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RESPONSE OF MAIZE *(Zea mays L)* CROP TO DIFFERENT PLANTERS

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Abstract: Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Tillage and crop establishment is the key for achieving the optimum plant stand and the method of planting and machinery plays a vital role for better establishment of crop under a set of growing situation. Therefore, three planters namely tractor operated raised bed planter, inclined plate planter and manually operated multicrop planter were evaluated in field for sowing of maize. The mean quality of feed index was maximum for raised bed planter as 82.04% and for inclined plate planter and manually operated multicrop planter was 80.83% and 76.67% respectively. The mean multiple index for raised bed, inclined plate and manually operated multicrop planter was 9.26%, 6.39% and 10.75% respectively. The mean miss index for raised bed planter, inclined plate planter and manually operated multicrop planter were 8.70%, 12.78% and 12.58% respectively. The mean grain yield per ha was found maximum for raised bed maize planter as 7.017 $t.ha^{-1}$ and for inclined plate planter and manually operated planter it was 5.778 $t{\cdot}ha^{-1}$ and 6.097 $t{\cdot}ha^{-1}$ respectively. The number of cobs per ha were also maximum for raised bed maize planter as 66,431 and for inclined and manually operated planter number of cobs per ha were 61,945 and 62,992 respectively. The per cent saving in labor cost and time in maize sown with raised bed planter was 89.90% and 91.80% as compared to maize sown with traditional manual method and was highest amongst three planters. There was saving of 10-15% water in maize sown with raised bed planter as compared to maize sown on flat with other planters.

Key words: *raised bed planter, inclined plate planter, maize, germination, yield*

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INTRODUCTION

In India, maize is the third most important food crops after rice and wheat. According to advance estimate it is cultivated in 8.7 million ha (2010-11) mainly during *Kharif* season which covers 80% area. Maize in India, contributes nearly 9% in the national food basket and more than R_s. 100 billion to the agricultural GDP at current prices apart from the generating employment to over 100 million man-days at the farm and downstream agricultural and industrial sectors. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc.

Maize is mainly sown directly through seed by using different methods of tillage and establishment but during winters where fields are not remain vacant in time (till November), transplanting can be done successfully by raising the nursery. However, the sowing method (establishment) mainly depends on several factors *viz* the complex interaction over time of seeding, soil, climate, biotic, machinery and management season, cropping system, etc. Therefore it is very important that different situations require different sowing methods for achieving higher yield. Sowing/planting should be done on the southern side of the east-west ridges/beds, which helps in good germination. Planting should be done at proper spacing.

The effect of ameliorative tillage on the dynamics of some important productive morphological characteristics on two crops of sunflower and maize was studied. Ameliorative tillage systems had better effect for all investigated morphological properties (root distribution, biomass stalk, leafs, head of sunflower, ear maize, and grain yield) on this heavy soil type. Ameliorative tillage system increased significantly grain yield of maize 629 $kg \cdot ha^{-1}$ compared with conventional tillage systems on control variants. [1].

A prototype punch planter was developed for no-till corn to provide different seed spacing. Plant population was adjusted by changing planter punch wheels. Seed spacing of 136, 165, and 210 mm were obtained by constructing three punch wheels with different punch lengths, represented by external diameters of 650, 825, and 1,000 mm, respectively. Laboratory and field tests were conducted at speeds of 1.5, 2.0, and 2.5 $m \cdot s^{-1}$ to evaluate the effect of the punch lengths and speeds. Field tests were conducted in three different residue covers (corn, grain sorghum, and soybean). Overall, high values for quality of feed index (spaces between seeds or plants within 0.5 and 1.5 the theoretical seed spacing) were observed. Despite problems with synchronization between the seed meter and punch wheels, the length of the punches offered no performance limitations at the speeds tested. A soil cleaning device was designed to reduce soil sticking to the punches and reduce soil disturbance. The volume of soil displaced by the smallest punch wheel (650 mm) was less than half of that displaced by a commercial no-till planter. Differences in planting depth due to residue cover and punch wheel diameter were minimal. Emergence was delayed under the corn residue cover and may have influenced the lower performance of the planter prototype as compared to the other two residue types [2].

A three - row bullock drawn multi-crop inclined plate planter was developed at C.I.A.E Bhopal for sowing different type of crops. The calibration for the seed and fertilizer rate was done in the laboratory of C.A.E. , R.A.U., Pusa, Samastipur. The seed rate was found 20.60 kg·ha^{-1} for the maize crop and fertilizer rate was found from 9.3 kg·ha^{-1} to 124.3 kg·ha^{-1}. The wheel skid was in tolerable limit as it was recorded 4.53 %. The field capacity was 0.23 ha·hr^{-1} and field efficiency was 51.1%. The plant population was found 10-12 plants per square meter. The cost of sowing per hectare was 3.5 times economical than traditional method [3].

No-tillage and raised beds are widely used for different crops in developed countries. A field experiment was conducted on an irrigated maize-wheat system to study the effect of field layout, tillage and straw mulch on crop performance, water use efficiency and economics for five years (2003–2008) in northwest India. Straw mulch reduced the maximum soil temperature at seed depth by about 3ºC compared to the no mulch. During the wheat emergence, raised beds recorded 1.3ºC higher soil temperature compared to the flat treatments. Both maize and wheat yields were similar under different treatments during all the years. Maize and wheat planted on raised beds recorded about 7.8% and 22.7% higher water use efficiency than under flat layout, respectively. Straw mulch showed no effect on water use and water use efficiency in maize. The net returns from the maize-wheat system were more in no tillage and permanent raised beds than with conventional tillage. Bulk density and cumulative infiltration were more in no tillage compared with conventional tillage [4].

In rain fed conditions the success of crop production depends on timely seeding. The seed rate for various dry land crops varies from 4 to 140 kg kg.ha^{-1}. Availability of a multi crop planter with replaceable metering plate is crucial to meet the seed rate requirements and to reduce the cost involved in machinery management. Though different types of planters having different seed metering mechanisms were evolved, their performance is not up to the mark.

An inclined plate metering mechanism and newly developed horizontal metering plate was tested on a grease belt test rig developed at CRIDA for their comparative performance at three speeds, 2.5, 3.5 and 5 km·h^{-1} with castor and maize seeds. The average number of seeds metered at different forward speeds for selected variety of maize varied from 367.5 to 239 for inclined plate and 308 to 281 for horizontal plate when compared to theoretical metered seed of 270. In horizontal plate, the seed metering was more consistent and did not varied much with respect to speed of rotor and delivered 14.02 to 4.03% higher seed rate for castor. The mean seed spacing ranged from 19.3 to 23.1 cm. The horizontal rotor metered 94-98 frequency percentile seeds within 15-30 cm spacing intervals at operation speeds of 2.5 to 3.5 km·h^{-1}. It is concluded that, correct seed rate can be achieved with the selected speed ranges by re-designing the seed cells in horizontal plate rotor [5].

A horizontal rotor seed metering plate mechanism was developed and tested both under laboratory (2.5, 3.5 and 5 km·h^{-1} speeds) and field conditions. The mean number of seeds metered at different forward speeds for maize and castor crop varied from 184.8 to 192.6; 185.8 to 187.6, respectively when compared to theoretical metered seeds of 180. The quality of feed index of the planter ranged from 85 to 90.5% and 82.7 to 97% clearly indicated the frequency distribution of seeds with in space intervals > 10 to < 30 cm. The horizontal rotor metered 85 – 93 frequency percentile seeds within 15 – 30 cm spacing intervals at operation speeds of 2.5 to 3.5 km·h^{-1}. At average field speeds of 2 and 3.5 km·h^{-1}, 70 and 65 per cent of the seeds were sown, respectively in a spacing interval of 15-30 cm, which also indicated the higher quality of feed index for the developed planter [6].

Seed metering device is a heart of seed sowing machine which is evaluated for seed distance, seed size between seed varieties. Seed metering devices meter the seed from the seed box and deposit it into the delivery system that conveys the seed for placement on or in the seedbed. The major functional requirements of seed metering systems are to meter the seed at a predetermined rate/output (e.g. $kg \cdot ha^{-1}$ or seeds/meter of row length) meter the seed with the required accuracy (spacing) to meet the planting pattern requirements (i.e. drill seeding, precision drilling, etc); and cause minimal damage to the seed during the metering process. The seed sowing machine is a key component of agriculture field. The performance of seed sowing device has a remarkable influence on the cost and yield of agriculture products. Therefore present study was conducted to evaluate field performance of three different type of planters for sowing of maize crop.

Inclined plate seed metering device was designed and evaluated in laboratory for singulation and uniform placement of maize and soybean seeds at three different cell shapes and sizes. The performance parameters like average spacing, multiple index, quality of feed index and precision were measured. Among the combinations of design variables, the seed metering plate with semi-circular cell shape having cell size 7 mm diameter was found to be the optimum for metering maize seed. Average spacing, quality of feed index, multiple index, miss index and precision were 17.48 cm, 79.33%, 18.67%, 2% and 10.5%, respectively [7].

MATERIAL AND METHODS

The three planter's viz. tractor operated raised bed planter, tractor operated inclined plate planter and manually operated multicrop planter selected for the sowing of maize. The planters were calibrated in the laboratory to give a seed to seed spacing of 0.20 m and row to row spacing of 0.60 m (as per recommendations of PAU, Ludhiana) for maize variety PMH-2 at seed rate of 20 $kg \cdot ha^{-1}$. A germination test was carried out for the variety of maize seed to be sown which was used for the field evaluation of the unit. The weight of the 100 numbers of seeds was 30 g. The 100 seeds were placed in the incubator for three days on a blotting paper under controlled conditions. The germination was found to be 85%. The specifications and calibration method of of three planters used for the present study are shown in Tab. 1.

The raised bed planter had vertical plates with spoon type metering arrangement (Fig. 1). This machine makes two beds and sows 1-3 lines (adjustable) on each bed during operation and it was set to sow one line on each bed. The cost of this machine is R_s 60,000 per unit (US $ 950) and it is developed by Department of Farm Machinery and Power Engineering, P.A.U. Ludhiana. In inclined plate planter, planting attachment has been added to seed - cum - fertilizer drills (Fig. 2). The planter has 6 inclined plates and there were 24 grooves of spherical pattern on each plate. The groove to groove spacing was 12 mm and diameter of each groove was 10 mm. The cost of this machine is R_s 50,000 per unit (US $ 800).

In manually operated multicrop planter (Fig. 3), the planting mechanism has been mounted over the existing wheel hand hoe, used for intercultural operation and consists of a vertical plate with spoons. The capacity of the hopper is about 3.0 kg. The plant spacing can be varied by varying the number of spoons on the periphery of the vertical plate. The planting spoons are also available for sowing different crops like peas, cotton, maize and soybean. It requires two people for sowing i.e. one for pulling the machine from forward side and other for pushing it from backward side so as to make its operation comfortable. The desired seed rate and plant to plant spacing was achieved by changing the driven sprocket or planter plate laboratory calibration. The manually operated planter sows one row in single pass operation. The cost of this machine is Rs. 3000 per unit (USD 50). This machine was developed by Department of Farm Machinery & Power Engineering, P.A.U., Ludhiana.

Figure 1. Raised bed maize multicrop planter

Figure 2. Inclined plate planter

Figure 3. Manually operated planter

Table 1. Various specifications and calibration detail of three planters

Name of machine	Raised bed planter	Inclined plate planter	Manually operated multicrop planter
HP required	35 HP	35 HP	1.0 HP
Seed metering mechanism	Vertical plate with spoons	Inclined plate with grooves	Vertical plate with spoons
Ground wheel diameter (mm)	410	410	410
Diameter of seed metering plate (mm)	180	160	190
Number of spoons/ grooves on each plate	12	24	12
Spacing between two consecutive spoons/ grooves, mm	50	12	50
Seed rate and spacing adjusted	20 $kg \cdot ha^{-1}$ 0.60 x 0.20 m	20 $kg \cdot ha^{-1}$ 0.60 x 0.20 m	20 $kg \cdot ha^{-1}$ 0.60 x 0.20 m
Seed rate calibration method used	By changing the driving sprocket and planter plates	By changing the inclination of planter box and by changing driving sprocket and planter plates	By changing the driving sprocket and planter plate

After the laboratory calibration these planters were operated in field for sowing of maize. After the germination of maize crop miss index, multiple index and quality of feed index was recorded. The criteria for these three indices are given below.

Miss index. Plant missing is an indicator of how often the seedling skips the desired spacing. If the spacing between two plants was greater than 1.5 times the theoretical spacing, then it was considered as a miss.

Quality of feed index. The quality of feed index is measure of how often the plant spacing was closed to the theoretical spacing. If the spacing between two plants was more than half but not more than 1.5 times the theoretical spacing, then it was considered quality of feeding.

RESULTS AND DISCUSSION

Planting of maize was done with the machines viz. raised bed (ridge) planting as well as inclined plate planter and manual planter at the departmental research farm in sandy loam soil. The three machines were operated in the field and parameters like width, forward speed, depth of seed placement and fuel consumption were measured and are shown in Tab. 2. It is clear from Tab. 2 that average fuel consumption for raised bed planter was 4.95 $l \cdot hr^{-1}$ whereas for inclined plate planter it was 6.03 $l \cdot hr^{-1}$. The average field capacity of raised bed planter was 0.49 $ha \cdot h^{-1}$, for inclined plate planter was 0.48 $ha \cdot h^{-1}$, whereas for manually operated planter it was 0.23 $ha \cdot h^{-1}$, and the effect of different machines was significant on field capacity, as well as on forward speed at 5% level of significance. The depth of seed placement varied from 20-50 mm for three planters and the effect of different their effect on depth of seed placement was non-significant at 5% level of significance.

Table 2. Field parameters for three different planters

Name of machine	*Raised bed planter*	*Inclined plate planter*	*Manually operated multicrop planter*	*CD at 5 %*
Width of machine (m)	*1.80*	*1.80*	*0.04*	*---*
Mean forward speed ($km \cdot h^{-1}$)	*2.72*	*2.68*	*0.48*	*0.151757*
Mean effective field capacity ($ha \cdot h^{-1}$)	*0.49*	*0.48*	*0.23*	*0.0256957*
Mean depth of seed placement (mm)	*40.00*	*33.33*	*23.33*	*NS*
Mean fuel consumption ($l \cdot h^{-1}$)	*4.95*	*6.03*	*--*	*--*

Figure 4. Maize sown with manually operated planter

Figure 5. Maize sown with inclined plate planter

Figure 6. Maize sown with raised bed planter

For raised bed planter and inclined plate planter only one person was required whereas for manually operated multicrop planter two persons were required. After the maize crop germination (Fig. 4, 5, 6), data for number of singles, multiples and missing hills was also recorded and are shown in Tab. 3. The effect of three different planters on these indices was non-significant at 5% level of significance. The mean number of plants per ha for raised bed, inclined plate and manually operated multicrop planter were 71,394, 68,171 and 69,615 respectively and the effect was significant at 5% level of significance. The more number of plants in raised bed planter may be attributed to fact that more fertile soil is available for plant on beds.

The mean miss index was found to be maximum in inclined plate planter as 12.78% which occurred normally due to seed struck in any hole of metering plate. The mean multiple index values for raised bed, inclined plate and manually operated multicrop planter were 9.26%, 6.39% and 10.75% respectively. The maximum mean multiple index were found in manually operated planter. Quality of feed index value was maximum for inclined plate planter as 82.04% and values for raised bed planter and manually operated multicrop planter were 80.83% and 76.67% respectively.

The different indices i.e. mean quality of feed index, multiple index and missing index for three different planters have been shown in Fig. 7.

Table 3. Germination data for the three different planters

Machine used for sowing of maize	*Raised bed planter*	*Inclined plate planter*	*Manually operated planter*	*CD at 5 %*
Mean plant to plant spacing (mm)	*190.30*	*201.30*	*182.30*	*NS*
Mean number of plants per ha	*71394*	*68171*	*69615*	*0.257984 E-05*
Mean miss index (%)	*8.70*	*12.78*	*12.58*	*NS*
Mean quality of feed index (%)	*82.04*	*80.83*	*76.67*	*NS*
Mean multiple index (%)	*9.26*	*6.39*	*10.75*	*NS*

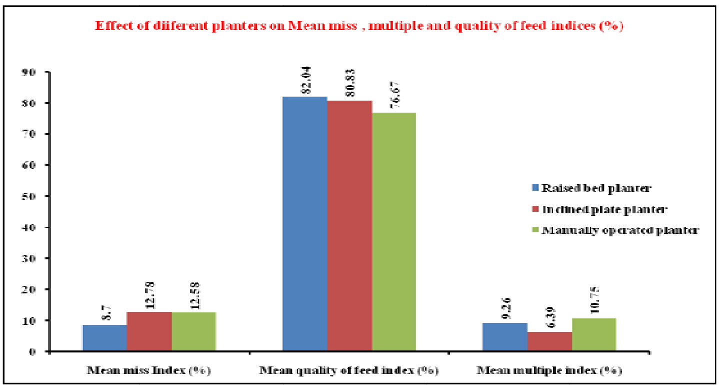

Figure 7. Effect of different planters on mean miss, quality of feed and multiple indices

After the crop maturity, maize samples were taken from three plots and various parameters like stalk height, girth, weight, grain weight per cob, yield etc were recorded. The average moisture content of maize was 22% (w.b.). The data recorded is shown in

Tab. 4. The mean stalk height, girth and stalk weight for maize sown with raised bed planter were 2.29 m, 60.30 mm and 12.22 t·ha^{-1} and were maximum for it, and mean number of cobs per ha were 66,431 (Fig. 8) for maize sown with raised bed planter and for inclined and manually operated planters were 61,945 and 62,992 respectively. The effect of three planters on mean stalk height, mean stalk girth, mean number of cobs per ha were significant whereas for mean stalk weight was non-significant at 5% level of significance. The mean cob length was maximum for raised bed planter with value 152.567 mm and mean cob diameter was maximum for manually operated planter with the value 23.63 mm. The effect of three planters on mean cob length and mean cob diameter was non-significant at 5% level of significance. The mean grain yield, mean grain weight per cob and mean 1000 grain weight were maximum for maize sown with raised bed planter and values were 7.017 t·ha^{-1}, 0.106 kg and 0.313 kg respectively The mean grain yield for inclined plate planter and manually operated multicrop planter were 5.778 and 6.097 t·ha^{-1} respectively and effect of three planters was found to be significant on mean grain yield at 5% level of significance. The mean grain yield per ha, mean 1000 grain weight and mean grain weight per cob for three planters are shown in Fig. 9. The water requirement or total number of irrigations applied were also lesser for raised bed planter sown maize as compared to other two treatments. The mean grain weight and mean 1000 grain weight for maize sown with inclined plate planter and manually operated multicrop planter were 0.093 kg, 0.296 and 0.097 kg, 0.299 kg respectively and effect of three different planters was found to be significant on these two parameters at 5% level of significance. The effect of three different planters were found to be significant on mean weight of empty cobs and non-significant on mean husk weight at 5% level of significance and values of these two parameters were minimum for maize sown with inclined plate planter. A graph was also plotted between mean grain weight per cob, mean 1000 grain weight and mean grain yield as shown in Fig. 10.

Table 4. Maize plant analysis for three different planter

Machine used for sowing of maize	*Raised bed planter*	*Inclined plate planter*	*Manually operated planter*	*CD at 5 %*
Mean stalk height (m)	*2.290*	*2.160*	*2.210*	*0.102313*
Mean stalk girth (mm)	*60.300*	*49.230*	*48.530*	*8.74917*
Mean stalk weight (t· ha^{-1})	*12.220*	*10.620*	*11.710*	*NS*
Mean number of cobs·ha^{-1}	*66431*	*61945*	*62992*	*52.12*
Mean cob length (mm)	*152.567*	*134.933*	*137.833*	*NS*
Mean cob diameter (mm)	*21.333*	*23.100*	*23.633*	*NS*
Mean weight of empty cobs (t· ha^{-1})	*1.982*	*1.440*	*1.745*	*0.291190*
Mean husk weight (t·.ha^{-1})	*1.118*	*0.626*	*0.661*	*NS*
Mean number of grains per cob	*347*	*316*	*325*	*8.13007*
Mean grain weight per cob (kg)	*0.106*	*0.093*	*0.097*	*0.00511590*
Mean 1000 grain weight (kg)	*0.313*	*0.296*	*0.299*	*0.00457233*
Mean grain yield (t· ha^{-1})	*7.017*	*5.778*	*6.097*	*0.00780599*

The equation for mean 1000 grain weight as a function mean grain weight per cob:

$$y = 61.96\,x^2 - 11.02x + 0.785 \quad (1)$$

The equation for mean grain yield as a function of mean grain weight per cob:

$$y = 1728x^2 - 248.6\,x + 13.95 \tag{2}$$

Eq. (1) shows relation between mean grain weight per cob and mean 1000 grain weight and Eq. (2) shows relation between mean grain weight per cob and mean grain yield per ha.

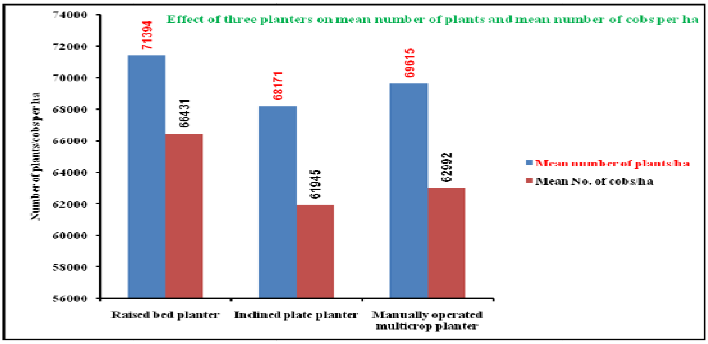

Figure 8. Effect of three different planters on germination of plants and cobs per ha

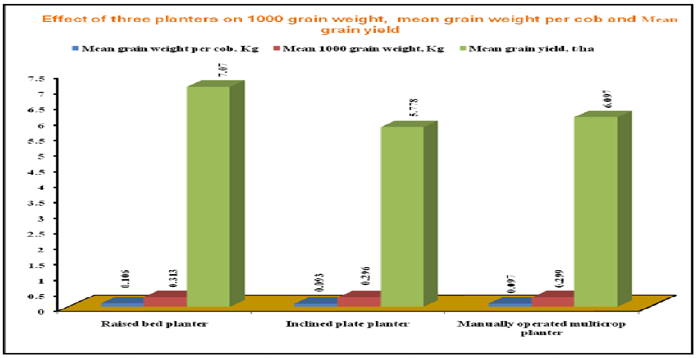

Figure 9. Effect of three planters on mean grain weight per cob, 1000 grain weight and grain yield

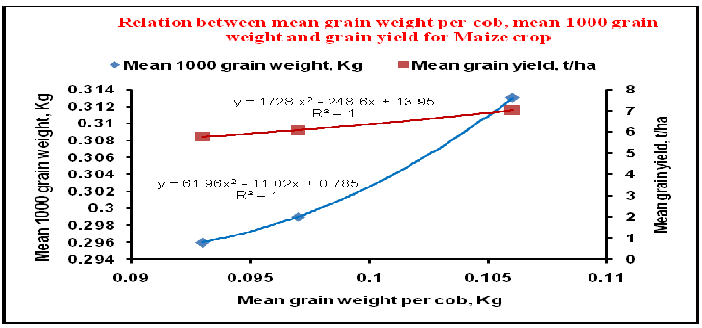

Figure 10. Relation between mean grain weight per cob, mean 1000 grain weight and mean grain yield

Economics of machines. The economics of three different planters was calculated and are shown in Tab. 5. The cost of manually operated multicrop planter was found to be minimum. The field capacity of traditional manual sowing was 0.04 $ha \cdot h^{-1}$. The per cent saving in time was found to be maximum for raised bed planter as compared with traditional method. The per cent saving in time with raised bed planter and inclined plate planters were 91.74% and 82.46% as compared with traditional manual method as shown in Tab. 5.

Table 5. Economics analysis of different planters used for sowing of maize

Method of planting	*Bed planting*	*Flat planting*	
Planter used for sowing maize	*Raised bed planter*	*Inclined plate planter*	*Manually operated planter*
Cost of machine operation , Rs·ha^{-1} (Including fixed and variable costs)	*472.39 (USD 8)*	*538.81 (USD 9)*	*115.19 (USD 2)*
% saving in labor cost as compared to traditional method	*89.90 %*	*87.98 %*	*75.96 %*
% Saving in time as compared to manual method	*91.80 %*	*91.74 %*	*82.46 %*
% Saving in irrigation water with bed planting as compared with flat planting	*10-15 %*	----	----

CONCLUSIONS

1. The mean quality of feed index was maximum for raised bed planter as 82.04 % and for inclined plate planter manually operated multicrop planter was 80.83 % and 76.67% respectively.
2. The mean multiple index for raised bed, inclined plate and manually operated multicrop planter was 9.26%, 6.39% and 10.75% respectively.
3. The mean miss index for raised bed planter, inclined plate planter and manually operated multicrop planter were 8.70%, 12.78% and 12.58% respectively.
4. The mean grain yield per ha was found maximum for raised bed maize planter as 7.017 $t \cdot ha^{-1}$ and for inclined plate planter and manually operated planter it was 5.778 $t \cdot ha^{-1}$ and 6.097 $t \cdot ha^{-1}$ respectively.
5. The number of cobs per ha were also maximum for raised bed maize planter as 66,431 and for inclined and manually operated planter number of cobs per ha were 61,945 and 62,992 respectively.
6. The cost of operation per ha with raised bed, inclined and manual planters were Rs. 472.39, 538.81 and 115.19 respectively.
7. The per cent saving in labor cost and time in maize sown with raised bed planter was 89.90% and 91.80% as compared to maize sown with traditional manual method and was highest amongst three planters
8. Also there was saving of water from 10-15% in maize sown raised bed planter as compared to maize sown on flat with other planters.

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ODGOVOR KUKURUZA *(Zea mays L)* NA RAZLIČITE SEJALICE

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Sažetak: Kukuruz (*Zea mays* L) je jedan od najrasprostranjenijih useva koji se lako prilagođava različitim agro-klimatskim uslovima. Obrada i setva su ključni za postizanje optimalnog stanja useva. Zato su ovde ispitivane dve traktorske i jedna ručna sejalica. Indeks srednjeg kvaliteta bio je najveći kod setve u leje (82.04%), kod sejalice sa nagnutom pločom i ručne sejalice iznosio je 80.83% i 76.67%, redom. Srednji višestruki indeks za sve sejalice, istim redom, iznosio je 9.26%, 6.39% i 10.75%. Srednji indeks gubitaka bio je 8.70%, 12.78% i 12.58%, redom. Srednji prinos zrna bio je 7.017 $t.ha^{-1}$, 5.778 $t{\cdot}ha^{-1}$ i 6.097 $t{\cdot}ha^{-1}$, redom. Broj klipova/ha iznosio je 66.4, 61.95 i 62.99, redom. Smanjenje troškova i vremena rada iznosilo je 89.9% i 91.8% u poređenju sa tradicionalnom ručnom setvom. Ušteda vode od 10-15% je ostvarena kod kukuruza sejanog sejalicom za leje u poređenju sa setvom na ravnu podlogu sa druge dve sejalice.

Ključne reči: *sejalica u leju, sejalica sa nagnutom pločom, kukuruz, nicanje, prinos*

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