Journal of the Arkansas Academy of Science

Volume 5 Article 13

1952

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EFFECT OF DIFFERENT IONIC RATIOS OF NUTRIENTS ON THE GROWTH RESPONSE OF YOUNG COTTON PLANTS[1]*

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Plant nutrition has received the attention of investigators for almost three centuries. Satisfactory plant growth on synthetic mineral-nutrient solutions was attained nearly a century ago. At present, fifteen elements are considered to be essential for plant growth.

Tottingham (7), Shive (6), Hoagland (3), and others have undertaken studies to formulate the best nutrient solutions for plant growth. Kuzmenko, et al. (4) have reported that the yield of cotton was less when cotton plants were grown to maturity on Hellriegel's nutrient solution containing a 1-1-1 ratio of N-P-K than when grown on a 1-4-1 ratio until flowering, followed by 4-1-4 to maturity. Olsen (5) found that the rate of absorption of ions from a nutrient solution is influenced by the ratio between concentrations of ions in the nutrient solution, but not by their absolute concentration.

This investigation was initiated to determine the effect of different ionic ratios of N-P-K on the growth and yield of cotton. The effect of ionic ratio on growth and development during the period from germination to square (flower bud) formation is reported herein.

Methods and Materials

The experiment was performed in the greenhouse. Each treatment consisted of three replications or pots. Seeds of cotton (*Gossypium hirsutum* L., variety Arkot 2-1) were planted on January 9, 1951, in six inch pots containing ten parts of sand, one part soil, and a half part manure compost. All except the two best seedlings were removed from each pot on January 18.

Equal volumes of nutrient solution were applied to each pot. As the plants increased in size, larger volumes of solution were supplied. During the 54-day period, 2,075 milliliters of nutrient solution was added to each pot. Tap water was supplied as needed to replenish losses by transpiration and evaporation. Wilting was kept to a minimum. The pots were flushed at weekly intervals as the plants became older and received larger quantities of nutrients. Flushing was kept to a minimum at other times.

The ionic ratios employed and the quantities of salts in the nutrient solutions are given in Table 1. All of the essential mineral elements were added as chemically pure salts, except copper which was assumed to be present in sufficient quantity in the distilled water used in preparing the nutrient solutions. The molar concentration of nitrogen, phosphorus, and potassium in the 1-1-1 ratio was 0.005.

Results

A comparison of some of the plant characteristics after 54 days growth on the ionic ratios is found in Table 2. Two series of plants were given the 1-2-1 ratio, thus two sets of data are recorded under that ratio.

The number of the node on the main stem at which the first visible square developed was recorded for each plant. The cotyledonary node was designated node "one". These data are presented in Table 3. The analysis of variance test indicated statistical significance between treatments but not between plants.

Plants which produced fruiting branches at the lower nodes also developed visible squares earlier, except for those plants on the 1-4-1 ratio.

[1]Contribution from the Department of Agronomy, University of Arkansas.

*Research Paper No. 1019, Journal Series, University of Arkansas. Published with the permission of the Director of the Arkansas Agricultural Experiment Station.

Table 1. Composition of Nutrient Solutions.

Salt	Ratio of N-P-K				
	1-1-1	1-2-1	1-4-1	2-1-2	3-0.2-1.2
	Gm./1.	Gm./1.	Gm./1.	Gm./1.	Gm. / 1.
$Ca(NO_3)_2 \cdot 4H_2O$	0.472	0.472	0.472	0.708	0.950
KCl	0.075	0.075	0.075	0.224	-
KH_2PO_4	0.545	0.545	0.545	0.545	-
KNO_3	-	-	-	0.303	0.610
$NaH_2PO_4 \cdot H_2O$	-	0.690	2.071	-	-
$NH_4H_2PO_4$	0.115	0.115	0.115	0.115	0.120
$MgSO_4 \cdot 7H_2O$	0.400	0.400	0.400	0.400	0.400
$FeSO_4 \cdot 4H_2O$	0.010	0.010	0.010	0.010	0.010
H_3BO_3	0.0006	0.0006	0.0006	0.0006	0.0006
$MnSO_4 \cdot H_2O$	0.004	0.004	0.004	0.004	0.004
$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$	0.005	0.005	0.005	0.005	0.005
$ZnSO_4 \cdot 4H_2O$	0.002	0.002	0.002	0.002	0.002
Initial pH of solution	5.1	4.9	4.8	5.0	4.9

Table 2. Comparison of Plants Maintained on Different Ionic Ratios of Nitrogen, Phosphorus, and Potassium for 54 Days after Planting.

Plant character	Ratio of N-P-K				
	1-1-1	1-2-1	1-4-1	2-1-2	3-0.2-1.2
Ave. height of 6 plants (centimeters)	36.2	45.2 41.2	33.3	45.5	46.3
No. of plants with a visible square after 54 days growth	1	4* 3	0	4	6
Color of leaves	Very pale green	Pale green	Very pale green	Green	Dark green
Color of stems	Pale green	Pale green	Pale green	Green	Dark green

*Three plants in this series produced visible squares earlier than any of the other plants in this experiment. Squares approximately five milli-meters in in width were evident 48 days after planting.

Table 3. Influence of Nutrient Ratio on Nodal Position Along Main Stem at which the First Square Developed.

	Ratio of N-P-K				
	1-1-1	1-2-1	1-4-1	2-1-2	3-0.2-1.2
Range in node number	8-10	7-8 7-9	7-8	8-10	7-8
Average node number (Average of 6 plants)	8.7	7.3 8.0	7.8	9.0	7.5

L. S. D. between treatment means for 5% level is 0.96; for 1% level is 1.30.

Discussion

Tabulation of the composition of nutrient solutions employed in solution culture studies reveals some widely divergent ionic ratios. Shive's "best" and "next best" solutions and the solutions developed by Hildebrandt, Riker, and Duggar (2) for the growth of excised tissues of sunflower and tobacco are good examples. Certain plants seem to grow well on one ratio and not so well on another. It seems questionable whether this is simply a reflection of the different requirements for a given essential element.

In the present study, the early growth of the cotton plants does not seem to be correlated directly with the quantity of nitrogen and phosphorus in the nutrient solution, since no consistent pattern of growth performance was evident on these ionic ratios. The ratios 1-4-1, 1-1-1, and 1-2-1 are listed in order of increasing superiority for plant development (See Table 2). On the basis of these three ratios, it would seem that there was too much phosphorus in the 1-4-1 ratio and insufficient phosphorus in the 1-1-1 ratio. The plants grown on the 3-0.2-1.2 ratio were superior to the plants grown on the above-mentioned ratios, yet this nutrient solution had only one-tenth of the phosphorus present in the 1-2-1 ratio solution. Thus, although poorer growth was apparent in the 1-1-1 than in the 1-2-1 ratio, the results with the 3-0.2-1.2 ratio would indicate that this poor growth was not due to a lack of phosphorus in the 1-1-1 ratio nutrient solution.

The effect of increasing nitrogen on color of the leaves and stems was consistent, but increasing nitrogen had little influence on height growth in the 1-2-1, 2-1-2, and 3-0.2-1.2 ratios. Further investigation is required since the results may be confounded by the change in potassium as the nitrogen was increased.

It appears that the ionic ratio itself has an influence on the growth response of the cotton plant.

Summary

The ionic ratio of nitrogen, phosphorus, and potassium influenced the physiological and morphological response of young cotton plants.

Literature Cited

1. Curtis, O. F. and Clark, D. G. 1950. An introduction to plant physiology. McGraw Hill Book Co., New York. 752 pp.
2. Hildebrandt, A. C., Riker, A. J. and Duggar, B. M. 1946. The influence of the composition of the medium on growth in vitro of excised tobacco and sunflower tissue cultures. Amer. Jour. of Bot. 33: 591-597.
3. Hoagland, D. R. 1920. Optimum nutrient solutions for plants. Sci. 52: 562-564.
4. Kuzmenko, A. A., Seredenko, L. L. and Goiko, V. A. 1941. Ontogenetic development and yield of cotton as influenced by the proportion of mineral elements in the nutrition. Compt. Rend. (Doklady) Acad. Sci. URSS 31(3): 273-275. (Biol. Abs. 17: 22504. 1943)
5. Olsen, C. 1950. The significance of concentration for the rate of ion absorption by higher plants in water culture. Physiologia Plantarum 3: 152-164. (Field Crop Abs. 3: 1508. 1950)
6. Shive, J. W. 1915. A study of physiological balance in nutrient media. Physiol. Res. 1: 327-399.
7. Tottingham, W. E. 1914. A quantitative chemical and physiological study of nutrient solutions for plant cultures. Physiol. Res. 1: 133-245.