

RESPONSE OF *CYPERUS ROTUNDUS* L. TO FIVE MOISTURE LEVELS

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Cyperus rotundus L. is a field weed known in all the Southern States as nut grass. The plant produces rhizomes, tubers, basal bulbs and fibrous roots below ground, and rosettes of leaves, scapes, and umbels above ground. The response of nut grass to moisture is an important factor in field eradication and studies were started in the greenhouse to determine the levels at which the plant showed differential response to soil moisture. The results reported herein constitute part of the data collected.

Pear, corn, and lemon plants have been shown to respond to differences in moisture well above the so-called wilting point by ALDRICH, WORK, and LEWIS (1), DAVIS (2), LOOMIS (4), and FURR and TAYLOR (3). The distance from the plant to moisture was also shown by ALDRICH *et al.*, DAVIS, and FURR and TAYLOR to be a factor in the availability of soil moisture for plant growth. In the experiments cited, growth was measured as the soil moisture was reduced, but because of mechanical difficulties the soil could not be maintained at any one moisture level.

Methods

The experiment was started August 12, 1940, with 45 squat-type gallon pots in which the rapid growth of the roots minimized the factors of distance. One tuber was planted in each pot. The fresh weight of the tubers varied from 1.01 to 2.24 gm. with an average weight of 1.43 gm. There was no significant difference in the weight of tubers planted, between the moisture series or between replications. After twenty-four weeks there was no correlation between the initial weight of tuber and final weight of tubers, either within a moisture series or over the entire experiment. There also was no significant correlation between the initial weight of tuber and either total or initial number of shoots.

The pots were divided into nine replications and so placed along the length of the greenhouse bench as to minimize variations in light intensity and temperature. The soil used to fill the pots was a heavy silt to which organic material and sand had been added a year before the pots were filled. The moisture equivalent of the mixture was 16.93 per cent. and the determined wilting percentage for corn was 8.22 per cent. The soil in the pots absorbed at least 22 per cent. of its oven dry weight of water when watered by standing in pans of water for 24 hours or until the surface was wet. The moisture differences were obtained by wetting uniformly after the pots had dried to different levels of moisture to simulate different periods between

wetting in the field. When the weight of a pot was within 45 gm. of its calculated low-moisture weight, or 1 per cent. of the 4.5 kgm. of soil contained, the pot was watered. Each pot was marked when daily weighings showed that it was approaching the low moisture point and was then checked twice each day or oftener when rapid evaporation was taking place.

One series of pots was watered when the gross weight of the pot showed a moisture percentage of 18; the second series was watered when the gross weight showed that a moisture content of 15 per cent. was approached; the third series was watered when the soil moisture was lowered to 12 per cent.; the fourth series was watered when the soil moisture was lowered to 9 per cent.; the fifth series was watered when the soil reached 6 per cent. of moisture. The moisture percentage contained in the pots was calculated at the time of filling and checked at the end of the experiment.

Sudden increases in the temperature and wind velocity in the open greenhouse increased the rate of evaporation and transpiration so that in some cases moisture was lowered below the intended minimum. When such sudden drying occurred, for example a pot in the 18 per cent. series which contained more than 19 per cent. of soil moisture at 10 A.M. contained only 15 per cent. soil moisture at 4:30 P.M., the leaves were limp and the scapes bent. The following day, after watering, the leaves were yellow and the scapes died more rapidly than expected. Such damage occurred to plants that were suddenly lowered below the previous low moisture condition except in the 6 per cent. series. Plants subjected periodically to severe drying seemed to become hardened and did not show signs of wilting even though they were sometimes subjected to as rapid drying as the plants on the more moist series. Soil temperatures varied with location on the bench but did not vary more than 1 degree within a replication.

After 24 weeks of growth, the number of rosettes was counted, and the tops were cut at the ground surface and weighed. The bulbs and tubers were washed free of soil and counted, and the tubers and rhizomes weighed. Dry weights were also determined, but there was no significant difference in the percentage of dry matter either for tubers, including bulbs, or tops, including scapes and umbels.

Results

The data were treated by analysis of variance and indicate that there was a highly significant difference between moisture levels in the number of shoots, the number of tubers, the weight of tops, the weight of tubers, and the tuber-top ratio, table I. The total weights of the plants and the dry weights of the tubers follow almost exactly the analysis for the weight of tubers, as would be expected from the similar percentages of dry matter and the fact that the tuber weight is from three to six times the top weight, and therefore dominates the total. The number of tubers for each rosette

above ground was extremely variable but no significant differences were shown.

TABLE I

VARIANCE* OR MEAN SQUARES FROM ANALYSES OF FIVE OBSERVATIONS ON EACH OF 45 POTS OF *Cyperus rotundus* L. GROWN WITH FIVE MOISTURE TREATMENTS IN THE GREENHOUSE AT TUCSON

| SOURCE OF VARIANCE | DEGREES OF FREEDOM | NUMBERS OF TOPS | NUMBERS OF TUBERS | WEIGHT OF TOPS | WEIGHT OF TUBERS | TUBER/TOP RATIO |
|---------------------|--------------------|-----------------|-------------------|----------------|------------------|-----------------|
| Moistures | 4 | 1183.2† | 5286.8† | 1263.13† | 17031.6† | 7.39† |
| Replications | 8 | 14.1 | 204.8 | 3.59 | 329.8 | 0.25 |
| Interaction (error) | 32 | 26.8 | 92.7 | 24.39 | 238.7 | 0.67 |

* An asterisk denotes a significant difference greater than the 0.05 per cent. level.

† A dagger denotes a significant difference greater than the 0.01 per cent. level.

TABLE II

AVERAGES AND DIFFERENCES BETWEEN DIFFERENT MOISTURE LEVELS MAINTAINED IN POTS OF *Cyperus rotundus* L. FOR NUMBERS OF TOPS AND TUBERS, WEIGHTS OF TOPS AND TUBERS, AND FOR THE TUBER/TOP RATIO

| MINIMUM PERCENT-AVERAGE SOIL MOISTURE | NUMBER OF TOPS | | NUMBER OF TUBERS | | FRESH WEIGHT OF TOPS | | FRESH WEIGHT OF TUBERS | | TUBER/TOP RATIO | |
|---------------------------------------|----------------|--------------|------------------|--------------|----------------------|--------------|------------------------|--------------|-----------------|--------------|
| | AVER-AGE | DIF-FER-ENCE | AVER-AGE | DIF-FER-ENCE | AVER-AGE | DIF-FER-ENCE | AVER-AGE | DIF-FER-ENCE | AVER-AGE | DIF-FER-ENCE |
| % | | | | | | | | | | |
| 6 | 8.7 | | 28.3 | | 4.1 | | 26.3 | | 6.4 | |
| | | 4.7 | | 17.4* | | 5.4* | | 24.1† | | 0.9* |
| 9 | 13.4 | | 45.7 | | 9.5 | | 50.4 | | 5.5 | |
| | | 5.9* | | 19.5* | | 7.0† | | 29.2† | | 0.6 |
| 12 | 19.3 | | 65.2 | | 16.5 | | 79.6 | | 4.9 | |
| | | 8.0† | | 20.3* | | 8.4† | | 36.9† | | 0.1 |
| 15 | 27.3 | | 85.5 | | 24.9 | | 116.5 | | 4.8 | |
| | | 10.2† | | -3.8 | | 8.8† | | 13.2 | | 0.9* |
| 18 | 37.5 | | 81.7 | | 33.7 | | 129.7 | | 3.9 | |

Significant differences at:

0.05 per cent. 5.0 9.3 4.8 14.9 0.8

0.01 per cent. 6.7 12.5 6.4 20.0 1.1

Differences in excess of the 0.05 per cent. level of significance are marked with an asterisk (*), those in excess of the 1 per cent. level of significance are marked with a dagger (†).

Comparisons between adjacent moisture levels are shown in table II. The average number of tops per pot in the low moisture series was less than the number of tops in pots allowed to dry to only 9 per cent. soil moisture. The difference in number of tops between the two low moistures was not significant, but each further increase in the minimum moisture allowed was accompanied by a significant increase in the number of tops developed. The differences between the moisture series, mean of nine pots,

required to reach the five- and one-per cent. levels of significance are shown in the rows at the bottom of table II. The weight of the tops was similar to the number of tops but the difference in weight between the two low moisture levels was significant. The individual comparisons need not necessarily each be significantly different to show a significant over-all relation between the minimum soil moisture and the number and weight of tops. The very high probability of the significance of the relation is emphasized by the fact that every increase in the minimum moisture has increased top number and weight, and all but one of the individual comparisons was significant.

The number and weight of tubers developed was significantly different on the different moistures, as shown in table I. Comparisons of the individual averages show that the number of tubers failed to change significantly when the minimum moisture was increased above 15 per cent. Each increase in moisture from a minimum of six to a minimum of fifteen per cent. soil moisture resulted in a significant increase in both the number and weight of tubers.

The small difference in top weight between the two low moisture levels and the failure of the tuber weight to increase above 15 per cent. minimum moisture is shown most readily by the tuber-top ratio. A highly significant difference in tuber-top ratio on the different moisture levels is shown in table I. A more detailed study of the averages, table II, shows that the larger differences occurred between the two low and the two high moistures. The tuber-top ratio did not change significantly between 9 and 15 per cent. minimum moisture.

Discussion

Growth of plants in the field occurs with moisture fluctuating from saturation soon after a rain or irrigation to very dry soil or until another wetting which saturates the soil again. The natural differences in soil moisture are differences in volume of soil wet, and the frequency of wetting. In this experiment, the frequency of wetting was dependent upon the minimum soil moisture percentages permitted before the plants were irrigated. Some plants were not stressed for moisture at all, being always in soil wet above the moisture equivalent, and other plants were subjected to successively drier soil until the plants in the driest series were always subjected to soil dried below the wilting coefficient before being re-wet.

The plants were unable to grow in soil below the wilting coefficient, and were limited in total growth in the low series because of the time during which the soil was below this level. The difference in time available for growth could, therefore, account for the difference between the minimum moisture series of 6 and 9 per cent., but the plants in the 12-, 15-, and 18-per

cent. moisture series were never limited by complete lack of available moisture as measured by the wilting percentage, yet the plants responded to decreases of minimum moisture between 18 and 9 per cent. by decreased growth. The difference in growth through a range of soil moistures not usually considered limiting (5) may be the result of stoppage of food manufacture and transport, and particularly of growth (4) in the plant over the periods in the afternoons when transpiration had decreased the water content of the leaves. Significant differences in growth between the soil moisture levels would then be explained by the reduction in the time available for growth, as follows: Growth in the plants in soil containing 18 per cent. moisture would be interrupted only on the parts of warm days when the transpiration rate was high, while it would be restricted earlier in the afternoon and on more days in soil which was lowered to 15 per cent. moisture, and still longer interruptions would occur with each successive lowering of the minimum soil moisture, so that tuber development as well as top growth was checked on the 6-, 9-, and 12-per cent. soil moisture series.

The significant increase in the tuber-top ratio for plants grown on the lowest moisture level indicates that top development was limited by low moisture while the underground parts were still receiving sufficient food and moisture to provide some growth. The tuber-top ratio remained the same through the range of moisture from 9 to 15 per cent., indicating that, although total growth increased with increased moisture, the food supply was equally available, on the average, for both top and tuber development. The variations in the tuber-top ratio indicate that the moisture conditions affect the type of growth as well as the total quantity.

Summary

1. Each decrease in the minimum soil moisture percentage permitted before re-wetting to saturation resulted in a significant decrease in the weight of tops of *Cyperus rotundus* L.
2. Tuber development was decreased significantly by decreased soil moisture from a point 2 per cent. below the moisture equivalent.
3. Tuber-top ratios were significantly higher than average when the soil moisture minimum was below the wilting coefficient and significantly lower than average when the minimum soil moisture percentage was above the moisture equivalent.
4. Tuber growth was increased 150 per cent. and top growth 250 per cent. by raising the frequency of watering from a minimum of 9 to a minimum of 18 per cent. The 18 per cent. level of watering was nearly 100 per cent. better than the 12 per cent., even though both series were assumed to have a continuous supply of available moisture.
5. Under pot conditions, at least, growth may apparently be checked by

the availability of water in soil which was always wet above the wilting percentage.

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