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Effect of integrated nutrient management on growth, yield and quality of quality protein maize (QPM) (*Zea mays* L.) in lower Gangetic alluvial zone of West Bengal

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Abstract
The field experiment was directed at Agricultural Research Farm, Baruipur, South 24 – Parganas, West Bengal under University of Calcutta during the R*abi* season of 2018–2019 & 2019-2020 to find out the "Effect of Integrated Nutrient Management on Growth, Productivity and Quality of Quality Protein Maize (QPM) (*Zea mays* L.) in Lower Gangetic Alluvial Zone of West Bengal".The examination was spread out in a Randomized Block Design with three replications and twelve distinct treatments blends organic & inorganic sources of nutrients under well irrigated alluvial soil. VMH-53 (Vivek Maize Hybrid) was the selected cultivar with prolific high yielding characteristics and disease resistant capabilities. Two continuous *rabi* season trails uncover that mix of various natural and inorganic wellsprings of supplements expanded the growth, productivity and quality of QPM hybrid (*Zea mays* L.) without deteriorating the soil qualities. Treatment combination of (75% RDF @140:70:70 kg ha^{-1}) N:P:K + FYM 5 t ha^{-1} + Azotobactor @7.5kg ha^{-1} +PSB @7.5kg ha^{-1}) exhibited most efficient and economic than other treatment variables in terms of growth, quality, yield & yield ascribing characters net return and B: C proportion over other treatments. This was likewise liable for expanding the supplement status of the soil in respect of organic carbon, available N, P, K respectively over introductory status of the soil. These result suggest that in maize organic composts like FYM, Vermicompost, Azotobactor + PSB, could be effectively used in combination with chemical fertilizers to benefit the crop and improve soil health and soil fertility status there by increasing productivity, quality ensuring nutrition and food security.

Keywords: QPM, nutrient management, FYM, PSB, vermicompost, Azotobacter

Introduction
"Queen of Cereals", Maize is considered to be one of the most important cereal crops. In India, it ranks third as the most important food grain after Rice and Wheat. The crop holds immense potential for food and nutritional security. Universally, maize is among the most broadly delivered and devoured cereals crops. In 2019, about 1.15 billion MT of maize was produced covering an acreage of about 197 million ha^{-1} across 170 countries. During this year, global consumption of top three cereals (maize, wheat and rice) stood at 2,365 million MT of which maize held about 48% share (Source: FAOSTAT). India ranks 4th and 7th in terms of global maize acreage and production. Maize is important to India as 15 million Indian farmers are engaged in Maize cultivation. About 28% of maize produces in India is used for food purposes, about 11% as livestock feed, 48% as poultry feed, 12% in wet milling industry and 1% as seed (Bezboruah and Dutta, 2021) [4]. Therefore, maize crop is considered as a multipurpose crop which can contribute much to our national economy (Narang and Gill, 2004). The Projected demand for maize production by 2050 in India is around 121 million tonnes (Amarasinghe and Singh, 2008) [2]. Quality protein maize (QPM) holds superior nutritional value and is essentially exchangeable with normal maize. Protein malnutrition is a serious global issue demanding huge resources on healthcare. QPM looks and taste like normal maize with same or higher yield potential, but it contains nearly twice the quantity of essential amino acids, lysine and tryptophan which makes it richer in quality proteins (Anonymous, 2009) [3]. Quality protein maize has a great potential in human nutrition specially the malnourished children and is also a good source of protein requirement for pre-school children (Srivastava *et al.*, 2005) [12]. Quality protein maize is a nitrogen exhaustive crop and requires very high dose of the nutrient (Singh, 2010; Om *et al.*, 2014) [10]. Thus higher yield of QPM

can be obtained through the judicious and higher uses of two major nutrients (N and P) as these two nutrients alone contribute 40-60 per cent of the crop yield (Das *et al.*, 2010) [5]. An integrated use of inorganic and biofertilizers should be opted for maximizing economic yield and to improve soil health. (Syed ismail *et al.*, 2001). Sustainable yield levels could be achieved only by applying appropriate combination of green manures or organic manures and chemical fertilizers (Verma, 1991; Obi and Ebo, 1995) [14, 9]. Considering these facts and paucity of research findings on these aspects there is need to work out optimum combination of integrated nutrient fertilization approach for QPM hybrids the study entitled "Studies on the Effect of Integrated Nutrient Management on the Growth, Productivity and Quality of Quality Protein Maize *(Zea mays* L.) in Lower Gangetic Alluvial Zone of West Bengal was proposed with the following objectives: (I) To evaluate the influence of Integrated Nutrient Management on growth, yield attributes and yields of maize. (II)To study the effect of Integrated Nutrient Management on NPK uptake by the crop. (III)To workout economics of the treatments.

Material and Methods

The Experiment was conducted at the Baruipur Experimental Farm of University of Calcutta Located at 24-parganas (south) [880 28' East longitude, 22022' North Latitude] and 9.75m altitude at lower Gangetic Alluvial Zone of south 24 pargana's district of West Bengal during *Rabi* season for two consecutive years 2018-19 and 2019-20. The experimental field is clay loam in nature, soil pH evaluated 6.7 with organic carbon 0.54 with low in available nitrogen and potassium.

Baruipur falls under the Tropical climate as classified by Köppen and Geiger. The entire district is situated in the Ganges Delta and the southern part is covered by the Baruipur-Jaynagar Plain. The mean annual rainfall is 1700 mm to 1800 mm.The winter receives ample sunshine with less rainfall than summer. The selected cultivar VMH-53 which was developed by ICAR-VPKAS, Almora is an ideal hybrid suitable for cultivation at North-eastern part of India with average yield around 50-55 q ha^{-1}. Various agronomic practises, cultural operations were undertaken from sowing to cultivation during the course of investigation. Composite soil sampling was made in the experimental site before the imposition of treatments and was analyzed for physical and chemical characteristics. The field experiment was laid out in RBD design with three replications. Twelve treatments comprises of different levels of organic and inorganic nutrient fertilizer combinations i.e. F_0 (Control), F_1 (RDF @140:70:70 kg ha^{-1} $N:P_2O_5:K_2O$), F_2 (FYM 5 t ha^{-1}), F_3 (FYM 5 t ha + AZ+ PSB), F_4 (75% RDF + F_3), F_5 (50% RDF + F_3), F_6 (25% RDF + F_3), F_7 (Vermicompost @ 2.5 t ha^{-1}), F_8 (Vermicompost @2.5t ha^{-1} + Azotobactor @ 7.5 kg ha^{-1}) + PSB @ 7.5 kg ha^{-1}), F_9 (75% of RDF + F_8), F_{10} (50% of RDF + F_8), F_{11} (25% of RDF + F_8). Data collected were subjected to statistical analysis.

Results and Discussion

The result indicated that application of (75% RDF @140:70:70 kg ha^{-1}) N:P:K + FYM 5t ha^{-1} + Azotobactor @ 7.5kg ha^{-1} + PSB @7.5kg ha^{-1}) during growth stages registered significantly higher plant height (193.3 cm), higher LAI (3.6), AGR (4.3 g day^{-1} $plant^{-1}$), maximum dry matter accumulation (289.7 g plant $^{-1}$) on both the years of experimentation. This is due to the in-time availability of the needed nutrients combinations of organic and organic sources to the plant at the important growth stages. These results are in corroboration with the findings of Sujatha *et al*. (2008) [13] has been also reported similar results of positive effects of combination of sunhemp green manuring, use of biofertilizers and compost with inorganic fertilizers on growth and yield attributing characters of rainfed maize. Evidently, the treatments combinations has significant effect on plant growth attributing characters on QPM hybrid (Table 1).

The result pertaining to crop yield and yield attributing characters of QPM hybrid (Table 2) has contrasted significantly due to different treatment combinations of organic and inorganic sources of nutrient fertilizers.

The pooled analysis result of two year mean data (Table 2) revealed that, all the yield attributing characters; Number of cobs $plant^{-1}$ (1.50), Cob weight with grains $plant^{-1}$ (307.7 g), Length of cob (21.2 cm), Cob Girth (14.5 cm), No. of rows cob^{-1} (15.67), No. of grains cob^{-1} (424), Test Wt. (240 g) was registered superior with the treatment combinations of F_4 (75% RDF @ 140:70:70 kg ha^{-1}) N:P:K + FYM 5 t ha^{-1} + Azotobactor @ 7.5 kg ha^{-1} + PSB @ 7.5 kg ha^{-1}) over rest of the treatments. These results are in close conformity with the findings reported by Kalhapure *et al*. (2013) [6], Sujatha *et al*. (2008) [13] who reported that similar results of positive effects of combination of sunhemp green manuring, use of biofertilizers and compost with inorganic fertilizers on growth and yield attributing characters of rainfed maize.

The increase in average cob weight per plants $^{-1}$ due to ascribed to the fact that proper distribution of organic & inorganic composition of nutrient fertlizers to the plants which leds to better decomposition and mineralization results into better plant growth. Increase in better filled grains cob^{-1} is due to supply of nutrients to the crop during growth phrase and supply of sufficient photosynthates at the grain filling stage. These results are in harmony with Lakhum *et al*. (2020) [7].

Analysis of variance from two year pooled data revealed that all the treatments has been significantly impacted the grains, biological and stover yield of maize (Table 3). Application of 75% RDF @ 140:70:70 kg ha^{-1} N:P:K + FYM 5 t ha^{-1} + Azotobactor @ 7.5 kg ha^{-1} + PSB @ 7.5kg ha^{-1} produced highest grain yield (5.28 t ha^{-1}), stover yield (7.1 t ha^{-1}) and biological yield (11.8 t ha^{-1}) over rest of the treatments. Grain yield is the final product of morphological and physiological cycles happening during development and improvement of a harvested crop. Increase in yield observed in combination of organic & inorganic fertilizer is might be due to the increased growth and yield crediting characters in maize. Shanwad *et al.* (2010) [11] also has been reported the enhancement in maize productivity with combined application of nutrients through organic and inorganic resources. These results are in harmony with Kalhapure *et al.* (2013) [6].

Analysis of variance from two year pooled data showed that treatment combinations has significant effect on crude protein & crude fibre content on QPM hybrid. The result inferred from (Table 3) on quality parameters that application of 75% RDF @ 140:70:70 kg ha^{-1} N:P:K + FYM 5t ha^{-1} + Azotobactor @ 7.5kg ha^{-1} + PSB @ 7.5 kg ha^{-1} obtained maximum protein (11.77%) and cude fibre (34.65%) content. However, minimum crude protein (6.90%) and fibre (27.04%) content registered in control plot. The increase in protein content might be due to the fact that nitrogen as a vital part of amino acid which then builds up nitrogen content. The results are in agreement with those of Bakeir *et al.*, (2003) who stated that protein content enhanced by inorganic nitrogen application.

Table 1: Growth parameters of QPM as influenced by the treatment combinations of organic & inorganic sources of nutrient fertilizers at harvest (Pooled data)

Treatments	Plant height (cm)	LAI	DMA (g plant^{-1})	AGR (g plant^{-1} day^{-1})
F_0	151.3	3.3	259.0	4.3
F_1	182.2	3.6	276.5	4.1
F_2	171.0	3.4	269.2	4.3
F_3	176.8	3.5	271.9	4.1
F_4	193.3	3.6	289.7	4.0
F_5	185.5	3.6	282.7	4.0
F_6	181.0	3.5	275.1	4.1
F_7	168.7	3.4	266.0	4.4
F_8	175.3	3.5	270.2	4.2
F_9	189.5	3.6	285.1	4.1
F_{10}	184.3	3.6	279.2	4.1
F_{11}	179.8	3.5	273.5	4.3
S.Em +	2.51	0.02	3.28	0.21
CD (0.05)	NS	NS	NS	NS

Note: F_0 (Control), F_1 (RDF @140:70:70 kg ha^{-1} $N:P_2O_5:K_2O$), F_2 (FYM 5 t ha^{-1}), F_3 (FYM 5 t ha + AZ+ PSB), F_4 (75% RDF + F_3), F_5 (50% RDF + F_3), F_6 (25% RDF + F_3), F_7 (Vermicompost @ 2.5 t ha^{-1}), F_8 (Vermicompost @ 2.5t ha^{-1} + Azotobactor @ 7.5 kg ha^{-1}) + PSB @ 7.5 kg ha^{-1}), F_9 (75% of RDF + F_8), F_{10} (50% of RDF + F_8), F_{11} (25% of RDF + F_8)

Table 2: Yield attributing characters of QPM maize as influenced by the treatment combination of organic and inorganic sources of nutrients fertilizers (Pooled data)

Treatments	Number of cobs plant^{-1}	Cob weight with grains plant^{-1} (g)	Length of cob (cm)	Cob Girth (cm)	No. of rows cob^{-1}	No. of grains cob^{-1}	Test wt. (g)
F_0	1.00	262.8	14.1	9.8	12.67	286	180
F_1	1.17	291.7	18.7	13.5	14.83	381	212
F_2	1.00	260.5	15.9	12.3	14.00	326	208
F_3	1.33	267.7	16.8	12.8	14.33	326	213
F_4	1.50	307.7	20.4	14.5	15.67	424	240
F_5	1.50	306.3	20.0	14.0	15.00	390	223
F_6	1.33	285.5	17.9	13.2	14.50	366	211
F_7	1.00	274.3	15.7	12.3	13.67	308	207
F_8	1.33	266.8	16.5	13.1	14.17	335	209
F_9	1.50	301.3	21.2	14.4	15.17	402	225
F_{10}	1.17	289.5	19.5	13.4	14.67	384	214
F_{11}	1.33	272.3	17.9	13.1	14.67	365	210
S.Em +	0.28	9.29	0.85	0.44	0.51	10.06	4.97
CD (0.05)	NS	NS	NS	NS	NS	NS	NS

Note: F_0 (Control), F_1 (RDF @140:70:70 kg ha^{-1} $N:P_2O_5:K_2O$), F_2 (FYM 5 t ha^{-1}), F_3 (FYM 5 t ha + AZ+ PSB), F_4 (75% RDF + F_3), F_5 (50% RDF + F_3), F_6 (25% RDF + F_3), F_7 (Vermicompost @ 2.5 t ha^{-1}), F_8 (Vermicompost @ 2.5t ha^{-1} + Azotobactor @ 7.5 kg ha^{-1}) + PSB @ 7.5 kg ha^{-1}), F_9 (75% of RDF + F_8), F_{10} (50% of RDF + F_8), F_{11} (25% of RDF + F_8)

Table 3: Yield parameters of QPM maize as influenced by the treatment combination of organic and inorganic sources of nutrients fertilizers (Pooled data)

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)	Crude Protein (%)	Crude Fibre (%)
F_0	3.08	5.0	9.8	36.3	6.90	27.04
F_1	4.41	6.4	11.2	34.5	10.77	28.21
F_2	4.02	6.0	10.4	39.0	9.10	28.92
F_3	4.14	5.9	10.1	41.2	9.65	29.34
F_4	5.28	7.1	11.8	43.6	11.77	34.65
F_5	4.58	6.8	11.7	38.7	10.80	32.29
F_6	4.28	6.6	11.7	35.9	10.31	28.15
F_7	3.86	6.0	10.7	38.9	8.55	29.40
F_8	4.06	6.5	11.1	37.7	9.26	28.91
F_9	4.82	6.6	11.6	40.0	10.83	32.53
F_{10}	4.54	6.6	11.6	39.4	10.79	29.16
F_{11}	4.20	6.7	10.9	38.6	10.33	28.26
S.Em +	0.08	0.27	0.42	1.87	-	-
CD (0.05)	NS	NS	NS	NS	-	-

Note: F_0 (Control), F_1 (RDF @140:70:70 kg ha^{-1} $N:P_2O_5:K_2O$), F_2 (FYM 5 t ha^{-1}), F_3 (FYM 5 t ha + AZ+ PSB), F_4 (75% RDF + F_3), F_5 (50% RDF + F_3), F_6 (25% RDF + F_3), F_7 (Vermicompost @ 2.5 t ha^{-1}), F_8 (Vermicompost @ 2.5t ha^{-1} + Azotobactor @ 7.5 kg ha^{-1}) + PSB @ 7.5 kg ha^{-1}), F_9 (75% of RDF + F_8), F_{10} (50% of RDF + F_8), F_{11} (25% of RDF + F_8)

Conclusion

Based on the results obtained from research findings it can be inferred that the crop performed superior with the application of 75% RDF @ 140:70:70 kg ha^{-1}) N:P:K + FYM 5 t ha^{-1} + Azotobactor @ 7.5 kg ha^{-1} + PSB @ 7.5 kg ha^{-1} over rest of the treatments and were significantly enhance by the growth, yield and quality parameters. The experimental findings have clearly showed that, in QPM organic manures like FYM, Azotobactor + PSB, could be effectively used in combination with chemical fertilizers to benefit the crop and improve soil health. Also, quality protein maize (QPM) holds superior nutritional value and is essentially exchangeable with normal maize to mitigate problems on protein related deficiency in developing countries.

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