



## **Influence of Nutrient and Weed Management on Growth, Yield and Energetics of Maize**

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### **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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### **ABSTRACT**

A field experiment entitled "Influence of nutrient and weed management on growth, yield and bioenergetics of maize (*Zea mays* L.)" was conducted in agricultural research farm of Lovely Professional University, Punjab. The investigation was laid out in factorial randomized block design with three replications, aimed to study the impact of nutrient and weed management on growth attributes, yield attributes and bioenergetics of maize. The treatment consisted of three nutrient management treatments viz., T<sub>1</sub> (100% N through Recommended dose of fertilizer), T<sub>2</sub> (75% N through RDF and 25% N through vermicompost (P and K recommended doses)), T<sub>3</sub> (75% N through RDF and 25% N through Farmyard manure) (recommended doses of P and K); three weed management treatments, viz, W<sub>1</sub> (control), W<sub>2</sub> (Atrazine @1 kg a.i/ha + Tembotrione @110 g a.i/ha), W<sub>3</sub> (Live mulching with cowpea). The results of the experiment revealed that among the nutrient management treatments, significantly higher growth attributes, yield attributes, energy output, energy efficiency index was observed with treatment T<sub>2</sub> (75% N through RDF and 25% N through vermicompost) and the lowest was observed in treatment T<sub>1</sub> (100% N through RDF), the pooled data suggested that yield was significantly highest in treatment combination T<sub>2</sub>W<sub>2</sub> (75% N through RDF and 25% N through vermicompost along with Atrazine @1 kg a.i/ha + Tembotrione @110 g a.i/ha).

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## 1. INTRODUCTION

Maize (*Zea mays L.*) is considered as one of the most significant cereal crops in the global agricultural economy since it is used as food humans, feed for animals and raw material for the industrial purposes. It ranks fifth in terms of world's area and production as it is cultivated in an area of 193.7 million ha with a production of 1147.7 million tonnes with an average productivity of 5750 kg/ha. It is regarded as the "Queen of Cereals" because of its capability to generate higher yields when compared to the other cereal crops. It is globally cultivated in an area of 9.2 million ha which contributes around 4% of the world's maize area and has the production of 27.23 million tonnes with an average yield of 3 t/ha which represents 2% of the global production. It is the fourth largest cereal crop grown in India after rice, wheat and bajra and is widely grown in the states of Haryana, Uttar Pradesh, Punjab, Karnataka, Andhra Pradesh, Rajasthan and Tamil Nadu. Nutrient management is one of the most prominent factors that impact the growth and yield of the maize crop. In recent years, decline in productivity of maize has been observed mainly due to the deterioration of soil fertility status as a result of indiscriminate use of inorganic fertilizers over the years. These inorganic fertilizers severely impact the soil properties by altering the soil pH, reducing the microbial population and organic matter in the soil and causing disturbance to the soil ecosystem while leaving residues in the soil [1]. In this scenario, integrated nutrient management is one of the suitable options for ensuring long-term crop yields while maintaining soil fertility, especially in cereal-based cropping systems. So, in order to attain optimal crop productivity and sustainable ecosystem, balanced use of nutrients in the form of organic inputs becomes essential. Organic manures such as vermicompost and farmyard manure help in sustaining the soil productivity by enhancing the physico-chemical properties of the soil, they also aid to maximize the efficiency of the chemical fertilizers that are applied [2]. Organic manures mitigate the adverse effects of chemical fertilizers in the soil by lowering the chemical toxicity and promoting the growth of the microorganisms. They also help in providing trace amounts of micronutrients which are usually not supplied through inorganic fertilizers. Additionally, organic manures enhance

the cation exchange capacity and water holding capacity of the soil, resulting in a consistent supply of nutrients to the crop plants [3]. Hence, cheap alternative organic sources to optimize the use of chemical fertilizers and improve the soil health are of utmost importance in modern agriculture.

Amongst the biotic stresses, weeds are considered as one the most important limiting factors in cultivation of maize. During its early stages of development, maize is extremely susceptible to weed competition. Around 40- 60% yield losses occur in maize due to the uncontrolled growth of weeds and improper management practices [4]. Thus, a proper weed management is essential for minimizing the losses of crop yield due to the same. Integrated weed management comprises of various methods to control the weeds; hence it is considered to be an effective way along with the chemical fertilizers, cultural methods such as mulching, cover crops etc. can be used.

Keeping the above prospects in mind, the experiment has been laid out with the mentioned objectives:

1. To study the effect of nutrient and weed management on growth attributes of maize.
2. To study the effect of nutrient and weed management on yield and yield attributes of maize.
3. To study the energetics of maize.

## 2. MATERIALS AND METHODS

The experiment was conducted at agricultural research farm of Lovely Professional University, in the district of Kapurthala, state of Punjab during the *kharif* season of the year 2021. This experimental site is located at 31°14'43.8"N and 75°41'44.1"E with an average elevation of 252 m from mean sea level. The experimental site has subtropical weather, which is often favorable for the cultivation of maize. The average annual rainfall of the area is 816 mm. Average value of temperature (maximum and minimum) and relative humidity during the field experimental period of June-October in 2021 have been 45°C and 20°C and 82% and 38%, respectively. The

investigation was laid out in factorial randomized block design with three replications. The treatment consisted of three nutrient management treatments viz., T<sub>1</sub> (100% N through RDF), T<sub>2</sub> (75% N through RDF and 25% through vermicompost (P and K recommended doses)), T<sub>3</sub> (75% N through RDF and 25% through FYM (recommended doses of P and K)); three weed management treatments, viz, W<sub>1</sub> (control), W<sub>2</sub> (Atrazine @1 kg a.i/ha + Tembotrione @110 g a.i/ha), W<sub>3</sub> (Live mulching with cowpea). The field was ploughed and given pre-sowing irrigation. After the preparatory tillage, field was divided into 27 different plots of 5m x 4m size. Application of required amount of vermicompost and FYM as per doses was done as per the treatment requirements. The pre-treated seed of variety Laxmi CP-333 were sown by dibbling method in between the rows by using maize seed at the rate of 25 kg/ha with a spacing of 60 x 20 cm on 30 June, 2021. Plant protection measures and irrigations, whenever required were provided in same manner for all the treatments. Regular biometric observations were recorded at periodic intervals of 30DAS, 60DAS and 90 DAS, whereas yield attributes were recorded just before harvesting of crop. The crop was harvested at 90 days after sowing after which cobs were dried and threshed with hand operated maize sheller. Observations pertaining to the yield attributes were recorded for three randomly chosen plants from each treatment, and replication data was acquired by averaging the values. Bioenergetics parameters viz., energy inputs, energy output, energy efficiency index and energy intensiveness were determined by the energy equivalencies of various inputs used and, the quantity of the output obtained. The energy input was worked out treatment wise for each item of operation and estimated in megajoule/ ha (MJ/ha) taking the standard values of energy equivalents proposed by Binning *et al.* 1983, Gopalan *et al.* 1981, the energy input value is obtained from the product of energy equivalent and the quantity of various inputs used in maize production, whereas the energy output was calculated from the total produce including the grain yield and stover yield, taking the standard values of their energy equivalents proposed by Binning *et al.*, (1983) and Devsenapathy *et al.*, (2009). The collected data were statistically analysed by the method described by Gomez and Gomez (1981). The data was, however, interpreted using 0.05 probability levels, when the F test found significance, critical difference values were calculated.

### 3. RESULTS AND DISCUSSION

#### 3.1 Growth Parameters

The results of the present investigation revealed that growth parameters of plant such as plant height, leaf area were significantly influenced by the nutrient and weed management treatments and their combinations. Plant height and leaf area of maize at 30, 60 and 90 DAS has been presented in the Table 1.1. At 30 DAS, there was no significant influence of nutrient and weed management on the plant height and leaf area. However, at 30 DAS among nutrient management treatments T<sub>1</sub> had the maximum plant height and leaf area that was followed by the treatment T<sub>2</sub>. The reason behind this might be due to the readily available fertilizers and their higher utilization by the crop plants. Similar findings were reported by Singh *et al.*, [5]. Among the weed management treatments W<sub>2</sub> had the maximum plant height and leaf area which might be due to the increase in the proliferation of roots and shoots and better absorbance of nutrients as result of less crop-weed competition by the application of herbicides. The results are in conformity with the findings reported by Verma *et al.*, [6], Kolekar *et al.*, [7]. At 60 and 90 DAS, among the nutrient management treatments, T<sub>2</sub> had significantly higher plant height and leaf area when compared to other treatments, while T<sub>1</sub> had the lowest plant height and leaf area, whereas among the weed management treatments, W<sub>2</sub> had significantly higher plant height and leaf area in comparison to other treatments, while W<sub>1</sub> had lowest value of plant height and leaf area due to no weed management. Similar findings were reported by Nanjappa *et al.*, [8], Kannan *et al.*, [9].

#### 3.2 Yield Attributes

Data pertaining to the yield attributes revealed that yield attributes viz., Number of grains per cob, grain yield, stover yield, seed index were significantly influenced by the nutrient and weed management. The yield attributes of maize have been presented in Table 1.2. Among the nutrient management treatments, T<sub>2</sub> recorded the highest yield and yield attributes and the lowest yield was observed in T<sub>1</sub> which might be due to the increase in the photosynthates and biomass production with the combined application of vermicompost and inorganic fertilizer than sole application of inorganic fertilizers. Similar findings were reported by Baharvand *et al.*, [10] and Zaremanesh *et al.*, (2016). Among the weed

management treatments  $W_2$  recorded the highest yield and yield attributes, while the lowest values of yield and yield attributes were found in treatment,  $W_1$ . The reason behind this might be due to the better efficiency of herbicides in reducing the crop weed competition, and ensuring them better growth of plants, whereas  $W_1$  had recorded the lowest yield and yield attributes due to no weed management. The results are in conformity with the findings reported by Gupta et al., 2020.

### 3.3 Bioenergetics

Amounts of energy equivalencies and energy inputs in maize production as influenced by nutrient and weed management are furnished in Table 1.3 and 1.4 respectively. Energy output,

energy efficiency index and energy intensiveness have been presented in Table 1.5.

### 3.4 Energy Input

Maximum energy input was incurred under the treatment combinations  $T_1W_2$  (10407.15 MJ/ha) that was followed by  $T_1W_3$  (10325.57 MJ/ha). Variations in the energy input values might be due to the differences in variable energy inputs viz., fertilizer doses, manures, chemical herbicides and their respective energy equivalents as per the treatments.  $T_2W_1$  (7455.64 MJ/ha) had the lowest energy input among all the treatment combinations, which might be due to lowest dosing of the variable inputs. Similar findings were reported by Saikia et al., [1], who observed that the variable energy inputs differ due to distinct intercultural operations.

**Table 1.1 Influence of nutrient and weed management on growth parameters of maize**

|                                   | Plant height (cm) |        |        | Leaf area (cm <sup>2</sup> ) |        |        |
|-----------------------------------|-------------------|--------|--------|------------------------------|--------|--------|
|                                   | 30 DAS            | 60 DAS | 90 DAS | 30 DAS                       | 60 DAS | 90 DAS |
| Nutrient management               |                   |        |        |                              |        |        |
| $T_1$ - 100% RDF                  | 39.72             | 137.01 | 141.96 | 74.14                        | 395.89 | 406.19 |
| $T_2$ - 75% RDF + 25% VC          | 38.21             | 151.54 | 157.62 | 64.04                        | 447.11 | 465.64 |
| $T_3$ -75% RDF + 25% FYM          | 35.00             | 143.63 | 148.62 | 56.80                        | 418.87 | 440.60 |
| CD (p=0.05)                       | 1.45              | 1.18   | 1.02   | 1.73                         | 2.70   | 3.08   |
| S.Ed (±)                          | 0.71              | 0.56   | 0.48   | 0.87                         | 1.27   | 1.45   |
| Weed management                   |                   |        |        |                              |        |        |
| $W_1$ - Control                   | 33.74             | 132.37 | 137.54 | 58.89                        | 380.04 | 394.69 |
| $W_2$ - Atrazine + Tembotrione    | 39.56             | 151.77 | 158.66 | 70.23                        | 447.27 | 465.64 |
| $W_3$ - Live mulching with cowpea | 36.40             | 148.06 | 152.00 | 65.87                        | 434.56 | 451.22 |
| CD (p=0.05)                       | 1.45              | 1.18   | 1.02   | 1.73                         | 2.70   | 3.08   |
| S.Ed (±)                          | 0.71              | 0.56   | 0.48   | 0.7                          | 1.27   | 1.45   |

**Table 1.2. Influence of nutrient and weed management on yield attributes of maize**

|                                   | Number of grains/ cob | Grain yield (q/ha) | Stover yield (q/ha) | Seed index (g) | Harvest index (%) |
|-----------------------------------|-----------------------|--------------------|---------------------|----------------|-------------------|
| Nutrient management               |                       |                    |                     |                |                   |
| $T_1$ - 100% RDF                  | 470.27                | 24.81              | 51.37               | 34.66          | 32.55             |
| $T_2$ - 75% RDF + 25% VC          | 567.19                | 34.45              | 64.96               | 39.79          | 34.71             |
| $T_3$ -75% RDF + 25% FYM          | 540.53                | 31.81              | 61.71               | 36.40          | 34.03             |
| CD (P=0.05)                       | 2.73                  | 0.31               | 0.34                | 0.44           | 0.26              |
| S.Ed (±)                          | 1.29                  | 0.15               | 0.16                | 0.21           | 0.12              |
| Weed mangament                    |                       |                    |                     |                |                   |
| $W_1$ - Control                   | 423.62                | 22.77              | 46.31               | 33.13          | 32.96             |
| $W_2$ - Atrazine + Tembotrione    | 544.86                | 34.34              | 64.30               | 39.68          | 34.42             |
| $W_3$ - Live mulching with cowpea | 516.22                | 29.65              | 57.31               | 38.03          | 33.90             |
| CD (P=0.05)                       | 2.73                  | 0.31               | 0.34                | 0.44           | 0.26              |
| S.Ed (±)                          | 1.29                  | 0.15               | 0.16                | 0.21           | 0.12              |

**Table 1.3. Energy equivalencies of the inputs used in maize production**

| S.No | Particulars        | Units  | Equivalent Energy |
|------|--------------------|--------|-------------------|
| 1    | Maize Seeds        | kg     | 15.1              |
| 2    | Diesel             | lit    | 56.31             |
| 3    | DAP                | Kg     | 11.1              |
| 4    | MOP                | kg     | 6.7               |
| 5    | Emamectin Benzoate | kg     | 120               |
| 6    | Manures            | per kg | 0.3               |
| 7    | Harvest Labour     | per hr | 1.96              |
| 8    | Atrazine           | kg     | 120               |
| 9    | Tembotrione        | ml     | 0.102             |

**Table 1.4. Energy inputs in maize as influenced by nutrient and weed management**

| Treatment combination         | Energy Input |
|-------------------------------|--------------|
| T <sub>1</sub> W <sub>1</sub> | 10227.82     |
| T <sub>1</sub> W <sub>2</sub> | 10407.15     |
| T <sub>1</sub> W <sub>3</sub> | 10325.57     |
| T <sub>2</sub> W <sub>1</sub> | 7455.64      |
| T <sub>2</sub> W <sub>2</sub> | 8964.15      |
| T <sub>2</sub> W <sub>3</sub> | 8882.57      |
| T <sub>3</sub> W <sub>1</sub> | 9609.82      |
| T <sub>3</sub> W <sub>2</sub> | 9789.15      |
| T <sub>3</sub> W <sub>3</sub> | 8378.39      |

**Table 1.5. Influence of nutrient and weed management on energy output, energy efficiency index and energy intensiveness**

| Treatment combination         | Energy output    |            | Total energy output (MJ/ha) | Energy efficiency index | Energy intensiveness (MJ/Rs) |
|-------------------------------|------------------|------------|-----------------------------|-------------------------|------------------------------|
|                               | Economic Product | By-product |                             |                         |                              |
| T <sub>1</sub> W <sub>1</sub> | 30471.80         | 52470.83   | 82942.63                    | 8.10                    | 0.27                         |
| T <sub>1</sub> W <sub>2</sub> | 42003.17         | 72125.00   | 114128.17                   | 10.96                   | 0.20                         |
| T <sub>1</sub> W <sub>3</sub> | 39919.37         | 68050.00   | 107969.37                   | 10.45                   | 0.21                         |
| T <sub>2</sub> W <sub>1</sub> | 37679.53         | 63445.83   | 101125.37                   | 13.56                   | 0.16                         |
| T <sub>2</sub> W <sub>2</sub> | 62066.03         | 91662.50   | 153728.53                   | 17.14                   | 0.12                         |
| T <sub>2</sub> W <sub>3</sub> | 56333.07         | 86004.17   | 142337.23                   | 16.02                   | 0.13                         |
| T <sub>3</sub> W <sub>1</sub> | 34996.77         | 57762.50   | 92759.27                    | 9.65                    | 0.22                         |
| T <sub>3</sub> W <sub>2</sub> | 51511.13         | 79812.50   | 131323.63                   | 13.41                   | 0.15                         |
| T <sub>3</sub> W <sub>3</sub> | 47826.73         | 77341.67   | 125168.40                   | 14.93                   | 0.14                         |

### 3.5 Energy Output

Maximum energy output was observed in T<sub>2</sub>W<sub>2</sub> (153728.53 MJ/ha) that was followed by T<sub>2</sub>W<sub>3</sub> (142337.23 MJ/ha). Higher output of the economic product and by-product in these treatment combinations of might be the reason for high energy output. The findings are in conformity with Prasanta Neog et al., (2015). Treatment combination T<sub>1</sub>W<sub>1</sub> (82942.63 MJ/ha) had the lowest energy output when compared to the rest of the treatments, this might be due to the lowest economic and by-product obtained.

### 3.6 Energy Efficiency Index

Energy efficiency index is the rate at which input generates the output, maximum efficiency revealed that T<sub>2</sub>W<sub>2</sub> (17.15) had the maximum energy efficiency index that was followed by T<sub>2</sub>W<sub>3</sub> (16.02). This may be due to the increase in the grain yield of the respective treatment combinations. The minimum energy efficiency index was observed in T<sub>1</sub>W<sub>1</sub> (8.11) which might be due to the higher energy input and lowest grain yield obtained from the respective treatment.

### 3.7 Energy Intensiveness

Energy intensiveness is computed as

$$I = \frac{E_i}{P_i \times Y_i} \quad (1)$$

Where,  $E_i$  = energy input for crop

$P_i$  = price of the crop (Rs. /kg)

$Y_i$  = grain yield of crop (kg/ha)

Minimum energy intensiveness was observed in the treatment combination  $T_2W_2$  (0.12 MJ/Rs), followed by  $T_2W_3$  (0.13 MJ/Rs). The reason behind this is due to the lower energy input and higher grain yield obtained in the respective treatment combinations. The maximum energy intensiveness was observed in  $T_1W_1$  (0.27 MJ/Rs) which might be due to the maximum energy input and lowest grain yield obtained.

### 4. CONCLUSION

On the basis of results summarized above, it can be concluded that maximum growth parameters, yield attributes and energetics were observed with the application of 75% N through RDF and 25% N through vermicompost ( $T_2$ ) among the nutrient management treatments Atrazine @1 kg a.i/ha + Tembotrione @110 g a.i/ha ( $W_2$ ) among weed management treatments. Also treatment combination 75% N through RDF and 25% N through vermicompost along with pre- emergent application of Atrazine @1 kg a.i/ha + post emergent application of Tembotrione ( $T_2W_2$ ) performed best under the studied parameters. However, it must be tested in multiple locations in order to get better knowledge and viability before being suggested to the farmers.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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