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Performance evaluation of different sowing equipment for cultivation of wheat crop (*Triticum aestivum* G.)

■ **Arun Waghmode and Rajneesh Patel**

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See end of the Paper for authors' affiliation

Correspondence to :

Arun Waghmode
Department Farm Machinery and Power Engineering, Shriram College of Agriculture Engineering (JNKVV) Paniv, **Solapur (M.S.) India**
Email : waghmodemtech@gmail.com

■ **ABSTRACT :** The performance and evaluation of four sowing equipment treatment was determined for cultivation of wheat crop. Four different treatment such as zero till seed-cum-fertilizer drill, Roto till seed-cum-fertilizer drill, 1xcultivator + 1x disc harrow + seed-cum- fertilizer drill,1x cultivator + 2x disc harrow + raised bed planter (Aikins and Afuakwa, 2010) all prevailing environmental condition such climatic condition *i.e.* temperature and relative humidity, physical properties of soil *i.e.* soil moisture content, bulk density and shear strength, as well as machine and crop parameters were studied before sowing treatment (Benjamin and Cruse, 1987). There are several drills like conventional, zero till, rototill, raised bed planting etc. can be used for sowing wheat. The improved machines not only deliver the desired amount of seed and fertilizer but also save time and energy. The performance of seed drill is improved by manipulating the depth of sowing and thickness of soil cover over the seed as well as pressing the soil cover (Baumgartl and Horn,1991.) The initial bulk density of soil reduced in treatment T_1, T_2, T_3 and T_4 as the soil manipulation occurred. The soil moisture content after sowing decreased in all the treatments at different depths. The highest reduction was observed in treatment T_4 due to more tillage operation and used of raised bed planter. Better soil pulverization was observed in case of treatment T_2 where seed bed was prepared by rotary tiller. The cone index of soil was increased with depth. It was found to be minimum at different depths in treatment T_4 which includes 1 x cultivator followed by 2 x disc harrow then sowing by using raised bed planter. The similar trend was observed even at 100 DAS. The field efficiency was found to be maximum (77.02%) in treatment T_1 and minimum (60.91%) in treatment T_4. This is because maneuverability and initial in case of zero till dril. The plant height varied in different treatments till 15DAS, however, at latest age of crop growth. The plant height was near to each others though it was more in treatments T_3 and T_4. This is because soil was tilled deeper which probably helped in more root growth. The number of plants/m length, seed emergence was minimum in treatment T_1 and similar in other treatment. The plant population was also less in treatment T_1 and similar in treatment T_2, T_3 and T_4. It was found more in treatment T_4. Length of ear head in all the treatment was almost similar. The weed count was found to be minimum in treatment T_4 and maximum in treatment T_1 as there was no soil manipulation in treatment T_1. The crop cutting yield was minimum (48.3q/ha) in treatment and maximum in treatment T_4 (51.7q/ha), in treatments T_2 and T_3 there is slight difference in grain yield. The straw yield was minimum (57.95q/ha) in case of treatment T_1 probably due to less tillers and less plant population. 1000 grain weight was found similar in all the treatments (Bhattacharyya *et al.*, 2008).

■ **KEY WORDS :** Seed drill, Cultivator, Disc harrow, Planter, Soil properties, Energy, Economics

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India is basically agriculture based country covering agricultural land about 199.15 mha out of 329 mha in 2009 total geographical area (World Bank Report, 2010) and 75 per cent of farmers in the country are having land holding less than 2 ha and 70 per cent of the cropped in rain fed. The average yield of wheat in Madhya Pradesh and in India is 1835 kg/ha and 2830 kg/ha, respectively (Agricultural Statistics of Madhya Pradesh, 2009, Commissioner, Land Record, Gwalior). Madhya Pradesh is the largest state having geographical area 31 mha along with cropping intensity of 135 per cent with net sowing area of 16 mha. Agriculture contribute 44 per cent to the state economy. Multiple cropping schemes in Madhya Pradesh were possible through the extension facility to 32 per cent (in 2002) and mechanization of agriculture through extensive use of tractors, seed drills, multi-crop threshers, combined harvesters etc.The energy requirement in various activities in crop production agriculture varies considerably due to variation on technology level adopted by the farmers and also because of diverse agro-climatic conditions (Mittal and Dhawan, 1998). Energy plays a vital role in increasing agricultural productivity and energy from various sources is derived in agriculture. There is conventional zero till seed cum fertilizer drill which sow the seed directly in the field with minimum open up of land means without any field preparation so that better utilization of moisture and rest of nutrients and crop residues in paddy-wheat rotation, roto till seed cum fertilizer drill is used for combine operation of seed bed preparation by rotary motion of tines and sowing at a time so that better utilization of available moisture with minimum evaporation of soil moisture and mixing of crop residues which enhances the nitrogen after decomposition also conventional seed cum fertilizer drill is used to sow the seed on well prepared seed bed and leveled field with minimum compaction of soil on the sown seed but it requires irrigation in planting for better germination and raised planter are used to sow the seed on raised bed in better pulverized soil so that the minimum compaction of soil over sown seed, promote seed emergence, moisture is more available to the plants and better drainage facility during rainfall from furrow are available for sowing of wheat crop. These drill are used for sowing in different seed bed conditions and, therefore, have effect on seed placement, growth and crop yield.

METHODOLOGY

The experiment field was conducted in field number 44 of the form of Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur (M.P.). The university is located at 23°13'15.32" N and 79°57' 50.82" E and 390 m above MSL. Soil type was clay loam which has sand-29.10 per cent, silt-20.15 per cent, clay-50.75 per cent.

The following four treatments were selected for the experiment:

Table A: Specification of equipment

Name of equipment	Types of tynes	Spacing between two tynes (m)	No. of tynes	Total width (m)
Zero till drill	Inverted T-type	0.18	11	1.98
Roto till drill	C - type + reversible shovel	0.24	9	2.16
Seed drill	Reversible shovel	0.24	9	2.16
Raised bed planter	Inverted T-type	0.37	6	2.22
Cultivator	Double point shovel	0.22	9	1.98
Disc harrow	Discs	2 gang, 6 disc each	Ø 0.60m, spacing 0.23m	1.98

Remarks Ø = Diameter

Table B: Calibration of sowing equipment

Name of equipments	Diameter of ground wheel (m)	Number of revolution of ground wheel	Linear distance (m) =πD	Width of equipment (m)	Area covered (m^2)	Seed dropped (g)	Fertilizer dropped (g)
Zero till drill	0.37	20	23.25	1.98	46.04	340.69	736.64
Roto till drill	0.39	20	24.51	2.16	52.95	391.83	847.20
Seed drill	0.35	20	21.99	2.16	47.49	1139.82	
Raised bed planter	0.38	20	23.87	2.22	52.99	392.13	550*

Remarks :- (*) = Fixed

T_1 = Zero till seed-cum-fertilizer drill,

T_2 = Roto till seed-cum-fertilizer drill,

T_3 = 1x cultivator + 1 x disc harrow + seed-cum-fertilizer drill,

T_4 = 1 x cultivator + 2 x disc harrow + raised bed planter.

All the treatments were replicated thrice. The experiment was conducted in a field of 135m x 30m size. The field was divided in 12 subplots each of 45m x 7.5m size.

Wheat (HD-2864) was sown at the rate of 75 kg/ha. The recommended dose of fertilizer in the ratio of 120:60:40 of nitrogen: phosphorus: potassium per hectare was also applied as basal doze. The phosphorus, potassium is wholly applied during sowing and nitrogen is applied in dozes 30 per cent during sowing as basal doze and 30 per cent after three weeks and rest of 40 per cent after five weeks as top dressing.

The following sowing equipment were used in the experiment for sowing wheat.

– Zero till drill,

– Roto till drill,

– Seed cum fertilizer drill,

– Raised bed planter.

Width of implement = Spacing between two tines x Number of furrow.

The calibration of selected sowing equipment was as per standard procedure to apply seeds @75 kg/ha and fertilizers was in ratio of 120:60:40 kg/ha of N,P, and K, respectively.

■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Soil parameters:

Soil moisture content :

The variation soil moisture content is shown in Fig. 1. It is evident from the figure that before any tillage treatment was performed the soil moisture content was 18.8 per cent, 19.7 per cent and 24.2per cent at 25, 50 and 75 mm soil depth, respectively. Further the moisture content at shallower depth was found less due to the reason that on soil surface or at shallow depth the moisture loss occurs due to evaporation. The figure also shows that there was minimum loss of moisture in case of zero till drill (T_1) compared to other treatments and this is because of the reason that no tilling of soil in this treatment. The maximum soil moisture loss at different depths was observed in the case of treatment T_4 where field preparation was performed sing 1 x cultivator followed by 2 x disc harrow and seed was shown using a raised bed planter. The higher soil moisture loss is therefore due to tilling of soil to a deeper depth (Czyz and Dexter, 2008).

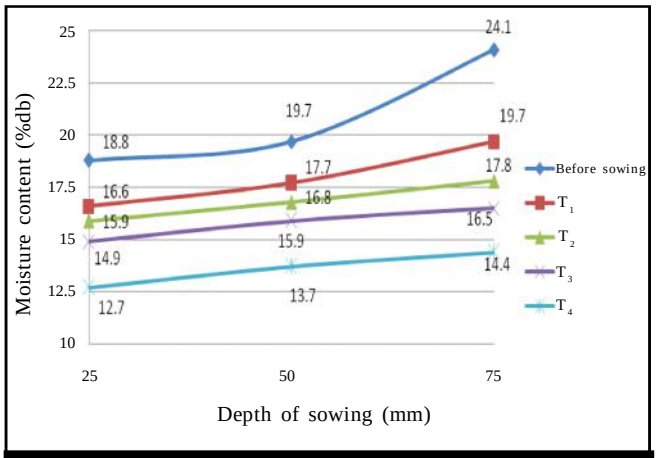

Fig. 1 : Moisture content of soil before and after sowing at different depth under different treatments

Bulk density of soil:

The variation in bulk density is presented in Fig. 2. It is evident from the figure that bulk density of soil before any operation was 1.56g/cc in all the treatments. In case of zero tillage treatment, there was virtually no change in bulk density after sowing as using this machine only a slit is formed for placing seeds in the field and there is no disturbance of soil. In the same treatment the bulk

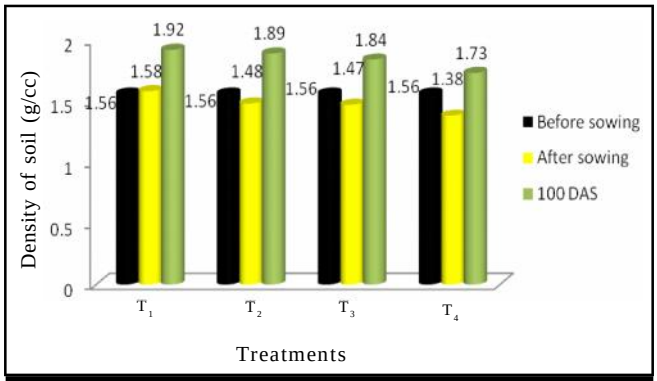

Fig. 2 : Density of soil under different tratments

density after 100DAS was observed to be 1.92g/cc which *i.e*. an increase from 1.56 to 1.92g/cc and with time this indicate more soil compaction.In case of roto till drill the bulk density reduced to 1.48g/cc from 1.56g/cc. The reduction is due to tilling of soil by rotary blades to a depth of 50mm. In this treatment the bulk density after 100DAS was found 1.89g/cc.

In treatment T_3 the bulk density reduced to 1.47g/cc after sowing from initially observed value of 1.56g/cc. This reduction in bulk density is because of the reason that the soil was tilled using 1 x cultivator followed by 1 x disc harrow, bulk density after 100DAS was found 1.84g/cc. This increase in because of settlement of soil due to irrigation and other natural process of crop growth. In case of treatment T_4 where the seed bed was prepared using 1 x cultivator followed by 2 x disc harrow, soil bulk density was observed as 1.38g/cc which is the lowest among all the treatment. This is obvious reason that in this treatment more tilling of soil has occurred causing more loosening of soil. The bulk density was found lowest (1.73g/cc) after 100DAS in this treatment and this also is due to reason stated above (Hardaha, 2002a).

Shear strength of soil:

The shear strength of soil at depth of 25 mm to 150 mm in all the treatment was measured using a cone penetrometer. The initial cone index of soil before performing any operation was found to be 0.756, 1.505, 2.373, 3.280, 3.615 and 4.021g/cm² at depth of 25, 50, 75, 100, 125 and 150mm. The cone index after sowing in treatment T_1 was observed as 0.661, 1.330, 2.285, 3.272, 3.623, 4.037kg/cm², in treatment T_2 0.287, 0.565, 0.828, 2.648, 3.037, 3.546, in treatment T_3 0.334, 0.780, 1.051, 1.669, 2.198, 3.154kg/cm² and in treatment T_4 0.295, 0.653, 0.900, 1.334, 1.931 and 2.839kg/cm², respectively. After 100 DAS in treatment T_1 it was found to be 0.667, 1.346, 2.309, 3.296, 3.631 and 4.053kg/cm², in treatment T_2 0.502, 1.139, 1.970, 2.981, 3.439 and 3.885kg/cm², in treatment T_3 0.382, 0.987, 1.875, 2.780, 3.316 and 3.554kg/cm² and in case of treatment T_4 0.358, 0.89, 1.663, 2.554, 2.908 and 3.246kg/cm², respectively. It is evident from the Fig. 3 that the cone index before performing any tillage operation and in zero tillage treatment was same because in zero tillage treatment no tilling of soil takes place. The reduction in cone index was found less in T_2 treatment followed by treatment T_3 and T_4. This is because the degree of soil manipulation which was less operation of a rotary tillage implement (roto till drill) compare to treatment (T_3) having 1 x cultivator followed by 1x disc harrow and treatment T_4 having 1 x cultivator followed by 2 x disc harrow. The figure also reveals that after 100 DAS the cone index under treatment T_1 was highest and in treatment T_4 was the lowest. This is due to the reason that in case of zero till drill there was no tilling of soil and in case of treatment T_4 comparatively more tilling of soil occurred during seed bed preparation and soil loosening due to operation of a raised bed planter (Benjamin and Cruse, 1987).

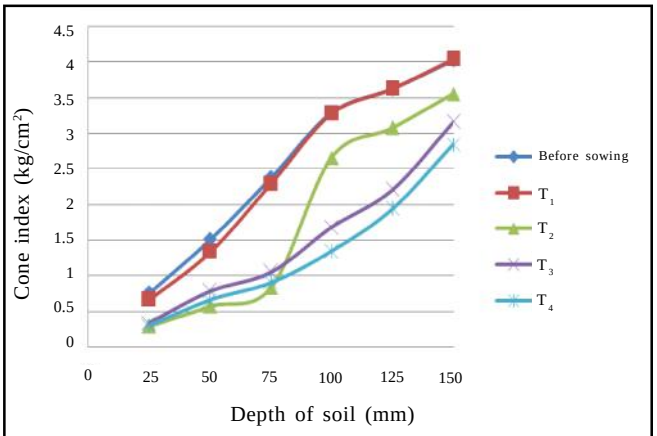

Fig. 3 : Cone index value of soil at different depth before and after sowing

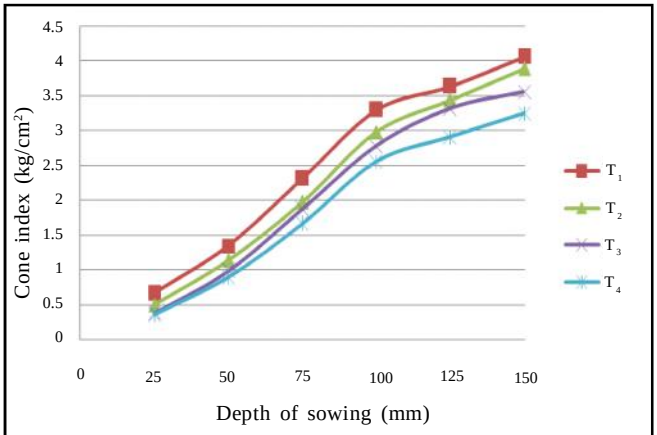

Fig. 4 : Cone index value of soil at different depth after 100 DAS

Soil pulverization :

The soil pulverization is indicated by soil aggregate and is represented by the mean mass diameter (MMD).

The MMD of soil aggregate upto depth of sowing was analyzed using sieve analysis. The observed sizes of soil aggregate are shown in Appendix Q. The Fig. 5 shows the MMD of aggregate in treatments T_2, T_3 and T_4 which are 8.35, 10.03 and 9.56mm, respectively. It is evident from figure that the treatment T_2 has lowest MMD aggregate because of rotary action of C-type rotavator tines causing more pulverization of soil. The treatment T_3 has highest MMD indicate lowest degree of soil pulverization as the operation includes 1x cultivator followed by 1 x disc harrow. The MMD in treatment T_4 was between treatment T_2 and T_3 because the tillage operation was done by using 1 x cultivator followed by 2 x disc harrow. In the case of T_1 treatment there was no soil pulverization because the sowing was done by zero till drill. It opens the slit of soil sufficient for the placement of seed and there is no pulverization of soil (Hardaha, 2002b).

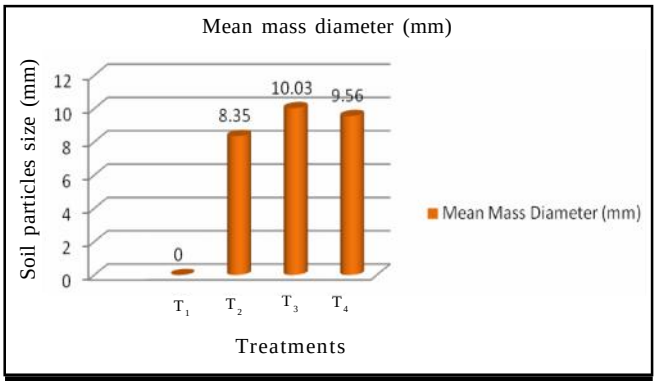

Fig. 5 : Soil pulverization under different treatments

Sowing depth:

The depth of sowing was measured in all the treatments a using a steel scale. The observed values are placed in Appendix I. As shown in the Fig 6 the depth of sowing in treatments T_1, T_2, T_3 and T_4 was 63.3 mm, 63.3 mm, 63.8 mm and 64.5 mm, respectively. The depth of sowing in T_1 and T_2 was same. In treatment T_3 seed placement was found at 63.8 mm depth. The depth of sowing in treatment T_4 was highest (64.5mm) because the operation involved 1 x cultivator followed by 2 x disc harrow and sowing by raised bed planter causing more deeper disturbance of soil. The above results indicate that in all the treatments seed placement was done at almost same depth despite of different practices adopted for seedbed preparation

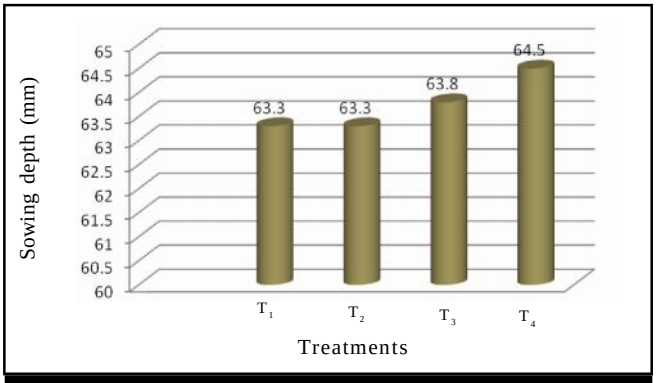

Fig. 6 : Depth of sowing under different treatments

Machine parameters:

Field efficiency:

The field efficiency of sowing equipment zero till drill, roto till drill, seed cum fertilizer drill and raised bed planter was determined and shown in Appendix I. It is evident from Fig. 7 that the field efficiency was found to be 77.02 per cent, 66.43 per cent, 63.29 per cent and 60.91 per cent in treatments T_1, T_2, T_3 and T_4, respectively. The higher field efficiency was observed in case of zero till drill probably due to lesser wheel slippage as the machine operates in no tilled soil and better maneuverability with tractor causing less of time in turning. In case of roto till drill the field efficiency was found to be less than zero till drill and this may be due to reason that combination of roto till drill with seed drill causing more wheel slip and more time required in turning. The field efficiency was found low also the conventional seed cum fertilizer drill and raised bed planter was operated in tilled soil. This is obvious due to

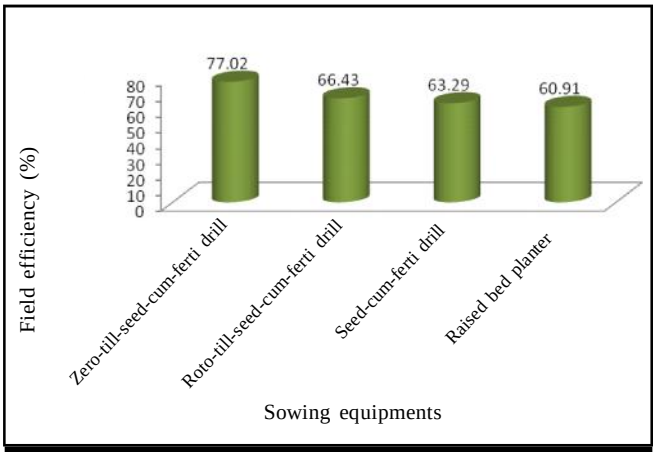

Fig. 7 : Field efficiency of different sowing equipment

the reason that more wheel slip occurs in loose soil, further maneuverability of raised bed planter is difficult than conventional seed cum fertilizer drill.

Fuel consumption:

The fuel consumption under treatments T_1, T_2, T_3 and T_4 is shown in Table 8 and it is depicted in Appendix I. It is evident from that the fuel consumption 16.13 lit, 13.49 lit, 31.23 lit and 39.1 lit was in treatments T_1, T_2, T_3 and T_4, respectively. The above observed fuel consumption is cumulative which includes fuel consumed during all the operation performed in a treatment. In treatment T_2 the fuel consumption was the lowest because within treatment field and sowing was done simultaneously and in roto tilling the fuel consumption is expected to be lower compared to conventional tillage using cultivator and disc harrow. The fuel consumption in treatment T_1 was higher than T_2 because sowing was done directly in the field without any soil manipulation. The fuel consumption in case of treatment T_4 was highest because the operation includes field preparation using 1 x cultivator followed by 2 x disc harrow and then sowing was using raised bed planter in tilled soil. Both in treatment T_3 and T_4 high fuel consumption was observed due to combination of two operations is field preparation using conventional tillage implements followed by sowing equipment.

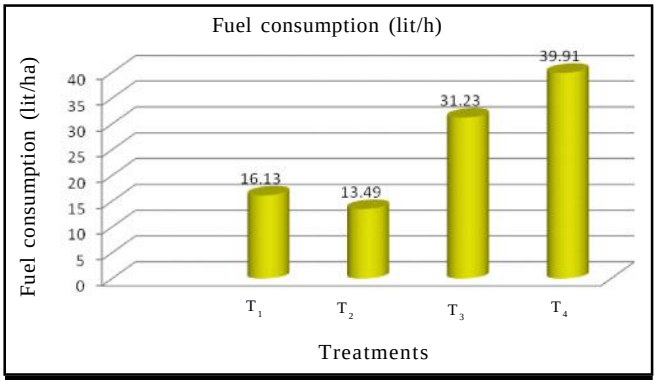

Fig. 8 : Feul consumption under different tratments

Crop parameters:

Seed emergence:

The seed emergence in treatments T_1, T_2, T_3 and T_4 were found to be 90 per cent, 96.9 per cent, 97.1 per cent and 96.9 per cent, respectively. It is evident from the Fig. 9 that lowest seed emergence (90%) was observed when crop was sown using zero till drill. This is due to the reason that when sowing using a zero till drill in a unprepared seed bed, seed are placed in a slit formed by furrow openers and some time seeds are placed out of slit and also not covered by soil which caused poor germination of seeds. In treatments T_2, T_3 and T_4 the seed emergence was found to be almost similar (97%). This because of the reason that in these treatment seed were placed in well pulverized soil prepared using roto till drill and conventional tillage methods.

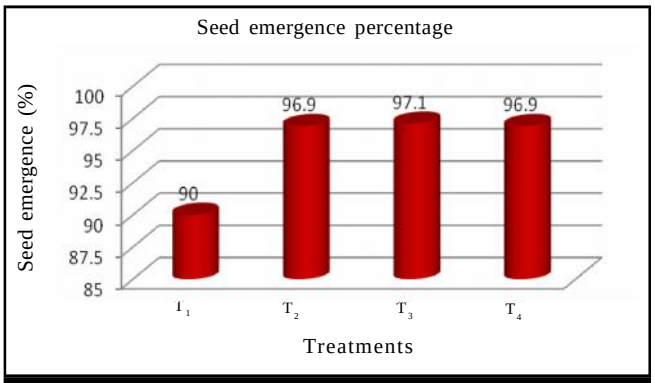

Fig. 9 : Percentage of seed emergence under different treatments

Plants population :

The Fig. 10 shows the plant population in different treatment at 15, 30 and 45 DAS. It was observed that 134, 136 and 135 plants/m² were found it treatment T_1 at 15, 30 and 45 DAS. In treatment T_2 and T_3 similar numbers of plant population 154, 155 and 156 numbers/ m² at 15, 30 and 45 DAS, respectively were found. The plant population was highest 169, 171 and 170 number/ m² at 15, 30 and 45DAS in treatment T_4.The result indicate that lowest plant population was observed when the crop was sown using zero till drill and this is because low rate of seed emergence (90%) as described in section 4.3.1. in treatment T_2 and T_3 and T_4 though the seed emergence was almost similar but higher plant population was observed under treatment T_4. This may be attributed to the fact that probably better crop establishment occurred when seed bed was prepared using 1 x cultivator followed by 2 x disc harrow and sowing by raised bed planter. The raised bed planter is becoming more popular because it provides crop growth on beds and irrigation or drainage of water in furrow which may result in lesser plant mortality. The results also reveals that moral less same number of plants survive during different after

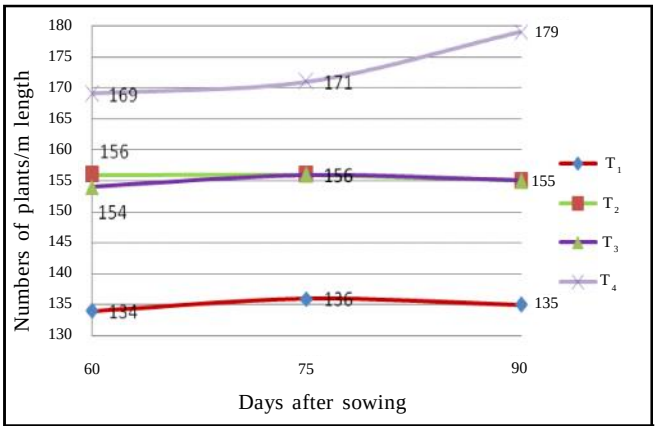

Fig. 10 : Number of plants/m² under different treatments

sowing in all the treatment.

Number of seeds (0 DAS) and plants per m length:

The Fig. 11 indicates that 30 numbers of seed were placed/m length when crop was sown using zero till drill. 32 numbers seeds/m length were placed when roto till drill and conventional seed cum fertilizer drill was used and raised bed planter 35 seeds/m length were placed.In case of zero till drill 28, 27 and 27 plants/m length were observed after 15, 30 and 45 DAS, respectively. This shows that though 30 seeds/m length were placed but 28 plants initially germinated and 27 remained after 45 DAS this due the reason that probably the seed which placed at shallow depth or on the surface of soil did not germinate, treatment T_2 and T_3 also there was 31 plants/ m length after 15DAS and 30 plants /m length after 45 DAS were found to be exist were as initially 32 seeds

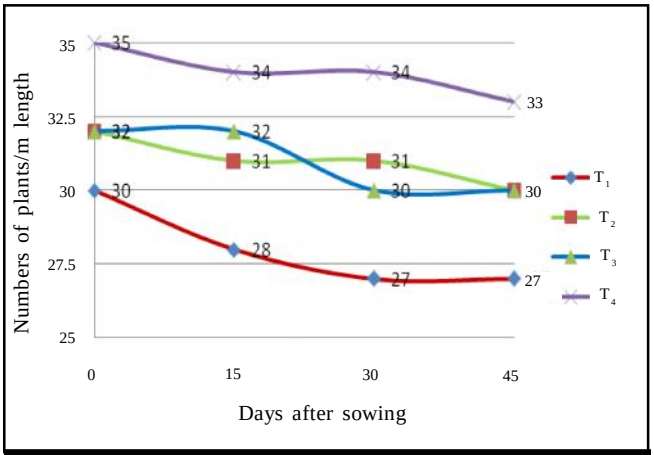

Fig. 11 : Number of plants/m length under different treatments

were placed. Similar trend has been observed in treatment T_4. The germination of lesser number of plants than the number of seed initially placed is a common phenomenon as seed germination is never becomes 100 per cent. However, the results reflects that 93 per cent, 96.8 per cent, 100 per cent, 97.1 per cent of seeds found to be germinated in treatments T_1, T_2, T_3 and T_4, respectively.

Height of plant:

The overall height of plants in treatments T_1, T_2, T_3, and T_4 were 981 mm, 989 mm, 1012 mm and 1010 mm, respectively. It is evident from the Fig. 12 that the increase in height of plant in treatments T_1, T_3, and T_4 was uniform after 15, 30, 45, 60, 75 and 90 DAS but in T_2 after 15, 60, 75, and 90 DAS but there was suddenly increase in height in treatment T_2 after 30 and 45 DAS as compared other treatments because the soil pulverization was more which enhances the initial growth rate which was same after 60 DAS as others. The overall height of plants after 90 DAS was almost same in all treatments. The lowest height of plants was found in case of treatment T_1 because the soil bulk density and soil strength was highest. The height of plants in treatment T_3 and T_4 was almost was similar because tillage and sowing was done by using conventional cultivator and disc harrow.

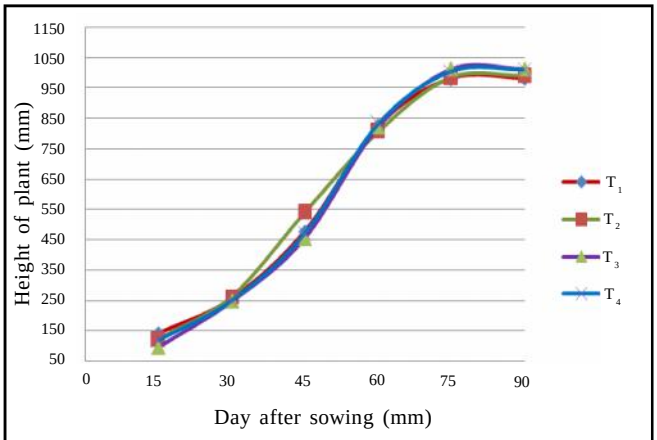

Fig. 12 : Plant height under different treatments

Numbers of tiller per plant:

The total numbers of tiller in treatments T_1, T_2, T_3, and T_4 after 45 DAS were 7, 9, 8 and 9, respectively. It is evident from Fig. 13 that the number of tillers per plant

in 15 DAS was highest in treatment T_3 (5) and lowest in treatment T_1 (2). At 45 DAS the number of tillers per plant was higher in T_2 (9) and T_4 (9) treatments than T_3 (8) but lower in treatment T_1 (7) because of the at upper surface the soil pulverization and soil strength was lower in treatment T_2 and T_4 resulting the growth of plants were well as compare to the treatment T_3 and T_1.

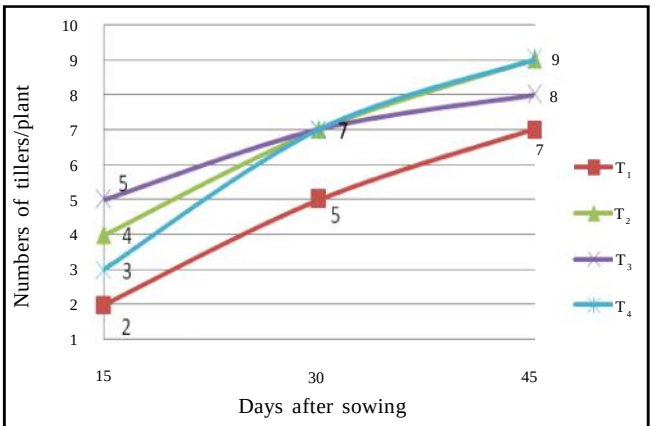

Fig. 13 : Number of tillers/plant under different treatments

Length of ear head:

In treatments T_1, T_2, T_3 and T_4 after 90 DAS were 154 mm, 157 mm, 153 mm and 157mm, respectively. It evident from the Fig. 14 that the initial spike initiation was well in case of treatment T_4 because field preparation was done by 1 x cultivator followed by 2 x disc harrow. Length of ear head was lowest in case of treatment T_1 at 60 DAS and highest in T_4 treatment. The length of ear head after 90DAS was approximately same in all treatments and there was no significance difference in length of head into one another treatment.

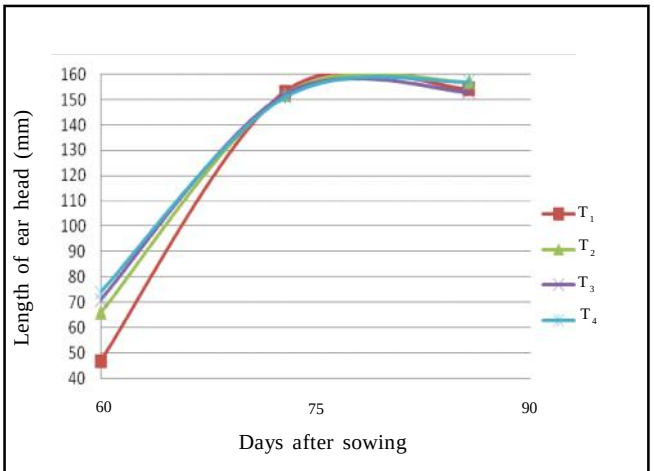

Fig. 14 : Length of ear head under different treatments

Number of weed count:

Number of the weed before and after field preparation/sowing was measured and variation is shown in Fig. 15. Initially the experimental field had 11 the number of weeds count/m² area. The figure shows that the weed count was measured at 15, 30 and 45 DAS in each treatment. In treatment T_1 the weed count was 9, 10 and 16 after 15, 30 and 45 DAS which shows that weed count has increased and this is because in this treatment no soil manipulation was done. In treatment T_2 the weed count of 15, 30 and 45 DAS was found to be 5, 6 and 7 numbers/m², respectively. There is decrease in weed count as soil was manipulated in this treatment by a roto tiller. Treatment T_3 has weed count of 6, 7 and 8 numbers/ m² after 15, 30 and 45 DAS which also lower than what was observed initially and this also due to tillage operation was performed for preparation of field. The minimum weed and of 3, 4 and 5 numbers/m² was observed at 15, 30 and 45 DAS in treatment T_4. This is because of the reason that pulverize seed bed was prepared which included 1 x cultivator followed by 2 x disc harrow. Thus, it can be said that tillage operations performed to prepared seed bed reduces weeds growth as weeds are cut and incorporated into the soil during operation.

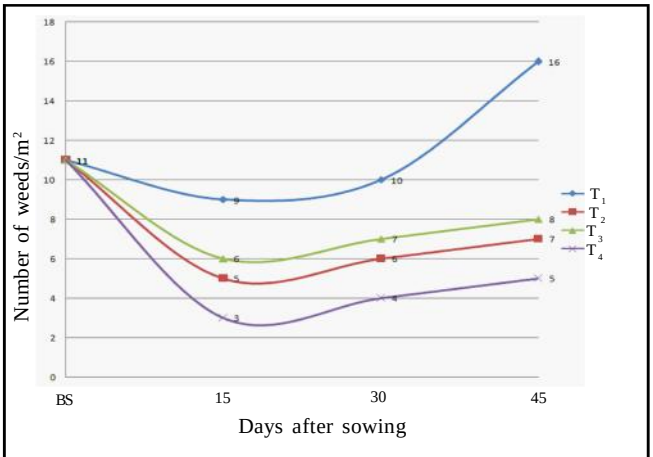

Fig. 15 : Number of weed counts days after sowing under different treatments

Grain yield:

The estimation of grain yield in various treatment was estimated by measuring the plot cutting yield. This was done by measuring the grain yield production/m² area in plot under a particular treatment. The plot cutting yield in treatments T_1, T_2, T_3 and T_4 was found to be 48.3, 49.2, 49.8 and 51.7q/ha, respectively as shown in Fig.16. the figure shows that the yield was minimum 48.3q/ha in treatment T_1 followed by T_2, T_3 and T_4. This trend shows that better manipulation of soil providing seed bed conducive to plant growth as resulted in more grain yield.

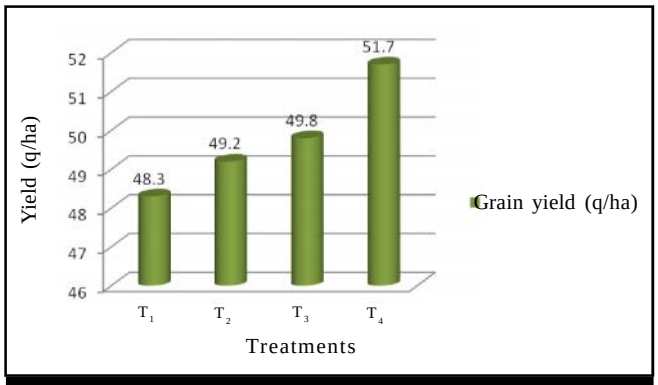

Fig. 16 : Crop yield under different treatments

Straw grain ratio :

The Fig.17 shows that the straw grain ratio in different treatments. It was found to be 1.2:1, 1.27:1, 1.34:1 and 1.23:1 in treatments T_1, T_2, T_3 and T_4, respectively. The straw grain ratio in treatments T_1, T_2, T_3, and T_4 can said to be very close than the observed value under treatment T_4. The highest (1.34) straw grain ratio in case of treatment T_4 was found. It may be due to reason that in this treatment number of plants/m length more than other treatments as shown in Fig. 11.

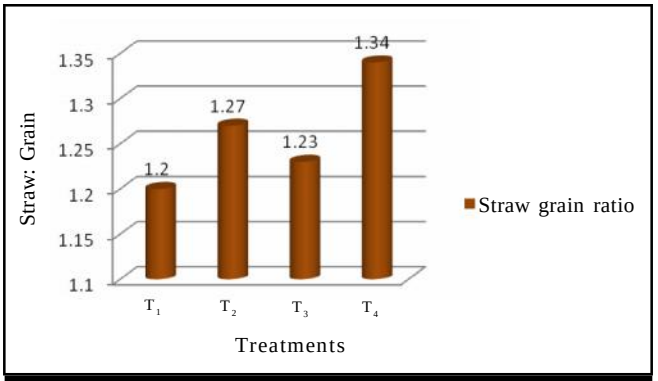

Fig. 17 : Straw grain ratio under different treatments

Weight of 1000 grain :

The Fig.18 shows that the weight of 1000 grain observed under all treatments. It was found to be 39.3g, 40.1g, 39.1g and 39.1g in treatments T_1, T_2, T_3 and T_4, respectively. Due to all over cause it can be said that practically there is no variation in grain weight under different treatment as difference is minimal.

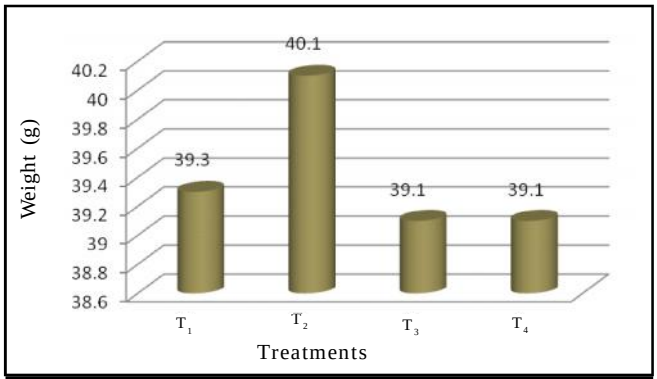

Fig. 18 : Weight of 1000 grain under different treatments

Conclusion:

The initial bulk density of soil reduced in treatment T_1, T_2, T_3 and T_4 as the soil manipulation occurred. The bulk density increased with days of sowing and on 100 DAS. It was minimum (1.73g/cc) as compare to other treatment as more soil opening and manipulation occurred in the treatments. The soil moisture content after sowing decreased in all the treatments at different depths. The highest reduction was observed in treatment T_4 due to more tillage operation and used of raised bed planter. Better soil pulverization was observed in case of treatment T_2 where seed bed was prepared by rotary tiller. The cone index of soil was increased with depth. It was found to be minimum at different depths in treatment T_4 which includes 1 x cultivator followed by 2 x disc harrow then sowing by using raised bed planter. The similar trend was observed even at 100 DAS. The plant height varied in different treatments till 15 DAS, however, at latest age of crop growth. The plant height was near to each others though it was more in treatments T_3 and T_4. This is because soil was tilled deeper which probably helped in more root growth. The number of plants/m length, seed emergence was minimum in

treatment T_1 and similar in other treatment. The plant population was also less in treatment T_1 and similar in treatment T_2, T_3 and T_4. It was found more in treatment T_4. Other than treatment T_1 tillers was found more in other treatments. Length of ear head in all the treatment was almost similar. The weed count was found to be minimum in treatment T_4 and maximum in treatment T_1 as there was no soil manipulation in treatment T_1. The crop cutting yield was minimum (48.3q/ha) in treatment and maximum in treatment T_4 (51.7q/ha), in treatments T_2 and T_3 there is slight difference in grain yield. The straw yield was minimum (57.95q/ha) in case of treatment T_1 probably due to less tillers and less plant population. 1000 grain weight was found similar in all the treatments. The field efficiency was found to be maximum (77.02%) in treatment T_1 and minimum (60.91%) in treatment T_4. This is because maneuverability and initial in case of zero till dril.

Authors' affiliations:
Rajneesh Patel, Central Farm Machinery Training Testing Institute, **Budni (M.P.) India**

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