Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(2): 676-679
Received: 16-01-2019
Accepted: 20-02-2019

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Response of integrated nutrient management on quality and economics of maize (*Zea mays*) crop

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Abstract
A field experiment was conducted at field no. 6 Student's Instructural Farm at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during the *Kharif* season 2017 to find out integrated nutrient management effect on maize with ten treatments i.e. T_1 (125% RDN), T_2 (100% RDN), T_3 (100% RDN + 25% N FYM), T_4 (100% RDN + 25% N FYM + S_{30}), T_5 (100% RDN + 25% N FYM + S_{30} + Zn_5), T_6 (75% RDN), T_7 (75% RDN + 25% N FYM), T_8 (75% RDN + 25% N FYM + S_{30}), T_9 (75% RDN + FYM + S_{30} + Zn_5), T_{10} (Control) in RBD with 3 replications. Maize variety Azad Uttam was taken for study. The result showed highest protein content (8.99%) in treatment T_5 and lowest protein content (7.62%) in treatment T_1. Economically the Net returns range is 20687 to 43306 Rs/ha and benefit cost ratio range 1.84 to 2.16 respectively. The treatment combination T_5 (100% RDN + 25% N FYM + S_{30} + Zn_5) gave the best result in terms of crop quality and economics of crop.

Keywords: *Kharif*, *Zea mays*, quality, economics, Azad Uttam

Introduction
Maize (*Zea mays* L.) is one of the most important cereal crop, next to rice and wheat and is used as a food for human and feed for animals. This crop has been developed into a multi dollar business in countries *viz*. Thiland, Tiwan, Singapore, Malaysia, USA, Canada and Germany, because of its potential as a value added product for export and a good food substitute. Maize is gaining immense importance on account of its potential uses in manufacturing starch, plastics, rayon, adhesive, dye, resins, boot polish etc. and due to this large uses it is rightly called a Miracle crop and also known as 'Queen of cereals' due to its high potential yield. In India, maize is grown in an area of 9.76 million hectares with production of 26.14 million tonnes and productivity of 2629.28 kg ha^{-1} (Government of India, 2017). Maize yield is generally higher in high solar intensities, lower night temperature and lower pest infestation. Optimum plant density leads to better utilization of solar radiation resulting into corn dry matter accumulation and biomass production. Uttar Pradesh is the major producing state contributes 60 percent area and 70 percent of maize production in India.
Paradar (2005) [11] noted that application of recommended dose of fertilizers through 50 percent FYM + 50 per cent chemical fertilizer and 50 per cent vermicompost + 50 percent chemical fertilizers were observed at par and these treatments significantly increased plant height of maize compared to control by 9.5 and 10.5 per cent, respectively.
Khadtare *et al.* (2006) [8] reported that application of 25% RDN through vermicompost prepared from different organic wastes noticed significantly higher protein content and total soluble sugar content compared to 25% RDN was applied through FYM.
Arun Kumar *et al.*, (2007) [2] state that the application of P_2O_5 and K_2O at recommended levels of grain maize i.e., 75 kg P_2O_5 ha^{-1} and 37.5 kg K_2O ha^{-1}along with 75% of recommended level of N of grain maize i.e., 112.5 kg N ha^{-1} was found to be necessary to increase the quality parameters *viz*., non-reducing sugar, total sugar and protein content.
Channabasavanna *et al.*, (2007) [5] observed that application of poultry manure at 1.0 t ha^{-1} with 100% NPK (150: 75: 75 kg ha^{-1}) gave significantly higher protein yield in maize over lower levels.
Almodares *et al.* (2009) [1] reported that application of 200 kg ha^{-1} urea had the highest biomass (64.80 t ha^{-1}) and protein content (8%) and it had the lowest soluble carbohydrates (12.80%) and fiber contents (31.90%).
Chavan (2009) [6] reported that The vermicompost @ 4.5 t ha^{-1} produced significantly more yield, sugar content and which was at par with FYM @ 5 t ha^{-1} further it was also significantly superior in respect of sugar content.

Balai *et al*. (2011) [4] noticed that combined application of FYM 10 t ha^{-1} + soil test recommended dose of NPK (120:60:30 kg ha^{-1}) recorded highest protein (10.13 per cent) and carbohydrate (69.98 per cent) in maize.

Thirupathi *et al.* (2016) observed that application of N and S @ 225 and 60 kg ha^{-1} recorded highest grain yield, stover yield, crude protein content and B:C ratio than other N and S contribution but it was on par with N and S @ 225 and 80 kg $ha^{-1.}$

Kumar *et al.* (2017) [9] revealed that application of S and Zn has resulted in significant improvement for crude protein, Ca, ash in baby corn. Application of 125% RDF (187.5-93.7-75 kg ha^{-1}) and 50 kg S ha^{-1} along with 10 kg Zn ha^{-1} has great impact on corn production in maximum corn yield, fodder yield, nutrient content and monetary returns to the growers.

Materials and Methods

The experiment was conducted on Maize during *kharif* season of 2017 under natural condition at field no. 6 Student's Instructural Farm at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The soil of the experimental field was alluvial in origin. Soil sample (0-15cm) depths were initially drawn from randomly selected parts of the field before sowing. The quantity of soil sample was reduced to about 500 gm through quartering technique. The soil sample was then subjected to mechanical and chemical analysis in order to determine the textural class and fertility status the soils were sampled to a depth of 0-30 cm of the soil, air-dried and sieved (2 mm) for soil analyses. Some physical and chemical properties of soils are given in Table 1.

Table 1: Some properties of the <2mm fraction of the top 30 cm of soil used for the site.

S. No.	Particulars	Values
A.	**Mechanical separates**	
1.	Sand (%)	59.6
2.	Silt (%)	17.4
3.	Clay (%)	23.00
4.	Textural Class	Sandy loam
B.	**Physico-chemical properties**	
5.	pH (1:2.5)	8.2
6.	EC (1:2.5) (dS/m at 25^0C)	0.20
7.	Organic Carbon (%)	0.36
8.	Available Nitrogen (kg/ha)	190.00
9.	Available Phosphorus (kg/ha)	13.50
10.	Available Potassium (kg/ha)	182
11.	Available Sulphur (kg/ha)	15.80
12.	Available Zinc (ppm)	0.56
13.	Particle Density (Mg/m^3)	2.54
14.	Bulk Density (Mg/m^3)	1.30
15.	Pore Space (%)	46.0

Maize variety Azad Uttam was taken for study. In the present experiment 10 treatments T_1 (125% RDN), T_2 (100% RDN), T_3 (100% RDN + 25% N FYM), T_4 (100% RDN + 25% N FYM + S_{30}), T_5 (100% RDN + 25% N FYM + S_{30} + Zn_5), T_6 (75% RDN), T_7 (75% RDN + 25% N FYM), T_8 (75% RDN + 25% N FYM + S_{30}), T_9 (75% RDN + FYM + S_{30} + Zn_5), T_{10} (Control)were laid out in Randomized Block Design(RBD) with three replications having plot size 5 x 4 meter square. Doses of fertilizers are applied @ 120 Kg N, 60 Kg P_2O_5, 40 Kg K_2O/ha 30 Kg S/ha, 5 Kg Zn/ha and Organic manure 60 tonne/ha through Urea, D.A.P and Murate of Potash, Elemental sulphur, Zinc oxide and Farm Yard Manure. Sowing is done @ 20 kg seed ha^{-1} maize variety Azad Uttam was used and sown on 22 June 2017. Row to row and plant to plant distance remain 60 and 20 respectively. Seed were sown about 5-6 cm depth

Field Preparation: The experimental field was ploughed once with soil turning plough fallowed by two cross harrowing. After each operation, planking was done to level the field and to obtain the fine tilth. Finally layout was done and plots were demarked with small sticks and rope with the help of mannual labour in each block.

Application of fertilizers: The crop was fertilized as per treatment. The recommended dose of nutrient i.e. N, P, and K was applied @ 120: 60: 40 kg ha^{-1} respectively.

Time and method of fertilizer: Half does N_2 and total phosphorus, potash, zinc and sulphur were applied as basal dressing. Remaining dose of nitrogen was applied through top dressing after knee-high stage. Well decompose FYM applied @ 60 t ha^{-1} 15 day after sowing.

Seed Treatment: To ensure the seeds free from seed borne diseases, seeds were treated with thiram 75% WDP (1.5g/kg of seed).

Seed and sowing: 20 kg seed ha^{-1} maize variety Azad Uttam was used and sown on 22 June 2017. Row to row and plant to plant distance remain 60 and 20 respectively. Seed were sown about 5-6 cm depth.

Intercultural operations: Weeding and hoeing were done with Khurpi and hand hoe after germination.

Irrigation: Tube-well was the source of irrigation. Irrigation was provided in the crop as and when required.

Harvesting: The crop was harvested at proper stage of maturity as determined by visual observations. Half meter length on either end of each plot and two border rose from each side as border were first removed from the field to avoid error. The crop in net plot was harvested for calculation on yield data. Produce was tied in bundles and weighted for biomass yield. Threshing of produce of each net crop was done by manually.

Grain Quality Analysis

Protein Content

Protein is estimated by multiplying N% content with the factor 6.25.

Economic impact evaluation of different treatment in maize

The VCR value are calculated under the following parameters

1. Gross return = Cost of grain + Cost of Stalk
2. Net return = Gross return – Cost of cultivation
3. Benefit: cost ratio (B: C) = $\frac{\text{Gross return}}{\text{cost of cultivation}}$

Rates

1. Maize grain- 1450 Rs. q^{-1}
2. Maize stalk- 300 Rs. q^{-1}
3. Urea - 660 Rs. q^{-1}
4. DAP - 2400 Rs. q^{-1}
5. MOP- 1170 Rs. q^{-1}
6. Elemental sulphur- 50 Rs. kg^{-1}
7. *Zinc oxide* (commercial) 150 Rs kg^{-1}
8. FYM 80 Rs q^{-1}

Statistical Analysis: The data on various characters studied during the course of investigation were statistically analyzed for randomized block design. Wherever treatment differences were significant ("F" test), critical differences were worked out at five per cent probability level. The data obtained during the study were subjected to statistical analysis using the methods advocated by Chandel (1990).

Results

Impact of INM on quality of maize

Protein content (N concentration (%) × 6.25) of maize grain at affected by different treatment is shown in table 2 and which revealed that protein content in grain varied from 7.62 to 8.99%. Maximum protein content was recorded (8.99 %) with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) which was 17.97% higher than minimum protein content (7.62%) at control (T_{10}). Integration of FYM, S and Zn also showed significant increase in protein content added with 100% RDN and 75% RDN. Variation in protein content within 75% RDN, 100% RDN and 125% RDN was found significant.

Table 2: Impact of Integrated Nutrient Management on quality of maize.

S. No.	Treatments	Protein content (%) Grain
1.	T_1	8.37
2.	T_2	8.12
3.	T_3	8.24
4.	T_4	8.62
5.	T_5	8.99
6.	T_6	7.87
7.	T_7	7.99
8.	T_8	8.49
9.	T_9	8.74
10.	T_{10}	7.62
S. E. ±		0.0217
C. D. (at 5 %)		0.081

Impact of INM on Economics

Data in regard to economics analysis *viz*. cost of cultivation, gross return, net return and benefit cost ratio are expressed in Table 3 perusal of the data reveled that maximum cost of cultivation (37207 Rs.) and gross return (80509 Rs.) and net return (43306 Rs.) was recorded with the application of T_5 (100 % RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by T_9 (75% RDN + 25 % N FYM + 30 kg S + 5 kg Zn) and minimum at control (T_{10}). Integration of FYM S and Zn, with 100 % RDN (T_5) found economically superior (B:C ratio 2.16) over all the treatment. It is interesting to report here that inorganic fertilizer treatment found economically superior than inorganic + organic manure treatments.

Table 3: Impact of Integrated Nutrient Management on economics.

S. No.	Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C Ratio
1.	T_1	31297	67267	35970	2.14
2.	T_2	29777	64274	34497	2.15
3.	T_3	34573	97829	33256	1.96
4.	T_4	36223	74620	38397	2.06
5.	T_5	37203	80509	43306	2.16
6.	T_6	28457	57951	29494	2.03
7.	T_7	33205	62671	29466	1.88
8.	T_8	34855	69122	34267	1.98
9.	T_9	35635	74654	39019	2.09
10.	T_{10}	24500	45187	20687	1.84

Discussion

Impact of INM on quality characteristics

It is an admitted fact that nutrition have appreciable and for reaching impact in quality composition of crop in order to monitor the impact of INM in terms of protein content have been analyzed.

Protein

Protein content (N content% in grain × 6.25) was studied to assess the grain nutritional quality. The data in respect to protein content in grain are given in table 2 and illustrated in revealed that protein content influenced significantly by all the treatments over control. Maximum protein content was noted (8.99%) with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by (8.74%) with T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum (7.62%) at control (T_{10}). Addition of S, Zn and FYM also accelerate the protein content significantly when applied with 100% RDN and 75% RDN. Results of the study are in conformity with the results of other investigators Channabasavanna *et al.*, (2007) [5], Almodares *et al.* (2009) [1], and Arun Kumar *et al.*, (2007) [2].

Impact of INM on economics

It is visualized from the data given in table 3 and on cost of cultivation gross return, net return and B: C ratio that the cost of cultivation was recorded higher with use of 100% RDN in combination of S, Zn and organic manure. Analysis of economics revealed that maximum cost of cultivation (37203 Rs. ha^{-1}) with T_5 (100% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by (35635 Rs. ha^{-1}) with T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum (24500 Rs. ha^{-1}) at control (T_{10}). Maximum gross return (80509 Rs. ha^{-1}) and net return (43306 Rs. ha^{-1}) was also recorded with T_5 (100 % RDN + 25 % N FYM + 30 kg S + 5 kg Zn ha^{-1}) followed by (74654 Rs. ha^{-1}), (39019 Rs. ha^{-1}) with T_9 (75% RDN + 25% N FYM + 30 kg S + 5 kg Zn ha^{-1}) and minimum (45187 Rs. ha^{-1}), (20687 Rs. ha^{-1}) at control (T_{10}) respectively. Addition of S, Zn and FYM with 100 % RDN (T_5) was found economically superior (B: C ratio 2.16) followed by T_2 100 % RDN (B: C ratio 2.15) in comparison to other treatments. This might be due to obtain maximum gross return. These findings are in the line of the findings of Karforma *et al.* (2012) [7], Ravi *et al.* (2012) [12], Lingaraju *et al.* (2010) [10] and Ashok *et al.* (2008) [3].

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