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Effect of integrated nutrient management on growth, yield and economics of maize (*Zea mays* L.) under central plain zone of Uttar Pradesh

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Abstract
The present field experiment was conducted at an Agricultural Farm Rama University, Kanpur (U.P) India. the Central Plain zone of Uttar Pradesh, during Rabi season of 2020-21. The experiment comprised of 7 treatment combinations in randomized block design with three replications consisted of T_1: 100% RDF, T_2: 100% RDF + FYM @ 5 t ha^{-1}, T_3: 100% RDF + FYM @ 10 t ha^{-1}, T_4: 100% RDF + FYM @ 15 t ha^{-1},T_5: 75% RDF + FYM @ 5 t ha^{-1}, T_6: 75% RDF + FYM @ 10 t ha^{-1}, T_7: 75% RDF + FYM @ 15 t ha^{-1}. On the basis of the results emanated from present investigation, it could be concluded that application of 100% RDF + FYM @ 15 t ha^{-1} applied in wheat to significantly increases growth parameter i.e. plant height and yield attributes i.e. length of cob, no. of cob per plant, no. of grain per cobs and seed index (g). Results also showed that among the different fertility levels, application of 100% RDF + FYM @ 15 t ha^{-1} significantly enhanced productivity parameters i.e. grain yield, straw yield, biomass yield except harvest index over the 100% RDF. Higher values of economics *viz.*, gross return (Rs. 140822 ha^{-1}), net return (Rs. 79495 ha^{-1}) and B:C ratio (1.30) in maize was observed with the application of 100% RDF + FYM @ 15 t ha^{-1} except cost of cultivation.

Keywords: Cob, economics, FYM, harvest index, maize and yield

Introduction
Maize (*Zea mays* L.) is the world's most important cereal, providing as both human food and cattle feed. It is thought to have originated in Central America. It is one of the most versatile new crops available. After rice and wheat, this cereal is ranked third among cereals. This crop is regarded as the "Queen of Grains" because to its tremendous production potential. In India, the area of Maize is 9.18 million hectares, and the production is 27.23 million tonnes, along with average productivity of 29.73 quintal/ha. The area of Maize in the world is 197.2 million hectares and the production is 1148.48 million tonnes with the productivity of 59.23 quintals/ha. In Uttar Pradesh, 0.73 million hectare area is under maize cultivation with 1.53 million tonnes of the production and 20.90 quintals/ha productivity. (DAC & FW 2018- 19).
Maize grains include around 10% protein, 4% oil, 70% carbs, 2.3 percent crude fiber, 10.4 percent albuminoids, and 1.4 percent ash. Maize grain contains considerable amounts of Vitamin A, nicotinic acid, phosphorus, riboflavin, and vitamin E, and additional maize products, such as corn starch and corn syrup, are made from it. It's high in carbohydrates, protein, iron, vitamin B, and minerals.
Maize is a thorough crop in terms of extracting more micro and macro nutrients from the soil in order to increase productivity. To produce a fresh crop of 40 tonnes per hectare, it consumes roughly 160-210 kg N, 55 kg P, 175 kg K, and 40 kg Mg per hectare. In India, during past four decades intensive agriculture involving exhaustive high yielding varieties of cereals and decreasing inputs of organic sources have led to severe degradation of the soil resulting in a reduction on soil organic matter, soil fertility and productivity (Kachroo and Dixit, 2005) [2].
Green manuring, biofertilizers, FYM, compost, vermicompost, and other organic sources of nutrients are used in the organic package of crop cultivation. Application of different organic-inorganic sources was found very effective in realizing high yield, better economy (Kumar *et al.*, 2005) [3] and improved residual fertility of the soil (Pathak *et al.*, 2005) [8]. Among its many functions, nitrogen plays a significant role in plant metabolism. The productivity of maize is largely dependent upon its nutrient management particularly that of nitrogen. It is well known that maize is a heavy feeder of nitrogen (Shilpashree *et al.*, 2011) [13].

Material and Methods

Experiment site

The field experiment was conducted during *rabi* season of 2020-2021 at Agricultural Research Farm, of Rama University, Mandhana, Kanpur Nagar (U.P.) which is situated in the alluvial tract of Indo - Gangetic Plain in central part of Uttar Pradesh between $25^0$26' to $26^0$58' North latitude, $79^0$31' to $31^0$34' East longitude and on the altitude of 125.9 meters. The irrigation facilities are adequately available on this farm. The farm is situated in the main campus of the university.

Soil of Experimental Field

The experimental field is clay loam in texture, alkaline in reaction (pH 8.2), low in organic carbon (0.40%), available N (166.53 kg ha^{-1}), medium in available P (18.78 kg ha^{-1}), and high in available K (266.27 kg ha^{-1}).

Study Design

The experiment was laid out in a randomized block design (RBD) assigning treatment combinations *viz.* T_1: 100% RDF, T_2: 100% RDF + FYM @ 5 t ha^{-1}, T_3: 100% RDF + FYM @ 10 t ha^{-1}, T_4: 100% RDF + FYM @ 15 t ha^{-1},T_5: 75% RDF + FYM @ 5 t ha^{-1}, T_6: 75% RDF + FYM @ 10 t ha^{-1}, T_7: 75% RDF + FYM @ 15 t ha^{-1}. With three replications. Each treatment was randomly allocated within them. The row-to-row and seed to seed distance were 60 and 20 cm, respectively.

Harvest Index

The harvest index was worked out with the help of following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

Net Profit (ha^{-1}): The net profit from each treatment was calculated separately by using the formula given below.

Net profit (ha^{-1}) = Gross return - Cost of cultivation

Cost Benefit Ratio (C: B)

The benefit ratio for each treatment was calculated by using following formula.

$$\text{Cost Benefit Ratio} = \frac{\text{Cost of Cultivation}}{\text{Gross Return}}$$

Statistical Analysis

The data recorded during the course of the investigation were subjected to statistical analysis by "Analysis of variance technique". The significant and non-significant treatment effects were judged with the help of 'F' (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level. (Chandel, 1998).

Result and Discussion

Growth Characters

The data revealed that maximum plant height 36.64 cm at 30 DAS, 129.36 cm at 60 DAS and 182.45 cm at 90 DAS and 183.82 cm at harvest stage, dry matter accumulation 6.09 g at 30 DAS, 189.21 g at 60 DAS, 365.21 g at 90 DAS and 355.68 g $plant^{-1}$ at harvest was found with the application of 100% RDF + FYM @ 15 t ha^{-1} followed by 75% RDF + FYM @ 15 t ha^{-1}. The minimum plant height 34.06 cm at 30 DAS, 119.36 cm at 60 DAS and 170.27 cm at 90 DAS and 171.32 cm at harvest stage, dry matter accumulation 5.54 g at 30 DAS, 175.02 g at 60 DAS, 345.23 g at 90 DAS and 336.01 g $plant^{-1}$ at harvest was found with the application of 75% RDF. The results of the present investigation are also in agreement with the findings of Panwar (2008) [7], Wailare *et al*., (2017) [15] and Gunjal and Chitodkar (2017) [1].

Table 1: Effect of different treatment combinations of nutrients on growth parameters of Maize

Treatments	Plant height (cm)				Dry Matter Accumulation (g $plant^{-1}$)			
	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest
T_1	34.26	120.21	171.22	172.06	5.62	177.61	347.06	338.63
T_2	34.62	123.26	175.36	176.32	5.71	182.21	354.63	343.56
T_3	35.66	128.11	181.08	182.21	5.96	187.23	359.21	347.65
T_4	36.64	129.36	182.45	183.82	6.09	189.21	365.21	355.68
T_5	34.06	119.36	170.27	171.32	5.54	175.02	345.23	336.01
T_6	35.11	123.25	174.88	175.98	5.61	176.32	347.10	337.12
T_7	35.82	126.24	178.68	179.86	5.76	181..96	353.96	344.12
C.D.(P=0.05)	NS	7.95	9.05	9.54	0.22	9.54	12.44	10.64
S.Ed (+)	1.23	2.65	3.02	3.18	NS	3.18	4.14	3.54

Yield Attributes

A cursory glance of data revealed that that maximum length of cob (19.76 cm), number of cob $plant^{-1}$ (1.40), number of grains cob^{-1} (684.19), and seed index (27.36 g) was found the application of 100% RDF + FYM @ 15 t ha^{-1} followed by 75% RDF + FYM @ 15 t ha^{-1}. The minimum length of cob (17.23 cm), number of cob $plant^{-1}$ (1.24), number of grains cob^{-1} (542.32), and seed index (26.0 g) was found with the application of 75% RDF. The results of present investigation are also in agreement with the findings of Shah and Wani (2017) [12], Raman and Suganya (2018) [10] and Tetarwal *et al.* (2011) [14].

Table 2: Effect of different treatment combinations of nutrients on yield components of Maize

Treatments	Length of Cob	No. of Cob $Plant^{-1}$	No. of grains per cob	Seed Index (g)
T_1	17.42	1.26	556.12	26.01
T_2	18.18	1.32	583.36	26.46
T_3	18.98	1.37	640.36	26.85
T_4	19.76	1.40	684.19	27.36

T_5	17.23	1.24	542.32	26.00
T_6	17.96	1.27	561.36	26.24
T_7	18.36	1.33	586.23	26.64
C.D.(P=0.05)	2.26	NS	88.32	NS
S.Ed (+)	0.75	0.60	29.44	1.08

Productivity Parameters

The data revealed that maximum productivity parameter, i.e. Grain yield (76.12 q ha^{-1}), straw yield (100.94 q ha^{-1}), biological yield (177.06 q ha^{-1}) and harvest index (42.00%) was found with the application of 100% RDF + FYM @ 15 t ha^{-1} followed by 75% RDF + FYM @ 15 t ha^{-1}. The minimum Grain yield (65.65 q ha^{-1}), straw yield (96.35 q ha^{-1}), biological yield (165.00 q ha^{-1}) and harvest index (40.00%) was found with the application of 75% RDF The results of present investigation are also in agreement with the findings of Ravi *et al.* (2012) [11], Mishra *et al.*, (2019) [6] and Ponmozhi *et al.*, (2019) [9].

Table 3: Effect of different treatment combinations of nutrients on productivity parameters of Maize

Treatments	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Biomass Yield (q ha^{-1})	Harvest Index (%)
T_1	66.02	96.36	162.38	40.65
T_2	69.78	96.28	166.06	42.02
T_3	72.21	99.70	171.91	42.00
T_4	76.12	100.94	177.06	42.99
T_5	65.65	99.35	165.00	40.00
T_6	68.12	94.04	162.16	42.01
T_7	70.54	98.56	169.10	41.71
C.D.(P=0.05)	4.32	6.06	10.04	NS
S.Ed (+)	1.44	2.45	3.34	1.03

Economics

Maximum gross return (Rs. 61327 ha^{-1}), net return (Rs. 79495 ha^{-1}) and cost of cultivation (Rs. 140822 ha^{-1}) was observed in treatment T_4 [100% RDF + FYM @ 15 t ha^{-1}] and the minimum gross return (Rs. 54865 ha^{-1}), net return (Rs. 66588 ha^{-1}) and cost of cultivation (Rs. 121453 ha^{-1}) was observed in treatment T_5 [75%RDF]. Maximum benefit cost ratio (1.30) was observed in treatment T_4 [100% RDF + FYM @ 15 t ha^{-1}] and the minimum benefit cost ratio (1.21) was observed in treatment T_5 [75%RDF]. FYM was the most economically viable manure treatment method due to low operating costs and higher returns on investment thus, can be recommended to farmers for production of a fertilizer that increases maize yields with assurance of economic returns. Similar finding were reported by Mahesh *et al.* (2010) [4], and Mahato *et al.*, (2020) [5].

Table 4: Effect of different organic sources of nutrients on economics of Maize.

Treatments No.	Gross return (₹)	Cost of cultivation (₹)	Net return (₹)	Benefit Cost ratio
T_1	55327	122137	66810	1.21
T_2	57327	129093	71766	1.25
T_3	59327	133589	74262	1.25
T_4	61327	140822	79495	1.30
T_5	54865	121453	66588	1.21
T_6	56865	126022	69157	1.22
T_7	58865	130499	71634	1.22

Conclusion

On the basis of above to find it is concluded that application of 100% RDF in combination with FYM @ 15 tonnes ha^{-1} gave the maximum growth, yield component and productivity parameter after crop harvest was found to be the best result of maize. So farmers should be suggested for better production and net profit in maize cultivation should apply 100% RDF + FYM @ 15 t ha^{-1}so that best results in terms yield and profit can also be obtained.

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