HILGARDIA

A JOURNAL OF AGRICULTURAL SCIENCE PUBLISHED BY
THE CALIFORNIA AGRICULTURAL EXPERIMENT STATION

Volume 37, Number 8 · February, 1966

Studies on the Growth Rate and Nutrient Absorption of Onion

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This paper reports the development and nutrient absorption of plants of the onion cultivar Southport White Globe, growing in the field. Growth curves for leaf number, plant height, plant fresh and dry weight, and per cent dry matter are presented. The onion plants produced more than 64 per cent of their fresh weight and more than 72 per cent of their dry weight during the period of bulbing to harvest. Approximately 28 per cent of the fresh weight and 36 per cent of the dry weight of the plants were produced after tips of the leaves dried and tops had begun to collapse.

Chemical analyses of the plants showed that total N, P, K, Ca, Mg, and Na tended to decrease during plant growth. At harvest, total N and P were higher in the bulb than in the whole plant; K, Ca, Mg, and Na were lower.

Nutrient uptake curves of two crops are presented. Maximum rate of growth during bulbing was accompanied by maximum rate of nutrient uptake. At harvest the crops had removed, in pounds per acre, averages of: N, 143; P, 23; K, 113; Ca, 87; Mg, 13; and Na, 10.

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Studies on the Growth Rate and Nutrient Absorption of Onion[1]

INTRODUCTION

An understanding of the development of the common onion (*Allium cepa* L.) from seedling through bulbing, and of the plant response to photoperiod and temperature, is fundamental to good crop production. Also, a thorough knowledge of growth pattern and nutrient uptake of onions is essential for sound management practices, particularly in irrigation and fertilizer application. Jones and Mann (1963)[2] described the sequence of changes from seedling growth through bulbing and maturity of a spring planting of the cultivar Excel, grown at Davis, California. The relation of bulbing and seedstalk formation to daylength and temperature has been reported by a number of investigators (Atkin and Davis, 1954; Boswell, 1924; Gardner and Allard, 1923; Jones, 1928; Jones and Emsweller, 1939; Magruder and Allard, 1937; and Thompson and Smith, 1938). Only limited information is available regarding the rate of growth under field conditions (Binkley, Ferguson, and Fauber, 1951) and the course of nutrient absorption by the onion crop (Zink, 1962).

The present field study of growth and nutrient uptake was undertaken to establish a background for cultural studies on onion crops. Although this study was restricted to the Salinas Valley, the information reported is pertinent to long-day cultivars that are grown in similar latitudes on mineral soils.

MATERIALS AND METHODS

Culture and Growth Measurements

Five commercial fields in the Salinas Valley, latitude 36° to 36.6° N, were selected for study. The cultivar Southport White Globe was grown in all trials. Bulb onions in this area are direct-seeded—two rows on a 40-inch bed—during February and early March. General information on cultural methods in this region is given by Davis (1957). Irrigation, fertilizer, and cultural practices in plots of approximately one-half acre each were the same as for the commercial field in which each plot was located. These details are given for each trial in tables 8 through 12.[3]

[1] Submitted for publication December 14, 1964.

[2] See "Literature Cited" for citations referred to in the text by author and date.

[3] All tables in this paper are grouped, starting on page 214. Data for trials 1 through 5 are given in tables 8 through 12.

Onion plants from trials 1 and 2 were sampled at 14-day intervals from shortly after emergence to date of harvest. Each sample consisted of 25 or 50 plants, with root system, selected at random. Fifty plants were collected when the plants were small, and 25 plants on the last four sampling dates. Data on fresh weight, dry weight, number of leaves visible without dissection, plant height, and per cent of population bolting were recorded. Plant height was measured from the tip of the longest leaf to the base of the root plate. The percentage of the plant population bolting was determined the first week of August from a random sample of one thousand plants.

Plant samples were taken before 9:00 a.m. so that water content of plants, as influenced by diurnal fluctuation, would be at a minimum. Samples were taken directly to the laboratory, where fresh weight was determined, then were dried in an oven at 60° C. The dried material was used for mineral analysis. Bulb fresh weight, per cent dry matter, and mineral absorption data for trials 3 through 5 were determined from 50 mature bulbs with tops and roots removed. Plant population for each field was ascertained from 10 locations of 0.01 acre each in the trial area. Thermograph records were kept of the air temperature 6 inches aboveground during the growing period.

Analyses of Dry Plant Materials

Dried plant parts were ground in a Wiley mill to pass a 20-mesh screen. A representative sample of this material was analyzed for the following constituents:

Nitrate-Nitrogen. The weighed ground sample was extracted overnight with 2 per cent acetic acid. A little charcoal (Norit A) was added to clear the solution before filtering. Nitrate-nitrogen was then determined by the conventional phenoldisulfonic acid method.

Total Nitrogen and Phosphorus. These were determined by standard procedures given by the Association of Official Agricultural Chemists (Horowitz, 1955).

Potassium, Sodium, Calcium, and Magnesium. The concentration of each of these elements was obtained by analysis of the ashed sample, by means of a flame spectrophotometer (Yamaguchi and Minges, 1956).

Soil Analyses

Samples were taken from the surface foot of soil before preplant fertilizer application. Each sample was a composite of 30 soil cores. A representative sample of this material was analyzed, using the methods of Hester (1948), except that extractions were made with 125 me per liter sodium acetate, pH 5.0, 50 ml per 15 gm of soil.

RESULTS AND DISCUSSION

Effects of Photoperiod and Temperature on Growth

Temperature and photoperiod are the two most important factors affecting the development of the onion plant. Under the conditions of this study, plants developed at first under increasing daylength and rising temperatures, then under shorter days but still-rising temperatures (fig. 1). Magruder and Allard (1937) found that the cultivar Southport Yellow Globe, which is closely related to Southport White Globe, required a minimum of 13 hours of light in order to bulb slightly, and 14 hours for good bulbing. In this study the minimum 13 hours of daylight needed for slight bulbing was met in mid-April, and 14 hours of daylight in mid-May. The first indication of bulbing was observed on June 5 in trial 1, and on June 11 in trial 2. Thompson and Smith (1938) showed that bulbing is not determined by daylength alone, but by the interaction of daylength and tempera-

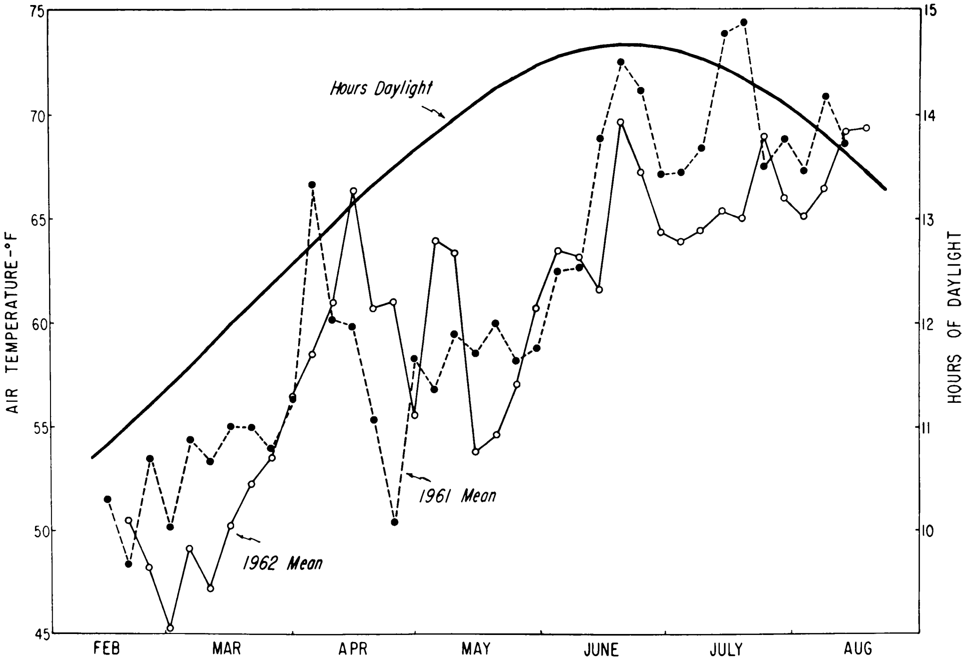

Fig. 1. Hours of daylight and five-day mean air temperatures during growth of Southport White Globe onions in 1961 (trial 1) and 1962 (trial 2). (Hours of daylight taken from records of Federal Aviation Agency, Salinas, Calif.)

ture. Daylength and other factors being equal, onions bulb more quickly at warm than at cool temperatures. The temperature and growth data indicate that Southport White Globe bulbs satisfactorily when daylength is approximately 14 hours, and mean air temperatures during the month before bulbing are approximately 59° F (table 1).

Cool temperatures and size of plant or bulb influence bolting (Thompson and Smith, 1938; Davis and Jones, 1944). Little or no flowering is induced in small bulbs or plants by cool temperatures. Bolting was observed in late June in both trials. Population bolting in trial 1 (19.8 per cent; 1961) was twice that found in trial 2 (8.1 per cent; 1962). The trials were planted with seed from two different sources, which may possibly account for the differences in bolting percentages. A second explanation could be that during the period when temperatures were favorable for the initiation of inflorescence, plants in trial 1 were larger than those in trial 2. Air temperatures during April and May of 1961 were slightly cooler than in 1962 (table 1, fig. 1).

Plant Growth Characteristics

Growth curves for plant height, leaf number, plant fresh and dry weights, and per cent dry matter for trials 1 and 2 are shown in figures 2 and 3, respectively. In both trials, mean plant height increased until early July, then decreased as leaf tips dried and tops started to collapse. On July 31 (trial 1) and August 6 (trial 2) approximately 14 per cent of the plant tops, while yet green, had weakened just above the bulb and had fallen over. At the time the bulbs were lifted, on August 14 (trial 1) and August 20 (trial 2), nearly 50 per cent of the tops had collapsed. The remaining plants had semi-erect, partially dry tops, or were bolters.

The number of leaves visible without dissection increased fairly uniformly to about 10 in early July (trial 1) and to approximately 9.5 in late June (trial

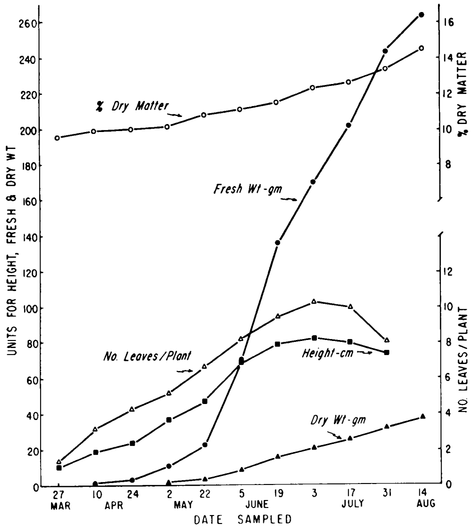

Fig. 2. Growth curves of Southport White Globe onions, showing plant height, leaf number, plant fresh and dry weights, and per cent dry matter, trial 1.

2). When the first indication of bulbing was observed in early June, the mean numbers of leaves per plant were 8.2 and 8.8 for trials 1 and 2, respectively.

Plant fresh weights and dry weights increased slowly during early growth. When half the total growing period had passed, approximately 7 per cent of the fresh weight and 5 per cent of the ultimate dry weight had been produced by the plants in both trials. When bulbing was first observed in trial 1 (June 5), the plants had produced 27 per cent of their fresh weight and 20 per cent of their dry weight. Plants in trial 2 had produced 36 per cent of their fresh weight and 28 per cent of their ultimate dry weight when bulbing was observed on June 11. The period of most rapid increase in fresh weight extended from late May through July.

Plant fresh and dry weights increased until harvest in both trials. Approximately 28 per cent of the fresh weight and 36 per cent of the dry weight of the plants were produced during the period when tops were drying and bulbs maturing. These data indicate that the practice of beating the tops off to facilitate mechanical harvesting should be delayed as long as possible to obtain maximum production.

The per cent dry matter in the whole plant increased fairly uniformly during crop growth, the rate increasing slightly as plants approached maturity. Dry matter at harvest was 14.5 and 14.4 per cent for trials 1 and 2, respectively.

Bolting was first evident in late June. The flower stalk elongated very rapidly through July and early August. Only a few umbels opened before harvest. The percentages of plant population bolting in early August were 19.8 and 8.1 for trials 1 and 2, respectively.

Table 2 shows mean fresh weight of field-cured bulbs, with tops and roots removed, and per cent dry matter. The differences in mean weight per bulb for the five trials can be attributed in part to cultural practices. Bulbs from trial 4 were relatively small. The population was quite high in this trial—approximately 157,000 plants per acre. Furthermore, trial 4 had the lowest nitrogen fertilizer program. In contrast, trial 1, with approximately 110,000 plants per acre and relatively high nitrogen fertilizer, produced bulbs with the heaviest mean fresh and dry weights. Dry matter in the bulbs ranged from 14.9 to 16.3 per cent. No relation was noted between fertilization and percentage of dry matter in mature bulbs.

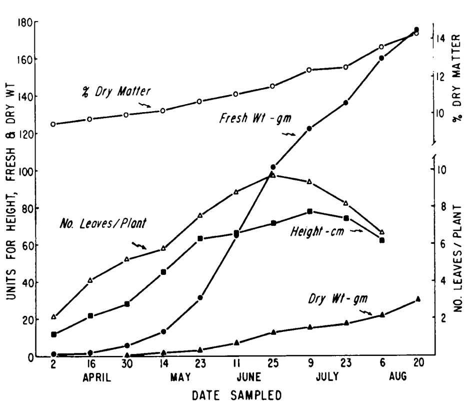

Fig. 3. Growth curves for Southport White Globe onions, showing plant height, leaf number, plant fresh and dry weights, and per cent dry matter, trial 2.

Nutrient Absorption and Mineral Content During Growth

A knowledge of the nutrient requirement of the crop and nutrient level of the soil would be important in planning a fertilizer program to obtain maximum production with minimum cost. Data on the nutrient element composition of the plants during growth of the crop in trials 1 and 2, expressed as per cent dry weight, are presented in tables 3 and 4, respectively. Soil analysis data for trials 1 and 2 are reported in table 5.

Nitrate-Nitrogen. Nitrate-nitrogen (NO_3-N) contents of the plants were 0.21 and 0.15 per cent, shortly after emergence, in trials 1 and 2, respectively. Samples taken later in the growth of the crop were less than 0.015 per cent of dry weight, and are reported as a trace. This indicates that NO_3-N analysis of the whole plant is not a reliable method of determining the nitrogen status during growth of a bulb-onion crop. In contrast, in a green-onion nutrient study, NO_3-N content fluctuated during the growth period (Zink, 1962). These fluctuations, for the most part, were related to time of nitrogen fertilization and/or rate of growth. The range in NO_3-N was found to be 0.02 to 0.44 per cent on a dry-weight basis in green onions. This difference between bulb-onion and green-onion plants, in NO_3-N composition, probably can be explained by the heavier preplant nitrogen application in the green-onion study and the larger amounts of nitrogen applied as sidedressings over the same crop period.

Total Nitrogen. Total N tended to decrease during growth. This decrease may be related to the accelerated plant growth during the bulbing period.

In trial 1 the May 8 sample showed an increase in total N content of the plant. This increase may be due, in part, to a sidedressing of nitrogen fertilizer applied May 2. However, no interruption in the general trend of total N decrease was observed with additional nitrogen sidedressings. Plants in trial 2 showed no fluctuation in total N content that could be related to nitrogen fertilization during crop growth. Total N ranged from 4.16 to 1.52 per cent.

Phosphorus. The P composition generally tended to decrease during crop growth. The P content of the plant ranged from 0.40 to 0.24 per cent, dry weight.

Potassium. The K composition of the plant in trial 1 decreased during crop growth. In trial 2 the K content fluctuated somewhat during early growth, then decreased sharply at the onset of bulbing. The decrease continued until the last sampling date, which showed a slight increase.

Soil analyses for trial 2 show the K level to be slightly low. This may account for the sharp decrease in K in the plant at the onset of bulbing, and for the generally lower K content of the plants in trial 2 as compared with plants of approximately the same stage of development in trial 1. Potassium ranged from 4.41 per cent in onion seedlings to 1.15 in maturing plants. Zink (1963) has shown a similar sharp decrease in K composition of garlic plants at bulbing.

Calcium. The Ca composition of plants in trial 1 generally tended to decrease during crop growth. Calcium in plants from trial 2 fluctuated slightly during early crop growth, but tended to decrease until bulbs started to mature, then increased slightly. The Ca composition in plants ranged from 1.74 per cent during early growth to 0.86 in mature plants. It is interesting to note that in a study on garlic grown on a similar soil type with approximately the same Ca soil level, the Ca content of the garlic plant increased during crop growth from 0.29 per cent in the planted clove to 1.14 at harvest (Zink, 1963).

Magnesium. The Mg composition of the plants in trial 1 showed a general trend to decrease during crop growth. In trial 2 Mg tended to decrease until bulbs started to mature, then increased

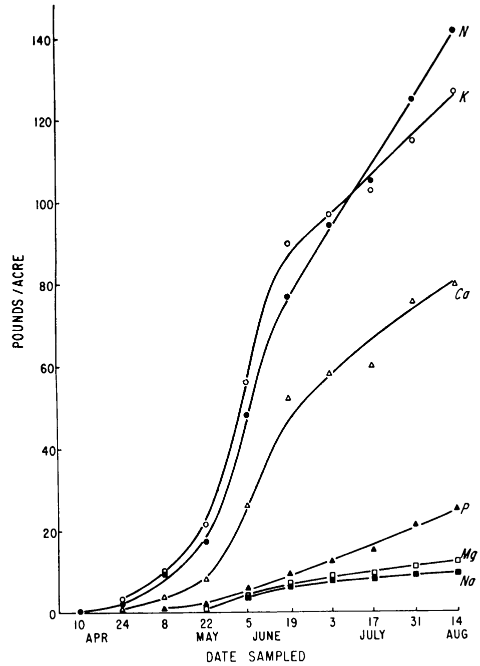

Fig. 4. Mineral absorption by Southport White Globe onions during crop growth, trial 1.

slightly until harvest. The Mg content ranged from 0.42 to 0.12 per cent.

Sodium. The Na content of the plants in trial 1 decreased during crop growth. In trial 2 the Na fluctuated somewhat during growth, with a tendency to decrease. The Na content ranged from 0.52 to 0.10 per cent.

Comparison of Whole Plant and Bulb. A comparison of the analyses of complete plants at the time the crop was lifted (trials 1 and 2—table 3, August 14; table 4, August 20) with analyses of bulbs (table 2, trials 1 and 2) shows differences. Relative to dry-matter content, total N and P were higher in the bulbs than in the whole plants; K, Ca, Mg, and Na were lower in the bulbs than in the whole plants.

Nutrient Uptake. Removal of nutrients from the soil by the crop was calculated from plant mineral analyses and dry-weight growth data. Figures 4 and 5 show the cumulative N, P, K, Ca, Mg, and Na uptake curves for trials 1 and 2, respectively. The rate of nutrient removal was very slow during early growth. When approximately one-half the total growing period had passed, the plants had removed less than 13 pounds of N, 1.3 pounds of P, and 15 pounds of K per acre. During the period of bulbing to harvest, the plants removed approximately 68 per cent of their total N, 75 per cent of the P, and 47 per cent of the K. Total nutrient absorption, in pounds per acre, in trial 1 was: N, 142; P, 25; K, 127; Ca, 80; Mg, 12; and Na, 9. Comparable figures for trial 2 show: N, 145; P, 21; K, 99; Ca, 94; Mg, 14; and Na, 11.

The nutrient absorption curves for N and P are similar in trials 1 and 2, and have the same general pattern of removal found in garlic (Zink, 1963).

In trial 1 the change in slope of the K-uptake curve (June 5 to August 14) is the result of a decrease in K composition of the plants associated with bulbing (fig. 4). The abrupt change in the slope of the K-uptake curve in trial 2 (May 28 to July 9) is due principally to an accelerated rate in the decrease

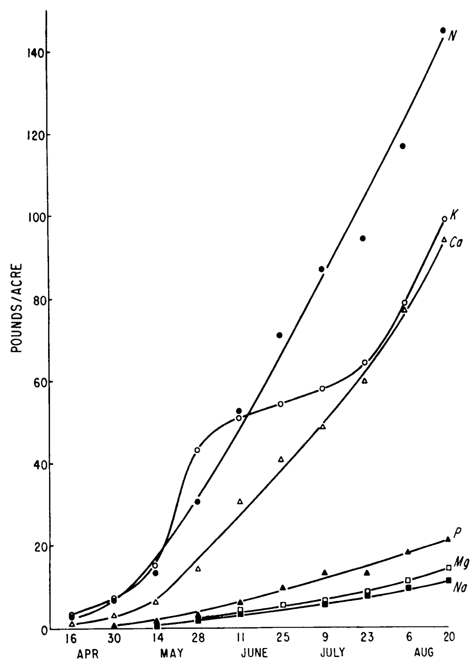

Fig. 5. Mineral absorption by Southport White Globe onions during crop growth, trial 2.

of the K content of the plants during early bulb formation (fig. 5). The second change in slope of the curve (July 23 to August 20) is the result, in part, of a deceleration in the rate of decrease in K in the plants, and to an increase in the rate of growth (mean dry weight per plant) as the crop approached maturity.

In trial 1 the change in slope of the Ca, Mg, and Na uptake curves during bulb formation and maturation was caused by a decrease of those elements in the composition of the plants (fig. 4). In contrast, the Ca, Mg, and Na absorption curves in trial 2 did not tend to level off during bulbing, but continued their general upward pattern until bulbs matured (fig. 5). This phenomenon can be explained by the interaction of two factors: Ca, Mg, and Na composition of the plant increased slightly or remained fairly constant during bulb maturation (July 9 to August 20); the rate of growth, as measured by mean dry weight per plant, accelerated slightly during the same period.

The data on mineral composition of the bulbs (table 2) suggest a relationship between the amount of N fertilizer applied and N composition of the bulbs. In trial 4 the crop was grown with a relatively low N fertilizer program, and the N content of the bulbs was significantly lower than that found in bulbs grown with a higher N fertilizer regime. No relation was found between the amount of P and K applied as fertilizer and the P or K composition of the bulbs.

Pounds of N, P, and K applied to the five crops, and calculated pounds removed by the bulbs at the time of harvest, are presented in table 6. Trial 4 was relatively low in nutrients removed. This was principally the result of small bulb size rather than low mineral content in the bulb.

Calculated pounds per acre of Na, Ca, and Mg removed by the bulbs are presented in table 7. Calcium removed by bulbs was found to be greater than the amount of P removed for any given trial; the amount ranged from 45 to 22 pounds Ca per acre. Magnesium removed ranged from 8.0 to 4.1 pounds per acre, while Na varied from 4.7 to 1.5 pounds per acre.

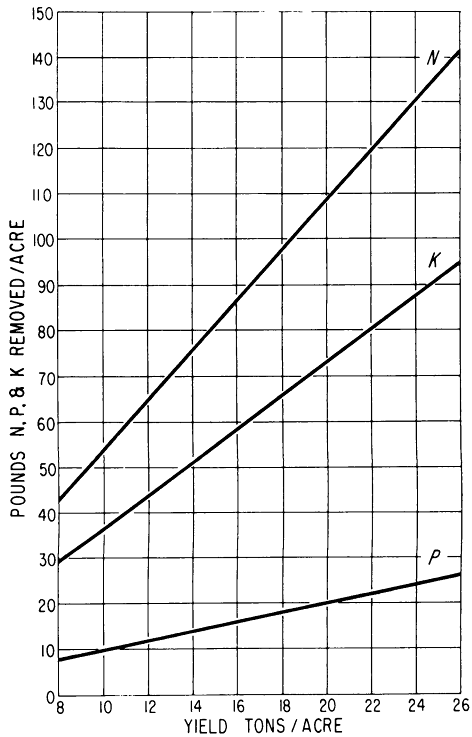

Fig. 6. Amounts of N, P, and K removed from soil, at different fresh-weight yield levels. Calculated on the basis of 15.8 per cent dry matter in mature onion bulbs, and mineral contents of: N = 1.71; P = 0.31; and K = 1.15, expressed as per cent of dry weight.

Figure 6 shows the pounds of N, P, and K removed from an acre at various yield levels. Calculations were made from the average mineral content of bulbs from the five trials. Such information could be useful in determining the residual fertilizer from an onion crop.

Results of some early fertilizer experiments show that 76 pounds of N, 7 pounds of P, and 71 pounds of K were absorbed per acre in the growth of a crop yielding 200 hundredweight of bulbs per acre (Hester and Sheldon, 1949). Unpublished data of O. A. Lorenz for a crop yielding 250 hundredweight of bulbs show a total absorption, in pounds per acre, of: N, 63; P, 13; and K, 73. The considerably higher nutrient uptake reported in this paper can be explained in part by the higher yields. The average nutrient absorption of trials 1 and 2 (N, 143; P, 23; K, 113 pounds per acre) approaches a 6:1:5 ratio.

Compared with that of many other crops, the root system of the onion plant is limited in spread and depth, and fills the soil poorly because of sparse branching; the bulk of the roots is in the upper 1 to 2 feet of soil (Weaver and Bruner, 1927). Abdalla and Mann (1963) reported that adventitious roots emerged at the rate of four or five per week, reached a maximum of 70 live roots per plant 20 days before harvest, then declined in number because old roots died more quickly than new roots were produced. The fact that individual onion roots are limited in size, and that new adventitious roots must be added to the root system as the plant top enlarges, indicates that soil moisture must reach the bulb base at least periodically during the growing season, and that a fairly high concentration of plant nutrients must be in the upper foot of soil.

Conflicting recommendations have been published (Davis, 1957; Pew, 1958) concerning the frequency of nitrogen application during growth of onion crops. Davis suggests that all of the nitrogen can be applied at planting on soils that do not leach readily; recommends split applications only for very light soils that are readily leached; and indicates that at least one-third should be applied when the crop is planted. In contrast, Pew recommends 40 to 50 pounds of nitrogen as a preplant application, and three to five additional light applications of 15 to 20 pounds per acre—the last one to be made before bulbs form. He further states that choice of nitrogen fertilizer apparently depends more on cost per unit of nitrogen than on other characteristics. In a study on liquid, dry, and gaseous fertilizers for onions, Lorenz, Bishop, and Wright (1955) reported best yields resulted from ammonium sulfate placed 4 inches deep under the plant row; nitric acid, aqua ammonia, urea, calcium nitrate, and ammonium sulfate in the irrigation water gave much lower yields. Aqua ammonia placed in the bed under the row resulted in low yields and created severe plant toxicity. When nitric acid was placed under the plant row the yield was very low, and poor growth was presumed to be due to leaching of nitrates in the soil. These results indicate that the form of nitrogen, placement, and time of application are critical in the production of onions. What is important to the onion grower is that an adequate supply of nitrogen be in the root zone during crop growth, especially during the period of bulbing when the demand for this nutrient is the greatest in the growth cycle.

Phosphorus fertilizer should be applied before planting to obtain maximum benefit from its use. Liquid or dry phosphorus fertilizers do not move appreciably in the soil following irrigations, but remain in the area where applied until used by plants (Lorenz, Bishop, and Wright, 1955). The dicalcium phosphates are not recommended for use on alkaline soils.

In the many fertilizer experiments conducted in California, results have shown that onions grown on mineral soils do not usually respond to potassium fertilization. If soil analysis or growth response indicates the need for potassium, best results will be obtained from preplant application.

SUMMARY

1. Southport White Globe onion, a cultivar, showed the first indication of bulbing in early June, approximately 25 days after a daylength of 14 hours was reached. Daily mean air temperatures the month before bulbing were in the range of 55° to 67° F.

2. The number of visible green leaves increased fairly uniformly to a maximum of about 10 per plant. When bulbing was first observed the mean number of leaves per plant was approximately 8.5.

3. In these trials, Southport White Globe onions produced more than 64 per cent of their fresh weight and more than 72 per cent of their dry weight during the period of bulbing to harvest. The period of most rapid growth extended from early bulbing until tops started to dry. Approximately 28 per cent of the fresh weight and 36 per cent of the dry weight of the plants were produced after tips of the leaves dried and tops had begun to collapse.

4. Chemical analyses of the plants showed that total N, P, K, Ca, Mg, and Na tended to decrease during plant growth. When plants were lifted for harvest, total N and P were higher in the bulb than in the whole plant; K, Ca, Mg, and Na were lower.

5. The rate of nutrient removal was very slow during early growth. Approximately 85 days after planting (half the total growing period), the plants had removed less than 13 pounds of N, 1.3 pounds of P, and 15 pounds of K per acre. During the period of bulbing to harvest the plants removed approximately 68 per cent of their total N, 75 per cent of the P, and 47 per cent of the K. At harvest, the crop had removed an average of 143 pounds of N, 23 pounds of P, 113 pounds of K, 87 pounds of Ca, 13 pounds of Mg, and 10 pounds of Na per acre.

ACKNOWLEDGMENTS

The author is indebted to the late Professor L. K. Mann for many helpful suggestions, to Professors O. A. Lorenz and G. N. Davis for their review of the manuscript, Messrs. J. W. Perdue and P. J. Riddle for assistance in the chemical analyses, and Mrs. S. S. Stein for drafting the figures. Soil analyses were courtesy of R. Hutchings Laboratory, Salinas, California.

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TABLES 1–12

TABLE 1

AVERAGE MONTHLY MAXIMUM, MINIMUM, AND MEAN AIR TEMPERATURES FOR THE CROP PERIOD OF SOUTHPORT WHITE GLOBE ONIONS
(Trial 1, 1961; Trial 2, 1962)

Month and year	Average monthly temperatures of crop period		
	Maximum	Minimum	Mean
	° F	*° F*	*° F*
February:			
1961	64.5	34.1	49.3
1962	56.0	35.4	45.7
March:			
1961	69.0	40.2	54.6
1962	64.6	37.8	50.2
April:			
1961	76.4	40.6	58.5
1962	78.2	42.8	60.5
May:			
1961	72.8	44.2	58.6
1962	73.6	44.4	59.0
June:			
1961	84.7	50.9	67.8
1962	82.0	48.0	65.0
July:			
1961	87.5	51.9	69.7
1962	81.2	50.2	65.7
August:			
1961	85.1	54.1	69.6
1962	84.8	51.0	67.9

TABLE 2

MEAN FRESH WEIGHT PER BULB, PERCENTAGE DRY MATTER, AND MINERAL CONTENT OF MATURE BULBS OF SOUTHPORT WHITE GLOBE ONIONS

Trial no.	Fresh wt. per bulb	Dry matter	Mineral composition of mature bulbs					
			N	P	K	Na	Ca	Mg
	gm	*per cent*	*per cent of dry weight*					
1	204.0	16.3	1.64	0.29	1.21	0.04	0.44	0.09
2	151.6	16.2	1.94	0.33	1.03	0.06	0.58	0.10
3	198.6	14.9	1.66	0.32	1.24	0.03	0.56	0.10
4	90.5	16.2	1.49	0.29	1.11	0.03	0.45	0.08
5	135.4	15.3	1.84	0.34	1.14	0.05	0.40	0.09

TABLE 3
MINERAL COMPOSITION OF WHOLE PLANTS DURING CROP GROWTH OF SOUTHPORT WHITE GLOBE ONIONS
(Trial 1, 1961)

Date of sample	Whole plant mineral composition						
	NO_3-N	N	P	K	Na	Ca	Mg
	per cent of dry weight						
April 10	0.21	4.16	0.40	4.41	0.38	1.60	0.36
April 24	Trace	3.01	0.31	3.58	0.38	1.33	0.29
May 8	Trace	3.38	0.32	3.44	0.38	1.38	0.32
May 22	Trace	2.85	0.30	3.49	0.24	1.40	0.25
June 5	Trace	2.49	0.29	2.94	0.21	1.38	0.22
June 19	Trace	2.02	0.25	2.36	0.18	1.37	0.20
July 3	Trace	1.85	0.24	1 92	0.16	1.16	0.16
July 17	Trace	1.71	0.24	1.67	0.13	0.98	0.14
July 31	Trace	1.58	0.26	1.46	0.11	0.96	0.14
August 14	Trace	1.52	0.27	1.36	0.10	0.86	0.13

TABLE 4
MINERAL COMPOSITION OF WHOLE PLANTS DURING CROP GROWTH OF SOUTHPORT WHITE GLOBE ONIONS
(Trial 2, 1962)

Date of sample	Whole plant mineral composition						
	NO_3-N	N	P	K	Na	Ca	Mg
	per cent of dry weight						
April 16	0.15	3.58	0.33	4.25	0.44	1.60	0.32
April 30	Trace	3.57	0.31	3.70	0.52	1.74	0.42
May 14	Trace	3.20	0.33	3.62	0.24	1.50	0.24
May 28	Trace	2.92	0.27	4.10	0.16	1.36	0.19
June 11	Trace	2.32	0.27	2.26	0.14	1.34	0.18
June 25	Trace	1.94	0.26	1.45	0.17	1.12	0.15
July 9	Trace	1.83	0.27	1.21	0.15	1.04	0.12
July 23	Trace	1.75	0.24	1.18	0.15	1.11	0.16
August 6	Trace	1.70	0.26	1.15	0.14	1.16	0.16
August 20	Trace	1.82	0.26	1.24	0.14	1.18	0.18

TABLE 5
SOIL ANALYSIS BEFORE PREPLANT FERTILIZER APPLICATION
(Trial 1, 1961; Trial 2, 1962)

Trial number	Mineral composition of soil				
	NO_3-N	PO_4-P	K	Ca	Mg
	ppm				
1	3	48	99	2,600	360
2	5	38	48	1,600	230

TABLE 6

CALCULATED GROSS YIELD PER ACRE OF SOUTHPORT WHITE GLOBE ONIONS, AMOUNT OF MINERALS APPLIED AS FERTILIZER, AND AMOUNT REMOVED BY BULBS, CALCULATED AT HARVEST

Trial no.	Yield per acre, fresh weight	N		P		K	
		Applied (actual)	Removed (calculated)	Applied (actual)	Removed (calculated)	Applied (actual)	Removed (calculated)
	cwt.	*lb./acre*					
1	495	228	132	26	23	0	98
2	479	256	150	20	26	0	80
3	538	256	133	44	26	84	99
4	313	128	76	26	15	0	56
5	406	186	114	50	21	42	88

TABLE 7

AMOUNTS OF SODIUM, CALCIUM, AND MAGNESIUM REMOVED BY BULBS OF SOUTHPORT WHITE GLOBE ONIONS, CALCULATED AT HARVEST

Trial no.	Minerals removed		
	Na	Ca	Mg
	lb./acre		
1	3.2	35.5	7.3
2	4.7	45.0	7.8
3	2.4	44.9	8.0
4	1.5	22.8	4.1
5	3.1	24.8	5.6

TABLE 8

FERTILIZER PROGRAM FOR SOUTHPORT WHITE GLOBE ONIONS, TRIAL 1*

Application dates	Fertilizer applied			Actual nutrients		
	N	P_2O_5	K_2O	N	P	K
	per cent			*lb./acre*		
Preplant	12	15	0	48	26	0
May 2	20	0	0	60	0	0
May 22	20	0	0	60	0	0
June 6	20	0	0	60	0	0
				228	26	0

* Planted February 10, 1961; harvested August 14; growth period: 186 days. Plants per acre: 110,000; Salinas silty clay loam, pH 8.4.

TABLE 9
FERTILIZER PROGRAM FOR SOUTHPORT WHITE GLOBE ONIONS, TRIAL 2*

Application dates	Fertilizer applied			Actual nutrients		
	N	P_2O_5	K_2O	N	P	K
	per cent			*lb./acre*		
Preplant	12	15	0	36	20	0
April 25	20	0	0	60	0	0
May 16	20	0	0	60	0	0
June 6	20	0	0	60	0	0
July 7	20	0	0	40	0	0
				256	20	0

* Planted February 17, 1962; harvested August 20; growth period, 184 days. Plants per acre, 143,500; Metz fine sand pH 8.3.

TABLE 10
FERTILIZER PROGRAM FOR SOUTHPORT WHITE GLOBE ONIONS, TRIAL 3*

Application dates	Fertilizer applied			Actual nutrients		
	N	P_2O_5	K_2O	N	P	K
	per cent			*lb./acre*		
Preplant	10	10	10	50	22	42
May 10	10	10	10	50	22	42
June 12	32	0	0	96	0	0
July 14	20	0	0	60	0	0
				256	44	84

* Planted March 11, 1962; harvested August 22; growth period, 172 days. Plants per acre, 123,000; Salinas fine sandy loam, pH 7.8.

TABLE 11
FERTILIZER PROGRAM FOR SOUTHPORT WHITE GLOBE ONIONS, TRIAL 4*

Application dates	Fertilizer applied			Actual nutrients		
	N	P_2O_5	K_2O	N	P	K
	per cent			*lb./acre*		
Preplant	16	20	0	48	26	0
May 3	20	0	0	40	0	0
June 22	20	0	0	40	0	0
				128	26	0

* Planted February 14, 1961; harvested August 25; growth period, 192 days. Plants per acre, 157,000; Salinas clay, pH 7.4.

TABLE 12
FERTILIZER PROGRAM FOR SOUTHPORT WHITE GLOBE ONIONS, TRIAL 5*

Application dates	Fertilizer applied			Actual nutrients		
	N	P_2O_5	K_2O	N	P	K
	per cent			*lb./acre*		
Preplant	10	10	10	50	22	42
May 15	32	0	0	96	0	0
June 19	20	0	0	40	0	0
				186	22	42

* Planted March 3, 1962; harvested August 24; growth period, 174 days. Plants per acre, 136,000; Salinas silty clay loam, pH 7.6.

4m-2,'66(F8625)P.F.–L.L.

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