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Effect of Zinc and Application Method of Fertilizers on Productivity, Fertility and Economics of Rabi Maize

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ABSTRACT

A experiment was conducted at farmer fields of Katihar district by Krishi Vigyan Kendra, Katihar, (Bihar Agricultural University Sabour, Bhagalpur) during two consecutive years of 2014-15 and 2015-16 to study the effect of zinc and application method of fertilizers on productivity, fertility and economics of rabi maize. The experiment was laid out in alluvial soil with three treatments and ten replications in RBD. The details of treatments was {(T_1–Farmer Practices (60:0: 0 :: N:P:K Basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS), T_2–RDF (60:60:40 :: N:P:K Basal + 45 kg N at 30 DAS+45 kg N at 60 DAS), T3– RDF (60:60:40:25 :: N:P:K:Zn Basal + 45 kg N at 30 DAS + 45 kg N at 60 DAS)}. Healthy and bold seeds of maize var. Pioneer 3522 were dibbled into the soil @ 1 seed hill^{-1} at a spacing of 60 cm X 20 cm. The growth and yield attributes of maize *viz.*, plant height, plant diameter, leaf length, leaf width, cob length, no of cob per plant, no of grains per cob, kernel and stove yield were significantly influenced by different method of nutrient application. There was a progressive increase in the growth and yield attributes with each application methods of nutrients applied from T_1 to T_2 and further increase in growth attributes were noticed when the graded levels fertility were supplemented with Zn as soil application T_3. There was a gradual and progressive increase in growth and yield attributes with basal application of PK and zinc in comparison to T_1 where PK applied at 30 days after sowing.

KEYWORD

growth and yield attributes, maize, nutrient application method, zinc

INTRODUCTION

Maize is one of the abundantly produced food grains next only to rice and wheat. It being a C4 plant has immense production potential and is called "Queen of cereals" and grown on 130 countries. Maize is an important cereal in India, and both its area and production has been steadily increased over the past two decades. In India, the major maize growing season is kharif which accounts for about 85% of the total maize area. However, in spite of maximum share in area, the relative contribution of kharif maize is comparatively much lower than rabi maize. Rabi maize contributes more than 25% to annual production with less than 10% of total maize growing area. The ability of the maize crop to grow in different seasons and high productivity of rabi maize gives it added advantage for inclusion in the cropping system as demand for more food grows. Several factors have been found to affect the productivity of rabi maize however; fertilizer management is one of the chief factors 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.

Nitrogen is a critical input in agriculture and is a powerful tool for increasing the grain yield in cereals. Maize has maximum nitrogen use efficiency of about 50% but under poor management, its efficiency varies from 30 – 40% (Patel et al., 2006). Among the major nutrients, P ranks next to N in its importance on account of the vital role being played in major life processes and its availability to the growing crop in required levels is of very important. Application of phosphorous in a balanced proportion with other essential nutrients has produced higher yields and ensured more profit to the farmers (Manimaran and Poonkodi, 2009). Seedling stage is very critical and any inadequacy of phosphorous during this stage will cause poor stand with stunted plants. Maize responds favorably to application of potassium owing to its high yield potential. Therefore, proper management of potassium nutrient is also essential since it plays an important role in activating various enzymes. Potassium affects plant metabolism, although the amount needed for this purpose is very small. Large amount of potassium is also needed for regulation of different physico-chemical processes in plants including water utilization by the plant (Mohamed Amanullah *et al.*, 2008). Total amount of K absorbed by the mature maize plant is more than any other essential element except N. The relative rate of K accumulation was very rapid and reached the maximum about 30 days earlier than the stage at which maximum accumulation of N and P or dry matter occurred (Reddy *et al.*, 2008). Among the micro nutrients, zinc is now been reported as the third most important limiting nutrient element in the crop production after N and P. Under Zn deficiency conditions, flowering and yields are reduced and growth period is prolonged resulting in delayed maturity and quality of the crop may also suffer. Zn is required for the synthesis of tryptophan which is the precursor of indoleacetic acid, the primary auxin in plants. The Zinc deficiency is a worldwide nutritional constraint for crop production in many types of soil, particularly in cereals growing in alluvial soil. The concept of balanced fertilization paves the way for optimum plant. Since most of the soils in Koshi region of Bihar are sandy clay in their textural class with medium to low in N, P and K the nutrient requirement of this crop, especially with respect to the major nutrients needs to be scientifically quantified in proper time but farmers of Koshi region not applied as a basal dose of nutrients specially P, K and Zn. Therefore, they enable to reap best

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harvest and to augment the profitability from this crop and hence the present investigation was conducted by Krishi Vigyan Kendra, Katihar to study the e**ffect of zinc and application method of fertilizers on productivity, fertility and economics of rabi maize.**

Material and Methods:

The experiment was conducted at farmer fields of Katihar district by Krishi Vigyan Kendra, Katihar, (Bihar Agricultural University Sabour, Bhagalpur) during two consecutive years of 2014-15 and 2015-16 to study the effect of **zinc and application method of fertilizers on productivity, fertility and economics of rabi maize.** It lies between Latitude 25'N to 26'N, Longitude 87' to 88'E with an altitude of 32 m above MSL. The climate is sub-tropical and humid having mean maximum and minimum temperature between 42^{0}C and 4^{0}C, respectively and the average annual rainfall of the district is about 1200 mm.

Experimental site and soil analysis

The experimental soils are non-calcareous light gray flood plain belongs to the Alluvial Tract (Agro ecological zone-II) lies between three major rivers Mahananda, Kosi and Ganga. The soil samples were collected from different farmer field before start the experiment and after harvesting of the crop in each year and at each sampling site, soil samples were collected from top soil and finding are presented in table 1. In October 2014 and March 2015 and October 2015 and March 2016, surface soil samples were collected with the help of Augar. At each sampling point four cores (5.0 cm diameter) were randomly taken within one meter at each other to a depth of 15 cm. About 500 g composite soil samples were obtained after combining at each point. A total of 75 % composite soil samples were air dried and pass through 2mm sieve. Organic carbon content was determined by the Walkley and Black method (1934). Available nitrogen was determined by the alkaline $KMNO_4$ method (Subbaiah and Asija, 1956), and available phosphorous (Olsen's method, 1954) and available potash were determined Flamphotometrically method (Tandon, 1999), available zinc was determined Atomic Absorption Spectrophotometer (Tandon, 1999). The pH and ECe were measured in soil suspension (1:2.5) using electrode (Chopra and Kanwar, 1991).

Experimental treatments and design

The experimental field was ploughed twice by a tractor drawn cultivator followed by rotovator for obtaining fine tilth and physico-chemical properties have been completed and presented in table 1. The experiment was laid out in RBD with three treatments and ten replications in 4.0 m X 2.5 m plot size. There were altogether 30 unit plots in the experiment. Individual plots were separated by bunds, buffer channels and irrigation channels to provide irrigation. The nutrient content in FYM on dry weight basis was 0.72 % N, 0.30 % P and 0.61 % K. FYM was applied one week before sowing and chemical fertilizers were applied as per treatments. The details of treatments was {(T_1–Farmer Practices (60:0: 0 :: N:P:K Basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS), T_2–RDF (Basal 60:60:40 :: N:P:K + 45 kg N at 30 DAS+45 kg N at 60 DAS), T3– RDF (Basal 60:60:40:25 :: N:P:K:Zn + 45 kg N at 30 DAS + 45 kg N at 60 DAS)} respectively. Healthy and bold seeds of maize var. Pioneer 3522 were dibbled into the soil @ 1 seeds hill^{-1} at a spacing of 60 cm X 20 cm i.e. plants density was 8300 plants ha^{-2}. All cultural practices i.e. thinning, weeding, irrigation, plant protections was follows as per requirements. The crop was harvested at maturity when the cobs dried and the entire plants turned yellow. The border row cobs were harvested first from each plot leaving the net plot area. Later, net plot area was harvested after separating the plants for recording biometrical observations. The cobs harvested from net plot were dried thoroughly under the sun and the stover was also dried under the sun separately for recording the weights. Shelling of cobs was done using mechanical hand shellers.

Pre-Harvest Observations

Ten 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. Plant height, plant diameter, leaf length, leaf width, cob length, no of cob per plant and no. of grains per cob were measured from every tagged plant. Finally, the cobs were harvested from the net plot area and the plants were cut and sun dried. After thorough drying of the plants, the weights were recorded for stover yield. Shelling of cobs was done with maize sheller and weight of kernels was recorded. To this kernel weight, kernel yield of ten plants which was sampled for recording post harvest observations was also added.

Chemical analysis of plant materials

Plant samples collected for recording dry matter accumulation at maturity from different treatments were oven dried, ground into powder, and used for chemical analysis. Plant and kernel samples taken at maturity were analyzed for nitrogen (Modified micro kjeldhal method, Piper, 1960); phosphorous (Vanado molybdophosphoric acid method, Jackson, 1973), potassium (Flame photometer method, Jackson, 1973) and Zn (Atomic absorption spectrophotometer, Tandon, 1999). From the chemical analysis data, uptake of the individual nutrients was calculated. Uptake was calculated by multiplying the nutrient content by the respective dry weight of kernel and stover and then summed up to represent total nutrient uptake at harvest as shown below.

$$\text{Nutrient uptake by grain (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) X Kernel yield (kg ha}^{-1})}{100}$$

$$\text{Nutrient uptake by stover (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) X Stover yield (kg ha}^{-1})}{100}$$

Statistical Analysis

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.

Economics

By using all the inputs, total cost of cultivation was calculated for each treatment. Based on prevailing market price of the output, gross returns were calculated. The net returns from each treatment were arrived at by deducting the cost of cultivation worked out with these prevailing costs of inputs and labour wages. The Benefit: Cost ratio (BCR) for all the treatments was worked out on the basis of net returns in terms of rupees after deducting the cost of treatments from gross returns.

Net returns = Gross returns – Total operational cost (Rs. ha-1)

$$\text{B:C Ratio} = \frac{\text{Net returns (Rs.ha}^{-1})}{\text{Cost of cultivation (Rs.ha}^{-1})}$$

RESULTS AND DISCUSSION

Effect of treatments on growth attributes of maize

The growth parameters of maize *viz.,* plant height, plant diameter, leaf length, leaf width, cob length, no of cob per plant and no. of grains per cob 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 % tasseling and silking did not alter to a statistically measurable level. Fertility levels exerted considerable influence on plant height at tasseling stage (table 2). There was a progressive increase in the growth attributes i.e. plant height, plant diameter, leaf length, leaf width with each application methods of nutrients applied from T_1 (60:0: 0 :: N:P:K Basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS) to T_2 (Basal 60:60:40 :: N:P:K + 45 kg N at 30 DAS+45 kg N at 60 DAS), and further increase in growth attributes were noticed when the graded levels fertility were supplemented further with Zn as soil application T_3 (Basal 60:60:40:25 :: N:P:K:Zn + 45 kg N at 30 DAS + 45 kg N at 60 DAS). Among the various levels of fertility, the tallest plants (184.25 cm) were produced in the plots which received the basal dose of one third nitrogen, full dose of phosphorous and potas along with soil application of 25 kg zinc. Plant height measured at maturity also followed similar trend as was observed at tasseling stage. There was a gradual and progressive increase in plant height with basal application of phosphorous, potash and zinc in comparison to T_1 where phosphorous and potash applied at 30 days after sowing.

Dry matter production of maize recorded at tasseling and maturity was significantly influenced due to different fertility levels (table 2). At tasseling, the plots which received the highest dose of NPK with $ZnSO_4$ as soil application (T_3 - RDF Basal 60:60:40:25 :: N:P:K:Zn + 45 kg N at 30 DAS + 45 kg N at 60 DAS) recorded maximum dry matter production which was however, comparable with the T_1 (60:0: 0 :: N:P:K Basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS) and T_2 (RDF Basal 60:60:40 :: N:P:K + 45 kg N at 30 DAS+45 kg N at 60 DAS).

Effect of different treatments on yield parameters of maize

Incremental dose of nutrients differed significantly in their ability to produce various yield parameters *viz.,* cob length, cob girth, cob weight, no. of rows cob^{-1}, no. of seeds row^{-1}, and 1000 kernel weight. Graded levels of nutrients have considerable influence on cob length (table 2). The longest cobs (16.87 cm) were noticed with the application of recommended basal dose of fertilizer along with zinc *i.e.* RDF 60:60:40:25 basal:: N:P:K:Zn + 45 kg N at 30 DAS + 45 kg N at 60 DAS) (T_3) which was however, comparable with T_2 (RDF (60:60:40 basal:: N:P:K + 45 kg N at 30 DAS+45 kg N at 60 DAS) 16.31 cm and T_1 (60:0: 0 :: N:P:K basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS) 14.76 cm. The cob length was minimum in plots which were supplied with the indiscriminate dose of nutrients (T_1) which was however comparable with T_3 and T_2.

Girth of cob was significantly influenced by various fertility levels to a statistically appreciable level (table 2). Maximum cob girth (16.5 cm) was recorded with application of the highest and judicious level of NPK + Zn as soil application (T_3) which was however, comparable decline without Zn with non basal application of PK (T_1-11.2 cm) and without Zn with basal application of NPK (T_2- 14.8 cm). The lowest cob girth was noticed with the injudicious fertility level (T_1).

Graded levels of fertility displayed a distinct statistical disparity with regarded to no of cob $plant^{-1}$ (table 2). Among the various nutrient levels tested, application of RDF basal 60:60:40:25 :: N:P:K:Zn + 45 kg N at 30 DAS + 45 kg N at 60 DAS) (T_3) exhibited its statistical superiority in producing maximum no of cob $plant^{-1}$ (1.39), which was however, at par with T_2 (RDF 60:60:40 basal:: N:P:K + 45 kg N at 30 DAS+45 kg N at 60 DAS)- 1.38 and T_1 (60:0: 0 :: N:P:K Basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS)- 1.35. The no of cob $plant^{-1}$ was lower in plots which received the lowest and injudicious level of nutrients.

Number of grain cob^{-1} was altered to a statistically detectable

Table 1: Effect of different treatments on physico-chemical properties of experimental soil

Treatments	pH (1 : 2.5)		ECe (d Sm^{-1})		OC (%)		N		P		K		Zn (ppm)	
							Available Nutrients (Kg ha^{-1})							
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T_1	6.92	6.83	0.19	0.21	0.26	0.26	189	180	22	19	235	232	0.42	0.40
T_2	6.94	6.82	0.19	0.23	0.31	0.32	204	208	22	25	238	240	0.42	0.42
T_3	6.95	6.88	0.21	0.30	0.33	0.35	215	224	23	27	241	248	0.45	0.48
CD (p=0.05)	0.02	0.02	NS	0.02	0.02	0.03	4.0	3.8	0.06	0.05	2.2	2.5	NS	0.2

Table 2: Effect of different treatments on growth attributes of maize

Treatment	Plant height (cm)	Plant diameter (cm)	Leaf length (cm)	Leaf width (cm)	Cob length (cm)	Cob grith (cm)	No of cob plant^{-1}	No of grains cob^{-1}
T_1	160.30	11.34	68.52	10.27	14.76	11.2	1.35	342
T_2	182.64	12.45	74.28	10.73	16.31	14.8	1.38	365
T_3	184.25	14.72	74.65	11.21	16.87	16.5	1.39	387
CD (p=0.05)	1.54	1.21	0.26	0.22	0.05	0.78	0.02	4.56

among various fertility applied method tried (table 2). Number of grain cob^{-1} increased progressively with successive increase in the applying method of PK and further increase was noticed when NPK was supplemented with Zn. Significantly higher number of grains cob^{-1} (387) was associated with T_3 (RDF 60:60:40:25 :: N:P:K:Zn basal + 45 kg N at 30 DAS + 45 kg N at 60 DAS), which was however, found parity with T_2 (60:60:40 :: N:P:K basal + 45 kg N at 30 DAS+45 kg N at 60 DAS) 365 and T_1 (60:0: 0 :: N:P:K basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS) 342.

Different methods of nutrients applied were found to influence number of grain plant^{-1} to a significant level (table 3). The highest number of grain plant^{-1} were noticed with the recommended level of fertiliser 60:60:40:25 :: N:P:K:Zn basal + 45 kg N at 30 DAS + 45 kg N at 60 DAS (T_3-537.93) which was however, comparable with T_2-503.70 (Basal 60:60:40 :: N:P:K + 45 kg N at 30 DAS+45 kg N at 60 DAS) and T_1-461.70 (60:0: 0 :: N:P:K Basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS). The lowest number of grain plant^{-1} was associated with the unbalanced doses of NPK supplied with T_1 (60:0:0:: N:P:K Basal+50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS) which was comparable with T_3-RDF Basal 60:60:40:25 :: N:P:K:Zn+ 45kg N at 30 DAS + 45 kg N at 60 DAS) and T_2 (Basal 60:60:40::N:P:K+45 kg N at 30 DAS+45 kg N at 60 DAS) exhibited its statistical superiority in producing maximum grain plant^{-1}.

As regards the kernel weight plant^{-1}, a clear disparity among the fertilizer application method was noticed (table 3). Maximum kernel weight plant^{-1} (153.31 g) was observed with the application of T_3 (RDF 60:60:40:25 :: N:P:K:Zn basal + 45 kg N at 30 DAS + 45 kg N at 60 DAS) which was however, comparable with T_2 (Basal 60:60:40 :: N:P:K + 45 kg N at 30 DAS+45 kg N at 60 DAS) 134.99 g and T_1 (60:0: 0 :: N:P:K Basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS) 108.04 g. While, the lowest kernel weight plant^{-1} was associated with the unscientific dose of PK and Zn.

Significant gains in the 1000 kernel weight were registered with scientific added levels of nutrients (table 3). Supply of NPK at the highest level along with soil application of Zn (T_3) produced significantly heavier kernels (285 g) which were however, comparable with the indiscriminant dose of NPK.

Yield structure of maize, which is the outcome of the interplay among a series of yield attributing characters *viz.*, cob length, cob girth, no of cob plant^{-1}, no of grains cob^{-1}, no of grains plant^{-1}, kernel weight plant^{-1} and 1000 kernel weight have shown a distinctly detectable disparity in the present investigation. It was noticed that the balanced and basal application of NPK tried with Zn as soil application (T_3) has resulted in the best yield structure. It is possible due to NPK are promote the growth and yield attributes by providing larger dry matter and photosynthetic surface, well developed root system as well as heavier individual kernels due to the ample cell turgidity and effective translocation of photosynthates from source to sink as a consequence of liberal absorption of N, P and K respectively.

Thus, the timely added levels of NPK favored the conversion of large dry matter to yield attributing characters. Together with the major nutrients, supply of Zn through soil application 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 Singh *et al.*, 2003., Sutaliya and Singh, 2005., Aruna *et al.*, 2006., and Azhar Ghaffari *et al.*, 2011.

Table 3: Effect of different treatments on yield attributes of maize

Treatment	No of grains plant^{-1}	Kernel wt plant^{-1} (g)	Stove wt. plant^{-1} (g)	Test wt 1000 seeds (g)	Grain yield (qt ha^{-1})	Stove yield (qt ha^{-1})
T_1	461.70	108.04	147.24	234	90.03	122.70
T_2	503.70	134.99	161.45	268	112.49	134.54
T_3	537.93	153.31	175.63	285	127.76	146.36
CD (p=0.05)	12.61	15.85	8.24	14.70	11.45	9.36

Effect of different treatments on kernel and stover yield of maize

Enhanced levels of nutrient supply exerted a significant and positive influence on the kernel yield of maize (table 3). The kernel yield increased progressively with apply of fertiliser with T_2 (60:60:40 :: N:P:K basal + 45 kg N at 30 DAS+45 kg N at 60 DAS) 112.49 qt ha^{-1} and the kernel yield was further escalated when these levels were supplemented with Zn through soil (T_3 -127.76 qt ha^{-1}) 60:60:40:25 :: N:P:K:Zn basal + 45 kg N at 30 DAS + 45 kg N at 60 DAS in comparison with T_1 (90.03 qt ha^{-1}) where nutrients supplied in unscientific manner 60:0: 0 :: N:P:K as basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS. The increase in kernel yield was 42 and 25 per cent higher with T_3 and T_2 in comparison with T_1 respectively where NPK are used in improper ways. Minimum kernel yield was produced in plots which received the unbalanced level of NPK (T_1).

Various applying method of nutrients levels exerted conspicuous influence on stover yield of maize (table 3). Maximum stover yield (146.36 qt ha^{-1}) was associated with the application of T_3 (60:60:40:25 :: N:P:K:Zn basal + 45 kg N at 30 DAS + 45 kg N at 60 DAS) followed by T_2 – 134.54 qt ha^{-1} (60:60:40 :: N:P:K basal + 45 kg N at 30 DAS+45 kg N at 60 DAS) then T_1- 122.70 qt ha^{-1} (60:0: 0 :: N:P:K as basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS). Significantly lower stover yield was obtained with T_1. Basal doses of NPK with Zn fertilizer application have profound influence on the kernel 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_3) has resulted in the best performance in terms of enhanced yield structure which in turn reflected in the highest kernel yield. The effect of first balanced basal dose was always higher than the second and the same was found to be continued, progressively declining in response with each successive increments. The same situation was encountered in the present study and the response got faded out beyond T_3 in the presence of Zn as soil application. Enhanced yield levels of maize with added levels of nutrients, particularity when the macronutrients were balanced with Zn was a thoroughly accepted fact as could be visualized from widely documented research evidence (Amar Singh *et al.*, 2000., Patil *et al.*, 2006., Anil kumar *et al.*, 2010 and Paramasivan *et al.*, 2011).

Stover yield of maize is the interplay effect of plant height and dry matter accrual and both the parameters were found to be the highest with the balanced and basal level of NPK tried with Zn as soil application (T_3). 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 balance dose of NPK with Zn. Larger variation in stover yield of maize due to balance dose of nutrients has been universally accepted and voluminous research data to conform this feature is available (Anil Kumar *et al.*, 2010 and Malla Reddy *et al.*, 2010).

Effect of different treatments on economics of maize

Perceptible differences were observed among the judicious fertilizers application method with regard to gross and net returns as well as B:C ratio (2.34). Among various fertility levels tried, maximum gross returns were recorded with T_3 (60:60:40:25 :: N:P:K:Zn basal + 45 kg N at 30 DAS + 45 kg N at 60 DAS), which was closely followed by T_2 (60:60:40 :: N:P:K basal + 45 kg N at 30 DAS+45 kg N at 60 DAS). As regards net returns, highest net returns (Rs. 118965/-) were observed with T_3 (60:60:40:25 :: N:P:K:Zn basal + 45 kg N at 30 DAS + 45 kg N at 60 DAS), however, the difference (Rs.17121/-) between T_2 (60:60:40 :: N:P:K basal + 45 kg N at 30 DAS+45 kg N at 60 DAS) was only marginal, while the B: C ratio (2.09) remained same among T_2 fertilization to maize crop.

The lowest net returns as well as B:C ratio were associated with T_1 (60:0: 0 :: N:P:K as basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS). Incremental dose of fertility level resulted in a steady and progressive increase in the kernel yield with a consequent increase in gross and net returns as well as B: C ratio from the lowest level (T_1) up to (T_2) while these parameters were further enhanced when the highest dose of chemical fertilizer was supplanted with Zn as soil application (T_3), indicating the potential advantage of NPK and Zn as soil application to maize crop to a level of adequacy and proper balancing. Abundant research data to conform this feature is available (Chandrashekara *et al.*, 2000., Channakesava *et al.*, 2000., Dilip Singh and Singh, 2006., Veeranna *et al.*, 2010 and Paramasivan *et al.*, 2011).

Effect of different treatments on post harvested soil fertility status

Post harvest available NPK and Zn status of soil was significantly altered due to the judicious application method of fertilizers (table 1). The highest values (224 kg ha^{-1}) for post harvest soil available N status was registered with T_3 (basal 60:60:40:25 :: N:P:K:Zn + 45 kg N at 30 DAS + 45 kg N at 60 DAS), which was however, comparable with T_1- 180 kg ha^{-1} (60:0: 0 :: N:P:K as basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS) and T_2- 208 kg ha^{-1} (60:60:40 :: N:P:K basal + 45 kg N at 30 DAS+45 kg N at 60 DAS).

As regards the soil available P, application of basal 60:60:40:25 :: N:P:K:Zn + 45 kg N at 30 DAS + 45 kg N at 60 DAS (T_3) recorded maximum value (27 kg ha^{-1}) which was however, comparable with T_1 - 19 kg ha^{-1} (60:0: 0 :: N:P:K as basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS) and T_2- 25 kg ha^{-1} (60:60:40 :: N:P:K basal + 45 kg N at 30 DAS+45 kg N at 60 DAS).

Significantly higher post harvest soil available K content was associated with the highest level of NPK + Zn as foliar spray (T_3- 248 kg ha^{-1}), while the lowest values for soil available K were recorded in plots which received the indiscriminate uses of NPK (T_1- 232 kg ha^{-1}).

Table 4: Effect of different treatments on economics of maize

Treatment	Cost of cultivation (Rs ha^{-1})	Gross Income (Rs ha^{-1})	Net Income (Rs ha^{-1})	BC
T_1	48206	123574	75368	1.56
T_2	48806	150650	101844	2.09
T_3	50840	169805	118965	2.34
CD (p=0.05)	44.53	32.85	38.50	NA

As regards Zn, maximum amount of post harvest soil available Zn was recorded in plots which received the balance level of NPK + Zn as soil application (T_3), which was however, found parity with T_1 (60:0: 0 :: N:P:K as basal + 50:40:20 N:P:K at 30 DAS+ 30 kg N at 60 DAS) and T_2 (60:60:40 :: N:P:K basal + 45 kg N at 30 DAS+45 kg N at 60 DAS).

The lowest values for soil available Zn were noticed with the unbalance application of NPK (T_1) which was however, comparable with judicious application of nutrients (T_3). Post harvest soil fertility dynamics is essentially governed by the amount of nutrients supplied at various growth stages of crop over and above the initial soil fertility status and the amount of nutrients absorbed by the dry matter that results from crop production (kernel and stover), besides usual losses and fixation factor *etc*,. In the present investigation, except for K, maximum N, P and Zn were associated with the highest level of nutrients supplied either through soil (T_3) while in the case of K, the highest post harvest soil available K was noticed with T_3. It is not unusual to notice higher residual soil fertility when the crop is supplied with ample amounts of major nutrients during its growing period. The present findings were in closely association with those reported by Paramasivan, *et al.*, 2011.

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