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SET PLENTY OF PLANTS TO SECURE GOOD YIELDS

There is evidently a difference in the response of sweetpotatoes to spacing on soils of different fertility levels or in connection with different rates of fertilizer application. There is also some evidence that there is a relationship between the date of planting and the spacing, and the Mississippi Station has experiments under way which compare, with Porto Rico and Triumph, six different spacings planted at five different times from early April to late June.

In Mississippi Farm Research for January 1941 the fertilizer recommendations for use with sweetpotatoes in the various regions of the state were given as follows:

Delta Area: Nitrogen only, 24 to 36 pounds to the acre of actual nitrogen.

Hill Soils: 6-8-4 or 6-8-8, 800 to 1000 pounds to the acre.

Upland Valley Soils: 4-8-8, 500 to 600 pounds to the acre.

If growers make these recommended fertilizer applications and plant the crop of Porto Rico potatoes between May 15 to June 15, the plants should be spaced approximately 12 inches apart in rows having a width from 3 to 4 feet, depending on the convenience to the grower. Earlier plantings may be spaced wider, if the grower can make good use of over-size potatoes. If planted later, they may be spaced as close as 8 inches.

In growing the Triumph in the starch factory area in South Mississippi, the available information indicates that spacings from 12 to 18 inches are equally profitable, considering the plants worth one dollar a thousand and assuming machine planting. If plants are plentiful and therefore cheap, and if facilities are available for machine transplanting and applying fertilizer at the same operation, the grower can well afford to space closer than 18 inches.

Growers should consider the fertility of their land, its water holding capacity, and whether the crop will suffer from weed competition, in deciding upon a spacing practice.

In many cases the total yield of Triumph sweetpotatoes is limited by unfavorable weather conditions. Especially is this true when the planting is done as late as June 15, because not enough of favorable growing season remains to allow for a good production of roots. In these instances each plant makes only a small weight of potatoes, regardless of the spacing, and the more plants one has the higher will be his yield.

One of the best practices to insure good yields, therefore, is to set plenty of plants. They should be set so that they will live and grow off fast, and each one will produce a good crop of roots.

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The influence of the planting distances of sweetpotatoes on the yield and grade of the crop is of great economic importance. The grower wants to obtain a high total yield in some instances, but in most instances the highest possible yield of U. S. No. 1 or market size sweetpotatoes is the objective. In general, the No. 2 grade may also be considered as marketable, although bringing a lower price than the No. 1. The grower also wishes to obtain this highest yield of marketable sweetpotatoes at the lowest unit cost.

The propagation of sweetpotatoes requires painstaking care, much planning, and detailed attention from the day the old crop is harvested until the new crop is set in the field. At best the setting out of a field of sweetpotatoes is a tedious, laborious, and expensive task. These facts cause a tendency for the growers to set fewer plants to the space allotted for growing sweetpotatoes, that is, to practice wide spacing of plants. Moreover, any reduction in the plant requirements means smaller needed supplies of seed stock, requiring less storage space and less propagation bed space.

Determining the most profitable spacing of sweetpotatoes must therefore involve several factors. With starch sweetpotatoes, such as the Triumph, where the unit price is the same regardless of grade, only the total yield and cost are important; but even in this instance, close spacing requires more plants and more work in setting, and the calculation should show whether such extra expense is justified in the profit column.

Table-stock sweetpotatoes, of which the Porto Rico is perhaps the leading variety in Mississippi, are marketed almost without exception on grade. Number 1 grade sweetpotatoes sell at a much higher price per pound or per bushel than number 2 grade, while Jumbos and Culls are unmarketable or nearly so. The objective, therefore, is to produce the maximum quantity of the marketable grades and the minimum quantity of the unmarketable grades. In view of the importance thus attached to the grade of the crop produced, determination of the most profitable rate of spacing becomes more complicated than in the case of starch potatoes marketed from the field ungraded and without storage or package. The yield of marketable grades, rather than total yield, is of chief importance for comparison with costs. Costs incurred after the potatoes are harvested—grading, curing, storage, packages—must be considered in addition to cost of plants, land preparation, setting, culture, harvesting, and delivery to market. Only when all these factors are considered can profit—the final measure of any farm practice—be determined in sweetpotato spacing experiments. Only such complete information can accurately guide farmers in their planting operations.

SWEETPOTATO SPACING STUDIES IN THE SOUTH

Considerable experimental work has been done in the various southeastern states with spacing sweetpotatoes. The results of those experiments are briefly reviewed in the following paragraphs. The recommendations on plant spacing for these states are also summarized.

Influence of Spacing on Grade

Beattie, Boswell and Hall (2), from experiments conducted over a period of 3 years in South Carolina, concluded that spacings of 6, 9, 12, and 15 inches between plants of the Porto Rico sweetpotato in 4-foot rows showed that the closer spacings decreased the proportion and yield of jumbo size roots and that the 6-inch spacings increased the proportion and yield of the Number 2 size over the 9-, 12-, and 15-inch spacings. They found that these spacings did not appreciably affect the proportion or yield of Number 1 or the total yield. Because of this lack of increase in the marketable grades and the additional requirements in plants and labor for closer spacings, they recommended 12 or 15 inches for spacing in the row for South Carolina conditions.

Woodward (10) conducted tests for 6 years on sandy soils at Tifton, Georgia, with the Porto Rico variety spaced by 4-inch differences from 4 to 28 inches in rows 3½ feet apart. A uniform fertilizer treatment was given to all spacings. He concluded that the yield of Number 1 potatoes varied very little, although the total yields were considerably higher from the closer spacings, the greater yield resulting from a greater amount of Number 2 grade and strings which were obtained from the closer spacings.

Uniform Fertilizer Application

In a supplementary test Woodward applied fertilizer so that, regardless of the spacing, each plant received the same amount of fertilizer, that is; when 800 lbs. were applied to a 16-inch spacing, 1600 lbs. would be applied to 8-inch spacing. In a 4-year average the data he obtained show that the yield of Number 1 and total yield gradually increased as the spacing decreased from 28 to 4 inches, with the yield being about 3 times as great on the 4- as the 28-inch spacing. He concluded, however, that the most conservative spacing of plants was 12 inches, taking into consideration the cost of plants and fertilizer and the returns from the Number 1 sweetpotatoes.

Miller and Kimbrough (6) found in experiments with 9-, 12-, 15-, 18-, and 21-inch spacings at Louisiana State University that a greater yield of over-size roots was obtained from wider spacings on the more fertile soils. They obtained higher total yields and higher Number 1 yields from the 12-inch spacing. The 9-, 12-, and 15-inch spacings produced about the same yield of Number 2, which exceeded slightly the yield of Number 2 from the wider spacings. The soil used in their experiments was very fertile, producing nearly 400 bushels of Number 1 grade sweetpotatoes. Apparently, under the conditions of those experiments, the effect of wider spacing was to make Number 1 grade out of some of the Number 2's and to make jumbos out of some of the Number 1's, as well as to reduce the total yield and No. 1 yield. They recommend a 12-inch spacing for June 1 planting on Louisiana soils.

Zimmerley (11), working with the Porto Rico variety planted on a Sassafras loam soil at Norfolk, Virginia, compared 10-, 14-, 18- and 22-inch spacings and found that in general the closest spacings gave the highest yields of marketable and total grades. The yields from the 10-inch were not significantly greater than those from the 14-inch, but the yields from both of these were greater than from the wider spacings.

The Alabama station (9) has conducted tests of plant spacing and fertilizer rate combinations in the southern part of that state for several years. For the early harvested (August) crop of the Triumph variety they recommend an 18-inch planting distance with 800 pounds to the acre of a 4-10-7 fertilizer mixture for best results.

The North Carolina station (8) has concluded that for that state the grower

of Porto Rico sweetpotatoes for market should space the plants 12 inches in rows 3½ feet apart. The recommendation is the result of data obtained in a 2-year test of 8-, 10-, 12-, 15-, and 18-inch spacings and a 4-year test of 12-, 18-, and 24-inch spacings.

South Carolina (5) growers are given the recommendation to plant Porto Rico 10 or 12 inches apart in rows 3½ to 4 feet apart for best yields of Number 1 potatoes.

The Arkansas station (3) recommends that the earlier the planting the closer must be the spacing to avoid jumbo grade production, and advises a 12-inch spacing for early planting with not more than 15 inches for medium season planting.

Spacing Work With Nancy Halls

At the West Tennessee Experiment Station (4) tests for the period of 1926-1931 with Nancy Hall planted at 6-, 12-, 18-, and 24-inch spacings in 3-foot rows at approximately 3-week intervals from the first week of May to the first week of July, showed that 6 inches was not too close on fertile soil. At all the dates of setting, the 6-inch and 12-inch spacings made decidedly greater total yields than the wider spacings, but the 18-inch was not much better than the 24-inch. In 1931 the crop was graded into "eating" potatoes and "seed" potatoes, and the greatest yield of the "eating" grade was found on the 18-inch and 24-inch spaced plots, at all planting dates.

Published Results in Mississippi

Realizing the importance of spacing sweetpotato plants in the production of this crop, the Mississippi Station has conducted tests of different spacings at several locations in the state for many years. The results of the earlier experiments have been published but they are reviewed briefly below.

At the Holly Springs Branch Station (1) 7-, 14-, and 21-inch spacings were compared for the Nancy Hall variety in 1923 and 1925 and for the Porto Rico in 1926. The results show that from 20 to 30 bushels were added to the total yield by each 7-inch reduction in space between hills in the row, in all years and with both varieties. It was concluded, that, taking into consideration the extra cost of plants and setting, the fourteen-inch spacing gave the most economical yield.

From 1925 to 1929 Price (7) planted Nancy Hall sweetpotatoes at State College at 10-, 15-, 20-, 25-, 30-, and 35-inch distances in the row and graded the yield into "marketable" and "unmarketable" roots. His results show that the closer the spacing up to 20 inches the higher the yield of marketable potatoes. The 10-inch spacing made a 5-year average of 40 bushels more than did the 15-inch spacing and 48 bushels more than did the 20-inch spacing. The wider distances about equaled each other in yield. Price weighed representative potatoes from the various spacings and found that there was an average increase in the weight of the potatoes of nearly one-tenth of a pound for each increase of 5 inches in planting distance.

MISSISSIPPI TESTS OF A TABLE VARIETY

During 1938, 1939, and 1940 experiments have been conducted at several Branch Experiment Stations in Mississippi with different plant spacings and different rates of fertilizer. The experiments fall into two general divisions: tests of a table variety, in which results are interpreted in terms of marketable grades; and tests of a starch or feed variety, in which results are interpreted in terms of total yields.

Porto Rico Variety Used

The Porto Rico, a table variety of good quality and high yield now widely plant-

TABLE 1.—SCHEDULE OF COSTS TO THE ACRE OF PLANTING AND CULTIVATING SWEETPOTATOES USING DIFFERENT RATES OF 4-8-4 AND DIFFERENT PLANT SPACINGS

Rate of 4-8-4, lbs. to the acre	Plant Spacing in row, inches	Fertilizer	Plants	Plowing, and preparing	Planting, fertilizer application	Two hoe-ings, three cutivations	Total fixed costs
500	9	$ 4.81	$16.60	$4.12	$6.47	$5.50	$37.50
500	12	4.81	12.45	4.12	4.91	5.50	31.79
500	18	4.81	8.30	4.12	3.36	5.50	26.09
1000	9	9.62	16.60	4.12	6.72	5.50	42.56
1000	12	9.62	12.45	4.12	5.16	5.50	36.85
1000	18	9.62	8.30	4.12	3.61	5.50	31.15
1500	9	14.43	16.60	4.12	6.97	5.50	47.62
1500	12	14.43	12.45	4.12	5.41	5.50	41.91
1500	18	14.43	8.30	4.12	3.86	5.50	36.21

ed in Mississippi, has been used in the first phase of the work. Throughout the experiments, planting and harvesting have been done at the time which represents the local practice for the particular area of the state. A 4-8-4 fertilizer mixture was applied in these experiments at the Holly Springs, Natchez, and Poplarville Branch Stations, at the rates of 500, 1000, and 1500 pounds to the acre; and on each of these fertilizer rates, plants were spaced 9, 12, and 18 inches apart in 42-inch rows. At the Delta Station previous experiments had shown that nitrogen fertilizer alone was the best application for sweetpotatoes, so that, in these tests ammonium sulfate alone was applied at the rates of 100 and 200 pounds to the acre with plants being spaced 9, 12, and 18 inches apart in 42-inch rows on each rate of fertilizer and on plots which received no fertilizer.

In these experiments all of the fertilizer for the various rates was applied several days before planting, and it was thoroughly mixed with the soil within the ridge as the latter was being prepared. The ridge method of culture was followed throughout. Harvesting was accomplished by plowing out the rows, assorting the potatoes into U. S. grades according to size, and weighing them immediately in the field.

Net Profits Interpretation

Since it is largely the net profit that growers are interested in, an effort has been made to present the data from these tests in such a way as to reveal the profits that can reasonably be expected from the various treatments. The costs involved in connection with different plant spacing and fertilizer rate practices vary greatly, and are detailed in tables which follow.

The value of the number 1 plus number 2 grades of Porto Ricos produced in these experiments has been considered as 80 cents for 60 pounds of freshly harvested potatoes. This was the average price of sweetpotatoes in Mississippi for the 10-year period of 1929 to 1938, according to U. S. census reports. In general, 60 pounds of freshly harvested sweetpotatoes will be required for marketing a standard crate from storage. The costs deducted from this crop value in computing the net profits are shown in table 1 for all of the experiments conducted at hill stations, and in table 5 for those at the Delta branch station.

Schedule of Production Costs

The fertilizer cost assumes home mixing of nitrate of soda, superphosphate, and muriate of potash, and its application with a machine simultaneously with plant transplanting. This is thought to be the cheapest method of fertilizer ap-

TABLE 2.—INFLUENCE OF PLANT SPACING ON TOTAL YIELD OF PORTO RICO SWEETPOTATOES — HOLLY SPRINGS

Pounds 4-8-4 to the acre,	Plant spacing in row, inches	Total yield, bu. (60 lbs.) to the acre
500	9	200
500	12	187
500	18	200
1000	9	230
1000	12	231
1000	18	218
1500	9	212
1500	12	214
1500	18	191

plication. Plants have been charged at one dollar a thousand, and planted with tractor-drawn standard transplanting machines. It is doubtful whether the estimate of transplanting costs for close spacing can be applied to mule drawn machines because teams usually do not travel slow enough for close planting. The cost of transplanting by machine may not vary greatly from the cost of transplanting by hand where the planted area is relatively small. The cost estimates for labor and power of plowing, preparing, hoeing and cultivating are based on standard good farm practice in the southeastern states.

In addition to the costs of producing the crop, scheduled in tables 1 and 5, are other costs. The cost of harvesting the crop has been figured at 4½ cents a bushel, and includes the plowing out, picking up by hand, roughly assorting the grades, and placing into some convenient style of field crates. A cost of 25 cents a bushel has been included to cover curing, storing, final grading, packing, crates, and hauling to market.

Experiments at Holly Springs

The soil used for these experiments at the Holly Springs branch station is classified as Grenada silt loam, one of the Brown loam soils, regarded as well adapted to sweetpotatoes. Only one year's results are available from recent work at that Station, and the data are presented in table 2. These data show that the greatest total yield was obtained from moderately close spacing in combination with moderately high fertilization. The potatoes were not graded and for that reason no attempt has been made to estimate the net profits from the various treatments.

With the application of 500 pounds of 4-8-4 fertilizer, the 9-inch and 18-inch spacings each yielded 200 bushels per acre. The highest yield in the test was from the 12-inch spacing and 1000 pounds of fertilizer, 231 bushels per acre. At the 1000-pound rate of fertilization, the 9-inch spacing yielded 230 bushels, and the 18-inch spacing yielded 218 bushels. Increasing the fertilizer to 1500 pounds per acre resulted in yields from all spacings lower than from the 1000 rate, and only slightly higher than from the 500-pound rate of fertilization.

Experiments at Natchez

The soil on which these experiments were planted at the Natchez station is also Grenada silt loam, and the plots in 1938 and 1939 were on a fertile area. Weather conditions were favorable for sweetpotato production, and high yields were obtained.*

The data in table 3 show that the total yield was increased as the spacing de-

*Planting, cultivating, and harvesting of the plots were under the supervision of S. J. Greer and W. T. Mallory in 1938, and S. P. Crockett and W. T. Mallory in 1939.

TABLE 3.—INFLUENCE OF PLANT SPACING ON PROFIT FROM PORTO RICO SWEETPOTATOES — NATCHEZ

Rate of 4-8-4, lbs. to the acre	Plant spacing in row, inches	1938			1939		
		60 lb. bu. to the acre		Net profit, dollars to the acre	60 lb. bu. to the acre		Net profit dollars to the acre
		Total	No. 1 & 2		Total	No. 1 & 2	
500	9	418	329	129.47	328	300	114.75
500	12	365	279	109.80	371	293	116.91
500	18	357	253	102.31	270	235	93.17
1000	9	361	269	93.96	377	293	106.14
1000	12	390	294	112.35	352	288	109.31
1000	18	419	322	132.27	337	300	121.10
1500	9	424	335	122.39	403	223	65.55
1500	12	331	254	87.00	401	303	111.86
1500	18	396	291	111.47	373	304	118.07

creased for each rate of fertilizer, with one exception in each of the years covered by the tests. The higher rates of fertilizer gave slightly higher total yields. In the yield of No. 1 plus No. 2 grades there was little difference between the higher and lower fertilizer rates, but at the 500-pound rate of fertilization, close spacing seemed to make an increased amount of marketable grades. The data show that the greatest net profit usually came from those treatments giving the highest yield of marketable (1 and 2) grades. The low rate of fertilizer and wide spacing gave, in general, the lowest profit.

The highest acre profit in 1938 was $132.27, and in 1939 $121.10. Both came from plots spaced 18 inches and fertilized with 1000 pounds of fertilizer. These profits did not differ greatly from profits in other treatments. It was only $2.80 more than the profit from 9-inch spacing and 500 pounds of fertilizer in 1938, and it was only $4.19 more than the profit from 12-inch spacing and 500 pounds of fertliizer in 1939.

Experiments at Poplarville

The soil on which these experiments were planted at the South Mississippi station at Poplarville is Ruston fine sandy loam, one of the Long Leaf Pine soils of low fertility, but usually considered to be adapted to the growing of good quality sweetpotatoes. The yields obtained there in 1939 and 1940 were very low, explainable at least in part by

TABLE 4.—INFLUENCE OF PLANT SPACING ON PROFIT FROM PORTO RICO SWEETPOTATOES — POPLARVILLE

Rate of 4-8-4, lbs. to the acre	Plant Spacing in row, inches	1939			1940		
		60 lb. bu. to the acre		Net profit, dollars to the acre	60 lb. bu. to the acre		Net profit dollars to the acre
		Total	No. 1 & 2		Total	No. 1 & 2	
500	9	104	53	—10.60	138	112	19.34
500	12	88	46	— 8.45	97	85	11.35
500	18	98	46	— 2.75	80	57	2.84
1000	9	133	61	—11.60	154	122	19.35
1000	12	152	66	— 3.36	122	89	8.32
1000	18	117	44	— 8.82	132	93	16.05
1500	9	190	90	— 1.95	126	90	— 1.95
1500	12	162	74	— 4.36	177	115	16.45
1500	18	150	68	— 1.70	129	87	7.94

Minus symbol (—) indicates loss.

TABLE 5.—SCHEDULE OF COSTS TO THE ACRE OF PLANTING AND CULTIVATING SWEETPOTATOES USING DIFFERENT RATES OF AMMONIUM SULPHATE AND DIFFERENT PLANT SPACINGS

Pounds Ammonium Sulphate to the acre	Plant Spacing in row, inches	Fertilizer	Plants	Plowing and preparing	Planting, fertilizer application	Two hoe-ings, three cultivations	Total fixed costs
100	9	$1.60	$16.60	$4.12	$6.47	$5.50	$34.29
100	12	1.60	12.45	4.12	4.91	5.50	28.58
100	18	1.60	8.30	4.12	3.36	5.50	22.88
200	9	3.20	16.60	4.12	6.72	5.50	36.14
200	12	3.20	12.45	4.12	5.16	5.50	30.43
200	18	3.20	8.30	4.12	3.61	5.50	24.73
None	9	0	16.60	4.12	6.22	5.50	32.44
None	12	0	12.45	4.12	4.66	5.50	26.71
None	18	0	8.30	4.12	3.11	5.50	21.03

the fact that in neither of these years was the rainfall favorable for sweetpotatoes.

The results in table 4 show, in the first place, that the low yields obtained prevented any net profit in 1939 and in one case in 1940. They show also that higher total and marketable yields were obtained from the closer spacings at all rates of fertilizer in 1939, and at the 500- and 1000-pound rates in 1940. In 1940 net profits from the 12-inch spacing exceeded profits from the 9- and 18-inch spacings at the 1500-pound fertilizer rate. The highest profits in 1940 and the lowest losses in 1939 came from those treatments which gave the highest yields of No. 1 plus No. 2 grades.

From the standpoint of profit, by a narrow margin, the best treatment in 1940 was the 9-inch spacing in conjunction with 1000 pounds fertilizer. This treatment yielded a net profit of $19.35. However, the 9-inch spacing with 500 pounds of fertilizer yielded a profit smaller by only 1 cent per acre. The 12-inch spacing was most profitable at the 1500-pound rate of fertilizer application, but was $2.90 less than from 9-inch spacing with 1000 pounds of fertilizer, and $2.89 less than the profit from 9-inch spacing with 500 pounds of fertilizer.

These data indicate that a total yield of more than 150 bushels per acre must be harvested before a profit can be made from the production of sweetpotatoes.

Experiments at Stoneville

The soil at the Delta station on which these experiments were planted is a very fertile soil classified as Sarpie loam and is well adapted to the growing of sweetpotatoes. High yields of sweetpotatoes are frequently made on this soil, fertilized with nitrogen only, or unfertilized. In the spacing experiment conducted at Stoneville in 1939 and 1940 only ammonium sulphate was applied to the three plant spacings, and in one series of similar plant spacings no fertilizer was applied. In terms of actual nitrogen, the 100-pound treatment contained 20 pounds of nitrogen and the 200-pound treatment contained 40 pounds of nitrogen.

The cost schedule used in calculating the results to the net profit basis are shown in table 5. The cost of the nitrogen in ammonium sulphate has been figured at 8 cents a pound for the actual nitrogen.

The results at the Delta station, presented in table 6 show that for 1939, not only the greatest total yield, but also the largest No. 1 plus No. 2 yield, and the highest net profit, resulted from 9-inch spacing without fertilizer. At the various fertilizer rates, the closer the plants were spaced, the greater was the

TABLE 6.—INFLUENCE OF PLANT SPACING ON PROFIT FROM PORTO RICO SWEETPOTATOES — STONEVILLE

Rate of ammonium sulphate, lbs. to the acre	Plant spacing in row, inches	1939			1940		
		60 lb. bu. to the acre		Net profit, dollars to the acre	60 lb. bu. to the acre		Net profit, dollars to the acre
		Total	No. 1 & 2		Total	No. 1 & 2	
100	9	326	256	95.38	216	183	58.33
100	12	307	220	83.82	212	177	62.00
100	18	262	178	67.20	198	144	49.91
200	9	254	182	56.23	249	205	67.90
200	12	252	179	61.41	242	195	69.53
200	18	251	153	52.92	239	173	63.07
None	9	363	270	104.58	198	161	49.27
None	12	321	255	103.68	191	155	52.93
None	18	302	204	82.50	147	117	38.35

total and the marketable yield. In 1940 the total and marketable yields were considerably lower than in 1939, due probably to the influence of weather conditions. With these lower yields in 1940, the greatest net profit resulted from 200 pounds ammonium sulphate with 12-inch spacing. Results from this treatment were practically the same in net profit, however, as the 200-pound and 9-inch treatment.

The 1939 top profit of $104.58 secured from 9-inch spacing and no fertilizer, only slightly exceeded the profit of $103.68 from 12-inch spacing and no fertilizer. Of the fertilized plots in 1939, the 100-pound fertilizer treatment was less profitable than no fertilizer, but more profitable than the 200-pound treatment. The reverse was true in 1940, when the unfertilized plots as a group were least profitable, the 100-pound treatment next, and the 200-pound treatment was most profitable. Highest profit in 1940, $69.53, was from 12-inch spacing with 200 pounds ammonium sulphate, followed in order by $67.90 profit from 9-inch spacing with 200-pounds fertilizer, $63.00 from 18-inch spacing with 200 pounds fertilizer, and $62.00 profit from 12-inch spacing and 100 pounds ammonium sulphate.

HIGH YIELDS MARKET GRADES FOR PORTO RICO PROFIT

Importance of Grades

Because of the lack of sale value and the low use value of the jumbo and cull (strings) grades, it is important for the grower to know how many bushels of these grades it is necessary for him to harvest and handle under any field treatment in order to get a given amount of marketable product. Data are presented in table 7 which show the distribution of these grades from the plots in 1939 at the Natchez, Poplarville and Delta stations. In 1940, the No. 1 and No. 2 grades were separated at the Delta and Poplarville stations, and the data are presented in table 8.

A drought during the growing period at Natchez in 1939 prevented the production of jumbo size roots, but there was a greater production of cull size there than was obtained at any other station or in any other year. The treatments had little effect upon the amount of cull size roots. At the Poplarville and Delta stations, more bushels of jumbo size were produced as the rate of fertilizer rate was increased, on all spacings. At neither station did the treatments have any appreciable effect upon the yield of culls. At the Delta station that year

TABLE 7.—DISTRIBUTION OF GRADES OF PORTO RICO SWEET POTATOES IN 1939 FROM THREE PLANT SPACINGS AND VARIOUS FERTILIZER TREATMENTS

Rate of 4-8-4 lbs. to the acre	Plant spacing in row, inches	Bushels (60 lbs.) to the acre of grades shown		
		Jumbos	Nos. 1 & 2	Culls
	Natchez Branch Station, Natchez			
500	9	0	271	57
500	12	0	308	63
500	18	0	217	53
1000	9	0	317	60
1000	12	0	283	69
1000	18	0	278	59
1500	9	0	336	67
1500	12	0	352	49
1500	18	0	317	56
	South Mississippi Branch Station, Poplarville			
500	9	21	53	30
500	12	21	46	21
500	18	26	46	26
1000	9	40	61	32
1000	12	50	66	36
1000	18	48	44	25
1500	9	67	90	23
1500	12	62	74	26
1500	18	52	68	30
Lbs. ammonium sulphate to the acre	Delta Branch Station, Stoneville			
100	9	38	256	20
100	12	66	220	20
100	18	64	178	20
200	9	46	182	26
200	12	52	179	21
200	18	77	153	21
None	9	62	270	31
None	12	41	255	25
None	18	77	204	21

there was an increased yield of jumbo size as the spacing increased.

In table 8 it is shown that at Stoneville the lower yields in 1940 resulted in a very low yield of the jumbo size, as well as a greatly reduced yield of the No. 1 size. More jumbo size roots also were produced with the higher rate of fertilizer and wider spacing. The highest yield of No. 1 grade, which commands the highest obtainable price when separated from No. 2, was obtained under 1940 conditions at the Delta from 12-inch spacing and 200 pounds of sulphate of ammonia. (table 6) On the plots not fertilized there were as high yields of No. 2 as of No. 1 grade. The No. 2 grade was about the same for all treatments, the variation in yields among plots being in the jumbo and No. 1 sizes.

At Poplarville in 1940 the various fertilizer treatments and plant spacings were practically alike in yield of No. 2 and cull grades. The 1000- and 1500-pound fertilizer rates made significantly more jumbos than the 500-pound rate. Also, the wider the spacing on these rates the more jumbos were produced.

TABLE 8.—DISTRIBUTION OF GRADES OF PORTO RICO SWEETPOTATOES IN 1940 FROM THREE PLANT SPACINGS AND VARIOUS FERTILIZER TREATMENTS

Lbs. Ammonium sulphate to acre	Plant spacing in row, inches	Bushels (60 lbs.) to the acre of U. S. grades			
		Jumbo	No. 1	No. 2	Culls
Delta Branch Station, Stoneville					
100	9	1	110	73	32
100	12	9	108	69	26
100	18	35	75	69	19
200	9	19	127	78	24
200	12	22	108	87	26
200	18	42	97	76	24
None	9	9	76	85	28
None	12	11	69	86	25
None	18	8	60	57	22
Lbs. to the acre, 4-8-4	South Mississippi Branch Station, Poplarville				
500	9	9	89	23	16
500	12	0	56	22	19
500	18	0	41	16	23
1000	9	10	97	25	22
1000	12	19	56	23	24
1000	18	26	68	24	18
1500	9	12	53	28	24
1500	12	36	104	19	18
1500	18	20	62	24	21

Except at the 1500-pound rate of fertilization, the 9-inch spacing made very much greater yields of No. 1 size. The most profitable treatment (table 4) was 9-inch spacing and 1000 pounds fertilizer.

STARCH POTATO TESTS IN THE LAUREL AREA

The production of sweetpotatoes for manufacture into starch is a new but important and increasing agricultural industry in Mississippi.

The nation's first sweetpotato starch factory was established at Laurel in 1934 by the Federal Emergency Relief Administration, to supply work to unemployed and an additional cash crop to low-income farmers. It has since been operated as a grower-owned cooperative, sponsored by the Farm Security Administration and the Agricultural Adjustment Administration. It received 265,000 bushels of sweetpotatoes in 1939, from which was manufactured 2,700,000 pounds of starch. Production was somewhat less in 1940, due to unfavorable weather conditions which greatly reduced yields, but the planted acreage is greatly increased in 1941. Considerable interest is being manifested not only in the use of sweetpotatoes for starch manufacture in additional areas, but also in processes of dehydration and use of the dehydrated product as a carbohydrate equivalent to corn in livestock feeding.

Sweetpotato of High Potential Value

The sweetpotato undoubtedly ranks high among the potentially valuable Southern farm crops. Yields secured under average good management in the Laurel area almost double the average for the state as a whole; and yields of 150 bushels to 200 bushels per acre means, roughly, the equivalent of a ton of starch per acre, or dehydrated sweetpotato meal equivalent to about 50 bushels of corn per acre. The sweet-

potato crop is laborious, and therefore expensive, to produce and harvest, however; and high yields and minimum-for-efficiency costs are necessary for growers to profit.

In view of the present and potential importance of sweetpotatoes for industrial usage, the Mississippi Agricultural Experiment Station in cooperation with the Bureaus of Plant Industry and of Agricultural Chemistry and Engineering USDA, has engaged in a rather complete field of research since the beginning of the industry in the Laurel area. These experiments have been concerned with varieties, plant production, fertilization, plant setting and spacing, culture, harvesting, storage, and product and by-product processes and utilization.

This report presents and summarizes data secured with reference to the spacing of plants in the row, together with certain general information on fertilization, plant setting, and production costs which are necessary for the factual interpretation of results.

Triumph Variety Used

The Triumph has long been grown in the South, is well adapted to Southern conditions, and is generally known as one of the highest yielding sweetpotato varieties. Southern tastes show decided preference to the moist, yellow varieties such as Porto Rico and Nancy Hall; and since the Triumph is a dry, white variety, it is not in favor as table stock in the South. The Triumph is grown in considerable quantities for table use, however, particularly in southern portions of Alabama, where a very large acreage is planted for early shipment to Northern markets.

The Triumph, under Mississippi conditions, combines high yield with high starch content; hence it has long been used on Southern farms as stock feed; and with the establishment of the starch factory at Laurel, the Triumph was adopted as the standard variety for starch-making purposes.

The production of Triumph sweetpotatoes for starch, or for dehydration, or for feeding to livestock, is essentially similar to the production of table varieties such as the Porto Rico. There are certain differences, however.

Net Profits Interpretation

High total yield at minimum unit cost is the objective in starch sweetpotato production. Market grades, though extremely important in the production of table varieties, are of little or no importance with starch sweetpotatoes, which are sold "field run" at a given price per bushel or per ton; that is, the price is the same for all the sweetpotatoes whether large or small, or whether smooth or irregular in shape. In fact, a large production of jumbos seem desirable, for a given weight of large potatoes is easier, hence less expensive, to harvest.

Earlier planting of the Triumph than of the table varieties seems desirable, since earlier planting usually means higher total yield.

Machine transplanting is apparently a necessity in starch sweetpotato production, because the acreage is relatively large on farms where grown, and because planting time is the labor peak in sweetpotato production. Mechanical transplanting not only enables a given number of workers to set a larger acreage in a day, but they also supply a small quantity of water to each plant set and so make the planting of the crop less dependent on local moisture conditions. These advantages apply also to sweetpotatoes to be used for table stock, but possibly to a slightly less urgent degree.

Transplanters have not been used for sweetpotatoes in the South to any considerable extent until recently, and are rapidly being improved and adapted to

TABLE 9.—SCHEDULE OF COSTS TO THE ACRE OF PLANTING AND CULTIVATING SWEETPOTATOES AT VARIOUS SPACINGS IN THE ROW AND WITH 1000 LBS. TO THE ACRE OF 6-8-6 FERTILIZER

Spacing in row, inches	Fertilizer and application	Plants	Trans-planting	Preparation, two hoeings, three culti-vations	Total fixed costs
6	$13.10	$24.90	$9.33	$9.62	$56.95
9	13.10	16.60	6.22	9.62	45.54
12	13.10	12.45	4.66	9.62	39.83
15	13.10	9.96	3.73	9.62	36.41
18	13.10	8.30	3.11	9.62	34.13
21	13.10	7.11	2.66	9.62	32.49
24	13.10	6.23	2.33	9.62	31.28

the crop. On this account, not enough data have been collected for an exact comparison of costs of transplanting by machine with cost of transplanting by hand. It appears at present that transplanting by machine is somewhat less expensive per acre than by hand, but the difference is not great. It is believed that as transplanting machines are better adapted and their operation is better understood, the expense of transplanting an acre by machine will be much less than by hand; but in the meanwhile the transplanting cost data shown in tables 1, 5, 9, and 12 may be of some practical use to the grower for comparison with his own costs, whether by machine or by hand.

In cooperation with the member-growers of the cooperative sweetpotato starch factory at Laurel, the Mississippi Station has carried on various spacing experiments during the years 1937, 1938, 1939, and 1940, using the Triumph variety. The experiments have been conducted on different fields and on different farms from year to year. This has served the purpose of quickly acquiring desired information on several principal types and grades of soil, and has enabled local growers to see and immediately profit by results secured. On the other hand, the fact that each of the tests was not located on one plot throughout the experimental period, prevents the averaging of results. Sprouts were used throughout those experiments and practically perfect stands were obtained on each plot.

In computing the profit from tested treatments, the value of the crop was assumed to be 30 cents a bushel, which is the amount paid for "field run" potatoes at the starch factory. The cost schedule (table 9) includes cost of producing the crop; to this is added an estimated cost for harvesting and hauling to the factory, at 8¼ cents per bushel.

Two Series of Experiments

The spacing experiments were in two series: one series in which plants were spaced different distances in the row, but in which all plots received uniform applications at the rate of 1000 pounds of 6-8-6 fertilizer per acre; in the other series, three plant spacings and three rates of 4-8-4 fertilizer were employed.

Spacing Starch Sweetpotatoes With Uniform Application Of Fertilizer

In the uniformily fertilized spacing test, plants were spaced at row intervals of 6, 9, 12, 15, and 18 inches, in 1937 and 1939. In 1940, plants were spaced at these intervals and also at 21- and 24-inch intervals. Rows were 42 inches wide. All plots received 1000 pounds to the acre of 6-8-6 fertilizer mixture, applied before setting the plants.

TABLE 10.—INFLUENCE OF PLANT SPACING ON PROFIT FROM TRIUMPH SWEETPOTATOES, 1000 POUNDS 6-8-6 TO THE ACRE — LAUREL

Plant spacing in row, inches	1937		1939		1940	
	60 lb. bu. to the acre	Net profit, dollars to the acre	60 lb. bu. to the acre	Net profit, dollars to the acre	60 lb. bu. to the acre	Net profit, dollars to the acre
6	294	6.99	352	19.61	342	17.61
9	188	—4.65	341	28.63	313	22.29
12	166	—3.75	307	26.94	329	30.88
15	171	0.78	283	25.14	303	29.49
18	167	2.19	275	25.68	285	26.79
21*					292	31.09
24*					282	30.09

*These spacings planted in 1940 only.

The tests in 1937 were located on moderately poor Cahaba sandy loam soil, a terrace or "second bottom" soil common to the coastal plains area. They were planted on May 22 and harvested October 8. Due largely to unfavorable weather conditions rather low yields were secured, with the 6-inch spacing yielding 294 bushels, the 12-inch spacing 166 bushels, and the 18-inch spacing yielding 167 bushels to the acre. Details shown in table 10 reveal that the 12-, 15-, and 18-inch spacings resulted in about the same total yield, while the 9-inch and 6-inch spacings gave much greater yields. The 6-inch was the only spacing that gave any worthwhile profit, and the 9- and 12-inch spacings actually gave losses.

Somewhat better yields were secured in 1939, when the test was located on moderately fertile Cahaba sandy loam soil, planted April 26 and harvested October 7. During this year closer spacings gave higher yields, and there was a gradual step-down in yields as the space between the plants was increased. The highest net profit in 1939 was secured from the 9-inch spacing. However, this profit was only $1.69 more than that secured from the 12-inch spacing, and only $2.95 more than that secured from the 18-inch spacing.

The 1940 test was located on fertile Cahaba sandy loam soil, planted June 14 and harvested November 7. In the Laurel area as a whole, weather conditions were quite unfavorable to sweetpotato production in 1940. On the farm on which this test was located rains fell at opportune times late in the season, and as shown in table 10, a good crop was harvested. As in the test of 1939 there was less difference in yield between the close and wide spacings, though the general downward trend of yield was continued as spacing was increased from 6 inches up to 18 inches. 1940 was the only year in which wider than 18-inch spacings were tested, and during this year there was but little difference in total yield between 18-inch, 21-inch, and 24-inch spacings. The highest net profit secured in 1940 was $31.09, from the 21-inch spacing, followed in order by a profit of $30.88, from the 12-inch spacing, and a profit of $30.09, from the 24-inch spacing.

During the three years in which this series of experiments was conducted, the peak in profits in 1937 was $6.99 from 6-inch spacing, in 1939 $28.63 from the 9-inch spacing and $30.88 from the 12-inch spacing in 1940, excluding the 21- and 24-inch spacings because they were tried only one year. In general, it may be observed that the highest yields were obtained from close spacing; but not every decrease in spacing gave a significant increase in yield, and in only one year of the three did the highest yield result in the highest net profit.

TABLE 11.—DISTRIBUTION OF GRADES OF TRIUMPH SWEETPOTATOES, FROM 1000 LBS. 6-8-6 FERTILIZER AND VARIOUS PLANT SPACINGS — LAUREL

Plant spacing in row, inches	Bushels (60 lbs.) to the acre of U. S. grades				
	Jumbo	No. 1	No. 2	Culls	Total
			1937		
6	3	149	72	70	294
9	7	86	45	50	188
12	6	92	36	32	166
15	21	98	26	26	171
18	6	87	37	37	167
			1939		
6	0	171	125	56	352
9	3	181	108	49	341
12	3	167	108	29	307
15	4	156	88	35	283
18	5	162	70	38	275
			1940		
6	0	216	101	25	342
9	0	224	55	24	313
12	2	251	61	15	329
15	13	219	57	14	303
18	7	230	37	11	285
21	15	237	34	6	292
24	13	230	27	12	282

The data in table 11 shows that in these trials the years making the higher total yields on the wider spacings also made the higher yields of over-size or jumbo potatoes. Small yields of jumbos were usually associated with a high production of No. 2 and cull sizes. When high total yields were made by the 6-, 9-, or 12-inch spacings, there was usually a high yield of No. 1 and No. 2 sizes. Grade or size may seem unimportant in starch growing; actually, it is easier and therefore less expensive to harvest relatively large sweetpotatoes than very small ones. Especially is this true if mechanical harvesting is done, because the larger, individually heavier, roots are more easily separated from the strings, vines and soil.

Spacing Starch Sweetpotatoes With Varying Rates Of Fertilizer

In the second series of spacing tests, plants were spaced 9, 12, and 18 inches apart in the drill and fertilizer was used on each of these spacings at the rate of 500, 1000, and 1500 pounds to the acre of a 6-8-4 fertilizer mixture. The schedule of costs at the different rates of fertilizer and different plant spacings is shown in table 12.

In determining profit, the appropriate amount from this schedule of costs, plus a charge of 8¼ cents a bushel for harvesting and handling, was deducted from the values of the total yield at 30 cents a bushel. The results from these fertilizer rate plant-spacing combinations are shown in tables 13 and 14.

In 1938 the tests were conducted on a moderately fertile Orangeburg sandy soil, an upland or hill soil common to the coastal plains area, planted May 5 and harvested October 26.

These data show that with one exception, for each fertilizer rate the greater total yields came from the closer spacing of plants. From the viewpoint of profit, at the 500-pound rate of fertilization the highest net profit came from 9-inch

TABLE 12.—SCHEDULE OF COSTS TO THE ACRE OF PLANTING AND CULTIVATING SWEETPOTATOES USING DIFFERENT RATES OF 6-8-4 AND DIFFERENT PLANT SPACINGS

Pounds 6-8-4 to the acre	Plant spacing in row, inches	Fertilizer	Plants	Plowing, preparing	Planting, fertilizer application	2 hoeings, 3 cultivations	Total fixed costs
500	9	$6.70	$16.60	$4.12	$6.47	$5.50	$39.39
500	12	6.70	12.45	4.12	4.91	5.50	33.68
500	18	6.70	8.30	4.12	3.36	5.50	27.98
1000	9	13.40	16.60	4.12	6.72	5.50	46.34
1000	12	13.40	12.45	4.12	5.16	5.50	40.63
1000	18	13.40	8.30	4.12	3.61	5.50	34.93
1500	9	20.10	16.60	4.12	6.97	5.50	53.29
1500	12	20.10	12.45	4.12	5.41	5.50	47.58
1500	18	20.10	8.30	4.12	3.86	5.50	41.88

spacing; at the 1000-pound rate of fertilization the highest net profit likewise came from the 9-inch spacing; but at the 1500-pound rate the highest net profit came from the 12-inch spacing. Generally, the yield was greater with 1000 pounds of fertilizer per acre but when the rate was increased to 1500 pounds the further increase in production was small. Net profits were highest from 500 pounds fertilizer per acre, next highest from 1000 pounds, and lowest from 1500 pounds. The highest profit for the year, $34.34 from 9-inch spacing and 500 pounds fertilizer, was only slightly more than the profit of $33.70 secured from 9-inch spacing and 1000 pounds fertilizer, and $32.22 from 12-inch spacing and 500 pounds of 6-8-4 fertilizer.

The tests were located in 1940 on a fertile Cahaba fine sandy loam soil, planted May 9 and harvested October 6. As shown in table 13, somewhat lower yields were secured, and as a whole profits were somewhat less. The highest yields were secured from 9-inch spacing and 1500 pounds of 6-8-4 fertilizer. The highest profit, $31.09, was secured from 12-inch spacing and 500 pounds of fertilizer. This was followed in order by a net profit of $28.76 from 18-inch spacing and 500 pounds of fertilizer; and $20.88 from 12-inch spacing and 1000 pounds of fertilizer.

In 1940, as in 1938, more profit was shown from 500 pounds than from 1000 pounds 6-8-4 fertilizer, and least profit was shown from 1500 pounds fertilizer.

In general, it is shown in table 14 that a higher yield of the jumbo size was

TABLE 13.—INFLUENCE OF PLANT SPACING ON PROFIT FROM TRIUMPH SWEETPOTATOES — LAUREL

Rate of 6-8-4, lbs. to the acre	Plant spacing in row, inches	1938		1940	
		60 lb. bu. to the acre	Net profit, dollars to the acre	60 lb. bu. to the acre	Net profit, dollars to the acre
500	9	339	34.34	263	17.93
500	12	303	32.22	289	31.09
500	18	254	27.26	268	28.76
1000	9	368	33.70	297	18.97
1000	12	314	27.66	283	20.88
1000	18	289	27.92	243	18.13
1500	9	329	18.27	304	12.83
1500	12	347	27.89	279	13.21
1500	18	292	21.63	265	16.38

TABLE 14.—DISTRIBUTION OF GRADES OF TRIUMPH SWEETPOTATOES, FROM DIFFERENT RATES OF 6-8-4 AND DIFFERENT PLANT SPACINGS —LAUREL

Rate of 6-8-4, lbs. to the acre	Plant spacing in row, inches	Bushels (60 lbs.) to the acre of U. S. grades				
		Jumbo	No. 1	No. 2	Culls	Total
			1938			
500	9	4	229	79	27	339
500	12	11	223	65	4	303
500	18	16	182	45	11	254
1000	9	23	233	81	31	368
1000	12	13	207	81	13	314
1000	18	27	181	44	37	289
1500	9	4	232	73	20	329
1500	12	13	225	62	47	347
1500	18	24	205	45	18	292
			1940			
500	9	17	182	53	11	263
500	12	10	195	54	30	289
500	18	28	183	42	15	268
1000	9	16	208	59	14	297
1000	12	38	177	49	19	283
1000	18	30	172	27	14	243
1500	9	54	186	49	15	304
1500	12	58	179	32	10	279
1500	18	46	179	27	13	265

obtained from the wider spacing than from the higher fertilizer rates. This increase in jumbos was usually made at a sacrfiice of No. 2 grade and in some cases also at a sacrifice of the cull or string size grade. This is a desirable condition, although a high total yield is often associated with greater net profit.

Tables 9 and 12 were prepared to show the approximate portion of the total cost that must be attributed to plant spacing and to fertilization. 1000 pounds fertilizer cost twice as much as 500 pounds of a similar grade, and 1500 pounds cost three times as much. Only half as many plants are required for the 12-inch spacing as for the 6-inch spacing and similarily only half as much expense is involved in transplanting at the 12-inch spacing as the 6-inch spacing. Thus a nice calculation is involved before the profit or lack of profit in either of these two practices can be even approximately determined.

12-Inch Spacing, Moderate Fertilization, Appear Best

Experiments here reported show considerable variation in the yield, grade, and net profit secured from sweetpotatoes, attributable to plant spacing and quantity of fertilizer applied. Throughout, however, it will be observed that the 12-inch or closer spacing is either more profitable or is but slightly exceeded in profit by wider spacings. The regularity with which the 12-inch spacing appears at the top of the profit column is striking in all of the tables showing results of spacing tests with the Porto Rico or table variety.

The case for the medium close spacing is not quite so clear in tables showing results from the Triumph or starch variety. Here the "field run" crop has a given value by the bushel or ton, and there is neither premium for high quality nor discount for low quality. Perhaps local factors, including plant sup-

ply and planting facilities, are important in determining the most desirable spacing of Triumph for starch production, or for dehydration, or for stock feed.

This work was primarily concerned with plant spacing but it necessarily included quantities and grades of fertilizer commonly used in sweetpotato growing. More extensive fertilizer investigations might show more profitable ratios of nitrogen, phosphorus, and potash and probably would more definitely indicate the quantity most profitable. It seems important, however, that the 1000-pound and 1500-pound fertilizer applications were but slightly, if any, more profitable than the 500-pound applications of 6-8-4 or 4-8-4 fertilizer.

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