Stroman, C. N.	1961	An approach to hybrid cotton as shown by intra-and inter-specific crosses. *Crop. Sci.*, 1 : 363-6.
Turner, J. H. (Jun)	1953	A atudy of heterosis in Upland cotton. 1. Yield hybrids compared with varieties. *Agron. J.* 45 : 484-6.
———	1953a	A study of heterosis in Upland Cotton. 2. Combining ability and inbreeding effect. *Ibid.*, 45 : 487-90.
Vaman Bhat, M.	1965	Studies on combining ability and short fruiting branch habit in hybrids of *G. hirsutum* L. *G. barbadense* L: M. Sc. (Ag.) Diss. for of Madras Univ (Unpub.)
Ware, J. O.	1930	Hybrid intensification of plant height in cotton and the relationship of node number and internodal length to the phenomenon. *J. Amer. Soc. Agron.*, 22 : 787-801.
	1931	Inheritance of seed weight and lint index in relation to heritability of lint percentage in cotton. *Ibid.*, 23 : 677-702
Young, E. F. and J. C. Murray.	1966	Heterosis and inbreeding depression in diploid and tetraploid cottons. *Crop. Sci.*, 6 : 436-8.

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Anion Exchange Capacity and Crop Responses

by

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.....oduction : The purpose of the present investigation is to study the phenomena of anion exchange capacity on the lateritic soils of Nanjanad (The Nilgiris). When the study of response of crops to application of different nutrients began, it was discovered that many soils were deficient in supplies of available phosphorus. In most of the soils the total quantity of the phosphorus was low being less than about 0·0075 per cent. When phosphorus in the form of superphosphate was applied on the surface of these soils, about 80 to 90 per cent of added phosphate was fixed and the rest turned to unavailable form.

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Differences of opinion have however been expressed regarding the manner in which the phosphate is retained by the soils. According to Chatterjee and Datta (1951) the fixation of phosphate may be due to its precipitation by iron, aluminium or calcium present or due to the adsorption or anion exchange capacity of soils. In this connection it is practically found by scientists like Dean and Rubins (1946) that the fixed phosphate may be released by the application of different anions like fluoride, chloride, oxalate ions and made available to plants through anion exchange.

Review of Literature: Several investigators have found that liming increases the availability of phosphorus in acid soils. Russel and Prescott (1916) conducted the experiments with anions and considered that the mechanisms of the system was an adsorption reaction. Dean and Rubins (1947) showed that phosphate and arsenate could be alternatively adsorbed and mutually replaced. They proved that the anion exchange capacity of soils increased proportionately as the clay content of the soils increased. Sinha and Mandal (1955) showed that the anions like formate, fluoride and hydroxyl were more effective in releasing the fixed phosphate ions than citrate, oxalate and tartrate ions.

Franklin and Reisonauer (1960) evaluated that the clay content or the clay type of the soil was indirectly related to the phosphorus adsorbing capacity of the soil. Paul (1935) had stated clearly that the high phosphorus fixing power of clay soils was due to the anion exchange capacity. Mariakulandai (1955) proved that the availability of phosphorus in laterite soils of Nanjanad increased by the application of silicophosphate to the soil. Dickman and Bray (1941) while investigating the problem of releasing the fixed phosphate found that the complete recovery of fixed phosphate was obtained by shaking kaolinite with 50 ml. of 0·1 N neutral ammonium fluoride solution for about a minute.

Bavoy and Ernest (1955) had stated that the application of fluoride ion at concentrations (0·1 to 1·0 mg/100 gm. of soil) would be tolerated by plants. There would not be any symptoms of burning on vegetation at fluoride ion concentrations between one and three mg/100 gm of dry matter. Unnikrishnan (1961) working in this problem of anion exchange capacity on laterite soils of Kerala has shown that liming alone or in combination with P, in doses of 1500 lb. and 3000 lb./acre decreased the anion exchange capacity considerably and increased the H-ion concentration of the soil.

Materials and Methods: Pot culture experiment was conducted with lateritic soils of Nanjanad, raising *ragi* (Co. 1) crop in the pot culture house of the Agricultural College and Research Institute, Coimbatore. The effect of four anions *viz.*, fluoride, acetate, citrate and oxalate was studied. There

were fourteen different treatments with graded doses of sodium fluoride, potassium acetate, potassium citrate and potassium oxalate in combination with superphosphate at 60 lb. P_2O_5 per acre. The treatment were as follows:

No.

1. Control
2. Superphosphate at 60 lb. P_2O_5/acre
3. " " and Sodium fluoride 0·25 M 5 cc.
4. " " " " 0·50 M "
5. " " " " 0·75 M "
6. Superphosphate at 60 lb. P_2O_5/acre and Potassium acetate 0·25 M 20 cc.
7. " " " " 0·50 M "
8. " " " " 0·75 M "
9. " " Potassium citrate 0·25 M "
10. " " " " 0·50 M "
11. " " " " 0·75 M "
12. " " Potassium oxalate 0·25 M "
13. " " " " 0·50 M "
14. " " " " 0·75 M "

The anions namely fluoride, acetate, citrate and oxalate ions were chosen with a view to find out the factor which would make phosphate available to the crop more readily through the property of anion exchange capacity of soils. The concentration of superphosphate at 60 lb. P_2O_5 per acre was chosen to supply to the soil enough P_2O_5 content. Fifteen lb. of lateritic soils of Nanjanad were taken in each glased pot. The experiment was replicated three times.

The crop was sown on 1—2—1962 and transplanted on 26—2—1962. The solutions of different anions in graded doses were applied to the pots 5 days before transplanting. Only limited concentrations of the fluoride ions were used so as to avoid fluoride toxity to the growing crops.

Growth measurements were taken periodically once in a fortnight, till the crops attained the maximum growth. The earheads were harvested seperately and the grains were analysed for phosphorus content with a view to find out the differences in the uptake of phosphorus due to the application of the anions.

Results: The data on height are given in table. In the initial stages, 0·25 M citrate (treatment No. 9) induced quicker growth upto 57·6 cm. In the next stage, the highest growth was recorded when treated with 0·25 M solution of oxalate ions, followed by fluoride at 0·75 M

concentrations and citrate at 0·25 M concentration. The final growth measurement, however, showed that acetate in all concentrations and citrate at 0·25 M concentration induced better growth than the other treatments. So it may be stated that not only the anions but their concentrations also appear to have effect on growth.

The yield data of *ragi* grain and straw is given in table. The results indicates clearly that the maximum yield of *ragi* straw as well as grain was obtained by the application of 0·25 M potassium citrate solution (Treatment No. 9).

The grain samples were analysed for total phosphorus to determine the P content of the grains due to several treatments. The results of this analysis as well as the calculated phosphate uptake are furnished in table. From the analytical data it is found that the maximum uptake of phosphorus is in the grain samples collected from the pots under the treatment 0·25 M potassium citrate solution, though the percentage of phosphorus is the highest in the grain from the treatment of 0·75 M sodium fluoride. The phosphorus uptake by the grain under the treatment super phosphate alone, comes to 0·08 while the phosphorus uptake by grains under other treatments ranges from 0·105 to 0·168 which indicate that the anions aid in better uptake.

TABLE *Growth measurements, yield of grain and straw and phosphate uptake of Ragi (Co. 1)*

Treatment No.	Growth measurements in cm. on			Yield in gm. per plot		P_2O_5 per cent	Phosphate uptake
	13-3-'62	28-3-'62	16-4-'62	grain	straw		
1	50·2	70·6	89·9	14·50	66·00	0·32	0·046
2	44·7	72·2	90·1	14·59	78·83	0·55	0·080
3	49·5	72·3	90·5	16·42	86·90	0·65	0·106
4	49·6	72·4	88·6	17·69	85·50	0·65	0·115
5	55·3	73 6	90·0	16·84	94·23	0·90	0·152
6	54·1	72·6	91·7	14·19	83·23	0·74	0·105
7	47·8	70·8	91·3	15·72	70·73	0·72	0·113
8	56·1	71·5	92·1	17·31	82·50	0·86	0·149
9	57·6	73·5	91·0	21·31	99·83	0·79	0·168
10	52·4	71·6	86·0	15 10	82·13	0·89	0·134
11	53·9	72·4	89·5	16·32	74·33	0·85	0·139
12	51·8	75·7	88·8	15·29	89·25	0·77	0·118
13	50·6	71·7	89·8	17·17	74·70	0·75	0·129
14	52·1	69·7	87·0	14·60	78·60	0·83	0·121

Yield of grain significant at $P = 0·05$ and straw at $P = 0·01$.

Conclusions:

Grain: T_9, T_1, T_8, T_{13}, T_6, T_2, T_{11}, T_7, T_{12}, T_{10}, T_{14}, T_3, T_5, T_4

Straw: T_9, T_8, T_{12}, T_3, T_1, T_6, T_8, T_{10}, T_2, T_{14}, T_{13}, T_{11}, T_7, T_4

Discussion: To study the influence of different anions namely fluoride, acetate, citrate and oxalate applied along with 60 lb. of P_2O_5 as super/acre to the soil, pot culture experiments were conducted and data on the growth of plants, the yield and the phosphorus uptake was collected.

The data on the growth of the *ragi* plants at three different stages indicate that in the initial stages, the citrate ions, irrespective of the concentrations used have given the maximum growth, while the superphosphate alone treated ones have given lesser growth than that of the control pots. So, it is evident that the mere application of superphosphate alone to the lateritic type of soils does not appear to increase the growth of plants. In the middle stage of growth, there are no notable increases with regard to all other treatments except fluoride treated ones. In the final stage, the maximum growth was recorded by the plants in pots treated with acetate ions irrespective of the concentrations of the ions used. It is noteworthy that the application of 0·75 M acetate ions has recorded the maximum growth of 92·1 cm. The superphosphate treated plants have recorded only lesser growth than that of control one.

Yield of Ragi grain and straw: Examinations of the table showing the yield of *ragi* grain and straw reveal that the maximum yield of *ragi* grain and straw was recorded by the 0·25 M citrate (Treatment No. 9) treated plants followed by the fluoride treated ones irrespective of the concentrations used. Regarding the straw yield alone the fluoride ions treated pots gave the maximum yield followed by citrate ions irrespective of the concentrations used. Comparing the control as well as super phosphate alone treated pots, the later gave more of straw yield than the former. But in the case of grain yield the increase is practically insignificant being only 0·09 gm. From the above data it may be stated that the application of fluoride ions tends to give increased straw yield whereas the application of citrate ions will result in increased yield of both straw and grain. It may be seen that the three anions acetate, citrate and oxalate have the same cation potassium. So, the differences in straw and grain yield can be attributed only to the anions and not to the cation. Yield data of both grain and straw were statistically analysed and found to be significant at $P = 0·05$ and 0·01 respectively.

Phosphate uptake: Regarding the phosphate uptake of plants, the phosphate uptake is almost doubled in the super treated plants when compared to those in control pots. It is evident that the influence of the four anions has resulted in the increase of phosphate uptake. The more of phosphate uptake was recorded by the citrate treated plants followed by the fluoride treated plants irrespective of the concentrations used. As the concentrations of the fluoride ions as well as the acetate ions increases,

there is proportionate increase in the phosphate uptake also. But in the case of application of citrate ions, the increase in the concentration tends to decrease the phosphate uptake by plants. However, the maximum phosphate uptake was recorded by the citrate ions at the concentrations 0·25 M solution treated plants.

Conclusions: 1. The application of superphosphate alone will not give better growth of plants though the uptake of phosphate is more than that of plants in the controlled pots.

2. The application of fluoride ions irrespective of the concentrations used tends to result in the increased uptake of phosphate but it fails to give better yield of *ragi* grain. But comparatively, the yield of straw is better.

3. The application of the particular concentration *viz.*, 0·25 M solution of citrate ions gives the maximum yield of *ragi* grain and straw. Moreover, the phosphate uptake of the plants under this treatment is the maximum, though the growth of plants does not attain the maximum limit.

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REFERENCES

Bavoy, C. V. and F. Ernest	1955	Detection of deposits of Fluorine and Chlorine on vegitation in the vicinity of Chemical factories. *Ann. agric. Suisse.*, 55: 959–74.
Chatterjee, B. and S. Datta.	1951	Phosphate fixation by clay minerals *J. Soil Sci.*, 2: 224–33.
Dean, L. A. and N. J. Rubins.	1947	Anions Exchange in Soils. Exchangeable Phosphorus and anion exchange capacity. *Soil Sci.*, 63 : 377–406.
Dickman, S. R. and R. H. Bray.	1941	Replacement of adsorbed phosphate from Kaolinite by Fluoride. *Soil Sci.*, 52: 263–73.
Franklin, W. T. and H. N. Reisenauer.	1960	Anion exchange and clay type. *Soil Sci.*, 90 : 192–19.
Mariakulandai, A.	1955	Improvement of phosphate availability in the laterite soil of Nilgris by application of silicophosphate. *J. Indian Soc. Soil Sci.*, 3 : 15–22.
Paul, H.	1935	Some observations on the mechanism of phosphorus fixation in some soils. *J. agric. Sci.*, 39: 249–53.
Russel, E. J. and J. A. Prescott	1916	The reaction between dilute acids and the phosphorus compounds of the soil. *J. agric. Sci.*, 8: 65–110.
Sinha, H. and S. C. Mandal.	1955	Anion Exchange and Exchangeable Phosphorus in some Bihar soils. *Sci & Cult.*, 20 : 597–59
Unnikrishnan, C. K.	1961	"Anion Exchange studies in laterite soils of Kerala". M. Sc. (Ag.) Thesis. Madras Univ. (unpubl.)