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Effect of Foliar Nutrition on Nutritional Quality of Baby Corn (*Zea mays* L.) and Dehydrated Babycorn Enriched Products

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ABSTRACT

Baby corn is a wide spread crop which has tremendous potential to alleviate nutritional disorders in humans through its consumption. A field experiment was conducted in University of Agricultural Sciences, Bengaluru to study the effect of foliar application of macro and micronutrients on nutritional quality of baby corn in which application of 75% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$ has recorded significantly higher crude protein and sugar content in the babies and also lower crude fibre content in babies (18.72 %, 0.028 % and 5.78 %, respectively). Nutrient content viz., nitrogen, phosphorous, potassium, zinc and iron in babies were significantly higher with application of 75% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$ (3.00 %, 0.96 %, 3.12 %, 46.33 ppm and 52.67 ppm, respectively). Baby corns (babies) were dehydrated to get powdered baby corn. Bakery and value added products were prepared with inclusion of baby corn powder. It was observed that significantly higher sensory scores were recorded among bakery products however they did not vary much among value added products.

Key words: *Baby corn, Foliar nutrition, Nutritional quality etc.*

INTRODUCTION

Baby corn is a vegetable crop grown round the globe and it is harvested at the silking stage. Chinese are using young cobs as vegetable for generations and it has spread to other Asian counties due to change in tradition and culture and also invasion of westernized lifestyle. The food habit in India has drastically changed over decades which has waved path for popularization of baby corn consumption and even production. Day-by-day nutritional quality in our daily food is reducing and many scientists are involved in bringing out the healthy diet for human beings. To address the situation foliar nutrition would be a solution for this maintenance of nutrition in our diet. Many of the countries are facing zinc deficiency and it has been a practise to consume required zinc along with the diet externally. By practising the foliar application of nutrients to crop plants, they biofortify the nutrients and when consumed it will be available to humans.

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The availability of macro and micronutrients added to the soil are affected by soil environmental factors leading to various losses. Foliar application is a particular technique to supply macro and micro-nutrients which avoids wastage or loss of nutrients which enhances nutrient use efficiency and reduces the cost of cultivation. Again foliar application of nutrients will be an added advantage in rapid absorption.

The foliar nutrition can prevent soil nutrient overloading and lower the risk of environmental threats. During the foliar nutrition, nutrient efficiency can reach up to 85 per cent whereas application of fertilizers through soil has only 30-60 per cent of efficiency depending on nutrient type. Foliar feeding was stimulated by Tukey and Wittwer during 1950's at Michigan State University, using radioactive isotopes of known plant nutrients which were absorbed by plant foliage and translocated throughout the plant[5]. There are mainly two advantages of foliar application of fertilizers over soil application *viz.*, about more than 90 per cent fertilizers are utilized by the plant when applied in foliar form and about 95 per cent of the foliar fed nutrients are translocated. After supplying nutrients through foliar spray are found in the smallest root within 60 minutes, if conditions are optimum and foliar fertilizer use efficiency in sandy loam soils is upto 20 times more effective when compared to soil applied fertilizers[8]. Bakery goods in India continue to grow steadily in 2014. However, due to growing awareness regarding healthier lifestyle and eating habits, the present day consumer looks for new bakery products, better appeal, taste and convenience from bakery foods[10]. Biscuits and cakes are most relished products that can be enriched with baby corn powder. Processed and value added ragi products are consumed to a great extent and these products can also be enriched with baby corn powder. Keeping these things in view study was conducted to study the effect of foliar nutrition on quality of baby corn (*Zea mays* L.).

MATERIAL AND METHODS

The experiment was conducted at Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru which is situated at 13º 05' North latitude and 77º 34' East longitude and at an altitude of 924 m above mean sea level which comes under eastern dry zone (ACZ-V) of Karnataka. The soils of the experimental site are red sandy clay loam. Composite soil samples were taken at random from upper 30 cm layer and were analyzed for physico-chemical properties. The soil reaction was neutral (6.56), medium in available nitrogen (428.37 kg ha^{-1}), available phosphorus (45.56 kg P_2O_5 ha^{-1}), available potassium (243.93 kg K_2O ha^{-1}), low in zinc (0.48 ppm) and iron (1.80 ppm). Treatments were, T_1: 50% RDF + 1.0% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$, T_2: 50% RDF + 1.0% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$, T_3: 50% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$, T_4: 50% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$, T_5: 75% RDF + 1.0% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$, T_6: 75% RDF + 1.0% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$, T_7: 75% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$, T_8: 75% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$, T_9: UAS (B) package (150:75:40 kg N: P_2O_5: K_2O ha^{-1}). Nitrogen in RDF has been applied in two splits, one at the time of sowing (50 %) and other at 30 DAS (50 %), respectively. 19:19:19 foliar spray was given at 20 and 40 DAS, $ZnSO_4$ and $FeSO_4$ spray was given at 30 DAS. Quantity of spray solution used was 500 litres ha^{-1}. For all plots FYM was applied @ 10 t ha^{-1}. The soil and plant analysis was done in laboratory of Department of Agronomy, College of Agriculture, UAS, Bengaluru.

One gram plant sample was pre-digested for overnight with nitric acid and kept for digestion with di-acid mixture of nitric acid and perchloric acid (9:4). The filtered digested material was made up to 50 ml volume with 6 N HCl and was used for the analysis of all mineral elements. Nitrogen content was estimated by modified Micro-Kjeldhal's method[7] and expressed in percentage. Phosphorus content in the digested plant

sample was estimated by Vanado molybdate phosphoric yellow colour method in nitric acid medium and the colour intensity was measured at 660 nm wave length[7]. Potassium in the plant samples digest was estimated by atomizing the diluted acid extract in a flame photometer7. Zinc and Iron in plant digested sample was determined by using Atomic Absorption Spectrophotometer and expressed in ppm. Crude protein content was estimated by modified Micro-Kjeldahl method[11] and expressed in terms of percentage (Crude protein content = % Nitrogen x 6.25). Crude fibre content was estimated by volumetric method[11] and expressed in terms of percentage. Sugar content was estimated using Dubois method[6] and expressed in terms of percentage. The baby corn was chopped and dried in oven at 60 ^{0}C and then it was powdered. The powder was used to prepare value added and bakery products *viz.*, ragi hurihitu, ragi laddu, cup cake, masala biscuit and coconut cookies. These were evaluated for quality attributes by a semitrained panel of 20 members using five point scale. The parameters for evaluation were appearance, texture, flavour, taste and overall acceptability[13,14]. The experimental data collected on quality components of plant were subjected to Fisher's method of "Analysis of Variance" (ANOVA)[10]. Wherever, F- test was significant, for comparison among the treatment means, an appropriate value of critical difference (C.D.) was worked out. If F-test found non-significant, against C.D. values NS (Non-Significant) was indicated. All the data were analyzed and the results were presented and discussed at a probability level of five per cent.

RESULTS AND DISCUSSION

Application of 75% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (18.72 %) recorded significantly higher crude protein concentration (Table 1). Significantly lower crude protein concentration was recorded with application of 50% RDF + 1.0% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (12.75 %). The increase in crude protein content of babies may be due to the more concentration of nitrogen in the cobs through higher uptake of nitrogen and timely supply of nitrogen fertilizer through foliar application in addition to soil applied nitrogen and reduced loss of nitrogen though leaching and volatilization which finally increased the net photosynthesis facilitated by the increased leaf area. Again higher uptake of nitrogen has been facilitated by application of zinc which catalyses nitrate reductase enzyme and the formation of protein is activated by potassium[16]. The improved protein content in cobs due to the foliar fertilization is also in line with Amal *et al.*[1] and Arune *et al*[4].

Application of 50% RDF + 1.0% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (5.78 %) recorded significantly higher crude fibre concentration (Table 1) which was on par with application of 50% RDF + 1.0% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$ (5.76 %).Significantly lower crude fibre concentration was recorded with application of 75% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (4.64 %). The lower crude fibre content in babies was mainly attributed to higher crude protein and tissue concentration of nitrogen in the babies that decreased the deposition of lignin and cellulose. The protein and fibre content in plant are normally inversely related. The results are in line with Roopashree[12].

Among the different treatments, sugar content in babies did not vary significantly due to foliar application of macro and micro nutrients. However, higher sugar concentration in babies was recorded with application of 75% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (0.028 %) and lower sugar concentration (Table 1) in babies was recorded with UAS (B) package (0.021 %). The increased total sugar content was due to improved availability of the potassium through foliar fertilizers which involved in the transport of more solutes to the sink and increased photosynthetic activity in the leaf which was mainly governed by the presence of trace elements like manganese in the foliar fertilizers and also the better source-sink relationship, directly influenced the sugar content of baby corn. The results are in conformity with Manja Naik[9].

Among the different treatments, application of 75% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (Table 2) recorded significantly higher nitrogen (3.00 %) concentration in babies and which was on par with application of 75% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$ (2.93 %). Significantly lower nitrogen concentration in babies was recorded with application of 50% RDF + 1.0% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (2.04 %). Application of 75% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (0.96 %) recorded significantly higher phosphorus concentration (Table 2) in babies and which was on par with application of 75% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$ (0.94 %). Significantly lower phosphorus concentration in babies was recorded with application of 50% RDF + 1.0% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (0.65 %). Among the different treatments, application of 75% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (3.12 %) recorded significantly higher potassium concentration (Table 2) in babies and which was on par with application of 75% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$ (3.05%). Significantly lower potassium concentration in babies was recorded with application of 50% RDF + 1.0% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (2.12 %). Application of 75% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (46.33 ppm) recorded significantly higher zinc concentration (Table 2) in babies. Significantly lower zinc concentration in babies was recorded with application of 50% RDF + 1.0% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (31.67 ppm). Application of 75% RDF + 1.5% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (52.67 ppm) recorded significantly higher iron concentration (Table 2) in babies which was on par with application of 75% RDF + 1.5% 19:19:19 spray + 0.5% $ZnSO_4$ + 0.1% $FeSO_4$ (52.00 ppm). Significantly lower iron concentration in babies was recorded with application of 50% RDF + 1.0% 19:19:19 spray + 0.2% $ZnSO_4$ + 0.1% $FeSO_4$ (46.68 ppm).

Totally five products were prepared by using baby corn powder. They were categorized into baked products and value added ragi products. The sensory evaluation of baked products with baby corn powder, *viz.*, masala biscuit, coconut biscuit and cup cake is presented in Table 3. In case of masala biscuit, higher mean score (3.4) was recorded with control (without baby corn powder) followed by 10 per cent (2.7), 15 per cent (2.3) and the lowest score was recorded with 20 per cent (1.9) baby corn powder. The difference between sensory characteristics and different proportions of baby corn powder was statistically significant. But the interaction of sensory characteristics and different proportions of baby corn powder was statistically non significant. It was observed that coconut biscuit (4.2) had higher mean score in control (without baby corn powder) followed by 10 per cent (3.5), 15 per cent (3.0) and the lowest score was recorded with 20 per cent (2.8) baby corn powder. The difference between sensory characteristics was statistically non significant but, the difference between different proportions of baby corn powder was statistically significant. The interaction of different proportions of baby corn powder and sensory characteristics was statistically non significant. In case of cup cake, the higher mean score (4.0) was recorded with control (without baby corn powder) followed by 10 per cent (3.6), 15 per cent (3.6) and the lowest score was recorded with 20 per cent (3.4) baby corn powder. The difference between sensory characteristics and different proportions of baby corn powder was statistically significant. But the interaction of sensory characteristics and different proportions of baby corn powder was statistically non significant. Among experimental products, masala biscuit and coconut biscuit with 10 per cent baby corn powder recorded higher sensory scores of 2.7 and 3.5, respectively when compared to the 15 and 20 per cent baby corn substitution. In case of cake, 10 per cent and 15 per cent baby corn powder based cake recorded higher sensory score of 3.6 compared to 20 per cent baby corn powder substitution (3.4). The results are in

conformity with the study conducted by Anis *et al.*[2], Sharma *et al.*[15] and Anitha and Rajyalakshmi[3].

The sensory evaluation of value added ragi products is presented in Table 4. In case of ragi hurihittu, the higher mean score (4.0) was recorded with control (without baby corn powder) followed by 10 per cent (3.1), 15 per cent (2.7) and the lowest score was recorded with 20 per cent (2.5) baby corn powder. The difference between sensory characteristics was statistically non significant. But the difference between different proportions of baby corn powder was statistically significant. But the interaction of sensory characteristics and different proportions of baby corn powder was statistically non significant. In case of ragi laddu it was observed that the higher mean score (3.9) was recorded with control (without baby corn powder) followed by 20 per cent (3.7) and the lowest score was recorded with 15 per cent (3.6) and 10 per cent (3.6) baby corn powder. The difference between sensory characteristics, different proportions of baby corn powder and interaction of sensory characteristics and different proportions of baby corn powder was statistically non significant. Among value added ragi products *viz.*, ragi hurihittu and ragi laddu, the sensory characteristics did not vary significantly. With respect to ragi laddu, the laddu prepared with 20 per cent baby corn powder substitution had higher sensory over all acceptability score which indicated suitability of baby corn powder for blending with other ingredients.

Table 1: Crude fibre, crude protein and sugar content in babies as influenced by foliar application of macro and micro nutrients

Treatments	Crude protein (%)	Crude fibre (%)	Sugar concentration (%)
T_1	12.75	5.78	0.025
T_2	12.91	5.76	0.025
T_3	14.13	5.48	0.022
T_4	15.54	5.35	0.021
T_5	15.83	5.05	0.021
T_6	16.79	5.18	0.024
T_7	18.72	4.64	0.028
T_8	18.29	4.77	0.024
T_9	17.70	4.91	0.021
S.Em. ±	0.03	0.08	0.003
C.D. (p = 0.05)	0.09	0.24	NS
C.V.(%)	9.26	9.52	9.12

Table 2: Nutrient content in babies at harvest as influenced by foliar application of macro and micro nutrients

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Zinc (ppm)	Iron (ppm)
T_1	2.04	0.65	2.12	7.17	22.18
T_2	2.07	0.66	2.15	9.82	22.21
T_3	2.26	0.72	2.36	13.02	22.93
T_4	2.49	0.80	2.59	13.17	24.16
T_5	2.53	0.81	2.64	14.30	25.17
T_6	2.69	0.86	2.80	14.50	26.50
T_7	3.00	0.96	3.12	21.83	28.17
T_8	2.93	0.94	3.05	16.50	27.50
T_9	2.83	0.91	2.95	15.83	26.83
S.Em. ±	0.05	0.01	0.05	1.75	0.44
C.D. (p = 0.05)	0.14	0.04	0.14	5.27	1.33
C.V.(%)	9.98	9.56	9.28	9.21	9.26

Table 3: Sensory evaluation of baked products with substitution of baby corn powder (N=20)

Product(P)	Sensory Characteristics(C)				
Masala biscuit	Appearance	Texture	Flavour	Taste	Overall acceptability
A	3.6	3.4	3.5	3.3	3.4
B	3.0	2.8	2.5	2.5	2.7
C	2.5	2.5	2.3	1.9	2.3
D	2.1	2.1	1.9	1.6	1.9
			C	P	B/w C & P
	SEm±		0.08	0.07	0.15
	CD @ 5%		0.18	0.16	NS
Product(P)	Sensory Characteristics(C)				
Coconut biscuit	Appearance	Texture	Flavour	Taste	Overall acceptability
A	4.4	4.0	4.2	4.3	4.2
B	3.5	3.3	3.5	3.7	3.5
C	3.1	2.9	2.9	3.0	3.0
D	3.1	2.9	2.5	2.7	2.8
			C	P	B/w C & P
	SEm±		0.09	0.08	0.18
	CD @ 5%		NS	0.19	NS
Product(P)	Sensory Characteristics(C)				
Cup cake	Appearance	Texture	Flavour	Taste	Overall acceptability
A	4.4	3.8	3.8	4.1	4.0
B	4.0	3.5	3.5	3.5	3.6
C	3.7	3.7	3.4	3.6	3.6
D	3.8	3.4	3.2	3.2	3.4
			C	P	B/w C & P
	SEm±		0.09	0.08	0.17
	CD @ 5%		0.20	0.18	NS

A - Control (without baby corn powder), B - 10% Baby corn powder, C - 15% Baby corn powder, D - 20% Baby corn powder, NS - Non-significant, * - Significant at 5 per cent level

Table 4: Sensory evaluation of value added ragi products with substitution of baby corn powder (N=20)

Product(P)	Sensory Characteristics(C)				
Ragi hurihittu	Appearance	Texture	Flavour	Taste	Overall acceptability
A	3.9	3.8	4.2	4.4	4.0
B	3.5	3.3	2.7	2.8	3.1
C	2.9	2.8	2.6	2.4	2.7
D	2.8	2.6	2.4	2.2	2.5
			C	P	B/w C & P
	SEm±		0.11	0.1	0.22
	CD @ 5%		NS	0.23	NS
Product(P)	Appearance	Texture	Flavour	Taste	Overall acceptability
Ragi laddu					
A	4.0	3.6	3.9	4.2	3.9
B	3.7	3.4	3.5	3.8	3.6
C	3.7	3.7	3.4	3.9	3.6
D	4.0	3.6	3.6	3.8	3.7
			C	P	B/w C & P
	SEm±		0.09	0.08	0.18
	CD @ 5%		NS	NS	NS

A - Control (without baby corn powder), B - 10% Baby corn powder, C - 15% Baby corn powder, D - 20% Baby corn powder, **NS** - Non-significant, ***** - Significant at 5 per cent level.

CONCLUSION

Nutrient deficiency is a major problem in soils as well as in humans for which the foliar nutrition address the problem of nutrient deficiency by biofortification. Fresh baby corns can be dehydrated to obtain baby corn powder and can be stored for long period and can be utilised to enrich bakery and value added products to an extent of 10 to 15 percent.

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