

LITERATURE CITED

1. Brantley, B. B., and G. F. Warren. 1960. Effect of nitrogen on flowering, fruiting, and quality in the watermelon. *Proc. Amer. Soc. Hort. Sci.* 75: 644-649.
2. 1961. Effect of nitrogen nutrition on flowering, fruiting and quality in muskmelon. *Proc. Amer. Soc. Hort. Sci.* 77: 424-431.
3. Geraldson, C. M. 1956. Symptoms of nutritional disorders of vegetable crop plants. *Fla. Agr. Exp. Sta. Ann. Rep.*, p. 255.
4. 1957. Factors affecting calcium nutrition of celery, tomato, and pepper. *Proc. Soil. Sci. Soc. Amer.* 21: 621-625.
5. Jamison, F. S. 1937. Phenological studies on truck crops in Florida. *Fla. Agr. Exp. Sta. Ann. Rep.*, p. 84.
6. Lachman, W. H. 1948. Some effects of blossom removal on vegetative development and defoliation in determinate tomato plant. *Proc. Amer. Soc. Hort. Sci.* 51: 341-345.
7. Miller, C. H. 1961. Some effects of different levels of five nutrient elements on Bell peppers. *Proc. Amer. Soc. Hort. Sci.* 77: 440-446.
8. Miller, E. W. 1961. The effect of selected cultural practices on early yields and fruit size of Fireball tomatoes. Unpublished M. S. Thesis, West Virginia University, Morgantown.
9. Ozaki, H. Y. 1960. Fertilizer studies of the vegetable crops grown on the sandy soils of the lower East Coast. *Fla. Agr. Exp. Sta. Ann. Rep.* p. 272.
10. and C. T. Ozaki, 1956. Lime, N and K₂O treatments on spring-harvested peppers. *Fla. Agr. Exp. Sta. Ann. Rep.* p. 251.
11. Ozaki, C. T., and M. G. Hamilton. 1954. Bronzing and yield of peppers as influenced by varying levels of nitrogen, phosphorus and potassium fertilization. *Proc. Soil Sci. Soc. Fla.* 14: 185-189.
12. Ozaki, H. Y., C. T. Ozaki and M. G. Hamilton. 1955. The effects of applied nitrogen, phosphorus and potash on yield and growth of peppers. *Proc. Fla. State Hort. Soc.* 68: 230-233.
13. Ozaki, H. Y., and H. E. Ray. 1957. Fertilizer studies of vegetable crops grown on the sandy soils of the lower East Coast. *Fla. Agr. Exp. Sta. Ann. Rep.* p. 291.
14. United States Department of Agriculture, Crop Reporting Board. 1960. *Vegetable-Fresh Market, Annual Summary of Acreage, Production and Value.*
15. Watts, V. M. 1937. Growth and fruiting responses to pruning and defoliation of tomato plants. *Ark. Agr. Exp. Sta. Bul.* 347.

PRODUCTION OF SPRING VEGETABLES UNDER SHADE

HAROLD W. YOUNG

Assistant Horticulturist

North Florida Experiment Station

Quincy

A study to determine the performance of vegetables under shade was initiated at the North Florida Experiment Station to observe effects of shade upon soil moisture, temperatures (air, soil and plant), relative humidity, intensity, and insect and disease problems. Since the results with any one vegetable varied with the season of the year, this discussion is confined to spring-planted cucumbers, pole beans, and tomatoes.

Due to present market demands, spring-planted vegetables must be produced before July 15 and preferably in May and June to be profitable. If the period of production could be extended to July and August by the use of shade, there is a possibility of a Florida market which is now supplied by shipments from more northern areas.

In the early spring plant damage from short cold periods is very likely unless some method of plant protection is utilized. As the season progresses high temperatures, high light intensity and moderate wind velocities often result in plants wilting even though soil moisture is adequate. Throughout the growing season heavy rains may occur which can damage plant stands either by drowning or washing. Some of

the existing hazards could possibly be reduced by growing under shade.

In this area vegetable production under shade could utilize existing cigar-wrapper tobacco facilities. Crops needing support could be tied to shade supported wires. Often a higher percent of marketable products could be produced if grown on a trellis.

METHODS AND MATERIALS

1959—A field previously cropped to cigar-wrapper tobacco was divided into four blocks, each 48 feet by 80 feet. Two of the blocks were completely enclosed in shade cloth. The harvested plots consisted of single 52 foot rows spaced 4 feet apart. Water was supplied as needed by a Skinner type overhead irrigation system. Soil analyses and fertilizer applications are shown in Table 1. The plots were treated with Telone in February 1959.

Marketer cucumbers and Florigreen pole beans were seeded, and Manalucie tomato plants were transplanted on March 27. The pole beans were tied to strings which were suspended from row wires. Heavier twine was used for the cucumbers and it was necessary to periodically wrap the plants around the twine. The tomatoes were pruned to two stems and tied to 6 foot stakes.

Insect and disease control was achieved by weekly dustings of 1 percent parathion and 10 percent Zineb. Sevin and sulphur were used several times on the pole beans.

1961—An area previously in field crops was divided into ten blocks each 50 feet wide by

Table 1: Soil test analyses and fertilizer applications on shaded and unshaded plots used in 1959.

<u>Soil analyses</u>						
<u>Treatment</u>	<u>Date</u>	<u>pH</u>	<u>P₂O₅</u>	<u>K₂O</u>	<u>CaO</u>	<u>MgO</u>
Shaded	1/9/59	5.43	71	725	879	399
	1/5/60	5.67	56	220	611	193
Unshaded	1/9/59	5.35	79	833	869	423
	1/5/60	5.66	60	342	581	207

Fertilizer applications

<u>Date</u>	<u>Lbs. per acre</u>	<u>Formula</u>	<u>How applied</u>
3/25/59	500	6-8-6	Bands
5/15/59	100	Ammonium Nitrate	Sidedress
7/1/59	100	Ammonium Nitrate	Sidedress
9/21/59	500	6-8-6	Bands

Table 2: Soil test analyses and fertilizer applied in 1961.

Soil test analyses

<u>Date</u>	<u>pH</u>	<u>P₂O₅</u>	<u>K₂O</u>	<u>CaO</u>	<u>MgO</u>
7/1/60	5.2	29	200	216	56
8/15/61	6.5	28	124	1357	437

Fertilizer applications

<u>Date</u>	<u>Lbs. per acre</u>	<u>Formula</u>	<u>How applied</u>
2/20/61	4000	Dolomite lime	Broadcast
3/23/61	420	6-8-6	Bands
4/14/61	840	6-8-6	Bands

40 feet long. Alternate blocks were shaded and not shaded. Soil test analyses, before and after the spring 1961 crops, as well as fertilizer applications are shown in Table 2. The area was broadcast treated on August 5, 1960, with Methyl Bromide.

Marketer cucumbers and Kentucky Wonder 191 pole beans were seeded on March 7. Tomato plants (Manapal and Manalucie) were transplanted March 14. Handling of these crops was the same as in 1959 except that the tomatoes were wrapped around heavy twine which was tied to the row wires. The same insect and disease control was used as in 1959. Self recording hygrothermographs located at soil level were used to measure air temperatures and relative humidity.

RESULTS AND DISCUSSION

The records of air temperatures and relative humidity in general agreed with results previously reported by Purdy (4) and Trotter and Griffiths (6). On very warm days temperatures under shade were 1 to 5 degrees cooler than in the sun. However, on cool days no significant differences were noted. Immediately prior to planting the crops in 1959, when temperatures near 30 degrees were recorded, temperatures of the shaded plots were either the same or 1 to 2 degrees warmer. Results to date would indicate that one layer of cloth as used in this experiment usually would provide little or no protection from freezing temperature; however, soil moisture conditions could be expected to modify the temperature difference.

Purdy (4) and Trotter and Griffiths (6) found that the average relative humidity was significantly higher under shade. In this experiment similar results were obtained; however, there were many times when there was no difference in relative humidity.

Considered more important in this work was the differences in light intensity and soil moisture. Records were not taken on soil moisture; however, Trotter and Griffiths (6) found that soil moisture at both the 2 and 4 inch levels was higher under shade. The greatest variation occurred at the 2-inch level. In this experiment light intensity did not appear to be a limiting factor under the shade.

Leaf temperatures were not measured; however, on days with high temperatures the unshaded plants often wilted during the afternoon even with adequate soil moisture.

After cultivation followed by heavy rains, the soil surface of unshaded plots was packed, whereas the shaded plots remained undisturbed.

In 1959, bees were not seen in the shaded (completely enclosed) plots and cucumbers were not pollinated until the side was lifted. On the other hand, in 1961, bees entered the enclosed shade plots through small openings where the cloth was torn by the wind.

In general shaded vegetable plants had longer internodes and larger leaves. This is in agreement with results of Duggar (2), Romshe (5), Young (7) and others. The succulent, vigorous appearing vegetative growth would suggest a higher humidity immediately surrounding the leaves as well as some reduction in evaporation from the soil surface. It usually seemed more humid under the shade even though the instruments recorded slight differences.

Consistent differences between shaded and unshaded plots in insect populations and foliage diseases were not evident; however, insects were often less numerous under the shade.

In the following discussion of each crop the yield figures of each treatment are based on the average of 2 replications in 1959 and 5 replications in 1961.

Table 3: Cucumbers (Marketer variety) in shaded and unshaded plots.

Year	Seeding date	Days to first harvest	Harvest period			Yield in 48-lb. bushels per acre	
			First	Last	Days	Shaded	Unshaded
1959	3/27	55	5/22	6/24	33	963	679
1961	3/7	77	5/23	6/20	27	780	564

CUCUMBERS

In both years Marketer cucumbers produced higher yields in the shaded than in the unshaded plots (Tables 3 and 5). As the season

advanced the advantages of the shade became more apparent. Shade planted cucumbers appeared more healthy and vigorous as internodes were longer and leaves larger.

Table 4: Cucumbers (Marketer variety) produced in shaded and unshaded plots in 1959.

	Shaded %	Unshaded %
Marketable	70.5	51.0
Unmarketable		
Rhizoctonia lesions	12.5	35.0
Poorly shaped fruit	17.0	14.0
	<u>100.0</u>	<u>100.0</u>

Table 5: Yield and quality of Marketer cucumbers grown in shade and sun plots at Quincy, Florida in the spring of 1961.

Treatment	Total yield in bushels per acre			Percent of fruit defective	
	May	June	Total	Pointed stem ends	Constricted stem end
Shaded	282	498	780	6.7	20.2
Unshaded	213	350	564	6.8	12.1

Table 6: Yield of tomatoes grown in shaded and unshaded plots at Quincy, Florida

Variety	Year	Trans- planting date	Days to first harvest	Harvest period			Total yield in bushels per acre	
				First	Last	Days	Shaded	Unshaded
Manapal	1961	3/14	85	6/7	7/10	33	26,353	38,513
Manalucie	1961	3/14	85	6/7	7/10	33	28,313	38,513
Manalucie	1959	3/27	66	6/2	7/14	42	27,116	31,276

Table 7: Yield of spring tomatoes in shaded and unshaded plots at Quincy.

Year	Variety	Shaded (lbs. per acre)			Unshaded (lbs. per acre)		
		June	July	Total	June	July	Total
1961	Manapal	14,774	11,579	26,353	32,488	6,025	38,513
1961	Manalucie	17,496	10,817	28,313	29,983	8,530	38,513
1959	Manalucie	5,030	22,086	27,116	15,400	15,876	31,276

In Table 4 it can be seen that a larger percentage of the fruits in the unshaded plots were unmarketable because of *Rhizoctonia* lesions. As *Rhizoctonia* rarely affects fruit that does not touch the soil surface most of the damaged fruit set early and therefore touched the soil. This and other observations, Young (7), illustrated that fruit losses due to *Rhizoctonia* can be eliminated by any type of training that will elevate the fruit above the soil surface.

In 1961 (Table 5) it can be seen that May yields under shade were slightly greater and June yields were considerably larger than in unshaded plots. Constricted stem ends have usually been associated with low potassium or high nitrogen applications, but insufficient pollination might cause a similar condition. As the shaded plots had a higher percentage of this defect, either or both causes may have been involved. Utilization of nitrogen by the plants in the shaded and unshaded plots might have been different due to light intensity. A nitrogen assimilation difference was suggested by Dug-

gar (2). This situation would warrant further investigation.

Powdery mildew was present in 1961 but differences between treatments were not of any significance. Downy mildew rarely is a problem in the spring crop.

TOMATOES

The tomatoes were harvested in the pink or later stage of maturity (Table 6). In total fruit harvested greater yields were on unshaded plots, probably because earlier fruit was produced on the unshaded plots (Table 7). On the other hand, larger yields were obtained after July 1 in the shaded plots. All plots were fertilized similarly and less nitrogen on the shaded plots might have increased early yields. Total yields were, in most cases, greater in the unshaded plots but there was more fruit potential left on the shaded plots when the plants were destroyed in preparation for a fall crop.

In Table 8 it can be seen that in general the June fruit in the unshaded plots were heavier. In July, however, the reverse was true in 1961.

Table 8: Average weight per fruit of spring tomato fruits in shaded and unshaded plots.

Year	Variety	Shaded (lb. per fruit)			Unshaded (lb. per fruit)		
		June	July	Total	June	July	Total
1961	Manapal	.521	.414	.479	.521	.383	.508
1961	Manalucie	.539	.496	.524	.632	.407	.585
1959	Manalucie	.433	.424	.426	.503	.453	.478

Table 9: Number of harvested tomato fruits per acre in shaded and unshaded plots.

Year	Variety	Shaded	Unshaded
1961	Manapal	54,595	77,827
1961	Manalucie	53,724	67,155
1959	Manalucie	59,616	64,584

Table 10: Percent of tomatoes with defects in shaded and unshaded plots. Percentages calculated on number of fruit and given to nearest whole number where above one.

Year	Variety	Treatment	Without defect %	Cracks			Blossom and rot %	Cat- face %	Sun- scald %
				Radi. al %	Concentric %	Bursts %			
1961	Manapal	Shaded	50	25	1	8	0.5	5	-
		Unshaded	41	17	9	5	0.8	15	1.0
1961	Manalucie	Shaded	57	24	1	3	0.2	7	-
		Unshaded	34	25	6	3	1.0	25	0.4
1959	Manalucie	Shaded	47	26	All crack types grouped		1.0	3	-
		Unshaded	56	38			0.1	5	

The overall average weight of fruit in both years was greater in the unshaded plots. The number of fruit harvested was greater in all cases in 1961 (Table 9).

In 1961, shading significantly reduced the percentage of catfaced fruits (Table 10). Weather conditions at the time of fruit setting was prob-

ably not the entire answer as catfaced fruits were present in unshaded plots during the entire harvest period.

In studies which did not distinguish between the kind of fruit cracking, Brown and Price (1) reported that shading reduced cracking incidence by 10 percent and Romshe (5) found that some varieties had more, and some less cracked fruit under shaded conditions. As

Table 11: Pole Beans grown in shaded and unshaded plots.

Year	Variety	Seeding date	Days to first harvest	Harvest period			Yield in bushels per acre	
				First	Last	Days	Shaded	Unshaded
1961	Ky. Wonder 191	3/7	69	5/15	6/8	24	418	430
1959	Florigreen	3/27	55	5/22	6/24	33	659	859

Table 12: Yield and Rhizoctonia stem lesion incidence in Ky. Wonder 191 pole beans in shaded and unshaded plots in the spring of 1961.

Plant spacing	Treatment	Yield in bus. per acre			Rhizoctonia lesions	
		May	June	Total	Index	% plants with lesions
6 inch	Shaded	142	189	331	0.83	37
	Unshaded	177	280	457	0.97	38
9 inch	Shaded	117	194	311	0.76	38
	Unshaded	130	300	430	1.02	47
12 inch	Shaded	242	176	418	0.90	48
	Unshaded	290	140	430	0.80	45

many environmental factors influence cracking, the data in Table 10 on cracking might not be an expression of shading alone.

POLE BEANS

Florigreen variety was grown in 1959 and Kentucky Wonder 191 in 1961 so a direct comparison can not be made. However, overall yields of both varieties were highest in the unshaded plots (Table 11). These are records from plots with 12-inch spacing.

As the plants in the shaded plots have always appeared more vigorous, a spacing trial was

conducted in 1961. Bean seeds were planted 1 inch apart in the row and after emergence were thinned to 6, 9 or 12 inches. The 12 inch spacing produced the highest yields in May (Table 12). In June both the 6 and 9 inch spacings produced greater yields. In general, the unshaded plots outproduced the shaded plots. A Rhizoctonia index was determined by scoring the stem lesion (from 0, none to 5, very severe) on each plant removed in the thinning operation and then averaging the total.

Table 13: Pod measurements of Ky. Wonder 191 pole beans in shaded and unshaded plots in the spring of 1961.

Plant Spacing	Treatment	Average Pod Measurements							
		Length inches	Thickness mm	Width mm	No. of seeds	% pods with missing seeds	a/ Curvature		Wt./ pod grams
							mm	mm	
6 inch	Shaded	7.2	9.0	12.2	7.6	12	22.6	15.6	13.9
	Unshaded	6.9	9.5	13.0	7.8	27	23.6	18.2	14.5
9 inch	Shaded	7.2	10.1	13.1	7.1	15	19.9	14.7	15.6
	Unshaded	7.1	9.8	12.4	7.6	17	21.0	16.4	13.8
12 inch	Shaded	7.1	9.2	13.0	7.6	15	23.9	16.0	14.8
	Unshaded	7.3	10.1	13.2	7.9	22	21.7	16.6	15.3
Ave. all spacings	Shaded	7.2	9.4	12.7	7.4	14	22.1	15.4	14.7
	Unshaded	7.1	9.8	12.8	7.7	22	22.1	17.0	14.8

Curvature

a/ Measured with suture to side

b/ Measured with suture up.

To compare measurements (Table 13) of pods produced on shaded and unshaded plots, measurements were made on 100 pods of each treatment at four intervals during the season. Mature pods which still contained green seeds were selected. Although not conclusive the data suggest that shading might reduce the number of missing seeds. Furthermore, there are indications that two important problems in this area, pods with missing seeds and curved pods, are not related.

SUMMARY

In a study of spring-planted cucumbers, pole beans and tomatoes in shaded and unshaded plots, differences of air temperatures and relative humidity between shaded and unshaded plots were present, but of small magnitude. Shade provided protection from heavy rainfall and reduced light intensity.

Cucumbers produced highest yields in the shade while the highest yields of pole beans were produced in the unshaded plots. Early yields of tomatoes were greatest in the unshaded plots but late yields were greater in the shade. In general, shade reduced early yields, but extended the harvest season.

LITERATURE CITED

1. Brown, H. D. and Price, C. V. Effect of irrigation, degree of maturity, and shading upon the yield and degree of cracking of tomatoes. *Proc. Amer. Soc. Hort. Sci.* 32:524-528. 1934.
2. Duggar, B. M. The physiological effects of shading plants. *Proc. Amer. Soc. Hort. Sci.* 1:15-17. 1903.
3. Frazier, W. A. A study of some factors associated with the occurrence of cracks in the tomato fruit. *Proc. Amer. Soc. Hort. Sci.* 32:519-523. 1935.
4. Purdy, W. G. Factors influencing the growth of plants in cloth houses. *Proc. Amer. Soc. Hort. Sci.* 30:578-579. 1934.
5. Romshe, F. A. Growth, production and fruit quality of tomatoes grown under cloth. *Proc. Amer. Soc. Hort. Sci.* 36:692-694. 1939.
6. Trotter, A. R. and Griffiths, A. E. Observations on the effect of shade on vegetables. *Proc. Amer. Soc. Hort. Sci.* 36:550-554. 1938.
7. Young, H. W. Comparison of shaded and unshaded vegetables planted in the spring, 1959. North Florida Experiment Station Mimeo Rpt. 60-6. 1960.