# Integrated nutrient management on growth, yield and economics of maize (*Zea mays* L) under terai region

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**ABSTRACT**

*A field experiment was conducted during the Kharif season of 2007 and 2008 to study on the effect of integrated nutrient management on maize. The experiment was laid out in Randomized Block Design with eight treatments and three replications. The results indicated that $T_8$ (25% RDF + 5 + Vermicompost ha$^{-1}$ recoded significantly higher LAI and dry matter production, cob length, grain yield and (50% RDF + 5 t FYM ha$^{-}$) uptake of nitrogen, phosphorus and potassium over other treatments. In terms of economics $T_5$ fetched higher net returns (Rs. 21256.38) and $T_3$ (75% RDF + 2.5t FYM ha$^{-1}$) recorded the highest B: C ratio (1.40).*

***Key words***: Economics, maize, nutrient uptake, INM and LAI.

Maize (*Zea mays* L) is one of the important cereal crop next to wheat and rice in the world. It is well known that maize is a heavy feeder of nutrients and because of this nature; it is a very efficient converter of solar energy into dry matter. Continuous use of only chemical fertilizers in intensive cropping system is leading to imbalance of nutrients in soil, which has an adverse effect on soil health and also on crop yields. On the other hand, continuous uses of organics help to build up soil humus and beneficial microbes besides, improving the soil physical properties. Therefore, in the present context, a judicious combination of organics and chemical fertilizers helps to maintain soil and crop productivity. The lack of information on these aspects under rainfed condition made an impetus to undertake the present investigation.

## MATERIALS AND METHODS

The experiment was conducted at the research farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during the *Kharif* season of 2007 and 2008. The farm is situated at 26$^0$19'86" N latitude and 89$^0$23'53" E longitude at an elevation of 43 meter above mean sea level. The average rainfall varies between 2200 to 3200 mm of which 80% falls during June to September. The area is humid and warm except having a short winter spell during December to February. The soil is sandy loam, acidic with a pH of 5.38, low in available nitrogen (128 kg ha$^{-1}$), medium in available phosphorus (26 kg ha$^{-1}$) and available potash (76 kg ha$^{-1}$). Eight treatments , $T_1$=100% RDF NPK, $T_2$=125% RDF, $T_3$=75% RDF+ 2.5 t FYM ha$^{-1}$, $T_4$=75% RDF+ 1 t vermicompost (VC) ha$^{-1}$ ,$T_5$=50% RDF+ 5 t FYM ha$^{-1}$ ,$T_6$=50% RDF+ 2.5 t V.C. ha$^{-1}$,$T_7$= 25% RDF+ 7.5t FYM ha$^{-1}$, $T_8$=25% RDF+ 5 t ha$^{-1}$ and $T_9$=control were tried in a randomized block design with three replications at a spacing of 60 x 20 cm in plots of 5 x 4 m. Fertilizer responsive, high yielding variety “Ganga-3” was sown on 17$^{th}$ and 21$^{st}$ June in 2007 and 2008. FYM and vermicompost were applied 15 days before sowing. The data were analysed statistically for comparing the treatment means.

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## RESULTS AND DISCUSSION

### Plant height

The tallest plant (227.85 cm) was recorded with the application of 75% recommended dose of chemical fertilizer + vermicompost@ 1 t ha$^{-1}$ which was closely followed by $T_3$ (75% RDF+ 2.5 t FYM ha$^{-1}$) and $T_5$ (50% RDF+ 5 t FYM ha$^{-1}$). Verma et al. (2006) opined alike.

### Leaf area index (LAI)

It was revealed that combine application of organic and inorganic sources of nutrient recorded higher values of LAI in comparison with the sole application of chemical fertilizers. Treatment receiving 25% recommended dose of chemical fertilizer + vermicompost@ 5 t ha$^{-1}$ recorded the highest value of LAI (3.58) at 60 days after sowing which was statistically *at par* with $T_6$, $T_5$ and $T_4$ might be due to greater availability of soil nutrient through out the growth period from the combined application of organic and inorganic sources of nutrients. These results confirm the findings of Tollenaar *et al.* (2006).

### Dry matter accumulation

Treatment receiving 25% recommended dose of chemical fertilizer + vermicompost @ 5 t ha$^{-1}$ recorded the highest (159.14 and 159.84 g plamt$^{-1}$) dry matter accumulation followed by $T_6$ (157.78 and 157.18 g plamt$^{-1}$) and $T_7$ (146.78 and 146.53 g plamt$^{-1}$) during both the years of experimentation, which may be due to the greater availability of applied nutrients and higher uptake of primary nutrients by maize from the combined application of organic and inorganic sources of nutrients. These results are in agreement with of Verma *et al.* (2006) and Tollenaar *et al.* (2006).

**Cob length**

Treatment receiving 25% recommended dose of chemical fertilizer + vermicompost @ 5 t $ha^{-1}$ recorded the highest length of cob (18.50 cm) followed by $T_7$ (18.19 cm). Sole application of chemical fertilizer recorded lower cob length compared with other treatments except $T_9$, might be due to greater availability of nutrient through combined application of organic and inorganic sources of nutrients.

**Grain yield**

Grain yield was recorded maximum (3.47) under $T_8$ (25% + VC @ 5 t $ha^{-1}$) which was statistically at par with $T_7$ (25% RDF + FYM @ 7.5 t $ha^{-1}$) and minimum with $T_9$ (control). Substitution of 75% recommended dose of NPK through FYM lowered the grain yield of maize in comparison with the substitution of NPK through vermicompost might be resulted from higher number of kernels per row, kernel rows per cob and number of kernels per cob as well dry matter accumulation and dry matter partitioning and indirectly higher nutrient uptake by maize from vermicompost treated plots. The results are in close conformity with those of Verma *et al.* (2006) and Tollenaar *et al.* (2006).

**NPK uptake and availability**

The uptake of N, P and K by maize increased when 75% of recommended dose of chemical fertilizer was substituted by vermicompost @ 5 t $ha^{-1}$ (Table 3). The maximum uptake of N, P and K by the maize was recorded with the treatment receiving 25% + VC @ 5 t $ha^{-1}$ whereas the lowest uptake of nutrients by the maize was observed with 100% RDF, might be due to synchronous supply of nutrient throughout the growth period from combined application of chemical fertilizer and vermicompost or FYM. However, between two organic sources, vermicompost was proved superior to FYM. This finding was supported by Verma *et al.* (2006). The application of vermicompost had significant effect on the available N and K status of the soil after the maize harvest. The highest amount of available nitrogen was observed under $T_8$ (25%RDF + VC @ 5 t $ha^{-1}$), followed by $T_7$ (25% RDF + FYM @ 7.5 t $ha^{-1}$). Maximum available phosphorus after maize harvest was noticed in $T_7$ (25% RDF + FYM @ 7.5 t $ha^{-1}$) followed by $T_8$ and $T_1$. The improvement in available phosphorus status of the soil might be due to build up of phosphorus in the soil owing to addition of phosphorus through FYM. The increased availability status of nutrients in the soil might be due to their subsequent release from vermicompost and FYM. The result confirms the findings of Jamwal (2006).

**Economics**

It was revealed that the highest net return (Rs.21256) was obtained from the treatment receiving 50 % RDF + FYM @ 5 t $ha^{-1}$ ($T_5$) followed by 25% RDF + FYM @ 7.5 t $ha^{-1}$ ($T_7$) and 75% RDF + FYM @ 2.5 t $ha^{-1}$ ($T_3$). Among the treatments $T_3$ fetched higher B: C ratio (1.40) followed by $T_5$ (1.37) and $T_4$ (1.29). $T_8$ (25% RDF + VC @ 5 t $ha^{-1}$) treatment recorded lowest B: C ratio (0.57) though it produced higher grain yield, due to higher per unit cost of vermicompost (Rs. 2.50 $kg^{-1}$) than FYM (Rs.0.80 $kg^{-1}$) which was not compensated by additional yield of maize and 75% substitution recommended dose of chemical fertilizer.

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**Table 1: Effect of integrated nutrient management on growth attributes of maize**

| Treatments | Plant Height (cm) | | | LAI at 60 DAS | | | Dry mater accumulation at harvest (g $plant^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2006** | **2007** | **Pooled** | **2006** | **2007** | **Pooled** | **2006** | **2007** | **Pooled** |
| $T_1$ | 221.07 | 222.07 | 221.57 | 3.36 | 3.46 | 3.41 | 127.49 | 128.49 | 127.99 |
| $T_2$ | 216.90 | 217.40 | 217.15 | 3.38 | 3.53 | 3.46 | 133.30 | 133.80 | 133.55 |
| $T_3$ | 227.40 | 227.90 | 227.65 | 3.40 | 3.55 | 3.48 | 137.00 | 137.50 | 137.25 |
| $T_4$ | 227.20 | 228.50 | 227.85 | 3.46 | 3.57 | 3.52 | 137.99 | 139.29 | 138.64 |
| $T_5$ | 226.77 | 227.97 | 227.37 | 3.46 | 3.58 | 3.52 | 138.64 | 139.84 | 139.24 |
| $T_6$ | 220.30 | 221.50 | 220.90 | 3.47 | 3.59 | 3.53 | 156.58 | 157.78 | 157.18 |
| $T_7$ | 225.43 | 225.93 | 225.68 | 3.51 | 3.47 | 3.49 | 146.28 | 146.78 | 146.53 |
| $T_8$ | 222.53 | 223.23 | 222.88 | 3.60 | 3.56 | 3.58 | 159.14 | 159.84 | 159.49 |
| $T_9$ | 177.60 | 177.93 | 177.77 | 2.82 | 2.78 | 2.80 | 117.88 | 118.21 | 118.04 |
| **S Em (±)** | **4.07** | **4.09** | **4.07** | **0.01** | **0.05** | **0.03** | **0.62** | **0.66** | **0.63** |
| **LSD(P=0.05)** | **12.21** | **12.26** | **12.23** | **0.04** | **0.14** | **0.08** | **1.87** | **1.98** | **1.88** |

**Table 2: Effect of integrated nutrient management on cob length, grain yield and economics of maize**

| Treatments | Cob length (cm) | | | Grain yield (t $ha^{-1}$) | | | Net income (Rs. $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|---|---|---|---|
| | **2006** | **2007** | **Pooled** | **2006** | **2007** | **Pooled** | | |
| $T_1$ | 15.29 | 16.29 | 15.79 | 2.61 | 2.75 | 2.68 | 15712 | 1.14 |
| $T_2$ | 16.05 | 16.55 | 16.30 | 2.90 | 3.04 | 2.97 | 18260 | 1.27 |
| $T_3$ | 16.45 | 16.95 | 16.70 | 3.11 | 3.26 | 3.19 | 20464 | 1.40 |
| $T_4$ | 16.68 | 17.98 | 17.33 | 3.19 | 3.33 | 3.26 | 20234 | 1.29 |
| $T_5$ | 17.05 | 18.25 | 17.65 | 3.29 | 3.39 | 3.34 | 21256 | 1.37 |
| $T_6$ | 17.13 | 18.33 | 17.73 | 3.30 | 3.40 | 3.35 | 18116 | 0.97 |
| $T_7$ | 17.94 | 18.44 | 18.19 | 3.31 | 3.42 | 3.37 | 20728 | 1.27 |
| $T_8$ | 18.15 | 18.85 | 18.50 | 3.41 | 3.52 | 3.47 | 13828 | 0.57 |
| $T_9$ | 14.86 | 15.20 | 15.03 | 1.86 | 1.97 | 1.91 | 9810 | 0.88 |
| **S Em (±)** | **0.15** | **0.32** | **0.20** | **0.03** | **0.04** | **0.04** | **-** | **-** |
| **LSD(P=0.05)** | **0.46** | **0.96** | **0.61** | **0.10** | **0.11** | **0.11** | **-** | **-** |

RDF – Recommended dose of fertilizer, VC – Vermicompost

$T_1$=100% RDF, $T_2$=125% RDF, $T_3$=75% RDF+ 2.5 t FYM $ha^{-1}$, $T_4$=75% RDF+ 1 t VC $ha^{-1}$, $T_5$ = 50% RDF+ 5 t FYM $ha^{-1}$, $T_6$=50% RDF+ 2.5 t VC $ha^{-1}$, $T_7$= 25% RDF + 7.5t FYM $ha^{-1}$, $T_8$ = 25% RDF + 5t V C$ha^{-1}$ and $T_9$ = control.

**Table 3: Effect of integrated nutrient management on uptake and availability of nitrogen, phosphorus and potassium**

| Treatments | Nitrogen uptake (kg ha$^{-1}$) | | | Phosphorus uptake (kg ha$^{-1}$) | | | Potassium uptake (kg ha$^{-1}$) | | | Available N (kg ha$^{-1}$) | | | Available $P_2O_5$ (kg ha$^{-1}$) | | | Available $K_2O$ (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2006** | **2007** | **pooled** | **2006** | **2007** | **pooled** | **2006** | **2007** | **pooled** | **2006** | **2007** | **pooled** | **2006** | **2007** | **pooled** | **2006** | **2007** | **pooled** |
| $T_1$ | 109.47 | 110.47 | 109.97 | 21.05 | 22.05 | 21.55 | 105.30 | 106.30 | 105.80 | 125.53 | 126.53 | 126.03 | 27.21 | 28.21 | 27.71 | 83.04 | 84.04 | 83.54 |
| $T_2$ | 112.64 | 113.14 | 112.89 | 21.85 | 22.35 | 22.10 | 106.67 | 107.17 | 106.92 | 151.73 | 152.23 | 151.98 | 21.75 | 22.25 | 22.00 | 76.88 | 77.38 | 77.13 |
| $T_3$ | 112.66 | 113.16 | 112.91 | 24.39 | 24.89 | 24.64 | 119.37 | 119.87 | 119.62 | 135.60 | 136.10 | 135.85 | 22.68 | 23.18 | 22.93 | 76.70 | 77.20 | 76.95 |
| $T_4$ | 113.69 | 114.99 | 114.34 | 24.69 | 25.99 | 25.34 | 119.46 | 120.76 | 120.11 | 131.37 | 132.67 | 132.02 | 21.81 | 23.11 | 22.46 | 75.34 | 76.64 | 75.99 |
| $T_5$ | 116.32 | 117.52 | 116.92 | 24.70 | 25.90 | 25.30 | 119.55 | 120.75 | 120.15 | 133.73 | 134.93 | 134.33 | 22.30 | 23.50 | 22.90 | 81.39 | 82.59 | 81.99 |
| $T_6$ | 117.91 | 119.11 | 118.51 | 25.49 | 26.69 | 26.09 | 121.41 | 122.61 | 122.01 | 149.60 | 150.80 | 150.20 | 21.21 | 22.41 | 21.81 | 73.63 | 74.83 | 74.23 |
| $T_7$ | 118.29 | 118.79 | 118.54 | 25.76 | 26.26 | 26.01 | 122.92 | 123.42 | 123.17 | 153.43 | 153.93 | 153.68 | 28.62 | 29.12 | 28.87 | 85.25 | 85.75 | 85.50 |
| $T_8$ | 133.97 | 134.67 | 134.32 | 26.36 | 27.06 | 26.71 | 123.20 | 123.90 | 123.55 | 154.84 | 155.54 | 155.19 | 27.45 | 28.15 | 27.80 | 85.88 | 86.58 | 86.23 |
| $T_9$ | 65.73 | 66.06 | 65.89 | 11.75 | 12.08 | 11.92 | 75.33 | 75.66 | 75.49 | 96.00 | 96.33 | 96.17 | 15.16 | 15.50 | 15.33 | 48.63 | 48.97 | 48.80 |
| **S Em (±)** | **0.47** | **0.59** | **0.52** | **0.30** | **0.38** | **0.31** | **0.61** | **0.62** | **0.60** | **0.88** | **0.92** | **0.88** | **0.27** | **0.37** | **0.29** | **0.70** | **0.78** | **0.72** |
| **LSD (P=0.05)** | **1.42** | **1.78** | **1.55** | **0.91** | **1.13** | **0.93** | **1.83** | **1.86** | **1.79** | **2.62** | **2.77** | **2.66** | **0.82** | **1.12** | **0.87** | **2.09** | **2.33** | **2.17** |

RDF – Recommended dose of fertilizer, VC – Vermicompost

$T_1$=100% RDF, $T_2$=125% RDF, $T_3$=75% RDF+ 2.5 t FYM ha$^{-1}$, $T_4$=75% RDF+ 1 t VC ha$^{-1}$,
$T_5$ = 50% RDF+ 5.0 t FYM ha$^{-1}$, $T_6$=50% RDF+ 2.5 t VC ha$^{-1}$, $T_7$= 25% RDF + 7.5t FYM ha$^{-1}$, $T_8$ = 25% RDF + 5.0t V Cha$^{-1}$ and
$T_9$ = control