The Andhra Agric. J 65 (4): 790-794, 2018

Yield and Quality of Corn (*Zea Mays* L.) as Influenced by Nutrient Management Practices

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ABSTRACT

A field experiment was conducted during *rabi,* 2015 to Optimize the nutrient management strategy for enhancing the productivity and quality of hybrid maize. The experiment was laid out in a randomized block design with nine treatments and replicated thrice. Application of recommended dose of fertilizers (180-60-50 kg N, P_2O_5 and K_2O ha^{-1}) supplemented with 30 kg S ha^{-1} along with foliar application of $ZnSO_4$ + $FeSO_4$ @ 0.5% each at booting and silking recorded the highest stature of yield attributes of maize viz., cob length and girth, number of seeds cob^{-1}, seed weight cob^{-1} and thousand seed weight, and yield, which was significantly superior over the rest of the treatments tried. The lowest values of yield attributes and yield were recorded with control. Among the nutrient management practices tried, foliar application of $ZnSO_4$ and FeSO4 @ 0.5% each at booting and silking + sulphur @ 30 kg ha^{-1} along with 100% RDF recorded significantly the highest protein, zinc and iron content in the seed. The lowest protein, zinc and iron content in the seed were recorded in control.

Key words : *Maize, Nutrient management, Quality, Yield*

Maize (Zea mays L.) is third most important cereal crop after rice and wheat in the world agricultural economy, both as a food for human and as feed for livestock. It is known as "queen of cereals" because of its maximum yield potential (22 t ha^{-1}) among the cereals and expanded use in different agro industries. In India, it is grown over an area of 9.5 million hectares with a production of 23.3 million tonnes with 2452 kg ha^{-1} of productivity (DACNET, 2014). Maize is being a C_4 plant has a tremendous yield potential and responds well to growth resources. Despite the impressive strides in acreage and production for last two decades, the productivity of maize in India (2452 kg ha^{-1}) is far below the world average productivity (5490 kg ha^{-1}).

Imbalance and inadequate nutrition is the prime reason attributed to low productivity and poor quality of newly evolved high yielding single cross hybrids in India. Maize is a high nutrient demanding crop, which requires micronutrients along with major nutrients (Verma, 2011).

The availability of nutrients like nitrogen, phosphorus, potassium, sulphur, zinc and iron in balanced proportion in the soil is essential for improving the yield and quality (Randhawa and Arora, 2000). Undoubtedly, the use of high analysis fertilizers must be accompanied by matching doses of zinc and iron applied at the right time through an appropriate mode (soil or foliar), for sustaining and improving the productivity besides quality in corn (Singh *et al.,* 1986).

MATERIAL AND METHODS

The experiment was conducted during *rabi*, 2015-16 on dryland farm of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The soil was sandy loam in texture, neutral in soil reaction (pH 6.9), with low in organic carbon (0.43%) available nitrogen (125.4 kg ha^{-1}), phosphorus (14.2 kg ha^{-1}), potassium (142.4 kg ha^{-1}), sulphur (12.5 kg ha^{-1}), zinc (1.02 kg ha^{-1}) and iron (2.80 kg ha^{-1}) content. The experiment was laid out in a randomized block design with nine treatments and replicated thrice. The treatments consisted of nine nutrient management practices viz., control, 100% RDF (180-60-50 kg N, P_2O_5 and K_2O ha^{-1}, 125% RDF, 150% RDF, 100% RDF + FYM @ 5 t ha^{-1}, 100% RDF + 25 kg $ZnSO_4$ ha^{-1}, 100% RDF + $ZnSO_4$ + $FeSO_4$ each @ 25 kg ha^{-1} , 100% RDF + sulphur @ 30 kg ha^{-1} + $ZnSO_4$ + $FeSO_4$ each @ 25 kg ha^{-1}, 100% RDF + sulphur @ 30 kg ha^{-1} + foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silking. The maize hybrid DHM-117 was tested in the present experiment. Total protein content was estimated with Lowry's method (Lowry *et al.,* 1951), Zinc and iron content of the seeds was determined by Atomic absorption spectrophotometer (Tandon, 1993). in the laboratory.

RESULTS AND DISCUSSION

Effect of nutrient management practices on yield attributes of Maize

Application of recommended dose of fertilizers (180-60-50 kg NPK ha^{-1}) supplemented with 30 kg S ha^{-1} along with foliar application of $ZnSO_4$ + $FeSO_4$ @ 0.5% each at booting and silking resulted in higher stature of yield attributes of maize v*iz* length and girth of the cob, number of seeds cob^{-1}, seed weight cob^{-1} and thousand seed weight (Table -1), which was significantly superior over the rest of the treatments tested. Supply of adequate nutrients lead to an increase in leaf area, photosynthesis etc., which inturn result in the formation of healthy cobs. Further, increase in cob length and girth with foliar spray might have been the result of increase in availability of zinc caused by the direct absorption of the zinc by the foliar spray (Mohsin *et al*., 2014). The variation in the number of seeds cob^{-1} to applied nutrients is the outcome substantiated by the findings of Bakry *et al*., (2009) who reported that micronutrient proved beneficial and salubrious in enhancing all physiological and yield parameters of maize crop with good response interms of number of grains cob^{-1}. Balanced supply of nutrients resulted in better crop growth coupled with early tasseling and silking, which enable the crop to have more number of days for accumulating the assimilates in sink through longer period of translocation, which would have resulted in more number of seeds cob^{-1}. The results are in accordance with Potarzycki and Grzebisz (2009), who observed that application of zinc produced 17.8 per cent higher number of seeds cob^{-1} than those supplied with N, P and K alone. The difference between T_8, T_4, T_7 and T_5 could not reach the level of significance and all the nutrient management strategies were comparable among them with respect to the above said yield attributes. Control (T_1) recorded the lowest values of the above said yield attributes in maize. Different nutrient management practices failed to exert significant influence on number of cobs plant^{-1} except control (T_1), which recorded the lowest number of cobs plant^{-1}. The reason for having statistically similar number of cobs plant^{-1} among the nutrient management practices might have been that this character was mainly genetically controlled and was less influenced by environmental factors (Khan *et al*., 1999).

Seed Yield

Seed yield of maize was significantly influenced by various nutrient management practices (Table 2).The highest seed yield (5307 kg ha^{-1}) of maize was recorded with foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silking + 30 kg sulphur ha^{-1} along with 100% RDF (T_9), which was significantly superior over the rest of the nutrient management practices tried, which resulted in 41.7 per cent higher seed yield over 100% RDF (T_2). Seed yield of maize is a function of yield attributes, which were significantly higher with these nutrient management practices. Application of 150% RDF (T_4), 125 % RDF (T_3), FYM @ 5 t ha^{-1} or $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} or $ZnSO_4$ and $FeSO_4$ each @ 25 kg + sulphur 30 kg ha^{-1} along with 100% RDF (T_5, T_7 and T_8) were the next best treatments, which were comparable among themselves. The comparatively lower yields recorded with soil application of zinc and iron along with N, P, K and sulphur (T_8) over the foliar application of zinc and iron along with N, P, K and sulphur (T_9) might be due to combination of leaching, fixation and voltalization (Ghaffari *et al*., 2011). The yield recorded with soil application of 25 kg $ZnSO_4$ ha^{-1} along with 100% RDF (T_6) was comparable with 100% RDF (T_2) and significantly superior over control (T_1). Foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silking + 30 kg Sulphur ha^{-1} along with 100% RDF (T_9) resulted in 12.7 per cent higher seed yield over soil application of 25 kg each $ZnSO_4$ and FeSO4 + 30 kg S ha^{-1} along with 100% RDF (T_8). The favourable effect of foliar application of zinc might be attributed to its direct influence on auxin production, which inturn enable the plant to produce more drymatter and consequently enhanced the partitioning of photosynthates towards newly formed sink, which resulted in early bloom, prolonged flowering period, which inturn resulted in more number of seeds and higher seed weight cob^{-1}, which is a direct function of yield leading to higher seed yield (Mostafavi, 2012). Control (T_1) recorded the lowest seed yield (404 kg ha^{-1}) because of the deflated stature of growth parameters and yield attributes and finally lower yields due to the deficiency of N, P, K, Zn, Fe and sulphur as the experimental soil is poor in available nitrogen, phosphorus, potassium, zinc, iron and sulphur.

Stover Yield

Among all the nutrient management practices, the highest stover yield of maize (5568 kg ha^{-1}) was recorded with foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silking + 30 kg S ha^{-1} along with 100% RDF, which was however comparable with application of 150% RDF and significantly superior over rest of the nutrient management tried. Stover yield of maize was the interplay effect of plant height and drymatter accumulation and both the parameters were found to be the highest with 150% RDF and foliar spray of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silkig along with 30 kg S ha^{-1} and 100% RDF. This might be due to increased availability of essential plant nutrients from the enhanced level of nutrients applied to the crop in T_4 and balanced supply of nutrients in T_9. Enhanced stover yield is the outcome of the positive and synergistic interaction between the nutrient supply and growth stature of maize as reflected in enhanced growth parameters with supply of highest dose of NPK or optimum dose NPK with foliar application zinc and

Table 1. Yield attributes of maize as influenced by nutrient management practices

Treatments	Cob length (cm)	Cob girth (cm)	Number of seeds cob^{-1}	Seed weight cob^{-1} (g)	Thousand seed weight $^{-1}$ (g)
T_1 : Control	9.1	9.0	98	20.6	180.07
T_2 : 100% RDF (180-60-50 kg N, P_2O_5 and K_2O ha^{-1})	14.2	14.1	369	89.37	270.01
T_3 : 125% RDF	16.5	15.8	405	100.3	293
T_4 : 150% RDF	17.5	16.5	414	102.35	306.13
T_5 : 100% RDF + FYM@5 t ha^{-1}	16.3	15.7	404	100.12	287.5
T_6 : 100% RDF + $ZnSO_4$@ 25 kg ha^{-1}	15.0	14.4	375	92.37	277.21
T_7 : 100% RDF + $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1}	16.4	15.7	407	100.25	290
T_8 : 100% RDF + $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} + Sulphur @ 30 kg ha^{-1}	16.8	15.9	409	100.33	295
T_9 : 100% RDF + Sulphur @ 30 kg ha^{-1} + Foliar application of $ZnSO_4$ and $FeSO_4$ @	18.8	17.5	443	106.92	311.26
SEm±	0.4	0.36	9.38	1.05	3.25
CD (P=0.05)	1.2	1.1	2.4	3.16	9.75

Table 2. Yield and quality of maize as influenced by nutrient management practices

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Protein content (%)	Zinc content (mg kg^{-1})	Iron content (mg kg^{-1})
T_1 : Control	404	1541	20.77	3.75	34.9	36.2
T_2 : 100% RDF (180-60-50 kg N, P_2 and K_2O ha^{-1})	3744	4229	46.95	7.96	45.6	46.8
T_3 : 125% RDF	4567	5068	47.4	8.5	47.7	47.2
T_4 : 150% RDF	4880	5550	46.94	9.56	49.8	47.9
T_5 : 100% RDF + FYM@5 t h^{-1}	4484	4989	47.22	8.51	50	48.4
T_6 : 100% RDF + $ZnSO_4$@ 25 kg ha^{-1}	4027	4528	46.53	9.08	56.8	49.6
T_7 : 100% RDF + $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1}	4535	5049	47.32	9.05	57.1	56.8
T_8 : 100% RDF + $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} + Sulphur @ 30 kg ha^{-1}	4708	5127	47.86	1089	57.7	57.1
T_9 : 100% RDF + Sulphur @ 30 kg ha^{-1} + Foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silking	5307	5555	48.85	11.85	64.7	63.6
SEm±	138	140	0.28	0.17	2.07	2.01
CD (P=0.05)	415	420	0.9	0.51	6.2	6

iron along with sulphur (Jyothi *et al*., 2015). The increase in grain and stover yield was due to role of zinc in metabolism of plants as an activator of several enzymes, which inturn may directly or indirectly affect the synthesis of carbohydrates and protein (Narwal *et al*., 1993). The lowest stover yield (1541 kg ha^{-1}) was recorded with control due to poor vegetative growth as a result of non supply of nutrients.

Harvest Index

The highest harvest index in maize was recorded with foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silking + 30 kg S ha^{-1} along with 100% RDF (T_9), which was significantly superior over rest of the nutrient management practices tried (Table 2). This might be due to better absorption and translocation of nutrients (N, P, K and S including zinc and iron) in balanced proportions, where foliar application coincided with the peak crop demand and thereby maintainance of better source sink relationship owing to higher harvest index. The lowest harvest index was recorded with control (T_1) might be due to poor source sink relationship owing to inadequate nutrient supply.

Grain Protein content:

Nutrient management practices exerted considerable influence on the protein content of maize grain. Foliar application of zinc and iron increased the protein content considerably over soil application (Table 3).

Foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silking + sulphur 30 kg ha^{-1} along with 100% RDF (T_9) recorded significantly higher protein content (11.85%), which was significantly superior over rest of the nutrient management practices tried. The next best treatment was soil application of 25 kg each $ZnSO_4$ and $FeSO_4$ + 30 kg sulphur ha^{-1} along with 100% RDF. The highest protein content was associated with T_9 which might me due to balanced supply of nutrients along with required quantity of nitrogen as it is important component of proteins. Further, the increase in grain protein content may be due to the fact that nitrogen is an integral constituent of amino acids, which are the basic units of the protein. These results are in consonance to those reported by Singh *et al*., (1986). Zinc plays a major role in metabolism of plant as an activator of several enzymes, which inturn directly affect the protein metabolism. The lower protein content associated with application of 100% RDF (T_2) might be due to deficiency of sulphur , zinc and iron, which reduced total amount of proteins because of direct effect of these nutrients on protein synthesis (Cakmak *et al*., 2008). The lowest protein content (3.75%) was recorded with control (T_1) as the available nutrients in the soil may not be sufficient to meet the demands of sink during post anthesis period.

Grain zinc content

The highest zinc content in the seed was obtained with foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silking + sulphur @ 30 kg ha^{-1} along with 100% RDF (T_9), which was significantly superior over rest of the nutrient management practices tried. This might be due to the fact that foliar applied zinc ions possess high mobility within the plants leading to increased concentration of zinc in the seed. Foliar application of $ZnSO_4$ lead to increase in concentration of zinc in both seed and vegetative parts of the plants, which was mainly due to the vital physiological role of zinc in the plant cell (Alloway, 2004). Zinc content recorded with soil application of 25 kg each $ZnSO_4$ and $FeSO_4$ + 30 kg S ha^{-1} along with 100% RDF, $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} along with 100% RDF and 25 kg $ZnSO_4$ ha^{-1} along with 100% RDF (T_8, T_7 and T_6) were statistically comparable among them and were the next best treatments. This might be due to application of zinc leading to higher zinc content in the seed. Similar results were also reported by Ozturk et al. (2006) in wheat. The lowest zinc content in seed was recorded in treatments involving non application of zinc (T_5, T_4, T_3, T_2 and T_1) as the soils are deficit in available zinc (1.02 kg ha^{-1}).

Grain Iron Content

The highest iron content of seed was registered with foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% each at booting and silking + 30 kg sulphur ha^{-1} along with 100% RDF (T_9), which was significantly superior over rest of the nutrient management practices tried. Soil application of $ZnSO_4$ and $FeSO_4$ each @ 25 kg + 30 kg sulphur ha^{-1} along with 100% RDF (T_8) and soil application of $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} along with 100% RDF (T_7) recorded statistically on par iron concentration in grain and were the next best treatments. The higher iron content in the grain associated with T_9 might be due to better absorption of foliar applied iron in the leaves and it is translocated to the source and largely stored as ferric phospho proteins called phytoproteins (Prasad, 2006). The lowest iron content in the seed was recorded with treatments involved in non application of iron (T_6, T_5, T_4, T_3, T_2 and T_1) as the soils are deficit in available iron (2.80 kg ha^{-1}). Khurana *et al.,* (2002) observed spectacular response of maize to zinc and iron application.

CONCLUSION

The highest seed yield and quality of maize *viz*. Protein content, zinc and iron content in the grain was recorded with foliar application of $ZnSO_4$ and

$FeSO_4$ @ 0.5% each at booting and silking + 30 kg sulphur ha^{-1} along with application of 180-60-50 kg N, P_2O_5 and K_2O ha^{-1} (100% RDF), which was significantly superior over the rest of the nutrient management practices tried, which resulted in 41.7 per cent higher seed yield and protein content (11.85%), over 100% RDF.

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Received on 04.01.2018 and revised on 05.03.2018