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Irrigation and Fertilization Experiments with Vegetables at Dandridge, Tennessee

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and

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AGRICULTURAL EXPERIMENT STATION
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SUMMARY

On terrace soils of the Holston and Monongahela series, tomatoes and beans make some response to P when grown without irrigation. Neither crop, under experimental conditions reported in this bulletin, made a significant response to either N or K. If these crops are to be fertilized and not irrigated, P is the one element which seems likely to bring about increased yields.

When these crops were irrigated, P and K gave significant increases in production. Again, only P appears to be highly important for bean production at the levels of production shown by the data.

Irrigation apparently increases the effectiveness of fertilization. This is particularly true for beans. In one case, with a 5-10-5 fertilizer, irrigation increased the yield over non-irrigated plots 2.4 times.

When crops are irrigated, more attention needs to be given to insect and disease control than when irrigation is not used.

IRRIGATION AND FERTILIZATION EXPERIMENTS WITH VEGETABLES AT DANDRIDGE, TENNESSEE

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and
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Reason for Experiments

The flooding of the French Broad River bottoms by the TVA Douglas Reservoir drove out a highly productive vegetable business. The loss of this enterprise significantly altered the economy of the area, so studies were initiated to determine whether or not the high terrace soils could be used as replacements for the flooded land. These soils, chiefly of the Holston, Nolichucky and Monongahela series, are moderately well drained but are relatively infertile. Fertilization and other soil-improvement measures are necessary if profitable crops are to be produced on them. This bulletin reports the results from experiments testing the value of fertilization and irrigation as aids to vegetable production on these soils.

METHODS

Plots were established on most nearly level land available. The bean experiment was established on Monongahela fine sandy loam, the tomato and cabbage experiments on Holston fine sandy loam. Buffer rows were established between plots to minimize cross feeding. In the case of both beans and tomatoes, all plots were 43.5 feet long with a minimum of five and a maximum of seven rows per plot. The center three or five rows were used for record.

Each treatment was replicated three times. The experiments were continued through four growing seasons. Each series of experiments included an unirrigated, unfertilized treatment. Other treatments were 5-0-5, 5-5-5, 5-10-5, 5-10-10, 10-10-5, 5-10-0 and 0-10-5 mixture at the rate of 600 pounds per acre, irrigated and not irrigated.

Cabbage was handled somewhat differently. Three replications of each of three treatments, with and without irrigation, were established. A 5-10-5 mixture of fertilizer at the rate of 30, 60 and 90 pounds of nitrogen was applied before setting, and 56 pounds of nitrogen as sodium nitrate was added as a side dressing. This was carried on for 1 year only.

Water was applied so that the irrigated plots received 1 inch of water per week including rainfall. Low pressure (15 psi) nozzles were used to apply the water at the rate of .25 acre inch per hour.

RESULTS

Soil Moisture Capacities

In order to have some understanding of the possible effect of soils or irrigation, the moisture release curves for each of the two soils were

determined by the Soil Conservation Service. The field moisture holding capacity (one-third atmosphere) of Holston fine sandy loam was 21.3 percent and the wilting coefficient (15 atmospheres) was 4.7 percent for the top 6 inches; and for the 6 to 12 inch layer field moisture capacity was 19.4 percent and the wilting coefficient was 6.1 percent. In the case of the Monongahela, the top 6 inches of soil had a field moisture capacity of 29.2 percent, and a wilting coefficient of 6.3 percent; the second 6 inches of soil had a field moisture capacity of 23.2 percent and a wilting coefficient of 7.8 percent.

There was essentially no major difference in the moisture release curves for the two soils except with respect to the total amount of water present in the soils. At five atmospheres or pressure, both surface soils retain about 20 percent of the moisture considered to be available for plant use.

IRRIGATION

Dry and Moist Years

The data, with respect to the effect of irrigation, are divided on the basis of moist years and dry years. The moist years were 1945 with 12.29 inches of rain during the growing season for beans and 18.15 inches of rain during the growing season for tomatoes, and 1947 with 7.30 inches for beans and 17.25 inches for tomatoes. The dry years were 1944 with 4.29 inches for beans and 9.20 inches for tomatoes, and 1946 with 2.79 inches of rain for beans and 7.82 inches for tomatoes.

Table 1 gives the average yields for all plots for each year, the average of the two dry and the two moist years and the overall average. The averages for each year are the result from 24 plots; for the moist and the dry years two sets of 24 plots each making a total of 48 plots, and for all years four sets of 24 plots making a total of 96 plots except in the case of cabbage.

Table 1. — *Yields of Tomatoes, Beans and Cabbage With and Without Irrigation*

Crops — Irrigated and Non-Irrigated	Dry 1944	Moist 1945	Dry 1946	Moist 1947	Dry yrs.	Moist yrs.	All yrs.
Irrigated[1]							
Tomatoes (Tons)[2]	7.1	5.0	5.3	4.3	6.2	4.6	5.4
Beans (Bushels)[3]	247	142	223	231	235	186	211
Cabbage (Tons)[4]	—	—	—	14.4	—	—	14.4
Non-Irrigated[1]							
Tomatoes (Tons)	6.6	4.3	7.0	5.5	6.8	4.4	5.6
Beans (Bushels)	36	89	44	176	40	132	104
Cabbage (Tons)	—	—	—	6.2	—	—	6.2

[1] LSD between irrigated and non-irrigated = 12 bushels of beans at .01 point; for tomatoes .9 tons at the .01 point.
[2] For tomatoes 1.2 tons at the .01 point between moist and dry year averages.
[3] LSD between moist and dry years for beans = 32 bushels between moist and dry year averages.
[4] LSD = 1.5 tons of cabbage at the .01 point.

Erratic Response with Tomatoes

Tomatoes made an erratic response to irrigation. In years with heavier rainfall, 1945 and 1947, neither the irrigated nor non-irrigated plots produced well.

The failure of tomatoes to respond to irrigation may be associated with the presence of fruit disease. Tomatoes used for canning in this area are not staked. Moist soils and high humidity provide excellent conditions for fruit rots. For example, in 1944 crop losses were 20 percent because of fruit rots. This was a dry year with 9.2 inches of rain during the growing season. In 1945 with a total of 18.15 inches of rain, 30 percent of the fruit was lost to rots. It is worth noting that these two extreme years show a 10 percent gain in fruit rots due to irrigation.

Dry Year and Irrigation Best for Beans

Beans responded well to irrigation at Dandridge. Even in years of considerable rainfall there was a marked yield increase. In 1945, with 12.29 inches of rain during the growing season, 2.6 inches of irrigation water increased bean yield by 94 percent. For beans it appears that a constant supply of water is more important than a large amount of water less well distributed. The rainfall in 1945 (12.3 inches) was more than the total amount of water, 11.3 inches (rainfall 4.3 inches plus irrigation 7.0 inches), which the beans got in 1944, yet the yield was 97 percent greater in 1944 than in 1945.

As with tomatoes, there appears to be a considerably lower bean yield during moist years which may be attributed to increased insect and disease damage. This was especially noticeable in 1945. Then the yield of irrigated beans was much lower with 12.29 inches of rain than with 4.29 inches of rain in 1944.

Doubled Cabbage Yields

The results for cabbage are for 1 year only. The yield in that year was more than doubled by irrigation. The yield increase from irrigation was due to increase in individual head size, which was more than doubled. The number of rotten cabbages was increased by about four times, indicating that the higher moisture supply favors the development of the various leaf, head and stem rots of this crop.

With all three of these crops it appears that irrigation carries with it the necessity for improved disease control if maximum benefits are to be obtained.

FERTILIZATION WITHOUT IRRIGATION

The effects of fertilization on beans and tomatoes are shown in Table 2 (averages of 4 years' results for each of the treatments).

Table 2.—*Yields of Tomatoes and Beans Receiving Different Fertilizer Treatments Without Irrigation*

600 pounds fertilizer per A.	Yields		Crop Increase		Increase in yield	
	Tomatoes Tons	Beans Bu.	Tomatoes Tons	Beans Bu.	Tomatoes Percent	Beans Percent
0-0-0	4.2	70				
0-10-5	6.2	91	2.0	21	47.6	30.0
5-0-5	4.5	74	.3	4	7.1	5.7
5-5-5	5.4	84	1.2	14	28.6	20.0
5-10-0	5.9	92	1.7	22	40.5	31.4
5-10-5	6.4	98	2.2	28	52.4	40.0
5-10-10	6.8	87	2.6	17	62.0	23.3
10-10-5	6.4	93	2.2	23	52.4	32.0

LSD for tomatoes 1.33 tons at the .01; .99 tons at the .05 level
LSD for beans — 21.6 bushels at the .05 level

Results from Fertilizer

The highest yield made by tomatoes was 6.8 tons per acre produced by a 5-10-10 application at the rate of 600 pounds per acre. On the basis of the confidence levels, this is not superior to 0-10-5, 10-10-5, 5-10-5 or 5-10-0 fertilizer treatment.

Among individual treatments, 5-10-0, 5-10-5 and 10-10-5 are significantly better than the 0-0-0 treatment. The 5-10-5 treatment is significantly better than 5-0-5 treatment at the 0.5 level. In each of these materials phosphorus is a major part. In passing it might be noted that without irrigation—even with the highest fertilizer treatments—yields were low for beans. For tomatoes without irrigation, fertilization was a useful practice.

Most Economical Rate for Cabbage

Cabbage was fertilized with a 5-10-5 mixture at 600, 900 and 1,200 pounds per acre. Three hundred and fifty pounds of sodium nitrate was applied as a side dressing. Yields at the first two levels were the same. At the highest level yields were reduced nearly 10 percent. It is not likely that this variation is significant except to show that 600 pounds of fertilizer seems the most economical application of the three.

FERTILIZATION WITH IRRIGATION

Phosphate Important

As under unirrigated conditions, some effect from fertilization was noted. When studing the individual treatments on tomatoes it seems that when P is omitted there is little increase in yield even when N and K have been added. The 5-10-10 treatment produced the highest yield of tomatoes, of 8.1 tons per acre, and this is significantly greater at the .01 level than 5-5-5, 5-10-0, 5-0-5 or 0-0-0 treatments. At the .05 level it is superior to all treatments except 5-10-5 and 10-10-5 (Table 3).

Considering beans, a 5-10-5 treatment produced the highest yield at 250 bushels per acre. This yield was significantly higher than that from 0-0-0 and 5-0-5 treatments at the .05 level.

Table 3. — *Yields of Tomatoes and Beans Receiving Different Fertilizer Treatments With Irrigation*

600 pounds fertilizer per A.	Yields		Crop Increase		Increase in yield	
	Tomatoes Tons	Beans Bu.	Tomatoes Tons	Beans Bu.	Tomatoes Percent	Beans Percent
0-0-0	4.5	157				
0-10-5	7.6	224	3.1	67	69	43
5-0-5	5.0	178	.5	21	11	13
5-10-0	6.4	207	1.9	50	42	32
5-5-5	6.0	220	1.5	63	33	40
5-10-5	7.4	250	2.9	93	66	59
5-10-10	8.1	222	3.6	65	80	41
10-10-5	7.2	240	2.7	83	60	53

LSD for Tomatoes at the .01 point 1.33 Tons; .99 Tons at the .05 point.
LSD for Beans at the .05 point 59 Bushels.

Irrigation and Fertilizer Use

Maximum results for tomatoes were obtained with a 5-10-10 fertilizer applied at the rate of 600 pounds per acre. The same fertilizer was most effective under both dry land and irrigated conditions. The difference in yield between tomatoes irrigated and not irrigated—1.3 tons—is more than four times the difference due to irrigation alone, and 21 percent greater than the difference due to fertilizer without irrigation. This indicates quite clearly that in addition to potential value for increasing crop yields under the climatic conditions at Dandridge, irrigation increases the utilization of applied fertilizer.

With beans somewhat the same inferences may be drawn. The most productive combination under dry conditions was a 5-10-5 fertilizer at 600 pounds per acre. The increase was 28 bushels per acre without irrigation and the same fertilizer with irrigation brought about an increase of 67 bushels per acre, 2.4 times greater than when no water was added.

With irrigation, cabbage yields were increased with each fertilizer increment: 5-10-5 fertilizer at 300 pounds producing 13.6 tons, 600 pounds producing 14.3 tons and 900 pounds producing 14.6 tons of cabbage per acre.

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