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Studies on Foliar Nutrition of Crops: III. Ragi and Maize.

by

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Introduction: The subject of feeding plants by means other than through the roots has gained much importance in recent years and the method of foliar feeding or foliar nutrition is now adopted in the case of many perennial crops as well as cereals and vegetable crops. Studies on this aspect of plant nutrition has been in progress since 1954 in the Plant Physiology section of the Coimbatore Research Institute and the results obtained on rice plants were presented in two previous papers, (18, 19). The present paper is intended to give a brief account of the responses shown by two other crops, namely ragi *(Eleusine coracana)* and maize *(Zea mays)*, to this method of supplying nutrients through the foliage.

Previous Work and Literature: In view of the very large output of papers on this subject in recent years, it is possible to mention only a few of the relevant references. Foliar feeding is found to be distinctly useful for a variety of crops under a variety of conditions, particularly where (1) quick responses are desired, (2) where soil fixation or leaching problems make soil-dressing with fertilizers ineffective, (3) where nutrient deficiencies of either macro or micro-nutrients have to be rectified and (4) where plants grow in special situations as in streets and thoroughfares where soil-dressings may be impracticable. In the case of perennial crops like apple, citrus and grapevine, foliar sprays are now recognized as an effective and convenient method of not only correcting specific deficincies of nutrient elements, but also of improving the yield and quality of the fruits harvested, (7, 9, 14). In grapevine, foliar sprays with one percent potassium nitrate (6) have been found more rapid and effective than manuring through the soil. Foliar applications of urea increased the yield and protein content of barley, while phosphate sprays increased only the phosphate content of the grains. A combination of the two was not as effective in improving yields as urea sprays by themselves (4). Urea, when applied in three post-blossom sprays on grapevine made the leaves greener and the vines more vigorous, while superphosphate sprays not only improved the yield and sugar content of grapes but had also a favourable effect on the subsequent year's fruit-buds that were developing at the time of spraying, (10). On cotton, an increase of nearly

50 percent in kapas (seed cotton) yield have been reported by workers at the Indian Agricultural Research Institute, New Delhi, (4) as a result of using foliar sprays with growth-regulating chemicals like naphthalene-acetic acid and naphthoxy-acetic acid. Spraying with urea at half-percent strengths increased cotton yields by 140 lb. per acre, in a region where nitrogen application to the soil was ineffective due to rapid leaching. The same chemical when sprayed twice, improved the yield by more than 27 per cent over controls (21).

On cereals, paddy yields were improved by foliar sprays of superphosphate (18, 19); in wheat, yield increases ranging from 21 to 41 percent were secured by spraying urea before flowering, and the protein was also improved from 9·3 to 16·9 percent (11). In applying these sprays it was also found necessary to have the spray solutions conform to the chemical composition of the particular crop plant than when the nutrients were applied to the soil. Thus in broccoli, which removes about 160 lb. N, 41 lb. P_2O_5 and 84 lb. K_2O, the foliar sprays should also be in a similar ratio, while for groundnut, with its high P and Ca requirement and low requirement of N, the sprays should also be in similar proportions (13).

For vegetable crops, foliar sprays had the additional convenience that they could be applied along with the ordinary fungicide sprays. In tomatoes, foliar sprays with calcium glycerophosphate were more helpful than even a complete nutrient solution like Knop's solution, but the best yields were obtained when a 3—12—12 fertilizer added to the soil was supplimented by urea as foliar spray. In pineapples, foliar application of N, P, and K nutrients increased fruit yields and speeded up the maturity (22).

Under certain conditions however, this spray method showed little or no effect. Thus, in cases where the soil was already rich in nitrogen or if it was too heavy in texture or when the spray solution was too dilute, no positive effects were obtained (10). In heavy clays even 50 parts per million of zinc in spray solution failed to induce any effect, whereas in in sandy soils distinct positive responses were obtained with much lower concentrations of zinc and copper. In pastures, urea sprays were not to be superior to soil dressing with nitro-chalk and it had the further disadvantage that the sprays damaged the clovers (20).

The foregoing brief survey is however sufficient to show that there are great practical possibilities in this method of feeding plants through their foliage.

Material and Methods: The methods adopted for these experiments on ragi and maize were similar to those adopted and described for the paddy experiments in a previous paper the main difference bring that most of the present studies were carried out in pot-cultures. The various nutrient salts were supplied as sulphates in two ways one as soil-dressings applied one week before planting ragi and the other as foliar sprays. In the light of previous experience, the concentrations of the nutrient solutions were in all cases kept low enough to avoid all risk of leaf-scorch and consequent set- backs to growth. Where such spray treatments were given only once, they were given one month after planting; when two sprays were given, the second was given two weeks after the first spray. Wherever possible, the same treatments were duplicated both in the field and in pot-cultures using the same strain. The experiments were of course laid out in approved layouts to facilitate statistical analysis of the results. The spray volumes were kept at 100 gallons per acre in all experiments. Growth was assessed on the same lines as previously adopted for paddy. Plant-heights were recorded at fortnightly intervals commencing from a month after planting or sowing. Tiller counts were recorded twice during the growth of the crop, once just before flowering and again at harvest time. The effects, if any, of the various treatments upon flowering; earliness was assessed by recording the date of emergence of the inflorescence on all plants in each treatment in pot-cultures. For yield records individual weights were recorded in pot-cultures of both fresh weight of plants and fresh and dry weight of grain and straw. The root weights were also recorded for each treatment in pot-culture studies. In the case of field experiments the plot yields were recorded and after threshing and drying, the weight of grain and straw were recorded.

Results: The results of five experiments on ragi and two on maize are summarised in Table 1. The former crop, i. e. ragi, is on the whole, some what less responsive to foliar spray treatments than maize, which is perhaps not surprising, since maize offers a much larger foliar surface than ragi, with its much narrower and keeled leaves. In maize the plant height was distinctly improved by many of the foliar treatments, but in ragi the same treatments showed little or no improvement in plant height. The increases in cob weight in maize were also of a higher order than in ragi grain yields, but the responses in weight of shoots (i. e. straw material), were uniformly less in maize. In the case of ragi, a single spray of half percent urea

improved grain yield by 5·3 percent and the straw yield by 9·9 percent; two such sprays showed a larger response of 8·2 and 11·2 percent in grain and straw respectively. Superposphate sprays on ragi did not show any clear-cut improvement of grain yield, except in one experiment, where two sprays of superphosphate recorded an increase of 30·8% in grain, but as this was a solitary instance it needs confirmation by further tests.

As between soil dressings and foliar sprays, magnesium sulphate at 20 lb. per acre, improved the grain and straw yields more or less to the same degree. A 40 lb. dose of the same salt did not show any further increase over the 20 lb. dose. A foliar spray with magnesiun sulphate improved straw yield by 11·2%, but the grain yield was increased by only 4·0%. Other spray treatments that are likely to be helpful in ragi (mainly for straw yields) were copper sulphate and manganese sulphate at 4 lb./100 gallons/acre and potassium nitrate at 10 lb./100 gallons/acre.

In the case of maize, the cob weight was improved by over 30% by urea, ammonium sulphate and by potassium sulphate; so that these treatments seem worthy of more extended trials under field conditions. Spray-treaments with superphosphate increased cob weight by 18 percent. It is interesting to note that the plant height was improved by 12·7% by a mere water spray, the cobweight and shoot weight, (i. e., the straw material), were both less than in control by nearly 7%.

Urea sprays were helpful to both ragi and maize, but two sprays did not give any more increase than a single spray. Potassium nitrate and superphosphate for ragi and ammonium sulphate for maize were the other two chemicals whereby grain yields were increased appreciably, but taking the entire series of experiments in general, it may be concluded that urea is perhaps the most consistently helpful chemical for use as foliar spray on crops.

Contrary to what was claimed by some workers regarding the helpful action of sucrose in conjunction with urea, this combination was found in the present studies, to be in no way superior to urea alone, neither on ragi nor on maize.

The effect of foliar sprays on root development is rather interesting. In ragi, the weight of roots was increased by any of foliar treatments tried; and especially with urea and superphosphate,

the increase over control was quite large, but in maize the root weights seemed to be depressed by the majority of foliar treatments tried, except in two cases. This aspect would seem to need further study for elucidation.

Discussion: It would be noted from the foregoing summary of results from the experiments carried out so far, that foliar sprays are definitely helpful as a method of improving crop yields, although a great deal of further study is required before we can formulate specific spray schedules for specific crops. It is also clear that the results observed are in general agreement with those recorded for for other crops by other workers, except in regard to combined sprays of urea plus sucrose and the response to mere water sprays as well, which is something new, and not recorded by any other worker so far. How far the soil type influences the response to foliar treatments has not been studied in these experiments, and the problem of determining the optimum stage of plant growth at which sprays are most helpful, as well as the optimum concentration of each chemical for the different stages of growth of remain as subjects for future investigations. For instance Webber (37) has noted that for micronurients like copper and zinc, the safe and effective concentration depended on the time the spray was given; thus for apple trees, up to 4% concentration could be used for zinc sulphate sprays in February, but only 0·1 percent was permissible in April. Again, in sugarbeet, potassium salts were most rffective when sprayed 30 to 60 days before harvest while phosphates were most effective when sprayed 15 to 30 days before harvest. Separate sprays of these elements were also more effective than joint applications (33).

Summary and Conclusions: The results of five foliar nutrition experiments on ragi and two on maize are summarized and discussed. Distinct increases in growth and yields are obtainable in both the crops by using *appropriate* chemicals at *suitable* strengths.

Urea was found to be the most consistently useful chemical in improving growth and yield of both ragi and maize. Certain micronutrients like copper zinc and manganese have also induced positive responses to foliar sprays with their salt solutions. Maize seems to be more responsive than ragi to foliar sprays and showed larger increases in yield of cobs, although the straw weight and root weight were not improved. In ragi straw weights were increased to a greater extent by foliar sprays than grain yield.

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TABLE I

Summary of Results of Foliar Spray Treatments on Ragi and Maize.
(Expressed as Percentages on untreated Control–100)

Treatments.	*Ragi* (Summary of 5 Expts)				*Maize* (Summary of 2 Expts)			
	Plant Height	Grain	Straw	Roots	Plant Height	Grain	Straw	Roots
1. Control (No treatment)	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
2. Water spray	100·3	105·7	104·2	100·5	112·7	93·0	92·7	117·4
3. Urea sprayed once	100·0	105·3	109·9	142·6	113·1	133·8	99·0	89·5
4. ,, ,, twice	106·2	108·2	111·2	132·7	107·8	118·7	90·2	84·7
5. Urea Sucrose once	102·8	108·3	105·2	153·5	101·8	105·4	88·9	74·5

TABLE I *Contd.*

Treatments	Plant Height	Grain	Straw	Roots	Plant Height	Grain	Straw	Roots
6. Urea Surcose twice	101·7	111·5	102·6					
7. Ammonium sulphate 0·5 % once	100·9	103·4	95·4	100·6	95 8	98·6	79·4	83·7
8. ,, ,, twice	102·1	104·7	98·3	103·1	101·2	133·6	82·3	116·9
9. Ammonium nitrate 1·0 % once	103·2	103·8	92·7					
10. ,, twice	99·3	98·7	102·9					
11. Potassium nitrate 1·0 % once	101·1	128·2	103·3					
12. ,, twice	102·6	106·4	106·9					
13. Potassium sulphate 0·5 % once	101·2	96·9	92 6	76·3	111·0	137·0	82·8	88·9
14. ,, twice	101·9	93·9	100·6	74·6	103·8	139·4	88·6	98·2
15. Super phosphate 0·5 % once	100·7	100·9	96·8	174·5	102·5	118·0	83·4	94·2
16. ,, twice	103·9	130·8	104·3					
17. Urea super once	101·7	107·8	106·8					
18. Farm yard manure alone to soil	107·5	98·1	124·3	118·8				
19. FYM Magnesium sulphate to soil	109·2	103·1	117·4	102·9				
20. FYM $MgSO_4$ 40 lb. to soil	109·3	102·7	117·7	121·7				
21. $MgSO_4$ spray once (8 lb)	101·1	104·0	111·2	117·3				
22. $FeSO_4$, 8 lb. spray once	98·0	94·6	88·1	125·7				
23. $MnSO_4$, 4 lb once	93·8	97·3	115·8	116·3				
24. $CuSO_4$, 4 lb once	98·8	88·1	117·7	127·1				
25. $ZnSO_4$, 4 lb once	93·4	103·2	91·9	119·8				