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ONION FERTILIZER EXPERIMENTS AT
LAREDO, BIG WELLS, AND
EAGLE PASS, TEXAS

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In experiments completed in 1935 at the Winter Garden station, onions grown on Webb fine sandy loam gave a profitable response to fertilizers containing nitrogen and phosphoric acid. Additions of potash did not give definite increases in yields.

Later, in a similar series of experiments, onions on Laredo silt loam near Laredo and Monteola clay near Big Wells responded to fertilizer in general but not to the marked extent which they had in previous experiments on Webb fine sandy loam near Winter Haven. There was no consistent response to fertilizer in general on Laredo very fine sandy loam near Eagle Pass.

As in the previous work, there was no marked response in yield by the onions to potash.

Side dressings of nitrate of soda tended to increase onion yields at all three localities, but most markedly on Laredo very fine sandy loam at Eagle Pass. On Monteola clay the increase due to nitrate side dressings was practically negligible.

Fertilizers with 1-3-0 or 1-3-1 ratios were no more effective than those with 1-2-0 or 1-2-1 ratios in increasing onion yields.

As before, potash had little or no effect on the keeping quality of the onions.

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ONION FERTILIZER EXPERIMENTS AT LAREDO, BIG WELLS, AND EAGLE PASS, TEXAS

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Upon the conclusion in 1936 of the detailed fertilizer experiments with Yellow Bermuda onions at the Winter Garden Substation No. 19, it was considered desirable to try some of the treatments on other types of soil used for onion culture in southwest Texas. Consequently, tests were conducted on Laredo silt loam near Laredo, on Monteola clay near Big Wells, and on Laredo very fine sandy loam near Eagle Pass. Among the important questions of the growers in these localities were: (1) Would the findings, particularly those relating to potash on the sandy loams at the Station's farm near Winter Haven, still hold good on these other soils? (2) Does presence or absence of potash in the fertilizer affect the keeping qualities of onions? (3) Are side dressings with nitrate of soda profitable?

Review of Previous Work

Previous studies having most bearing on the fertilizer problems involved are those conducted at this Station several years ago and reported in 1936 (4). After four years of testing various amounts of potash in the presence of constant amounts of nitrogen and phosphoric acid, and on a soil which chemical analysis indicated as being well supplied with potash, it was concluded: "Potash is the least essential of the three chief nutrients. It increased yields slightly the first year, but thereafter tended to decrease them. Results were never as consistent with potash as they were with either nitrogen or phosphoric acid." It might be added that the results with nitrogen and phosphoric acid, especially the latter, were for the most part very clear-cut, and left no question as to the effect which these nutrients had on the productiveness of onions. The importance of phosphoric acid in onion fertilizers has been established on various soils in Virginia, Michigan, New York, and Massachusetts (1, 3, 5, 6, 8). With the exception of some newly cleared woody muck soils in New York, nitrogen has been shown to be usually more or less effective in increasing onion yields in the four states listed above, as well as in New Mexico (1, 2, 3, 5, 6, 8). In contrast to these fairly consistent results with phosphoric acid and nitrogen, potash has been responsible for some variable results depending on the location and soil where the experiments were conducted. In Virginia, potash had little effect on the yield of onions according to a report in 1930 (8), and in 1935 only a slight increase in yield due to potash was reported from New Mexico (2). Reports from Michigan and New York on the contrary have credited decided increases in yields of onions due to potash (3, 5, 6). Such diverse findings due

apparently to the different soil conditions under which the experiments were conducted suggested different results might easily be possible in southwest Texas if tests were conducted on different soils.

In the storage test conducted with the onions harvested from the fertilizer tests at the Station, keeping quality was not affected by the presence or absence of potash in the fertilizer (4).

Side dressings of nitrate of soda to previously fertilized onions failed in tests at the Station to result in higher yields, and in fact one year actually resulted in a decrease of yield (4). Somewhat erratic results have been reported from Massachusetts as regards the effect of nitrate of soda as a side dressing to previously fertilized onions started from seed (1). In general, however, such a side dressing was beneficial. With onions started from dry sets, however, such a practice was clearly not beneficial.

Method of Procedure

Since it was desirable to keep the experiment as simple as possible, the treatments were limited to six or seven at each location in any one season. With the exception of the grower's treatment—where this was used—the treatments were the same at all locations, but were not the same all three seasons. The experiments were started in the season of 1936-37, and completed in the season of 1938-39.

In the first season, 1936-37, the following six treatments were tried at all three locations:

1. No fertilizer
2. 600 pounds per acre of 6-12-6
3. 600 pounds per acre of 6-12-6 plus a side dressing of nitrate of soda at the rate of 133 pounds per acre.
4. 600 pounds per acre of 6-18-0
5. 600 pounds per acre of 6-18-6
6. 600 pounds per acre of 6-18-12

These treatments were similar to those previously conducted at Winter Haven in order to see if the same general response would be obtained on different soils.

In the seasons of 1937-38 and 1938-39, the 6-18-6 fertilizer treatment was dropped and a 6-12-0 substituted. Also the nitrate of soda side dressing was transferred from the 6-12-6 to the 6-18-12 treatment. They then became:

1. No fertilizer
2. 600 pounds per acre of 6-12-0
3. 600 pounds per acre of 6-12-6
4. 600 pounds per acre of 6-18-0
5. 600 pounds per acre of 6-18-12
6. 600 pounds per acre of 6-18-12 plus a side dressing of nitrate of soda at the rate of 133 pounds per acre.

These were designed to compare fertilizers both with and without potash, as well as those having 1-2-0 or 1-2-1 ratios with those having

1-3-0 or 1-3-1 ratios, also unfertilized onions with those fertilized in various ways, and finally onions receiving side dressings of nitrate of soda with those not receiving such treatment.

In addition to these six standard treatments at each location, plats using the grower's special mixture or a fertilizer with some other formula were planted at Laredo and Big Wells in some seasons.

In all three locations the plats were laid out in approximately the same way. Minor variations in cultural procedure of course had to be made at each place to accommodate the methods of the cooperating growers. The plats at all places were close to $1/20$ acre in size, and in round figures were 9 to 12 feet wide by 200 or more feet long. At Laredo and Eagle Pass where the border method of surface irrigation is practiced, each plat consisted of a single area surrounded by the raised border which confined the water during irrigation. The rows were planted flat and were one foot apart. At Big Wells each plat consisted of seven rows each in the form of a low ridge. The rows were 16 inches apart there.

All the fertilizer treatments (except the nitrate side dressing) were applied broadcast several days before the onion plants were set out. The weighing, mixing and application of the fertilizer were all done by the Station which also supervised the harvesting, and collected the records at the various harvests which occurred in April and May. Weeding, cultivating, irrigating and all other cultural operations were carried out at the discretion of the individual cooperators, care being taken that all plats were handled alike and at the same time.

At Big Wells the outside rows, as well as several feet at each end of the plats, were not included in harvest records. At Eagle Pass and Laredo the entire plat was harvested. Aside from the possibility of a slightly heavier yield on the outside rows there was practically no possibility of interaction between the treatments. From the practical point of view, this method of harvesting coincided very well with the grower's methods, since his entire onion acreage was planted in such plats.

At Laredo and Eagle Pass the yields were usually so large that it was physically impossible under the circumstances to weigh all the onions as had been done on the smaller plats in the tests conducted at the Station itself. In some seasons such as the 1938 season at Eagle Pass, the yields were low enough to permit the weighing of all the onions. Where the onions were not all weighed, the measured bushels were counted and ten sample bushels from each plat weighed.

In all three locations three samples totaling approximately a bushel of clipped onions were taken from each plat for grading purposes in order to determine the percentages of U. S. No. 1 jumbos, U. S. No. 1 mediums, boilers and culls. Two samples were taken towards the ends of each plat, while the third was taken approximately in the middle. The samples were taken so as to represent all the onions in the given area. The variety

Yellow Bermuda was used at all locations in all three seasons, except at Big Wells in 1936-37 when Crystal White Wax was grown.

Storage Tests. In the summers of 1938 and 1939 simple storage tests were conducted to compare the keeping quality of onions which had received potash fertilizer, with those which had not. From each outlying location a bushel of U. S. No. 1 onions taken from the plats receiving the 6-18-12 fertilizer, and another taken from the plats receiving 6-18-0 were placed in common storage in a tile barn at the Experiment Station at Winter Haven. Periodic examinations were made of these stored onions throughout the summer and early fall. Losses in weight and in numbers of bulbs from decay were determined.

Previous Handling of Soil. A knowledge of the manner in which the soils on which these experiments were conducted is desirable for a better understanding of the results obtained.

At Laredo the Laredo silt loam was newly cleared land in the first year of test, and so the onion crop was the first grown upon it. The field was a large one of well over 100 acres, and since it was planted entirely to onions, the experimental planting represented only a small fraction of it. With the exception of the test plats, the entire field received an application each year of 400 to 450 pounds per acre of a fertilizer analyzing approximately 13.5-34-0. Thus as the experimental planting was set in a different location in this same field each year, the second and third year's plats were located in areas which had received rather heavy fertilizer applications in the previous year or two.

At Big Wells the onions were grown on land which had been in cultivation for a number of years. In the first and third years of these tests the onions followed crops other than onions, but in the second season they followed onions after an intervening period of summer fallow. In the first two years the preceding crops had been fertilized fairly generously with balanced fertilizers. In the third year the onion plats were placed on land on which sorghum had been planted for the preceding four years, and which had not had an onion crop, nor received fertilizer in a longer period than that.

At Eagle Pass the onions were also grown each year on land which had been under cultivation for a number of years. In general, rotation had been practiced, and in each of the three seasons that these tests were conducted, the soil had received good applications of a balanced commercial fertilizer in the previous season. In the second year of the tests the plats were located on an area in which onions had been planted the year before.

Soil Analyses. As a further check and possible aid in the interpretation of results, an analysis of the soil at each location was also made the first year (Table 5). These analyses were made by the Division of Chemistry.

Interpretation of Results. In order to obtain a satisfactory basis for determining whether the differences in yield between various treatments was due to the fertilizer applied or instead to some chance effect common in experiments of this type, most of the yield data were subjected to an analysis of variance in accordance with the procedure outlined by Snedecor (7). For each year there were three sets of data—one for each locality, and since the tests extended over three years there were nine such sets of data in all. Each of these sets was examined for significance separately. Following this the three year record at any one locality was taken as a unit and analyzed for significance. Actually the plats had not been arranged in the best way for statistical analysis since for the sake of simplicity in the cooperative work they had been systematically arranged rather than truly randomized. Because of this, values of F below that for Fisher's 1% point as given by Snedecor (7), but above those for his 5% point were considered of questionable significance, and only those above his 1% point considered truly significant. Values below the 5% value were considered as indicating a definite lack of significance.

When comparing two treatments, the minimum difference necessary to indicate a real or significant difference between them was calculated by multiplying the standard error by the t value corresponding to Fisher's 5 per cent point for the degrees of freedom involved.

Results in Terms of Yields

Results at Laredo

Yields as Affected by Fertilizer in General: The application of fertilizer resulted in noticeably higher yields of onions in practically all instances, than where no fertilizer was added at all (Table 1). In the average yield of U. S. No. 1 onions for 1938 and 1939 the fertilizer treatment with the lowest yield of onions was the 6-18-0 treatment resulting in a yield

Table 1. Effect of various fertilizer applications on the bushels of onions per acre on Laredo silt loam at Laredo, Texas

Fertilizer Used*	U. S. No. 1 (Jumbo & Medium Size)				Total Yields			
	1937	1938	1939	Ave. 1938 and '39 only	1937	1938	1939	Ave. 1938 and '39 only
None.....	496	347	476	412	618	430	588	509
6-12-0.....	549	541	492	516	682	630	630	630
6-12-6.....	549	526	523	524	682	619	641	630
6-12-6+N**.....	603				716			
6-18-0.....	467	526	470	498	611	601	625	613
6-18-6.....	481				604			
6-18-12.....	550	559	487	523	660	630	628	629
6-18-12+N**.....		586	493	540		657	634	646
13½-34-0.....	549	636	501	568	671	748	625	686

*All fertilizers except 13½-34-0 and the side dressings applied at rate of 600 pounds per acre. The 13½-34-0 applied at approximately 450 pounds per acre.

**N was a nitrate of soda side dressing applied at the rate of 133 pounds per acre.

of 498 bushels per acre. This was 86 bushels per acre more than the onions receiving no fertilizer. Onions receiving other fertilizer treatments yielded as high as 568 bushels, or as much as 156 bushels more per acre than onions receiving no fertilizer. Such a record would indicate that the application of fertilizer is on the whole decidedly profitable on the Laredo silt loam, even though it is a productive soil when left unfertilized.

Effect of Potash on Yield. A comparison of the yields attributed to the fertilizers with the formulas 6-12-0 and 6-12-6, as well as 6-18-0 and 6-18-12 in Table 1, shows that in practically every instance the onions receiving the 6 or 12 per cent of potash produced more U. S. No. 1 onions, as well as a higher total yield than those not receiving potash. The average increases due to potash however were not great. The onions receiving 600 pounds of 6-12-6 fertilizer yielded an average of 524 bushels per acre of U. S. No. 1 onions for the years 1938 and 1939 as against 516 bushels from the onions receiving the same amount of 6-12-0. The total yields from each of these two treatments were identical. Onions fertilized with the 6-18-12 mixture produced on an average for the same years, 523 bushels of U. S. No. 1 onions as against 498 bushels from the onions receiving the 6-18-0 mixture. The average total yield from the onions receiving the 6-18-12 fertilizer was 629 bushels per acre while that from the 6-18-0 fertilizer treatment was 613 bushels, or only 16 bushels less. This difference from a statistical point of view is too small to be significant. Thus although the presence of potash in the fertilizer tended to increase yields, its effect was of no commercial importance.

Effect of Nitrogen Side Dressing on Yield. The addition of 133 pounds per acre of nitrate of soda to onions which had already received the complete fertilizer 6-12-6 or 6-18-12 resulted in increased yields in all instances (Table 1). These increases although consistent were usually small. For example, the onions receiving the 6-18-12 fertilizer plus the side dressing of sodium nitrate in February yielded on the average in the years 1938 and 1939, 540 bushels of U. S. No. 1 onions per acre or only 17 bushels more than onions also fertilized with 6-18-12 but receiving no side dressing. The difference in the total yields for these same treatments was also only 17 bushels. Such a difference is too small to have significance. Thus it appears that a side dressing of nitrate of soda to onions on a Laredo silt loam which has already received as much as 600 pounds of 6-18-12 fertilizer is of questionable value. It will do no harm, but it may not result in any increased yields.

Comparison of Ratios. If the yields of onions resulting from the application of fertilizers with 1-2-0 and 1-3-0 ratios, that is, those having the formulas 6-12-0 and 6-18-0, are studied it will be seen that in all instances they were smaller whenever the latter fertilizer was applied (Table 1). Differences were not usually very great however. A similar but more marked trend was shown in 1937 between those receiving fertilizers with 1-2-1 and 1-3-1 ratios, namely the 6-12-6 and 6-18-6 fertilizer

treatments. This difference of 68 bushels of U. S. No. 1 onions per acre although not a definite proof in itself, was great enough, especially when considered in the light of the following year's results with the 1-2-0 and 1-3-0 ratios mentioned above, to indicate a trend in favor of the 1-2-0 or the 1-2-1 ratio. Even if the differences are interpreted as having no significance, it can be safely said that onions receiving fertilizers with 1-3-0 or 1-3-1 ratios did not outyield, even slightly, those onions receiving fertilizers with 1-2-0 or 1-2-1 ratios.

The 13.5-34-0 Fertilizer Treatment. The grower at Laredo applied to his general onion crop a broadcast treatment of 13.5-34-0 fertilizer at the rate of about 450 pounds per acre ahead of planting time. This was made up by mixing the 11-48-0 and 16-20-0 in equal proportions. Table 1 shows while on an average onions receiving this fertilizer outyielded onions receiving other mixtures, it also shows that this was not the case every year. In 1937 onions receiving 6-12-6 at the rate of 600 pounds per acre produced just as many bushels of U. S. No. 1 onions as those receiving 450 pounds of 13.5-34-0.

Results at Big Wells

Yields as Affected by Fertilizer in General. Onions receiving fertilizer in any one of the treatments followed in these experiments at Big Wells produced higher yields both of U. S. No. 1 bulbs and total yield, than those onions receiving no fertilizer at all (Table 2). In the average yield of U. S. No. 1 onions for 1938 and 1939 the fertilizer treatment with the lowest yield of onions was the 6-18-12 treatment resulting in a yield of 237 bushels per acre, or 31 bushels more per acre than those left unfertilized. The highest yielding fertilized onions produced 262 bushels of U. S. No. 1 onions per acre, or 56 bushels more per acre than the unfertilized ones. While the trend was always towards higher yields whenever fertilizer was used, the increases which could be attributed to fertilizer were not always great, nor could they, on the basis of an analysis of their causes, always be attributed to fertilizer.

Table 2. Effect of various fertilizer applications on the bushels of onions per acre on Monteola clay at Big Wells, Texas

Fertilizer Used*	U. S. No. 1 (Jumbo & Medium Size)				Total Yields			
	1937	1938	1939	Ave. 1938 and '39 only	1937	1938	1939	Ave. 1938 and '39 only
No fertilizer....	146	315	97	206	200	414	218	316
6-12-0.....	371	125	248	248	458	250	354	
6-12-6.....	181	367	115	241	226	475	248	362
6-12-6+N**	171				212			
6-18-0.....	187	380	131	256	235	461	252	356
6-18-6.....	190				232			
6-18-12.....	206	334	140	237	249	445	260	352
6-18-12+N**		374	150	262		464	268	366

*All fertilizers except the side dressings applied at the rate of 600 pounds per acre.

**N was a nitrate of soda side dressing applied at the rate of 133 pounds per acre.

Effect of Potash on Yield. On the basis of the records summarized in Table 2 there is a trend towards lower yields in most instances where potash was applied, as compared with where it was not applied. For example, the average yield of U. S. No. 1 onions for the years 1938 and 1939 in the plats receiving 600 pounds per acre of 6-18-0 fertilizer was 256 bushels, while that from the plats receiving 6-18-12 fertilizer was only 237 bushels.

Effect of Nitrogen Side Dressing on Yield. The application of a nitrate of soda side dressing to onions which had already received a complete fertilizer resulted in increased yields in most cases (Table 2). However, yields were not strikingly greater on the average. If the average yields for the years 1938 and 1939 are considered it is seen that onions which received the 6-18-12 fertilizer produced 237 bushels per acre of U. S. No. 1 onions as compared with 262 bushels per acre of No. 1 onions from the plats which received the 6-18-12 fertilizer plus 133 pounds of nitrate of soda as a side dressing later. Total average yields for the same period were also increased, but to a lesser extent. Although there seems to be a trend towards increased yields due to the nitrate side-dressings, such increases are not very significant; in many cases they were small, and in a few the yields were lower where the side dressing was applied.

Comparison of Ratios. Although a study of the figures in Table 2 indicate that slightly greater yields were obtained from the onions fertilized by the 6-18-6 and the 6-18-0 fertilizers (1-3-1 and 1-3-0 ratios), than were obtained from onions fertilized by the 6-12-6 and 6-12-0 fertilizers (1-2-1 and 1-2-0 ratios), the increases due to the greater application of phosphoric acid were so slight in most instances that they are really not significant. From the practical point of view the yields with fertilizers with formulas 6-12-0 or 6-12-6 should be just about as satisfactory as yields with the formulas 6-18-0 and 6-18-6, and less expensive.

Results at Eagle Pass

Yields as Affected by Fertilizer in General. On the Laredo very fine sandy loam used in these experiments at Eagle Pass, none of the fertilizers listed in Table 3 caused noticeable increases in the average yield of onions as compared to where no fertilizer at all was applied. A study of the records for the individual replications from which the averages for each have been obtained shows considerable inconsistency. Even in 1937 when the average of the four replications gave an advantage in yield to all the fertilized plats as compared to the unfertilized ones, some individual replications in the fertilized treatments had smaller yields than the same replication in the unfertilized treatment. Whether this was due to a naturally high fertility of the soil or to the preceding program of soil management, is difficult to say. The possible explanations for these results are discussed later.

Table 3. Effect of various fertilizer applications on the bushels of onions per acre on Laredo very fine sandy loam at Eagle Pass, Texas

Fertilizer Used*	U. S. No. 1 (Jumbo & Medium Size)				Total Yields			
	1937	1938	1939	Ave. 1938 and '39 only	1937	1938	1939	Ave. 1938 and '39 only
No fertilizer.....	534	85	674	380	572	146	722	434
6-12-0.....		105	643	374		160	702	431
6-12-6.....	659	75	536	306	677	132	580	357
6-12-6 +N**.....	731				760			
6-18-0.....	619	130	605	368	651	188	659	424
6-18-6.....	674				697			
6-18-12.....	664	104	571	338	689	164	623	394
6-18-12 +N**.....		155	695	425		212	750	481

*All fertilizer except the side dressings applied at the rate of 600 pounds per acre.

**N was a nitrate of soda side dressing applied at the rate of 133 pounds per acre.

Effect of Potash on Yield. A comparison of the yields of onions influenced by fertilizers containing potash (those with formulas 6-12-6 and 6-18-12) with those lacking potash (those with formulas 6-12-0 and 6-18-0) shows that in nearly every case onions receiving potash produced less than those not receiving it (Table 3). In other words potash in the fertilizer seemed more often to depress onion yields rather than to increase them. In the first year, 1937, however, stepping up the potash from 0 to 6 per cent (compare 6-12-0 with 6-12-6, and 6-18-0 with 6-18-6 in Table 3) increased yields, but where it was stepped up to 12 per cent (see 6-18-12), the yield was slightly lower than that of the 6-18-6 treatment, but still above that of the 6-18-0 treatment. However, fertilizer in general was more effective in 1937 than in either 1938 or 1939 (see above).

Effect of Nitrogen Side Dressing on Yield. Wherever a side dressing of sodium nitrate was applied to onions which had already received either the 6-12-6 or the 6-18-12 fertilizer initially, yields were noticeably increased in all instances (Table 3). Of all the treatments at Eagle Pass the nitrate of soda side dressing was not only the most marked in its effect, but the most consistent from replication to replication and year to year in producing a large increase in yield, both of U. S. No. 1 onions and of total yield. In 1937 onions receiving an initial application of 6-12-6 plus a side dressing of sodium nitrate in February produced 731 bushels of U. S. No. 1 onions per acre as compared with only 659 bushels from onions receiving the 6-12-6 fertilizer but no side dressing (Table 3). Similarly the same table shows that an average of the U. S. No. 1 yield for the two years 1938 and 1939 the onions fertilized initially with the 6-18-12 mixture and receiving the side dressing later produced 425 bushels, while those receiving the 6-18-12 mixture and no side dressing only produced 338 bushels. There was a similar average difference in the total yield. The yields for these treatments in 1938 and 1939 separately all show rather clear cut differences. Side dressings of sodium nitrate were profitable at Eagle Pass.

Comparison of Ratios. From the results obtained it is impossible to say whether fertilizers with 1-3-0 or 1-3-1 ratios, or fertilizers with 1-2-0 or 1-2-1 ratios were the most effective in increasing yields at Eagle Pass. A study of Table 3 will show that the average yields for each year varied, and behind these varied averages were replications with varied results. The average yields as computed on the basis of the 1938 and 1939 seasons are very close together for the 6-12-0 and the 6-18-0 fertilizer treatments indicating still further that one is probably just as effective as the other.

Discussion and Recommendations

Since the tests reported in this publication were primarily an extension of some of the key treatments used in extensive onion fertilizer experiments conducted on Webb fine sandy loam at Winter Haven, it seems desirable to consider the results in the light of those previously reported (4). Onions have also been grown at the Station on Crystal loamy fine sand and have responded according to unpublished records in much the same way as on Webb fine sandy loam. Table 4 gives in a condensed form the general results found on the different soils. It is obvious that in some instances the results were similar to those previously found at the Station,

Table 4. Response to fertilizers of Yellow Bermuda onions grown on various soil types

Soil Type	Location of Experiments	Fertilizer in General*	Potash**	Nitrate side dressing***	Fertilizers with †1-3-0 or 1-3-1 ratios
		Yield trend	Yield trend	Yield trend	Yield trend
Webb fine sandy loam	Winter Haven	definitely up	possibly down	possibly down	probably up
Crystal loamy fine sand	Winter Haven	definitely up	possibly down	possibly down	probably up
Laredo very fine sandy loam	Eagle Pass	variable	possibly down	probably up	variable
Laredo silt loam	Laredo	up	possibly up	up	possibly down
Monteola clay	Big Wells	up	down (?)	possibly up	possibly up

*Complete fertilizer mixtures, or nitrogen-phosphoric acid mixtures only.

**In presence of nitrogen and phosphoric acid.

***Following initial applications of complete fertilizer.

†In comparison to fertilizers with 1-2-0 or 1-2-1 ratios.

in others they were not. With the exception of the results especially pertaining to potash, those at the outlying locations rarely if ever showed as great differences in yield between the various treatments as occurred in the earlier experiments. With potash the results again lacked any really clear-cut trends. These results should enable growers on a wider range of soils to fertilize their onions with greater understanding.

Soil Analyses. A study of soil analyses also throws some light on the problem of fertilizers. In Table 5 is given the analyses of the soils used in various tests at Winter Haven as well as those in the outlying experiments. On the basis of the figures in this table one would expect all the soils in the outlying tests to be more fertile than those at Winter Haven, for the analysis of each of them shows more nitrogen, more phosphoric acid, and more potash. The Laredo silt loam ran particularly high in phosphoric acid, and all three soils at the outlying locations ran extremely high in potash. A word of caution as regards the interpretation of the data in Table 5 is perhaps necessary here. Because of the high lime content of these latter soils as indicated by high percentage of acid consumed one cannot always be sure of readings obtained with active phosphoric acid and active potash. Where the acid consumed is over 90, it may have interfered with the determination. These nutrients were however present more abundantly at Laredo, Big Wells, and Eagle Pass than they were at Winter Haven. This fact has some bearing on the following discussion.

Table 5. Analyses of top seven inches of soil in the localities of onion tests*

Nutrient and pH	Winter Haven		Eagle Pass	Laredo	Big Wells
	Crystal loamy fine sand	Webb fine sandy loam	Laredo very fine sandy loam	Laredo silt loam	Monteola clay
Nitrogen.....	0.033%	0.031%	0.079%	0.071%	0.128%
Active phosphoric acid**.....	21 ppm	28 ppm	68 ppm	447 ppm	180 ppm
Total phosphoric acid.....	0.023%	0.022%	0.123%	0.091%	0.107%
Active potash**.....	200 ppm	220 ppm	415 ppm	382 ppm	476 ppm
Total potash.....	0.54 %	.60 %	2.25 %	2.22 %	1.10 %
Acid consumed.....	3.0%	2.0%	100.0%	83.3%	91.6%
pH.....	6.43	6.60	8.30	8.28	8.23

*The analyses in this table were made from the soil taken from the actual fields where the tests were conducted. It should not be assumed that the analysis would always be the same for the type given, although it would probably approximate it.

**Given in parts per million—ppm.

Yields as Affected by Fertilizer in General. Only on Laredo very fine sandy loam was the use of fertilizer in general found to be of doubtful value (see Table 4). The response to fertilizer on the Laredo silt loam and the Monteola clay, while probably profitable in terms of yield return, was not nearly as marked as it had been on Webb fine sandy loam, as reported earlier (4). The results on Laredo silt loam and Monteola clay are to be more or less expected, as observations by agriculturists in general indicate that these soils are naturally more fertile than Webb fine sandy loam. The response shown by Laredo very fine sandy loam is somewhat unexpected, and not quite in line with the experiences claimed by growers who operate on this soil. In other words, a more definite response to fertilizer would normally be expected, on such a soil type. The lack of response of all the soils in the outlying locations as compared to that at Winter Haven is not surprising in the light of the analyses given in Table 5.

Effect of Potash on Yield. Nowhere was the response to potash significant. Such a result is not unexpected when one considers Table 5. On Laredo silt loam there was a tendency for the yields to be higher when potash was present in the fertilizer, but this trend was in no sense clear cut (see Table 4). On the other soils the trend if any, was down, just as it had been on the Webb fine sandy loam. While, of course, it is impossible to know the exact fertilizer requirements of every piece of land in the Winter Garden area, the results thus far obtained suggest rather clearly that potash is not a limiting factor in onion production in this section. Soil analyses also seem to justify this conclusion. Whether a grower applies potash or not, the yields of onions which he obtains are not going to be strikingly lower or higher in either case. Since it is a fact that soils can and do become depleted of various nutrients including potash it might be a desirable practice for a grower to include some potash in his fertilizer every five or six years. Better still would be trial applications of potash-containing fertilizer in a number of strips or plats across fields which had not received any potash in a number of years. If these areas showed a marked and consistent response to this treatment potash could probably be applied to such a field before the planting of another cash crop, especially onions. Such a trial treatment would probably be desirable at more frequent intervals on Laredo silt loam than it would on the other soil types mentioned in Table 4. On the other hand the yields of onions obtained on Laredo silt loam were always high, even from the unfertilized plats (see Table 1), emphasizing once again that even though potash seemed to increase yields there more than at any other place, it could not be the limiting factor that phosphoric acid proved to be on Webb fine sandy loam (4).

The Value of Nitrate Side Dressings. In all the outlying experiments reported upon here, there was a tendency for higher onion yields where nitrate side dressings were applied. On Laredo very fine sandy loam it was clear-cut, yields being very materially higher; on Laredo silt loam the increase in yield while usually noticeable was not always great enough nor consistent enough to assure that it would always be profitable under commercial conditions; on Monteola clay, the increase while more often there than not, was usually so small that one would not be warranted in saying that it would ever be profitable.

In view of the decided response of onions to the nitrate side dressings on Laredo very fine sandy loam, combined with the lack of response on this same soil to fertilizers in general as well as the variable results obtained in the treatments involving the fertilizers of varying ratio, it is possible that much heavier applications of nitrogen-carrying fertilizers should be made initially to onions grown on this soil type.

Comparison of Ratios. In none of the outlying experiments were fertilizers with 1-3-0 or 1-3-1 ratios as effective as they were at the Station on Webb fine sandy loam. On Laredo silt loam there was a very slight

tendency for the onions to produce less when they received a fertilizer with a 1-3-0 or a 1-3-1 ratio than where they received one with a 1-2-0 or a 1-2-1 ratio. On the Monteola clay the results were the opposite. On neither of these soils however were the differences really significant when examined statistically.

At Eagle Pass on the Laredo very fine sandy loam the results varied so much, it was impossible to find any trend whatsoever. In view of the rather striking response to nitrate side dressings on this soil, it is possible as already pointed out that this soil needs nitrogen to such an extent, that without it, the onions are unable to respond normally to applications of other materials.

It is of course realized that the data are insufficient to give complete support to some of the tentative conclusions discussed above, as for example the need for nitrogen on the Laredo very fine sandy loam. It was not feasible to plan these experiments on such an extensive scale that every question was answered. Where such circumstantial evidence exists however, a grower can conduct a simple test of his own to obtain further corroboration. Even when results of the most comprehensive of tests are available, growers should often conduct simple tests on their own land to determine the treatment best suited to their particular situation. The results of fertilizer experiment only suggest the most possible and desirable treatments, but such treatments may not necessarily be best under all circumstances.

Recommendations. From the results obtained in these experiments and in line with the discussion above the following recommendations can be made. Although the application of a complete fertilizer to an onion crop on Laredo silt loam and Monteola clay (both representative of some of the darker colored heavier soils in the Winter Garden-Laredo area) is not as profitable as similar applications on the sandy loams, it is nevertheless profitable and the practice can well be followed by onion growers.

Since potash is apparently no more needed on these heavier soils than it is on the sandy loams, mixtures such as 6-12-0, 6-18-0, 5-15-0, 11-48-0, and 16-20-0 can all be applied profitably, the first three at a rate of around 600 pounds per acre, the last two correspondingly less. Some growers mix 11-48-0 and 16-20-0 sack for sack (a 50:50 mixture), thus obtaining a fertilizer with a formula 13.5-34-0. In view of the fact that fertilizers having 1-2-0 and 1-2-1 ratios caused the onions to produce about as well as those receiving fertilizers with 1-3-0 and 1-3-1 ratios, the 13.5-34-0 mixture works out better than 11-48-0. Fertilizers lacking potash, and having a ratio approximating 1-2-0 should be cheaper than fertilizers with 1-3-0 or 1-4-0 ratios.

Sodium nitrate side dressings can still not be recommended as very profitable, except apparently on Laredo very fine sandy loam.

Results of Storage Tests

The storage tests were primarily to determine the effect of potash on keeping quality. Those lots which had higher percentages of the original bulbs still marketable at the periodic inspections were considered as having the better storage quality. Results in general indicated that potash did not increase keeping quality, although results varied somewhat with location and season.

The onions grown on the Laredo silt loam at Laredo showed a tendency in 1938 to keep better where they had received no potash during their growth period (Table 6). In 1939 they showed the opposite tendency to about the same extent (Table 7).

Table 6. Percentages of onions placed in storage, still marketable at different dates in 1938

Location where grown and fertilizer received	Number of bulbs originally placed in storage	May 23	June 18	July 28	August 23	Sept. 24	Oct. 20
Laredo:		(18 days)	(44 days)	(84 days)	(110 days)	(142 days)	(168 days)
6-18-0.....	122	98.4	94.3	82.8	73.8	63.1	55.7
6-18-12.....	110	97.3	89.1	78.2	66.4	54.5	40.0
Eagle Pass:		(18 days)	(44 days)	(84 days)	(110 days)	(142 days)	(168 days)
6-18-0.....	283	97.4	83.5	65.5	55.6	49.5	40.7
6-18-12.....	240	92.0	77.1	66.9	55.9	49.2	42.4
Big Wells:			(26 days)	(66 days)	(92 days)	(124 days)	(150 days)
6-18-0.....	194	—*	99.6	95.8	84.8	79.5	74.6
6-18-12.....	118	—*	100.0	97.5	89.2	81.2	76.2

*Storage only started on this date.

Table 7. Percentages of onions placed in storage, still marketable at different dates in 1939

Location where grown and fertilizer received	Number of bulbs originally placed in storage	June 7	July 3	August 16	Sept. 6	Oct. 4	Oct. 28
Laredo:		(32 days)	(58 days)	(102 days)	(123 days)	(151 days)	(175 days)
6-18-0.....	146	93.2	91.1	78.8	75.3	69.9	52.1
6-18-12.....	153	94.8	92.2	88.3	85.9	83.0	68.0
Eagle Pass:			(34 days)	(78 days)	(99 days)	(127 days)	(151 days)
6-18-0.....	175	—*	92.6	77.1	73.1	73.4	44.6
6-18-12.....	215	—*	94.9	78.6	67.4	60.9	40.0
Big Wells:		(32 days)	(58 days)	(102 days)	(123 days)	(151 days)	(175 days)
6-18-0.....	244	99.6	96.7	82.4	73.0	66.8	48.4
6-18-12.....	260	98.1	95.0	79.6	70.4	57.7	40.0

*Storage only started May 30.

With the onions grown on the Laredo very fine sandy loam at Eagle Pass, it seemed to make little difference in either 1938 or 1939 whether they had received potash or not. In both seasons, both treatments fluctuated back and forth so far as having the greater percentage of marketable onions still remaining at the successive inspections (Tables 6 and 7). At no time was there ever any great difference between the two lots.

On the Monteola clay at Big Wells, the onions again showed little difference in keeping quality on the basis as to whether they had received potash or not. At each inspection in both 1938 and 1939, there was always about the same percentage of marketable onions still remaining irrespective of whether they had received potash or not (Tables 6 and 7). The results secured in these experiments, suggest that potash fertilizer is no more a factor in the keeping quality of onions grown on the various soils of the Winter Garden Region of Texas than it was when first reported in 1936 in connection with the fertilizer experiments on Webb fine sandy loam (4).

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Summary

The results obtained in the outlying fertilizer experiments conducted with Yellow Bermuda onions in the Winter Garden-Laredo area over a period of three years lead to the following conclusions:

1. The response by the onions to fertilizer in general on the Laredo silt loam (Laredo) and the Monteola clay (Big Wells) was not nearly as marked as it had been in previous experiments on Webb fine sandy loam.

2. There was no consistent response to fertilizer in general on Laredo very fine sandy loam. This may be due to a deficiency in available nitrogen, or an unsatisfactory nutrient balance caused by a lack of nitrogen.

3. In none of the outlying locations was the response to potash significant. This finding agreed with the previous one on Webb fine sandy loam.

4. In all the outlying locations there was a tendency towards higher onion yields whenever nitrate of soda had been added to previously fertilized onions. This tendency was the most clear-cut on Laredo very fine sandy loam, was somewhat less on Laredo silt loam, and so small on Monteola clay that it lacked significance.

5. In none of the outlying experiments were fertilizers with 1-3-0 or 1-3-1 ratios noticeably more effective than fertilizers with 1-2-0 and 1-2-1 ratios in increasing onion yields. On Laredo silt loam there was a very slight tendency for the onions to be less productive with a fertilizer having a 1-3-0 or a 1-3-1 ratio than with one having a 1-2-0 or 1-2-1 ratio. On Monteola clay the results were the opposite.

6. With onions grown on any of the soils on which the fertilizer tests herein reported were conducted, the presence or absence of potash in the fertilizer used, seems to make little difference in their keeping quality.

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