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Nutrient Management Effects on Yield and Economics of *rabi* Maize (*Zea mays*)

K Jeevana Jyothi, A V Ramana, K V Ramana Murthy and N Sunanda
Department of Agronomy, Agricultural College, Naira 532 185, Andhra Pradesh

ABSTRACT

A field experiment was conducted during 2012-2013 at Agricultural College Farm, Naira to find out the best nutrient management package for *rabi* maize in North Coastal Zone of A.P. The growth parameters, yield attributes and yield of maize were significantly influenced due to different fertility levels tried. Although maximum yield was registered with T_8: 240-120-180 kg NPK ha^{-1}+ soil application of $ZnSO_4$ @ 50 kg ha^{-1}, it was comparable with T_7: 200-100-150 kg NPK ha^{-1}+ soil application of $ZnSO_4$ @ 50 kg ha^{-1}, T_{12}: 240-120-180 kg NPK ha^{-1}+ foliar spray of $ZnSO_4$ @ 0.5% and T_{11}: 200-100-150 kg NPK ha^{-1}+ foliar spray of $ZnSO_4$ @ 0.5%. Considering higher gross and net returns as well as B:C ratio, application of 200:100:150 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50kg ha^{-1}) (T_7) could be an effective nutrient package for remunerative maize cultivation in North Coastal Zone of A.P.

Key words : Foliar application, *Rabi* maize, Nutrient management, Soil application, Zinc.

Maize is one of the abundantly produced food grains next only to rice and wheat. It being a C_4 plant has immense production potential and is called "Queen of cereals" and grown on 130 countries. In India it is cultivated in an area of 8.67 M ha with a productivity of 2492 kg ha^{-1} during the year of 2011 – 2012 (Ministry of Agriculture, Govt. of India). In Andhra Pradesh, the area under maize cultivation during *rabi* 2011 – 2012 was reported to be 310.0 thousand ha (Ministry of Agriculture, Govt. of India). *Rabi* maize contributes more than 25% to annual production with less than 10% of total maize growing area.

Of late maize is gaining lot of popularity in North Coastal Zone of Andhra Pradesh, especially in *rabi* season owing to the growing demand for quality kernels for poultry feed, as this industry is fast packing up in this part of the state in addition to establishment of maize processing units. Several factors have been found to affect the productivity of winter maize however; fertilizer management is one of the chief factor that affect the growth and yield of maize. Maize is an exhaustive crop which requires adequate amounts of macro and micro nutrients in order to get better growth and exploit yield potential. Winter maize was proved to be more responsive to the fertilizer application (Savita Mehta *et al.,* 2011) due to its vigorous plant growth and longer duration.

Since most of the soils in North Coastal Zone are sandy loam in their textural class with medium to low in N and P and high in K, the nutrient requirement of this crop, especially with respect to the major nutrients need to be scientifically quantified to enable the farmers to reap better harvest and to augment the profitability from this crop and hence the present investigation is proposed.

MATERIAL AND METHODS

A field study was conducted during 2012-2013 at Agricultural College Farm, Naira to work out the nutrient requirement, including Zn for *rabi* maize. The soil of the experimental site was sandy loam in texture, slightly alkaline in pH, low in organic carbon (0.3 %), medium in available nitrogen (287.5 kg ha^{-1}), available phosphorus (20.0kg ha^{-1}) and available potassium (312.5 kg ha^{-1}). The experiment was laid out in a randomized block design with twelve treatments and replicated thrice. The treatments comprised of T_1: 120-60-90 kg NPK ha^{-1}, T_2: 160-80-120 kg NPK ha^{-1}, T_3: 200-100-150 kg NPK ha^{-1}, T_4: 240-120-180 kg NPK ha^{-1}, T_5: 120-60-90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}, T_6: 160-80-120 kg NPK ha^{-1}+ soil application of $ZnSO_4$ @ 50 kg ha^{-1}, T_7: 200-100-150 kg NPK ha^{-1}+ soil application of $ZnSO_4$ @ 50 kg ha^{-1}, T_8: 240-120-180 kg NPK ha^{-1}+ soil application of $ZnSO_4$ @ 50 kg ha^{-1}, T_9: 120-60-90 kg NPK ha^{-1} + foliar spray of $ZnSO_4$ @ 0.5%, T_{10}: 160-80-120 kg NPK ha^{-1}+ foliar spray of $ZnSO_4$ @ 0.5%, T_{11}: 200-100-150 kg NPK ha^{-1}+ foliar spray of $ZnSO_4$ @ 0.5% and T_{12}: 240-120-180 kg NPK ha^{-1}+ foliar spray of $ZnSO_4$ @ 0.5%. A popular maize hybrid, DHM – 117 was selected for experimentation. Healthy and bold seeds of maize were dibbled into the soil @ 2 seeds $hill^{-1}$ at a spacing of 60 cm×25 cm. Nitrogen was applied by hill placement in three equal splits *i.e.,* one each at sowing, knee high stage and tasseling stage through urea. Entire phosphorus was applied at the time of sowing through SSP and K_2O was applied in two splits *i.e.,* half as basal dose and remaining half at tasseling stage through MOP. The fertilizers were applied by hill placement as per the treatments. Five plants were tagged in each net plot area for recording observations that did not involve destructive sampling. All the observations were recorded on these plants at tasseling and maturity. Five plants in the second row from the border row in each plot were cut at ground level at each sampling for recording dry matter accumulation. The data recorded on various growth and yield parameters were analyzed following standard statistical analysis of variance technique suggested by Panse and Sukhatme (1978). Significance of the treatments was tested by F test at 0.05 level of probability and critical difference (CD) was calculated whether F test was found significant.

RESULTS AND DISCUSSION

Effect on growth parameters:

The growth parameters of maize *viz.,* plant height and dry matter production at tasseling and at harvesting were significantly influenced due to different fertility levels tried while, the number of days taken to attain 50 per cent tasseling and silking did not alter to a statistically measurable level.

Fertility levels exerted considerable influence on plant height at tasseling stage (Table 1). Among the various levels of fertility, the tallest plants were produced in the plots which received the highest dose of NPK + soil application of $ZnSO_4$ @ 50 kg ha^{-1} (T_8) which were however, comparable with T_{12} (240:120:180 kg NPK ha^{-1} + $ZnSO_4$ @ 0.5% as foliar spray), T_4 (240:120:180 kg NPK ha^{-1}), T_7 (200:100:150 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}), T_{11} (200:100:150 kg NPK ha^{-1} + $ZnSO_4$ @) 0.5 % as foliar spray) and T_3 (200:100:150 kg NPK ha^{-1}). Plants were at their shortest stature with the lowest level of nutrients supplied (T_1 - 120:60:90 kg NPK ha^{-1}) which were however, comparable with those under soil application of $ZnSO_4$ (T_5) and foliar application of ZnSO4 (T_9) at the same level of NPK.

Plant height measured at maturity also followed similar trend as was observed at tasseling stage. Maximum plant height was recorded in plots which received the highest dose of 240:120:180 kg NPK ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} as soil application(T_8), which was however, comparable with T_7 (200:100:150 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}), T_{12} (240:120:180 kg NPK ha^{-1} + $ZnSO_4$ @ 0.5% as foliar spray), T_4 (240:120:180 kg NPK ha^{-1}), T_{11} (200:100:150 kg NPK ha^{-1} + $ZnSO_4$ @) 0.5 % as foliar spray) and T_3 (200:100:150 kg NPK ha^{-1}). The lowest dose of 120:60:90 kg N, P_2O_5 and K_2O ha^{-1}(T_1) produced the shortest plants which were however, comparable with those under 120:60:90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1} (T_5) and 120:60:90 kg NPK ha^{-1} + application of ZnSO4 @ 0.5 % as foliar spray (T_9).

Dry matter production of maize recorded at tasseling and maturity was significantly influenced due to different fertility levels (Table 1). At tasseling, the treatment which received the highest dose of NPK with $ZnSo_4$ as soil application (T_8) recorded maximum dry matter production which was however, comparable with the immediate lower dose with zinc (T_7) which in turn was at par with T_{12} (240:120:180 kg NPK ha^{-1} + $ZnSO_4$ @ 0.5% as foliar spray), T_4 (240:120:180 kg NPK ha^{-1}), T_{11} (200:100:150 kg NPK ha^{-1} + $ZnSO_4$ @) 0.5 % as foliar spray) and T_3 (200:100:150 kg NPK ha^{-1}). The lowest dry matter production was associated with the lowest dose of NPK tried ($T_{1\ -}$ 120:60:90 kg NPK ha^{-1}) which was however, found parity with T_5 (120:60:90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}) and T_9 (120:60:90 kg NPK ha^{-1} + $ZnSO_4$ @) 0.5 % as foliar spray).

Graded levels of nutrients exerted statistically measurable influence on dry matter production at maturity (Table 1). Application of the highest dose of NPK with zinc as soil application

Table 1. Plant height and dry matter production of *rabi* maize as influenced by different levels of NPK and Zn.

Treatments	Plant height (cm)		Dry matter production (kg ha^{-1})		No of days to 50 % tasseling	No of days to 50 % silking
	At tasseling	At maturity	At tasseling	At maturity		
T_1	157.4	173.8	2470	8138	69.3	73.3
T_2	182.6	192.2	3040	9029	69.0	73.0
T_3	196.9	203.4	3447	10242	68.3	72.7
T_4	209.3	213.1	3621	10283	67.7	72.3
T_5	164.2	179.1	2478	8199	70.7	73.0
T_6	188.3	198.4	3192	9133	66.7	73.0
T_7	201.1	215.6	3967	10585	67.3	72.7
T_8	211.2	216.5	4494	10899	67.0	72.3
T_9	158.3	174.5	2473	8196	68.7	73.3
T_{10}	185.2	196.7	3110	9108	66.7	72.7
T_{11}	197.2	211.0	3573	10347	66.7	72.7
T_{12}	209.9	213.7	3690	10505	66.0	72.3
S.Em ±	7.4	5.6	187.3	260.6	1.2	0.4
CD (P=0.05)	21.7	16.5	549.5	764.4	NS	NS
CV (%)	6.8	4.9	9.8	4.7	2.9	1.0

Table 2. Plant height and dry matter production of *rabi* maize as influenced by different levels of NPK and Zn.

Treatments	Cob length (cm)	Cob girth (cm)	Cob weight (g)	Kernel weight cob^{-1} (g)	1000 kernel weight (g)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	13.1	11.3	121.9	102.4	174.5	3122	4103
T_2	14.5	13.8	151.9	130.6	218.5	4306	4744
T_3	14.9	14.3	183.4	156.9	252.2	4848	4581
T_4	15.2	15.4	185.1	157.6	255.4	4993	5378
T_5	13.4	11.7	125.1	104.9	178.8	3173	4142
T_6	14.7	14.4	156.9	133.7	229.8	4600	4934
T_7	15.1	14.6	201.2	173.5	292.8	5372	5477
T_8	16.1	16.4	204.4	177.4	298.4	5581	5762
T_9	13.2	11.6	124.4	103.8	178.7	3150	4128
T_{10}	14.5	13.9	155.8	132.2	221.1	4354	4752
T_{11}	15.0	14.4	192.2	167.9	256.0	5133	5265
T_{12}	15.7	16.0	195.5	169.9	271.5	5259	5390
S.Em ±	0.4	0.4	8.1	7.7	7.5	160.8	151.6
CD (P=0.05)	1.1	1.2	23.8	22.5	22.0	471.5	444.5
CV (%)	4.3	5.2	8.4	9.3	5.5	6.2	5.3

(T_8) registered the highest dry matter production which was however, on a par with T_7 (200:100:150 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}), T_{12} (240:120:180 kg NPK ha^{-1} + $ZnSO_4$ @ 0.5% as foliar spray), T_{11} (200:100:150 kg NPK ha^{-1} + $ZnSO_4$ @) 0.5 % as foliar spray) T_4 (240:120:180 kg NPK ha^{-1}), and T_3 (200:100:150 kg NPK ha^{-1}). The lowest dry matter production was noticed with T_1 (120:60:90 kg NPK ha^{-1}) which was however, comparable with T_5 (120:60:90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}) and T_9 (120:60:90 kg NPK ha^{-1} + application of $ZnSO_4$ @ 0.5 % as foliar spray).

Elevated level of nutrient supply might have enable the crop to absorb adequate amounts of major nutrients at the peak physiological requirement of the crop and thus resulted in the largest growth stature as a consequence of cumulative effect of taller plants and dry matter accumulation. Balanced fertilization, particularly when ample amounts of major nutrients are supplemented with vital micronutrients like Zn, certainly enables rapid cell division and cell elongation that might have resulted in improvement in plant height and dry matter production. Enhanced growth of maize with added levels of nutrients has been an undisputed fact and universally acceptable proposition as could be visualized from the widely documented research evidence Sutaliya and Singh (2005), Tank *et al* (2006), Anil Kumar *et al.* (2010) and Veeranna *et al.*(2010).

There were no conspicuous differences among the graded levels of nutrients tried with regard to the number of days required to attain 50 per cent tasseling and 50 per cent silking. Similar findings were also reported by Savita Mehta *et al.* (2011).

Effect on yield attributes:

Incremental dose of nutrients differed significantly in their ability to produce various yield parameters *viz.,* cob length, cob girth, cob weight and 1000 kernel weight (Table 2).

Graded levels of nutrients have considerable influence on cob length. The longest cobs were noticed with the application of the highest level of fertility *i.e.* 240:120:180 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1} (T_8) which was however, comparable with T_{12} (240:120:180 kg NPK ha^{-1} + $ZnSO_4$ @ 0.5% as foliar spray), T_4 (240:120:180 kg NPK ha^{-1}), T_7 (200:100:150 kg NPK ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} as soil application) and T_{11} (200:100:150 kg NPK ha^{-1} + $ZnSO_4$ @) 0.5 % as foliar spray). The cob length was minimum in plots which were supplied with the lowest dose of nutrients (T_1) which was however comparable with T_5 (120:60:90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}) and T_9 (120:60:90 kg NPK ha^{-1} + application of $ZnSO_4$ @ 0.5 % as foliar spray). Similar observations also made by Singh *et al.* (2003),

Maximum cob girth was recorded with application of the highest level of NPK + Zn as soil application (T_8) which was however, comparable with the same level of NPK + Zn as foliar spray (T_{12}) and without Zn at the same level of NPK (T_4). The lowest cob girth was noticed with the lowest fertility level (T_1) which was however, on a par with T_5 (120:60:90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}) and T_9 (120:60:90 kg NPK ha^{-1} + application of $ZnSO_4$ @ 0.5 % as foliar spray). Among the various nutrient levels tested, application of 240:120:180 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1} (T_8) exhibited its statistical superiority in producing maximum cob weight, which was however, on a par with T_7 (200:100:150 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}), T_{12} (240:120:180 kg NPK ha^{-1} + $ZnSO_4$ @ 0.5% as foliar spray), T_{11} (200:100:150 kg NPK ha^{-1} + $ZnSO_4$ @) 0.5 % as foliar spray) T_4 (240:120:180 kg NPK ha^{-1}) and T_3 (200:100:150 kg NPK ha^{-1}). The cob weight was minimum in plots which received the lowest level of nutrients (T_1) which was however, comparable with T_5 (120:60:90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}) and T_9 (120:60:90 kg NPK ha^{-1} + application of $ZnSO_4$ @ 0.5 % as foliar spray). Similar observations were also made by Manimaran *et al.* (2007)

Significant gains in the kernel weight were registered with added levels of nutrients. Supply of NPK at the highest level along with soil application of Zn (T_8) produced significantly heavier kernels which were however, comparable with the immediate lower dose of NPK along with Zn as soil application (T_7); the lowest 1000 kernel weight was recorded with the lowest level of NPK tried (T_1 - 120:60:90 kg NPK ha^{-1}) which was however, comparable with T_5 (120:60:90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}) and T_9 (120:60:90 kg NPK ha^{-1} + application of $ZnSO_4$ @ 0.5 % as foliar spray). Similar findings were confirmed with the findings of Sutaliya and Singh (2005),

Yield structure of maize, which is the outcome of the interplay among a series of yield attributing characters *viz.,* cob length, cob girth, cob weight and 1000 grain weight have shown a distinctly detectable disparity in the present investigation due to graded levels of fertilizer application. Added levels of NPK favored the conversion of large dry matter to yield attributing characters. Together with the major nutrients, supply of Zn either through soil or foliage might have provided the synergistic effect in maintaining higher chlorophyll content, favourable enzyme activity and other biochemical responses enabled higher out turn of photosynthates separable for creating a better yield structure. Similar observations were also made by Sutaliya and Singh (2005), Aruna *et al.* (2006) and, Azhar Ghaffari *et al.* (2011).

Effect on yield:

Enhanced levels of nutrient supply exerted a significant and positive influence on the kernel yield of maize (Table 2). The highest kernel yield was obtained with the highest dose of NPK + Zn as soil application (T8). However, T_8 (240:120:180 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}) was comparable with T_7 (200:100:150 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}), T_{12} (240:120:180 kg NPK ha^{-1} + $ZnSO_4$ @ 0.5% as foliar spray) and T_{11} (200:100:150 kg NPK ha^{-1} + $ZnSO_4$ @) 0.5 % as foliar spray). The increase in grain yield was 78.7, 72.1, 68.4 and 64.4 % higher with T_8, T_7, T_{12} and T_{11} respectively over the lowest dose of NPK (T_1) tried. Minimum grain yield was produced in plots which received the lowest level of NPK (T_1) which was however, on a par with T_5 (120:60:90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}) and T_9 (120:60:90 kg NPK ha^{-1} + application of $ZnSO_4$ @ 0.5 % as foliar spray). Malla Reddy *et al.* (2010) and Anil Kumar *et al.* (2010).

Maximum stover yield was associated with the application of 240:120:180 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1} (T_8) which was however, on a par with 200:100:150 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1} (T_7), 240:120:180 kg NPK ha^{-1} + $ZnSO_4$ @ 0.5% as foliar spray (T_{12}) and 240:120:180 kg NPK ha^{-1} (T_4). Significantly lower stover yield was obtained with T_1 (120:60:90 kg NPK ha^{-1}) which was however found parity with T_5 (120:60:90 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}) and T_9 (120:60:90 kg NPK ha^{-1} + application of $ZnSO_4$ @ 0.5 % as foliar spray). Similar observations were

Table 3. Economics of maize as influenced by different NPK levels and Zn during *rabi,* 2013.

Treatment	Yield (kg ha^{-1})	Cost of cultivation (Rs)	Gross returns (Rs)	Netreturns (Rs)	BCR
T_1	3122	26007	40586	14579	0.6
T_2	4306	28329	55978	27649	1.0
T_3	4848	30650	63024	32374	1.1
T_4	4993	32972	64909	31937	1.0
T_5	3173	28107	41249	13142	0.5
T_6	4600	30429	59800	29371	1.0
T_7	5372	32750	69836	37086	1.1
T_8	5581	35027	72553	37526	1.1
T_9	3150	26912	40950	14038	0.5
T_{10}	4354	29234	56602	27368	0.9
T_{11}	5133	31555	66729	35174	1.1
T_{12}	5259	33877	68367	34490	1.0

also made by Malla Reddy *et al.* (2010) and Anil Kumar *et al.* (2010).

Graded levels of fertilizer application has profound influence on the grain yield of maize. Optimal and balanced application of nutrients has a positive discrimination towards growth parameters which enabled elevated yield structure that decides the ultimate sink size. In the present investigation, it was noticed that the highest level of NPK with Zn tried ($T_{8)}$ has resulted in the best performance in terms of enhanced yield structure which in turn reflected in the highest grain yield. However, T_8 (240:120:180 kg NPK ha^{-1} + soil application of Zn @ 50b kg ha^{-1}) was comparable with the immediate lower dose of NPK + soil application of Zn (T_7), highest dose of NPK + Zn as foliar application (T_{12}) and the immediate lower dose + foliar application of Zn (T_{11}) indicating the fact that maize crop responds only up to 200:100:150 kg NPK ha^{-1} supplemented with soil application of $ZnSO_4$ @ 50 kg ha^{-1} (T_7) or foliar spray of Zn @ 0.5 % (T_{11}), beyond which the response was not only marginal. Enhanced stover yield is the outcome of the positive and synergistic interaction between nutrient supply and growth stature of maize as reflected in enhanced growth parameters with the supply of highest dose of NPK without Zn (T_4) or immediate lower dose with Zn as soil application (T_7). Larger variation in stover yield of maize due to incremental dose of nutrients has been universally accepted and voluminous research data to conform this feature is available with Malla Reddy *et al.* (2010) and Anil Kumar *et al.* (2010).

Economics:

Among various fertility levels tried, maximum gross returns were recorded with T_8 (240:120:180 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}), which was closely followed by T_7 (200:100:150 kg NPK ha^{-1} + soil application of $ZnSO_4$ @ 50 kg ha^{-1}). As regards net returns, highest net returns (Rs. 37526/-) were observed with T_8 (240:120:180 kg NPK ha^{-1} + soil application of Zn @ 50b kg ha^{-1}), however, the difference (Rs.440/-) between T_8 (240:120L180 kg NPK ha^{-1} + soil application of Zn @ 50b kg ha^{-1}) and T_7 (200:100:150 kg NPK ha^{-1} + soil application of Zn @ 50b kg ha^{-1}) was only marginal, while the B: C ratio (1.1) remained same between these two levels (T_8 & T_7) of fertilization to maize crop. The lowest net returns as well as B:C ratio were associated with T5 (120:60:90 kg NPK ha^{-1} + soil application of ZnSO4 @ 50 kg ha^{-1}). These findings were corroboared with those reported by Veeranna *et al.* (2010) and Paramasivan *et al.* (2011).

Conclusion

From the investigation, it can be concluded that since comparable yields were obtained with the application of 200:100:150 kg NPK ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} as soil application (T_7) and at the same level of NPK with Zn as foliar spray (T_{11}) as that of the immediate higher levels of NPK+ zinc either as soil application (T_8) or foliar application (T_{12}), despite marginal numerical difference in net returns between T_8 and T_7, considering similar values for B:C ratio, application of 200:100:150 kg NPK ha^{-1} + soil application of Zn SO_4 @50 kg ha^{-1} (T_7) could be an effective nutrient package for remunerative maize cultivation in North Coastal zone of Andhra Pradesh.

LITERATURE CITED

Anil Kumar S, Chidanandappa H M and Vijay Sankar Babu M 2010 Effect of different souces of zinc of growth, yield and uptake of nutrient by maize crop (*Zea mays* L.). *Mysore Journal of Agricultural Sciences.* 44 (1): 92 – 99.

Aruna M, Veeraraghavaiah R and Chandrasekhar K 2006 Productivity and quality of maize (*Zea mays* L) as affected by foliar application of N and Zn at flowering. *The Andhra Agricultural Journal . 53(1&2):* 17-19.

Azhar Ghaffari, Asghar Ali, Muhammad Tahir, Muhammad Waseem, Muhammad Ayub, Asif Iqbal and Atta Ullah Mohsin 2011 Influence of integrated nutrients on growth, yield and quality of maize (*Zea mays* L.). *American Jouirnal of Plant Sciences,* 2- 63 – 69.

Malla Reddy M, Padmaja B and Raja Rama Reddy 2010 Response of maize(*Zea mays* L.) to plant population and fertilizer levels in *rabi* under no till condition. *The Andhra Agricultural Journal,* 57(3):287-289.

Manimaran M, Santhy P and Mahendren P P 2007 Effect of split application and levels of K on yield of maize. *Annals of Agricultural Research* 28 (2) : 114-116.

Ministry of Agriculture, Government of India. 2011-2012 http:// www.indiastat.com.

Panse V G and Sukhatme P V 1978 Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi, pp. 361.

Paramasivan M, Kumaresan K R, Malarvizhi S, Malarvizhi P and Velayudham K 2011 Effect of different levels of NPK and Zn on yield and nutrient uptake by hybrid maize (COHM 5) in pilamedu and palaviduthi series of Tamil Nadu. *Madras Agricultural Journal,* 98 (10 - 12): 334 – 338.

Savita Mehta, Seema bedi and Krishnakumarvashist 2011 Performance of winter maize (*Zea mays*) hybrid to planting methods and nitrogen levels. *Indian Journal of Agricultural Sciences,* 81 (1): 50 –54.

Singh R N, Sutalya R, Ghatak R and Sarangi S K 2003 Effect of higher application of nitrogen and potassium over recommended level on growth, yield and yield attributes of late sown winter maize. *Crop Research.* 26 (1): 71 – 74.

Sutaliya R and Singh R N 2005 Effect of planting time, fertility level and phosphate-solubilizing bacteria on growth, yield and yield attributes of winter maize (*Zea mays*) under rice (*Oryza sativa*) – maize cropping system. *Indian Journal of Agronomy,* 50 (3): 173 – 175.

Tank D A, Patel S K and Usadadia V P 2006 Nitrogen management on maize (*Zea mays* L.). *Crop Research,* 31 (2): 323 – 324.

Veeranna G, Raghu Rami Reddy P and Jalapathi Rao L 2010 Plant density and nitrogen studies in zero tillage maize (*Zea mays* L.). *Journal of Research ANGRAU,* 38 (3&4): 72 – 75.

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