323	4356	4356	1162	2614	4937	4937
7) 50% reduction	1	290	581	871	871	1888	2033	4501	4356	2178	2614	5372	5227
8) 10% reduction	2	145	145	436	290	1452	2759	4501	4501	1597	2904	4937	4792
9) 30% reduction	2	290	290	726	581	1016	2178	4356	4066	1307	2468	5082	4646
10) 50% reduction	2	145	1016	1452	1162	871	2759	4792	3920	1016	3775	6244	5082
11) 10% reduction	3	1162	581	1742	1742	1016	2904	4356	4211	2178	3485	6098	5953
12) 30% reduction	3	145	871	1016	1016	871	2904	4646	4501	1016	3775	5663	5518
13) 50% reduction	3	0	0	0	0	436	2468	3775	3485	436	2468	3775	3485
14) 10% reduction	4	436	1162	1742	1742	726	3049	4066	3775	1162	4211	5808	5518
15) 30% reduction	4	0	1016	1452	1307	1016	2033	4066	3630	1016	3049	5518	4937
16) 50% reduction	4	436	1162	1597	1597	871	1597	2759	2759	1307	2759	4356	4356
Contrasts ^x													
1 vs. 4		NS	NS	NS	NS	NS	NS	NS	NS	NS	*	*	*
2 vs. 11		**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
4 vs. 16		NS	*	*	*	NS	NS	NS	NS	NS	NS	NS	NS

^zData are means of four replications. MED = medium-sized melons, LRG = large-sized melons, TOT = total melon number, and MKT = marketable melon number. Total melon number is the sum of small [<3.0 lb (1.35 kg)], medium [3.0–4.5 lb (1.35–2.03 kg)], large [>4.5 lb (2.03 kg)], and cull (misshapen or decaying) melons. Marketable melon number is the sum of small, medium, and large melons; 1 melon/acre = 0.4 melon/ha.

^yReplant time is the number of weeks after the initial planting.

^xOther contrasts evaluated that were found to be nonsignificant for all variables listed were: 1 vs. 2, 1 vs. 3, 2 vs. 5, 2 vs. 8, 2 vs. 14, 3 vs. 6, 3 vs. 9, 3 vs. 12, 3 vs. 15, 4 vs. 7, 4 vs. 10, and 4 vs. 13.

NS, *, ** Nonsignificant or significant at $P \leq 0.05$, or 0.01, respectively.

muskmelon plants produced more melons on a per plant basis and not by producing larger melons.

Discussion

Based on the two experiments, it appears that 'Athena' muskmelon stand deficiencies up to 30% does not reduce total or marketable numbers. But a stand deficiency of 50% or more will decrease total and marketable melon yields compared to a complete stand. Generally, replanting into 10%, 30%, and 50% stand deficiencies appears to increase early-season melon numbers regardless of the replant times used. For main-season or total-season harvests, total and marketable melon numbers in stand deficiencies of 10% do not appear to be increased by replanting. In most cases, replanting into a stand deficiency of 10% reduced total and marketable melon numbers for main-season or total-season harvests. However, some advantages were observed by replanting into stands reduced by 30% or 50% up to 2 weeks after the initial planting date. The data from the 1997 experiment (Table 2) indicated a trend toward increased total and marketable melon numbers by replanting. Even replanting four weeks after the initial planting improved melon numbers in the 30% stand deficiency, and up to 3 weeks after the initial planting in the 50% stand deficiency appeared to increase melon yields. However, in the 1998 experiment (Table 3), there was no advantage of replanting into the 30% stand

deficiency and a slight increase was observed by replanting into the 50% stand deficiency by 2 weeks after the initial planting date.

An observation was made in the field about 2 months into the growing season for both years of the tests that plants developing from seed sown at the 3- and 4-week replant dates appeared to be shaded by the earlier seeded muskmelon plants. This could have been a major detriment to the potential yield of a specific treatment. The later planted muskmelons were competing with the earlier planted muskmelons for space but due to their smaller size were being out competed by the larger plants. This would also have an effect on reducing the yields of the earlier planted muskmelon plants due to the space limitations caused by the smaller plants that produced little to no yield.

A 10% or 30% reduction in an 'Athena' muskmelon field will not significantly decrease melon numbers compared to a field with a complete stand. These results indicate that growers should not replant 'Athena' muskmelon unless a field has a stand reduction of more than 30%. In most instances, a field should not be replanted unless the grower is overly concerned with increasing the early season melon yields as this appears to be the only benefit in replanting stand deficiencies of less than 30%. Total and marketable melon numbers were generally higher if replanted by 1 or 2 weeks after the initial seeding date compared to 3 or 4 weeks later.

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