ducing leaching and increasing yields of transplanted tomatoes. Preliminary trials with transplanted onions and cabbage indicate that these crops may also do well under this system (Figure 3). An important consideration is to locate the banded fertilizer deep enough in the plant bed to insure adequate moisture at all times, but high enough to prevent free water from moving through it. This would generally be in in the center of the bed at a depth of 1 to 3 inches below the bed surface. A slight crown to the bed would aid in run-off of water away from the banded fertilizer during heavy rainfall.

Advantages of strip plastic over full bed cover with plastic include (1) much lower cost of material, (2) strips are not blown away during hurricane winds, (3) beds will absorb rainfall and overhead irrigation, and (4) supplementary fertilizer can easily be applied outside the plastic strip if needed. Since cultivation is not possible near the plastic strips, chemical weed control must be used in weedy fields. Full bed cover with plastic also has advantages over strip plastic: (1) aids in fumigation of soil for nematode and disease control, (2) effectively controls most weeds, (3) aids in prevention of bed erosion, and (4) protects fruits from decay caused by soil borne diseases.

The trials with seeded onions were not as successful as those with transplanted tomatoes. This was primarily due to the distance of the banded fertilizer under plastic from the seed drill. The supplementary fertilizer applied outside the plastic strip and near the drill was not adequate, and rains leached the nitrogen and potassium before the plants developed roots into the banded fertilizer zone. As a result, the deficient seedlings made very slow growth until the roots finally reached the banded fertilizer. Root systems of individual plants reached the fertilizer at different times, and this resulted in non-uniform growth and bulb size. It appears that for seeded onions the strip plastic technique must be supplemented with several applications of fertilizer placed near the plants until the roots have reached the banded fertilizer beneath the plastic.

EFFECT OF PLASTIC MULCH ON THE YIELD OF SEVERAL VEGETABLE CROPS IN NORTH FLORIDA[1]

H. H. BRYAN[2]

Many investigators (1, 2, 3, 4. 7, 8) have shown the advantage of using plastic mulch to retain soil moisture, prevent nutrient leaching, provide weed control, reduce insect and disease damage, and increase earliness, yield and quality of certain vegetable crops. Locascio and Thompson (6) showed that increasing levels of fertilizer increased strawberry yields. Most commercial growers in North Florida, however, have not used plastic mulches and indicate little or no knowledge of the product.

Preliminary tests were conducted in 1964 to study the effects of black, clear, and white on black polyethylene mulches on the yield of pole beans, cantaloupes, Southern peas, squash, sweet potatoes and watermelons. Experiments in 1965 were carried out to determine if fertilizer levels had any effect on yields of cantaloupes, cucumbers, okra, pole beans, summer squash, butternut squash, sweet potatoes and watermelons grown on various types of polyethylene mulches. Variety trials with broccoli, cabbage, cauliflower and lettuce were grown with no mulch and with black polyethylene mulch in the fall, 1965. All experiments were conducted on a Ruston loamy fine sand soil at the North Florida Experiment Station, Quincy.

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MATERIAL AND METHODS

1964 Experiments.—Six vegetable crops were seeded or transplanted through black, clear, white on black mulches and in unmulched check plots. Fertilizer as recommended in the "Commercial Vegetable Fertilization Guide" (Agricultural Extension Circular 225, University of Florida, Gainesville, Florida) was applied in bands 8 inches to each side of the bed center and covered with soil prior to application of the mulch. Basic fertilizer applications were made at the same time to check plots which were later sidedressed according to recommendations in Circular 225. Clear mulch and check plots were sprayed with the following herbicides in 40 gallons of water per acre before application of the mulch: canteloupes, watermelons—3 pounds a.i. NPA; pole beans, Southern peas, sweet potatoes—1 pound a.i. Trifluralin; and squash—3 pounds a.i. DNBP. Polyethylene film 1.5 mils thick and 4 feet wide was applied to the beds immediately after application of the herbicides on April 16. Plots were 50 feet x 6 feet and were arranged in a randomized complete block design for each crop. Bush Table Queen squash and Charleston Gray watermelons in peat pots were transplanted April 20. Georgia Red sweet potato slips were transplanted April 23. Kentucky Wonder 191 pole beans, Florisun cantaloupes and Producer Southern peas were direct seeded by hand through 3 inch holes made in the plastic with a metal drain pipe on April 20. Cantaloupes and watermelons were planted in one row per bed and pole beans, Southern peas, squash, and sweet potatoes were planted on two rows per bed.

1965 Experiments.—Spring. Fertilizer was applied in bands before bedding with mulched

Table 1. Total fertilizer used on plastic mulch plots before planting, and on check plots before planting and as sidedressing; herbicides used on check and clear mulch plots in 1965.

Crop	Fertilizer Rate	Pounds per Acre N	P_2O_5	K_2O	Herbicides Chemical	a.i./acre (lb.)
Pole Bean	Low	66	58	103	Trifluralin	1.0
	Medium	133	118	208	"	"
Okra (Spring)	Low	126	70	144	Trifluralin	1.0
	Medium	254	142	290	"	"
Okra (Fall)[1/]		135		135		
Summer Squash	Low	120	79	140	DCPA	10.5
	Medium	237	159	277	"	"
Sweet Potato	Low	45	63	103	Trifluralin	1.0
	Medium	92	129	211	"	"
Cantaloupe	Medium	211	159	251	NPA	3.0
	High	315	289	374	"	"
Cucumber	Medium	207	118	236	NPA	3.0
	High	319	187	366	"	"
Butternut Squash	Medium	181	118	210	DNBP	3.0
	High	269	179	314	"	"
Watermelon	Medium	207	118	236	NPA	3.0
	High	319	187	366	"	"

[1/] The spring okra crop was topped 2 feet from the ground in mid-August and allowed to sprout again for a fall crop.

and unmulched plots treated the same is in 1964. Low (one-half the recommended rate) and medium (recommended rate in Circular 225) fertilizer levels were applied to pole beans, okra, summer squash and sweet potatoes, medium and high (1.5 times the recommended rate) fertilizer levels were applied to cantaloupes, cucumbers, butternut squash, and watermelons (Table 1). Herbicides were sprayed on clear mulch and check plots immediately before applying the clear mulch (Table 1). Aluminum paint was sprayed on black plastic mulch after it was secured on the bed to obtain the "aluminum" treatment. Smoke film was used on cantaloupes, cucumbers, butternut squash and watermelons at the medium fertilizer rate. The following vegetable varieties (and their planting dates) were planted on mulch applied on April 7: Florida No. 1 cantaloupes (4/12), F-1 Ashley cucumbers (4/9), Butternut squash (4/9), and Charleston Gray watermelons (4/12) were transplanted in peat pots on one row per bed; Kentucky Wondere 191 pole beans (4/12), Clemson Spineless okra (4/12) and Early Prolific Straight Neck squash (5/7) were direct seeded through 3 inch holes in the plastic on two rows per bed. Georgia Red and Centennial sweet potato slips were transplanted (5/5) in two rows per bed on mulch applied on May 4.

Fall. Several varieties of cauliflower, cabbage, broccoli, and lettuce were seeded on August 18 and covered with cheese cloth frames 18 inches high and 4 feet wide for 4 weeks. Transplants were set in mid-October in a randomized complete block design for each crop with 2 replications on polyethylene mulch and 2 replications on unmulched beds. Three to four days before planting, 1000 pounds 10-10-10 and 11.2 pounds of Fertilezr Borate—65 per acre were broadcast over the entire block; then 400 pounds of 4-12-12 was broadcast where the mulch plots were to be located. After discing, plots for mulch received 600 pounds of 15-0-15 per acre in bands 6 inches to each side of 2 rows per 6-foot bed before bedding. Black polyethylene mulch was applied to the beds and transplants were set in 2 rows 30 inches apart on each bed. In-row plant distances were 12 inches for broccoli, cabbage and lettuce and 18 inches for cauliflower. Unmulched plots were sidedressed with 400 pounds of

Table 2. Effect of plastic mulch on the marketable yield of six vegetable crops in 1964.

	Check Yield		Increase of Marketable Mulch Yield over Check: Black		Clear		White/Black	
Crop Variety	Early (cwt/acre)	Total cwt/acre	Early (%)	Total %	Early (%)	Total %	Early (%)	Total %
Cantaloupe								
Florisun	(13.9)	118.6	(233)	60	(204)	20	(46)	15
Squash								
Bush Table Queen	(54.5)	151.7	(67)	39	(76)	40	(86)	55
Southern Pea								
Producer	(9.6)	53.6	(3)	-43	(58)	-27	(-70)	-27
Pole Bean								
Ky. Wonder 191		40.2		10		40		14
Sweet Potato								
Georgia Red		56.1		44		138		168
Watermelon								
Charleston Gray		177.5		53		211		65

4-12-12, 200 pounds each of 15-0-15 and 13-0-44 per acre 18, 32 and 55 days, respectively after transplanting. A severe freeze on January 29 and 30, 1966, terminated harvest of some of the later maturing varieties that remained in the field at that time.

Results and Discussion

1964 Experiments.—Early yields of cantaloupes were higher on black and clear mulch than on unmulched plots; early yields of squash were higher on all types of mulch. Early yields of Southern peas were higher on clear mulch plots and lower on white on black mulch (Table 2). Check yields ranged between average and good for the United States according to Knott (5).

Fifty days after seeding, cantaloupes on black and clear mulch had diameters of 3.8 inches compared to 2.7 inches on unmulched plots. Watermelon vines were 25 inches on unmulched plots and 44, 38 and 28 inches on clear, black, and whte on black mulch 30 days after planting; 50 days after planting fruit length was 8 inches on unmulched plots and 14, 12 and 11 inches on clear, black, and white on black mulch.

Yields obtained and the percentage increase of outstanding mulched over unmulched plots from crops that responded favorably to mulching were: 190 cwt cantaloupes on black mulch; 235 cwt squash and 151 cwt sweet potatoes on white on black mulch; 56 cwt pole beans and 552 cwt watermelons on clear mulch (Table 2). All mulches were unfavorable to Southern peas probably because of a *Fusarium* wilt species, which became more obvious on the mulched plots after the early harvesting was completed. Stands were about 18% better in mulched than unmulched plots 50 days after seeding but later they were reduced considerably by wilt.

Almost 90% of the watermelons harvested from clear and black mulch were mature before any were harvested from unmulched plots (Table 3). Clear mulch plots produced more early and large watermelons and cantaloupes; however, the highest total cantaloupe yields were on the black mulch plots. White on black film was associated with increased yields in both crops, but the extra cost of the material made the treatment uneconomical.

Largest sweet potato roots were produced on clear mulch plots; however, largest yields were obtained from white on black mulch plots (Figure 1). Unmulched and black mulched plots had

Table 3. Marketable yield, harvest sequence and fruit weight of Charleston Gray watermelons and Florisun cantaloupes grown on various types of mulch in 1964.

Crop Mulch	Yield cwt/acre	Percent harvested each date 6/19	7/6	7/17	Fruit Size pounds
Watermelons					
Check	177.5	0	0	100	24.5
Black	271.2	12	77	11	23.4
Clear	552.2	23	65	11	27.2
White/Black	293.5	0	65	35	22.5
Cantaloupes		6/29	7/6	7/15	
Check	118.6	12	48	40	2.5
Black	190.0	24	37	38	2.7
Clear	142.1	30	48	22	2.8
White/Black	155.5	13	33	54	2.6

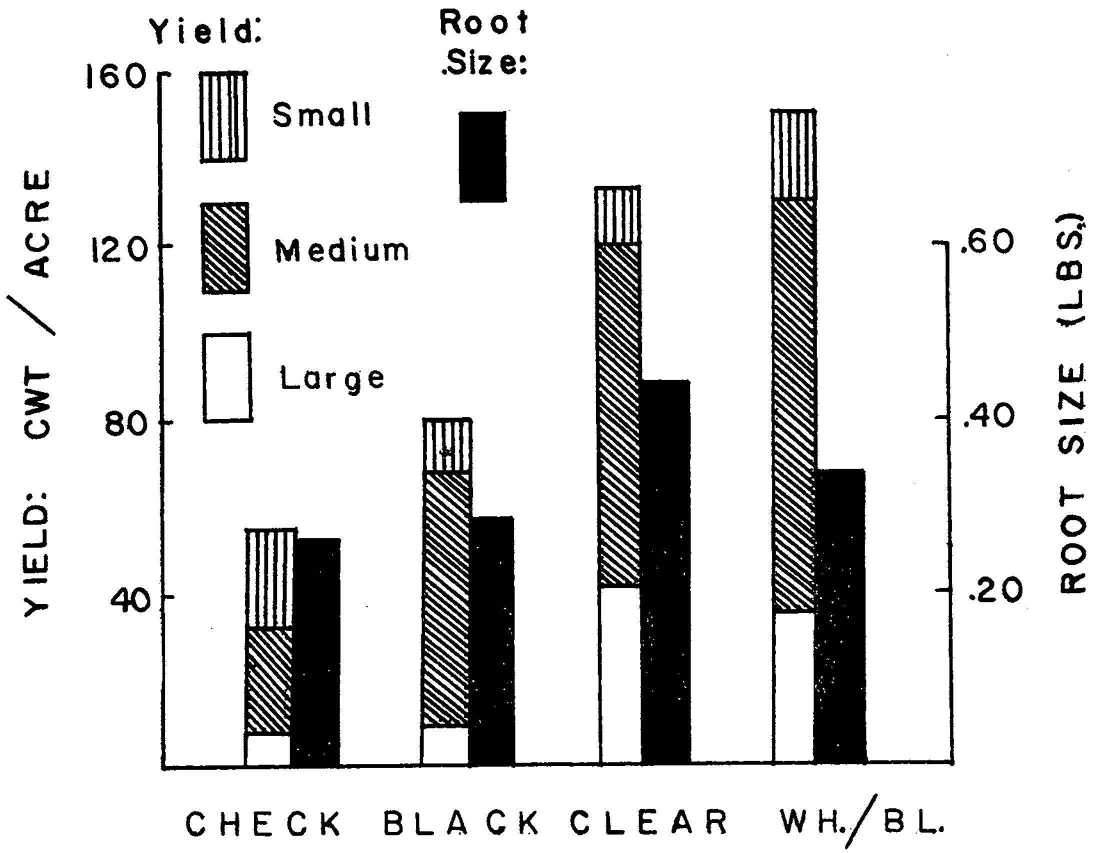

Fig. 1.—Effect of plastic mulch on marketable yield, grade and root size of Georgia Red sweet potatoes in 1966.

a lower percent of large roots than the clear or white on black plots, which might indicate that the two latter mulches might be harvested somewhat earlier with an even higher proportion of U.S. Number 1 (medium) roots.

Table 4 shows the approximate additional returns over unmulched plots from extra yields produced by mulch treatments after costs of film, herbicides and application have been deducted. The most economical mulch for cantaloupes in 1964 was black film. Money could be made from black mulch when prices are low, but the additional returns would not justify clear or white on black mulch if the price received were 5 cents per pounds (Table 4). In the same way, clear mulch would be the most practical mulch to use on watermelons and sweet potatoes. Note that extra returns for clear and white on black mulch on sweet potatoes are the same if the grower receives 5 cents per pounds; however, when the price drops, the extra cost of the white on black film results in a loss.

1965 Experiments.—Spring. Excessive rains occurred in early summer which hampered foliar disease control; however, in most cases the yields of unmarketable plots were comparable to those fertilized the same way in 1964.

With most crops, the medium fertilizer level resulted in highest yields (Table 5) but okra and sweet potato yields were gradually higher at the low fertilizer level. Pole bean yields were lower on aluminum and clear mulch; clear mulch plots of okra yielded 142% more than the checks in the spring trial, but mulch had little effect when plants were topped in August and allowed to produce a fall crop on the same stalks (Table 5). Stands of okra on black mulch at the med-

Table 4. Net additional returns[1/] per acre from black, clear, and white on black plastic over unmulched plots on three crops in 1964.

Mulch	Crops and possible Prices per Pound					
	Cantaloupes		Watermelons		Sweet Potatoes	
	5¢	10¢	1¢	2¢	2¢	5¢
Black	$260	$610	$-10	$ 90	$-50	$ 20
Clear	0	110	250	630	40	270
White/Black	-20	170	-80	30	-10	270

1/ Returns adjusted to pay for the following approximate costs of film, herbicides (clear mulch) and application: Black-$100, Clear-$120, White/Black-$200.

ium fertilizer level were poor, which accounts for its low response (Table 5). Black and aluminum mulch was associated with a 25% yield increase of summer squash. There were no differences in total marketable yield between sweet potato varieties; however, Centennial had 96 cwt U.S. Number 1 roots verus 64 cwt for Georgia Red. Since total yields were not significantly different, varieties were combined for data in Table 5. Aluminum decreases soil tem-

Table 5. Effects of plastic mulch and fertilizer level on yield in cwt per acre of 8 vegetable crops in 1965.

Crop	Check	Mulch			Fertilizer Level		
		Black	Aluminum	Clear	Low	Med.	High
Pole Bean	40	41	34	32	39	34	
Okra (Spring)	31	37	43	75	56	36	
Okra (Fall)[1/]	53	49	59	58			
Summer Squash	129	165	164	141	146	152	
Sweet Potato	78	120	171	132	140	115	
Cantaloupe	40	68	55	74		85	34
Cucumber	78	94	155	178		169	84
Butternut Squash	85	73	89	93		107	60
Watermelon	130	173	174	229		212	140

1/ Fall okra: spring crop topped 2 feet from the ground in mid-August and allowed to sprout again for a fall crop.

Table 6. Effect of black mulch on yield and quality of several varieties of cauliflower, cabbage, lettuce, and broccoli in the fall, 1965.

Crop	Number of Varieties	Black Mulch	Yield cwt/acre	% of crop harvested	Size pounds
Cauliflower	7	Yes	126	80	1.71
		No	131	91	1.53
Cabbage	15	Yes	201	80	1.69
		No	184	88	1.61
Lettuce	9	Yes	41	76	0.40
		No	23	66	0.30
Broccoli	9	Yes	29	84	0.27
		No	25	76	0.25

peratures as does white on black film. Aluminum covered plots yielded 119% more than unmulched plots.

Cantaloupe yields were 85% greater on clear and 70% greater on black mulch; cucumber yields were 128% greater on clear and 99% greater on aluminum mulch; Butternut squash was not greatly affected by mulch; and watermelon yields on clear mulch were 76% greater and fruit size 35% larger (Table 5). Smoke mulch at the medium fertilizer rate was not as effective as other mulches on cantaloupes, Butternut squash, or watermelons, and was not as effective as clear and aluminum mulch on cucumbers.

Fall. It was hoped that information concerning the value of black polyethylene mulch on 4 fall vegetables could be obtained by planting variety trials on mulched and unmulched plots. Cauliflower yields were not affected by mulch. However, plant stand was reduced and appearance and size were better on mulched plots (Table 6) Cauliflower may be a potential crop for the North Florida area because the growing season does not interfere with shade tobacco production.

Cabbage, lettuce and broccoli yields for mulch plots were greater than unmulched plots by 9%, 78% and 17%, respectively, and the percent of cabbage harvested was decreased but head size was increased on the mulch. Lettuce and broccoli plant stands and head size were improved by mulch, but lettuce is probably the only one of the 4 crops tested that could be grown economically with mulch in the fall. Mulched lettuce was much cleaner and had a better appearance. Salad Bowl and Buttercrunch lettuce varieties were particularly responsive to mulch; yields were increased from 4,200 to 6,200 and from 3,100 to 4,400 pounds per acre for each variety, respectively, on a mid-November planting on mulched and unmulched plots.

SUMMARY

Experiments were conducted in 1964 and 1965 to determine the effects of various types of mulches and fertilizer levels on several vegetable crops in North Florida. In 1964 it was found that black mulch was the most profitable to use on cantaloupes; clear mulch was the most economical for watermelons and sweet potatoes even though white on black mulch produced higher yields for the latter; clear and black mulch increased earliness of watermelons and cantaloupes; white on black mulch produced the highest yield of squash; clear mulch produced the highest yield of pole beans; and all mulches were unfavorable for Southern peas.

In 1965 clear mulch plots produced the highest yields of okra, cantaloupes, cucumbers, Butternut squash, and watermelons; aluminum mulch plots produced the highest yields of sweet potatoes and summer squash. Black mulch improved appearance and size of cauliflower, cab-

bage, broccoli, and lettuce, but only the latter was improved enough to make mulch economically feasible in the fall.

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Appreciation is expressed to Howard Gosche, Gering Plastics Company, who furnished the mulch applicator used in 1964 and all plastic materials for the experiments. The Gering machine was used as a model to build a mulch applicator with a bed press attachment for use in 1965.

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THE EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM ON THE YIELD OF OKRA

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ABSTRACT

Four experiments were conducted with okra to determine the effect of rates and ratios of N, P, and K on the marketable yields. Treatment responses evaluated were the linear, quadratic and linear 2-factor interaction effects. The linear effect of N had the most significant effect on increasing yields. Significant linear yield increases were obtained for P in one experiment and for K in three experiments. The linear 2-factor interactions were small and in most cases not significant at the 5 percent probability level.

The N, P, and K rates which were associated with the highest yield varied with each experiment. In all cases a fertilizer ratio of 1-1.3-1.3 (N-P_2O_5-K_2O) resulted in the highest yield of marketable okra.

INTRODUCTION

The fertility requirements for okra in regard to N, P, and K rates and ratios have not been extensively studied. Hester and Sheldon (1) reported that a combined weight of 11.5 tons of pods, leaves and stems of okra contained 21, 10, 62 and 46 pounds of N, P_2O_5, K_2O and CaO, respectively. This indicates that okra may not respond to as high a rate of N, P and K as some other vegetable crops, such as tomatoes.

In a study conducted by Sutton (2) okra yield increases were obtained from N, P and K applications. Although yield increases were obtained, the hghest rate of 93, 52 and 100 pounds per acre of N, P and K did not significantly increase yields over lower rates. To further study the effects of rates and ratios of N, P and K on the yield of marketable okra, four experiments were conducted.

EXPERIMENTAL METHODS

Four experiments were conducted at the Strawberry and Vegetable Field Laboratory on Scranton fine sand which had been previously cropped. Soil samples 0-6 inches in depth were taken August 30, 1963, April 6, 1964, August 31, 1964 and March 23, 1965 from each replication. The soil test results listed in Table 1 represent the average of three replications. The P, K and Ca were extracted with ammonium acetate buffered at pH 4.8. The experimental areas were fumigated in the row with VPM prior to planting. Also the experimental area for the fall of 1963 had D-D applied in the row.

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[1]Strawberry and Vegetable Field Laboratory, Dover.