# Performance of Planters Under Different Tillage Practices on Growth, Yield, Energy Use Efficiency, and Economics of *Rabi* Maize


## ABSTRACT

**Aim: To evaluate the performance of planters under different tillage practices on growth, yield, energy use efficiency, and economics of *rabi* maize**.

**Study design:** Split-plot

**Place and Duration of Study:** Maize Research Centre, ARI, Rajendranagar between November 2021 and April 2022.

**Methodology:** A field experiment was conducted at Maize Research Centre, ARI, Rajendranagar, Hyderabad, Ranga Reddy (District) during *rabi* 2021-22 to **evaluate the performance of planters under different tillage practices on growth, yield, energy use efficiency, and economics of *rabi* maize in sandy clay loam soils**. The experiment was assigned in fifteen treatments, laid out in a split-plot design with three replications. Treatments included were three tillage practices,(i)$M_1$=Conventional tillage**,**(ii)$M_2$=Reduced tillage, and(iii)$M_3$ = Zero-tillage in main plots and evaluated 5 planters viz., (i)$S_{1=}$Multi-crop vacuum planter,(ii)$S_2$ = Mechanical planter,(iii)$S_3$ =Seed-cum- fertilizer drill,(iv)$S_4$ - Bullock drawn plow and(v)$S_5$ - Manual sowing were randomly placed in subplots of the main plot.

**Results:** Interaction between planters and tillage practices realized significantly higher grain yield (10283 kg $ha^{-1}$) when the *rabi* maize was sown with a Multi-crop vacuum planter under conventional tillage practice compared to bullock drawn plow. However, it was comparable with Mechanical planter and manual sowing under conventional tillage as well as under reduced tillage practices. Irrespective of the planters significantly lower grain yield was obtained under zero-tillage practice. Overall, the cost of cultivation was high with conventional sowing practices (bullock-drawn plow/manual sowing compared to mechanical sowing with improved planters. Higher net returns were observed with multi-crop vacuum planters under conventional tillage practice (Rs.1,43,179 ha-$^{1}$)

**Conclusion**: In case of labor shortage, sowing with a multi-crop vacuum planter or Mechanical planter instead of sowing with conventional practices like a bullock-drawn plow and manual sowing can save time, and labor, reduce drudgery as well production costs. Thus, we can effectively carry out important field operations viz., sowing, weeding, and harvesting in time without much delay through mechanization in maize.



Keywords: Tillage practices, planters, growth parameters, yield attributes, yield, energy and economics


## 1. INTRODUCTION

Maize is a miracle crop grown in varied climatic conditions for food, fodder, feed, and industrial purpose. Worldwide, maize is cultivated in nearly 185 m ha area with a production of 1070 mt and average productivity of 5.6 t $ha^{-1}$. It is cultivated in 9.2 m ha with 27.8 mt productions and average productivity of 2.96 t $ha^{-1}$, (Directorate of Economics and Statistics, GoI 2020). Telangana State is cultivated in a total area of 6.35 l ha, out of which 3.86 l ha during *Kharif* under rainfed and around 2.491 ha during *rabi* under irrigated conditions (2019-20). In Telangana State, the rainfed maize realizes low yield levels of 4.9 t $ha^{-1}$, whereas, in winter maize under irrigated conditions realizes 7.0 t $ha^{-1}$. Most of our state's farmers are small or marginal and constitute 80 % of total holdings. Conventional practices are followed for most of maize farms,*viz*., seedbed preparation, sowing, inter-cultivation, harvesting and threshing which consume maximum time, energy, cost and drudgery to the growers. High labor demands in each operations' peak period adversely affect the operation's timeliness by reducing the crop yield. In any agricultural operation, timeliness of operations is one of the most critical factors which can only be achieved if an appropriate machine is engaged. Although the maize production in 2021 is 28.5 Mt, the demand is increasing in our country; hence, there is a need for mechanization. Using improved implements has the potential can increase productivity by up to 30% and reduce the cost of cultivation by up to 20%. The estimated percentage of agricultural workers in the total workforce would drop to 25.7% by 2050 from 58.2% in 2001. Average farm power availability for the country's cultivated areas has increased from 0.295 kW $ha^{-1}$ in 1971 to 2.02 Kw $ha^{-1}$ in 2017 Manpreet *et al.* [8].

Besides, Farm mechanization, Conservation agriculture practices including zero-tillage and minimum tillage reduce operational costs that include machinery, labor and fuel while increasing yields and better utilizing natural resources. Conservation agriculture holds tremendous potential for all sizes of farms and agroecological systems, Still, its adoption is perhaps most urgently required by small holder farmers, especially those facing an acute labor shortage. In the long term, Zero-till maize-based crop rotation reported an increase in the soil organic matter content through efficient management of crop residue and improved soil biological properties, and microscopic bio-diversity, the soil is enhanced by soil microfauna which includes bacteria, fungi, nematodes, and enzyme activity (Aikins *et al*. [1]) Minimum tillage involves considerable soil disturbance, though much less than that associated with conventional tillage. Minimum tillage is aimed at reducing tillage to the minimum necessary for ensuring a good seed bed, rapid germination, a satisfactory crop stand, and favorable growing conditions (Choudhary and Behera [3]).

Modernization of agriculture necessitates appropriate machinery for enhancing resource use efficiency and productivity, especially the more precise the planting operation, the better the quality and quantity of crop harvested. Currently, various planters have different types of seed metering mechanisms available to evaluate the suitability of the planters along with which have different types of seed metering mechanisms are available, to evaluate the suitability of the planters along with weeding, harvesting and threshing machines in maize.60-70% of the farmers in some districts of Telangana State are using bullock-drawn plows for sowing maize. Sowing with planters saves 91.80 % time compared to maize sown with traditional methods (Narang *et al*. [11]). The hypothesis of the present study is with the use of various machines in conservation, reduced, zero tillage lowers production cost enhances productivity, precision, timeliness, and efficient use of various crop inputs, and improves farm income. Hence, the present Research project has taken an objective to study the feasibility of different planters under different tillage practices on growth, yield, energy requirement, labor saving, and cost economics of *rabi* maize.

## 2. MATERIAL AND METHODS.

A field experiment was conducted during the *rabi* season of 2021-22 at Maize Research Centre, Agricultural Research Institute, Rajendranagar, Hyderabad with fifteen treatments, laid out in a split-plot design with three replications. The soil of the experimental site was Sandy clay loam in texture and slightly alkaline in reaction (pH 7.94), high in organic carbon (0.98%), medium in available nitrogen (290.5 kg $ha^{-1}$), and available Phosphorus

(40.5 kg ha$^{-1}$) and high in available Potassium (400.8 kg ha$^{-1}$) with Electrical Conductivity of 0.21 ds m$^{-1}$. As it was *rabi* crop requires five irrigations during the crop duration. Treatments included were three Tillage practices (i) $M_1$ **=**Conventional Tillage,(ii)$M_2$**=** Reduced Tillage, and (iii)$M_3$ **=** Zero -Tillage as main plot treatments of and five Planters $S_1$ - Multi-crop vacuum planter,$S_2$ - Mechanical planter,$S_3$ - Seed- cum- fertilizer drill,$S_4$- Bullock-drawn plow and $S_5$ - Manual sowing randomly placed in sub-plots of the main plot.

A medium duration (105 days) Maize hybrid DHM-121 was sown in the field with a seed rate of 20 kg ha$^{-1}$, maintaining 60 cm x 20 cm as spacing at a depth of 2-5 cm. A short-duration green gram crop was raised as a bulk during *the Kharif* season and followed by a maize crop under irrigated conditions during the *rabi* season after practicing different tillage treatments. The crop was fertilized with 240:80:80 kg (100% RDF) of Nitrogen, Phosphorus, and Potassium ha$^{-1}$ in the form of Urea, DAP and MOP and all the recommended package was adopted for plant protection. Besides planters for sowing operation other mechanical interventions were also adopted for weeding (power weeder and pre and post-emergence herbicides), inter cultivation (Mini tractor drawn inter cultivator), harvesting (Single row maize grain harvester) and threshing and shelling( Dehusker- cum sheller).The growth and yield parameters were recorded as per the procedure on a net plot basis. (Benefit: Cost ratio) were calculated by dividing the gross returns by the cost of cultivation. Finally, Input and out energy involved in maize production was calculated to arrive at energy ratio as well as energy productivity. The labor requirement for the planter were 21.73 man-hours per hectare saving 51.1 % time of planting in one hectare area in comparison to manual dibbling (Kumar *et al*. [7]).The saving of labor and time for different farm operations. In both mechanized and conventional practices were also assessed.

B:C ratio=$\frac{\text{Gross returns (Rs ha}-^{1})}{\text{Cost of cultivation(Rs ha}-^{1})}$

## 3. RESULTS AND DISCUSSIONS

### 3.1 Growth parameters

The data presented in (Table 1) revealed that, Conventional and reduced tillage practices had shown significant differences among growth parameters of maize compared to Zero-tillage practices. The $M_1$ Conventional tillage treatment recorded significantly higher plant height (193.80 cm), Leaf area (398.06 cm$^2$) and dry matter production (15622 kg ha$^{-1}$). Among the different types of planters sowing with a multi-crop vacuum planter has recorded significantly higher plant height (199.77 cm), leaf area (413.55 cm$^2$) and dry matter production (15701 kg ha$^{-1}$). The increase in plant height in conventional tillage maize could be ascribed to reduced crop weed competition, better aeration, soil moisture, nutrient availability and in turn better root growth resulting in significantly higher values of all the parameters of crop growth. Similar findings were reported by (Anjum *et al*. [2]) and (Karki *et al*. [6]). Even though the crop growth parameters were comparable with manual sowing, Multi crop vacuum planters provide an accurate and precise rate of seed placement and saving in seed rate compared to conventional methods. The planter corrected the problems associated with the manual methods of seed planting such as poor seed placement, poor spacing efficiency, and serious farm drudgery. Similar findings were reported by (Elijah *et al*. [5]) and Manjeet *et al.* [7].

### 3.2 Yield attributes and yield

The conventional tillage has recorded a Significantly higher number of plants ha$^{-1}$(79094), number of cobs ha$^{-1}$(76028.27), number of grain rows cob$^{-1}$(15.60), number of grains row$^{-1}$(36.13), test weight (36.58 g), cob length(19.36 cm), cob girth (15.89 cm) was observed in Conventional tillage practice($M_1$) followed by Reduced tillage practices($M_2$).

(Table 2&3). However, it is superior to zero-tillage. Among sub-plots $S_{1=}$ multi-crop vacuum planter recorded significantly higher yield (9046.89), number of plants $ha^{-1}$(77015), number of cobs $ha^{-1}$(77855), number of grain rows $cob^{-1}$(15.55), number of grains $row^{-1}$(36.77), test weight (37.75 g), cob length(20.44 cm), cob girth (15.85 cm) (Table 2 &3) However, the maize grain yield is statistically on par with manual sowing (8877 kg $ha^{-1}$). The interaction effect due to tillage practices and planters on grain yield (kg $ha^{-1}$) was significant. Maize crop sown with Multi-crop vacuum planter ($S_1$) under Conventional tillage ($M_1$) practice produced significantly higher grain yield (10283 kg $ha^{-1}$). The interaction effect might be good pulverization of soil under conventional tillage contributed to better crop establishment with optimum plant population, efficient utilization of resources including available soil moisture, nutrients, and solar energy at all stages of crop growth, and lower weed infestation. And finally has realized an increase in grain yield. Similar findings were reported by Anjum *et al*. [2]. Multi-crop vacuum planters provide an accurate and precise rate of seed placement. The planter was able to correct the problems associated with conventional seed planting practices, such as poor seed placement, poor spacing efficiency, and serious farm drudgery. Similar findings were reported by Elijah *et al*. [5] and Manjeet *et al.* [7].

### 3.3 Harvest index

The data presented in (Table 3) visualize that the tillage practices did not have a conspicuous effect on the harvest index, but the harvest index was influenced significantly by planters. The higher harvest index was noted with planters under S1,S2 and S3 treatments might be ascribed due to mechanical harvesting of the crop having realized lower stover yields. On the contrary, due to manual harvesting, higher stover yields were realized under S4 and S5 treatments and hence, the lower harvest index.

## 3.4 Economics

Conventional tillage ($M_1$) registered higher net returns (Table 3) and least net returns and B:C ratio was observed with Zero tillage ($M_3$) among the tillage practices. Among sub-plots with significantly higher net returns, B:C ratio was observed with multi-crop vacuum planter treatment. The least net returns were observed in Bullock drew plow treatment ($S_4$) due to higher missing index, multiple indexes thereby registered less plant population and overall yield. Maize under conventional tillage coupled with multi-crop vacuum planter recorded significantly higher gross returns, net returns, and B:C ratio due to vigorous plant growth, higher nutrient uptake improving translocation of photosynthates for elevated yield components production, and higher seed yields resulting in higher monetary returns and B: C ratio. These results tend to support the results of Manjeet *et al*. [7] and Anjum *et al*. [2].

## 3.5 Energy Use Efficiency

**In terms** of Energy requirement, the higher total input energy (22599 MJ $ha^{-1}$) in maize production was in mechanized practice than in Conventional practice (20952 MJ $ha^{-1}$). In contrast, higher total output energy was in conventional practice due to higher stover yields and hence, realized higher energy ratio (11.31%) and energy productivity(0.42kgMJ$^{-1}$)(Table 6). The increased use of inputs such as fertilizer, irrigation water, diesel, plant protection chemicals, electricity, etc. demands more energy human, animal, and machinery energy. Diesel and fertilizers contribute more than 50% of total energy input. These results tend to support the results of Sefeedpari *et al*. [10].

**Table 1. Growth parameters of maize as influenced by tillage practices and planters.**

| Treatments | Plant height (cm) | | | | Leaf area ($cm^2$) | | | | Dry matter production (kg $ha^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **30 DAS** | **60 DAS** | **90 DAS** | **Harvest** | **30 DAS** | **60 DAS** | **90 DAS** | **Harvest** | **30 DAS** | **60 DAS** | **90 DAS** | **Harvest** |
| **Tillage practices** | | | | | | | | | | | | |
| $M_1$ | 25.06 | 145.80 | 178.66 | 193.80 | 96.77 | 216.29 | 382.06 | 398.06 | 558.26 | 3837.06 | 14487.33 | 15622.00 |
| $M_2$ | 23.98 | 139.93 | 172.53 | 187.33 | 95.55 | 209.73 | 363.53 | 377.73 | 523.20 | 3606.20 | 13778.07 | 14772.60 |
| $M_3$ | 22.48 | 135.33 | 166.66 | 181.33 | 89.86 | 188.04 | 354.53 | 368.06 | 508.73 | 3471.40 | 13261.93 | 14530.33 |
| SE(m)± | 0.46 | 1.69 | 1.85 | 2.30 | 0.87 | 4.53 | 4.70 | 1.83 | 8.31 | 42.68 | 213.13 | 205.21 |
| CD (P=0.05) | 1.87 | 6.84 | 7.47 | 9.27 | 3.53 | 18.29 | 18.97 | 7.38 | 33.51 | 60.36 | 859.29 | 827.35 |
| **Planters** | | | | | | | | | | | | |
| $S_1$ | 26.56 | 151.33 | 180.11 | 199.77 | 99.78 | 219.88 | 396.00 | 413.55 | 600.11 | 3951.44 | 14186.78 | 15701.78 |
| $S_2$ | 22.11 | 130.11 | 169.77 | 178.77 | 92.46 | 192.41 | 347.88 | 352.11 | 482.77 | 3427.88 | 13656.33 | 14530.78 |
| $S_3$ | 23.18 | 141.33 | 172.88 | 184.66 | 93.55 | 210.33 | 367.55 | 382.55 | 524.55 | 3604.88 | 13899.33 | 14828.56 |
| $S_4$ | 21.50 | 129.55 | 163.00 | 176.88 | 89.22 | 187.55 | 338.00 | 349.44 | 462.55 | 3322.55 | 13363.89 | 14314.89 |
| $S_5$ | 23.58 | 149.44 | 177.33 | 197.33 | 95.28 | 213.26 | 384.55 | 408.77 | 580.33 | 3884.33 | 14105.89 | 15498.89 |
| SE(m)± | 0.66 | 2.58 | 3.34 | 3.60 | 2.13 | 4.14 | 6.76 | 7.16 | 18.37 | 99.76 | 180.03 | 264.62 |
| CD (P=0.05) | 1.94 | 7.58 | 9.82 | 10.58 | 6.25 | 12.15 | 19.87 | 21.03 | 53.95 | 141.08 | 528.62 | 776.99 |
| **Interaction** | | | | | | | | | | | | |
| SE(m)± | 1.12 | 4.34 | 5.50 | 6.03 | 3.14 | 7.85 | 11.94 | 11.25 | 18.58 | 160.34 | 351.02 | 458.45 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| SE(m)± | 1.03 | 3.79 | 4.14 | 5.14 | 1.96 | 10.14 | 10.52 | 4.09 | 29.65 | 95.44 | 476.59 | 458.87 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Note:** $M_1$ = Conventional tillage, $M_2$ = Reduced tillage, $M_3$ = Zero tillage, $S_1$ = Multi crop vacuum planter, $S_2$ = Mechanical planter, $S_3$ = Seed cum fertilizer drill, $S_4$ = Bullock drawn plough, $S_5$ = Manual sowing, cm- centimeter, DAS-Days after sowing, NS- Non significant

**Table 2. Effect of tillage practices and planters on yield attributes of maize.**

| Treatments | No. of Plants $ha^{-1}$ | No. of cobs $ha^{-1}$ | No. of grain rows $cob^{-1}$ | No. of grains $row^{-1}$ | Test weight (100 seed) (g) | Cob length (cm) | Cob girth (cm) |
|---|---|---|---|---|---|---|---|
| **Tillage practices** | | | | | | | |
| $M_1$ | 79094 | 76028.27 | 15.60 | 36.13 | 36.58 | 19.36 | 15.89 |
| $M_2$ | 73217 | 72251 | 15.20 | 34.73 | 35.17 | 18.16 | 15.43 |
| $M_3$ | 65914 | 64724 | 13.33 | 32.80 | 30.93 | 17.33 | 13.94 |
| SE(m)± | 1852 | 1647 | 0.308 | 0.36 | 0.29 | 0.35 | 0.36 |
| CD (P=0.05) | 7470 | 6643 | 1.24 | 1.48 | 1.18 | 1.44 | 1.47 |
| **Planters** | | | | | | | |
| $S_1$ | 77015 | 82107 | 15.55 | 36.77 | 37.75 | 20.44 | 15.85 |
| $S_2$ | 72213 | 65684 | 14.22 | 34.00 | 30.89 | 17.22 | 14.76 |
| $S_3$ | 73767 | 70981 | 15.11 | 34.77 | 35.11 | 17.96 | 15.07 |
| $S_4$ | 64844 | 60593 | 13.33 | 32.33 | 29.88 | 16.80 | 14.18 |
| $S_5$ | 75870 | 75639 | 15.33 | 34.88 | 37.50 | 19.01 | 15.55 |
| SE(m)± | 1553 | 1893 | 0.51 | 0.92 | 0.53 | 0.34 | 0.25 |
| CD (P=0.05) | 4562 | 5559 | 1.50 | 2.72 | 1.55 | 1.00 | 0.74 |
| **Interaction** | | | | | | | |
| SE(m)± | 3037 | 3364 | 0.85 | 1.48 | 0.87 | 0.63 | 0.53 |
| CD (P=0.05) | 10157 | 10762 | NS | NS | 2.67 | NS | NS |
| SE(m)± | 4143 | 3684 | 0.68 | 0.82 | 0.65 | 0.80 | 0.81 |
| CD (P=0.05) | 8999 | 10491 | NS | NS | 2.81 | NS | NS |

**Note:** $M_1$ = Conventional tillage, $M_2$ = Reduced tillage, $M_3$ = Zero tillage, $S_1$ = Multi crop vacuum planter, $S_2$ = Mechanical planter, $S_3$ = Seed cum fertilizer drill, $S_4$ = Bullock drawn plough, $S_5$ = Manual sowing, g- grams, cm- centimeter, NS- Non significant

**Table 3. Effect of tillage practices and planters on yield and economics of maize.**

| Treatments | Grain yield (kg ha$^{-1}$) | Stover yield (kg ha$^{-1}$) | Harvest index (%) | Cost of cultivation (Rs ha$^{-1}$) | Gross returns (Rs ha$^{-1}$) | Net returns (Rs ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|---|---|---|
| **Tillage practices** | | | | | | | |
| $M_1$ | 9519.73 | 6840.73 | 58.45 | 62110.00 | 186777.20 | 124667.20 | 2.36 |
| $M_2$ | 8697.26 | 6738.47 | 56.74 | 59610.00 | 170640.40 | 111030.40 | 2.22 |
| $M_3$ | 7759.60 | 6611.33 | 54.48 | 54410.00 | 152243.30 | 97833.36 | 2.16 |
| SE(m)± | 247.63 | 119.61 | 1.03 | - | 4857.98 | 4858.40 | 0.08 |
| CD (P=0.05) | 998.37 | NS | NS | - | 19585.60 | 19587.31 | NS |
| **Planters** | | | | | | | |
| $S_1$ | 9046.89 | 5913.89 | 60.22 | 55186.00 | 177500.00 | 122314.00 | 2.53 |
| $S_2$ | 8512.22 | 5510.00 | 60.58 | 54866.00 | 167009.80 | 112143.80 | 2.37 |
| $S_3$ | 8705.11 | 5397.67 | 61.68 | 53226.00 | 170794.30 | 117568.30 | 2.54 |
| $S_4$ | 8152.89 | 8305.33 | 49.43 | 60286.00 | 159959.70 | 99673.68 | 1.99 |
| $S_5$ | 8877.22 | 8524.00 | 50.87 | 69986.00 | 174171.10 | 104185.10 | 1.81 |
| SE(m)± | 176.91 | 137.12 | 0.63 | - | 3470.86 | 3470.92 | 0.06 |
| CD (P=0.05) | 519.42 | 400.17 | 1.84 | - | 10191.08 | 10191.25 | 0.17 |
| **Interaction** | | | | | | | |
| SE(m)± | 369.36 | 237.50 | 1.09 | - | 7246.55 | 7246.91 | 0.12 |
| CD (P=0.05) | 1266.40 | NS | NS | - | 24844.77 | 24846.25 | NS |
| SE(m)± | 553.72 | 267.46 | 2.35 | - | 10862.78 | 10863.73 | 0.18 |
| CD (P=0.05) | 1050.54 | NS | NS | - | 20611.12 | 20611.70 | NS |

**Note:** $M_1$ = Conventional tillage, $M_2$ = Reduced tillage, $M_3$ = Zero tillage, $S_1$ = Multi crop vacuum planter, $S_2$ = Mechanical planter, $S_3$ = Seed cum fertilizer drill, $S_4$ = Bullock drawn plough, $S_5$ = Manual sowing, kg ha$^{-1}$- Kilogram per hactare, Rs ha$^{-1}$- Rupees per hectare, NS- Non significant

**Table 4. Interaction effect of tillage and planters on grain yield (kg ha$^{-1}$) of maize**

| **Tillage practices** | **Planters** | | | | | |
|---|---|---|---|---|---|---|
| | **$S_1$- Multi-crop vacuum planter** | **$S_2$- Mechanical planter** | **$S_3$- Seed- cum-fertiliser drill** | **$S_4$- Bullock drawn plough** | **$S_5$- Manual sowing** | **Mean** |
| $M_1$- Conventional Tillage | 10283 | 9538 | 9273 | 8393 | 10110 | 9519 |
| $M_2$- Reduced Tillage | 9378 | 8529 | 8790 | 8277 | 8511 | 8697 |
| $M_3$- Zero –Tillage | 7479 | 7469 | 8051 | 7788 | 8010 | 7759 |
| **Mean** | 9046 | 8512 | 8705 | 8152 | 8877 | |
| | **SE(m)±** | | | **CD (P=0.05)** | | |
| Tillage practices (M) | 247 | | | 998 | | |
| Planters (S) | 176 | | | 519 | | |
| Sub (S) at same main (M) | 553 | | | 1050 | | |
| Main (M) at same or different sub (S) | 369 | | | 1266 | | |

**Note:** $M_1$ = Conventional tillage, $M_2$ = Reduced tillage, $M_3$ = Zero tillage, $S_1$ = Multi crop vacuum planter, $S_2$ = Mechanical planter, $S_3$ = Seed cum fertilizer drill, $S_4$ = Bullock drawn plough, $S_5$ = Manual sowing, kg ha$^{-1}$- Kilogram per hactare, Rs ha$^{-1}$- Rupees per hectare, NS- Non significant

**Table 5. Interaction effect of tillage and planters on test weight of maize**

| Tillage practices | Planters | | | | | |
|---|---|---|---|---|---|---|
| | **$S_1$-Multi-crop vacuum planter** | **$S_2$-Mechanical planter** | **$S_3$-Seed- cum-fertiliser drill** | **$S_4$- Bullock-drawn plow** | **$S_5$- Manual sowing** | **Mean** |
| $M_1$-Conventional Tillage | 39.43 | 33.53 | 37.96 | 33.60 | 38.40 | 36.58 |
| $M_2$-Reduced Tillage | 38.36 | 32.97 | 35.16 | 31.23 | 38.13 | 35.17 |
| $M_3$-Zero –Tillage | 35.46 | 26.16 | 32.21 | 24.83 | 35.96 | 30.93 |
| Mean | 37.75 | 30.89 | 35.11 | 29.88 | 37.50 | |
| | **SE(m)±** | | **CD (P=0.05)** | | | |
| Tillage practices (M) | 0.29 | | 1.18 | | | |
| Planters (S) | 0.53 | | 1.55 | | | |
| Sub (S) at same main (M) | 0.65 | | 2.81 | | | |
| Main (M) at same or different sub (S) | 0.87 | | 2.67 | | | |

**Note:** $M_1$ = Conventional tillage, $M_2$ = Reduced tillage, $M_3$ = Zero tillage, $S_1$ = Multi crop vacuum planter, $S_2$ = Mechanical planter, $S_3$ = Seed cum fertilizer drill, $S_4$ = Bullock drawn plough, $S_5$ = Manual sowing, kg $ha^{-1}$- Kilogram per hactare, Rs $ha^{-1}$- Rupees per hectare, NS- Non significant

**Table 6:** **Energy utilization in maize production under different tillage practices and planters**

| Treatments | Total Input energy (MJ $ha^{-1}$) | Total output energy (Mj$ha^{-1}$) | Energy ratio (%) | Energy productivity (kg$MJ^{-1}$) |
|---|---|---|---|---|
| **Main plots: Tillage practices** | | | | |
| $M_1$ | 21999.52 | 225449.30 | 10.29 | 0.43 |
| $M_2$ | 21959.26 | 212080.70 | 9.45 | 0.38 |
| $M_3$ | 21891.09 | 196707.80 | 9.03 | 0.34 |
| SEm± | - | 2985.43 | 0.19 | 0.012 |
| CD (P=0.05) | - | 12036.19 | 0.74 | 0.05 |
| **Sub-plots: Planters** | | | | |
| $S_1$ | 22584.24 | 206912.90 | 9.17 | 0.40 |
| $S_2$ | 22591.41 | 194004.70 | 8.59 | 0.37 |
| $S_3$ | 22599.21 | 195436.00 | 8.65 | 0.38 |
| $S_4$ | 21022.21 | 223664.10 | 10.24 | 0.37 |
| $S_5$ | 20952.72 | 237045.20 | 11.31 | 0.42 |
| SE(m)± | - | 3353.78 | 0.20 | 0.009 |
| CD (P=0.05) | - | 9847.28 | 0.59 | 0.028 |
| **Interaction** | | | | |
| SE(m)± | - | 5992.29 | 0.35 | 0.019 |
| CD (P=0.05) | - | NS | NS | NS |
| SE(m)± | - | 6675.64 | 0.42 | 0.027 |
| CD (P=0.05) | - | NS | NS | NS |

**Note:** $M_1$ = Conventional tillage, $M_2$ = Reduced tillage, $M_3$ = Zero tillage, $S_1$ = Multi crop vacuum planter, $S_2$ = Mechanical planter, $S_3$ = Seed cum fertilizer drill, $S_4$ = Bullock drawn plough, $S_5$ = Manual sowing, kg $MJ^{-1}$- Kilo gram per mega joules, MJ $ha^{-1}$- Mega joules per hectare,NS- Non significant, %- percentage

**Table7: Requirement of Man days and time in Mechanized *vs* Conventional practices**

| | Field operations | Machinery used | Mechanized practice | | Conventional practice | |
|---|---|---|---|---|---|---|
| | | | Man days ( $ha^{-1}$) | Time taken (hr $ha^{-1}$) | Man days ( $ha^{-1}$) | Time taken (hr $ha^{-1}$) |
| A | Sowing | Planters | 1 | 2.5-3.0 | | -- |
| | | Bullock drawn | -- | | 3 | 5 |
| | | Manual | -- | | 16 | 8 |
| B | Weeding | Power weeder | 3 | 5 | -- | |
| | | Mini tractor drawn inter rcultivator | 2 | 3.5 | -- | |
| | | Manual | -- | -- | 24 | 12 |
| C | Harvesting | Single row maize grain harvester | 4 | 5 | - | |
| | | Manual | -- | | 24 | 8 |
| D | Threshing and Shelling | Maize Dehusker-cum sheller | 6 | 1.5 | -- | |
| | | Manual | -- | | 18 | 10 |
| | **Total(A+B+C+D)** | | **16** | **18** | **85** | **43** |
| E | Common field operations(Bunds and channels formation, Irrigation, Spraying of herbicide and pesticide(two times), fertilizer application (4 times) | | 20 | 20 | 20 | 20 |
| F | Post-harvest operations(cleaning,bagging and transport) | | 16 | 12 | 16 | 12 |
| | **GrandTotal(A+B+C+D+E+F)** | | **52** | **50.0** | **121** | **75.0** |

Note One man day =6 hrs

### 3.6 Time and Man days

The data presented in Table(7) indicated that there was a saving of 69 man-days ha$^{-1}$(81%) and 25 hours (58%) time with mechanized practices compared to conventional practices. Further, an overall saving of 57% in man days and 33.3% in time was observed in mechanized practices compared to traditional practices in maize production. These results tend to support the results of Muhieldeen *et al*. [9].

## 4. CONCLUSION AND RECOMMENDATIONS

Sowing with a multi-crop vacuum planter or mechanical planter can save time, labor, and seed rate reducing drudgery and overall production costs. Hence, Mechanization with planters along with other mechanical interventions for weeding, harvesting and shelling is a viable option for maize cultivation

## REFERENCES


1. Aikins KA, Diogenes LA, Jensen TA, John B. Advances in residue management mechanisms of zero-tillage planters. An ASABE Meeting Presentation. 2020;Paper No: 1700449.
2. Anjum SA. Morphological and phenological attributes of maize affected by different tillage practices and varied sowing methods. American Journal of Plant Sciences. 2014;5: 1657-1664.
3. Choudhary RL, Behera UK. Conservation agriculture and nitrogen management in maize–wheat cropping system: effect on growth, productivity and economics of wheat. International Journal of Chemical Studies. 2020;8(2): 2432-243.
4. Clarke LJ. Strategies for agricultural mechanization development: the roles of the private sector and the government. Agricultural Support Systems Division, FAO Publication, 2000; Rome, Italy.
5. Elijah AA, Adejoke DA, Bernard O. Development of a self propelled multi crop two rows precision planter: a new design concept for the metering mechanism. International Journal of Mechanical Engineering and Technology. 2018;9(10): pp.349-358.
6. Karki TB, Nirmal G, Jiban S. Systems optimization through tillage and residue management and cropping system in maize based system. International Journal of Current Microbiology and Applied Sciences. 2014.Volume 3: pp.990-1002.
7. Kumar V, Rani V, Jain M, Kumar A, Kumar S, Naresh. Performance evaluation of manually operated ridge vegetable planter for okra. Current Journal of Applied Science and Technology. 2018; 26(5): 1-8.
8. Manjeet S, Mahesh K, Apoorv P, Karun S, Pramod KM. Comparative field performance of pneumatic planters for planting of maize crop. Agricultural Engineering Today. 2018; Vol. 42(3).
9. Manpreet J, Bhathla S, Ramanjit K.Improved technologies for higher maize production, maize Production. 2019; (https://www.intechopen.com).
10. Muhieldeen OA, Eldin S, Mohamed A, Yousif E. Comparision of different planting machines with manual sowing for sorghum crop in central of sudan. International Journal of Engineering Research and Technology. 2020; 2278-0181.
11. Narang MK, Chandel R, Thakur SS, Mishra A. Response of maize crop to different planters. Agricultural Engineering. 2015; No. 2, pp: 61-72.
12. Sefeedpari P, Shahin R, Seyyed HPK, Mohammad G. A source-wise and operation-wise energy use analysis for corn silage production, a case study of Tehran province, Iran. International Journal of Sustainable Built Environment. 2012;1, 158-166.