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Performance of Zero-Till Drill for Wheat Cultivation at Farmer's Fields

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Abstract: ***Feasibility testing and field evaluation of Pantnagar zero-till drill was conducted at farmer's fields during the years growing seasons 2011/12 and 2012/13. The performance evaluation of zero-till ferti seed-drill was carried out in an area of 0.20 ha at farmer's fields at Ambedkar Nagar district, Uttar Pradesh. It was observed that there was no effect of stubble on the performance of zero-till ferti seed-drill. However, the loose straw spread on the surface offers some hindrance in the working of the drill. The zero tillage sowing was found to be most time (88%) and energy efficient (79%) as compared to conventional method of sowing. Wheat crop can be sown 10-15 days early as compared to conventional method of sowing. This will result in timely sowing of wheat crop and increase in yield. The zero tillage sowing was more economical (79%) in comparison to conventional method. It was observed that zero-till drill system was found an acceptable machine by the farmers of district of Baghpat (U.P.) because the zero-till drill system gabe highest benefit cost ratio (1.76) in comparison to conventional system.***

Keywords: Fertilizers, Irrigation, source of power, tillage, wheat and zero-till drill machine

1. Introduction

Tillage is a major time and energy consuming crop production operation. India is one of the main wheat producing and consuming country of the world. After the Green Revolution, the production of wheat has shown a huge increase. The major states involved Uttar Pradesh, Punjab and Haryana. They account for nearly 70 percent of the total wheat producton the country. Punjab and Haryana yield the highest amount of wheat because of the availability of better irrigation facilities. In traditional agricultural systems wheat populations often consist of landraces, informal farmer-maintained populations that often maintain high levels of morphological diversity. Although landraces of wheat are no longer grown in Europe and North America, they continue to be important elsewherer. Rice-wheat copping system is very common in India. It contributes to over 70 per cent of total food grain production of the country, with an area of 12 Mha under this cropping system. It is necessary that production of rice and wheat must keep pace with the growing population of our country. Delay sowing due to presence of crop residue reduced crop yield of 30-40 kg per ha per day (Berawall, 1995 and Hobbs, 1988) if crop is sown after mid November. This loss can be saved through early seeding of wheat by no tillage techniques. This technique advances the sowing operation by 10-15 days and also reduces the cost of production by saving energy. The zero tillage technique also improves the soil environment for crop growth, reduces erosion, conserves the time and energy and decreases the cost of farming (Edminikster and Miller, 1959). Keeping above facts in view, study was conducted to see the Performance evaluation of zero till ferti seed drill with conventional and reduced tillage method by sowing of wheat and study of economy and energy consumption in zero-till ferti seed-drill in comparison to conventional system.Thus, it is necessary that production of rice and wheat must keep place with the growing population of our country. However, the factors such as degradation in natural resource shift in cropping pattern and energy constraints etc. are causing reduction in the productivity of these crops. in irrigate rice-wheat system; rice is mostly transplanted in puddle field. He seed bed preparation for wheat after rice harvest is difficult due to the presence of crop residue particularly when rice is harvested by combine. It requires number of tillage operation. Farmers generally perform tillage operation as many as possible with the belief that more tillage would result in more crop yield. This causes delay in sowing which result in reduced crop yield of 30-40 kg per ha per day if crop is sown after 13th Nov. (Beranwall 1985 and Hobbs ET, 1991). Buhtz et al. (1970) reported that higher emergence under zero-tillage was obtained on medium textured soil in short stubble with friable soil surface. It was due to higher moisture availability in upper surface zone. Further they observed that numerous furrows created by the increased number of earthworms helped in higher concentration of oxygen under zero-tillage. Chaudhary (1998) conducted the field experiment to investigate the effect of zero-till, strip till and conventional tillage sowing system on soil physical properties, total fuel and time requirement and crop establishment. He reported that the zero till sowing of wheat after rice harvesting was moist time saving as compared to strip till and convectional sowing method. In case of zero till and strip sowing the yield was obtained almost equal, however, it was higher as compared to conventional method and sowing. Pop et al. (1998) observed that deep ploughing to a depth of 30 to 40 cm increased that water content of soil in spring more that did ploughing to 20 cm. It also led to increased development of wheat roots. Niclsen (1990) also reported that labour requirement could be reduced by 55 to 65% in reduced

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tillage and compared with conventional method. The fuel consumption also fell from a maximum of 49 lit/ha for conventional ploughing to maximum of 18 lit/ha for direct drilling. Singh and Singh (1995) developed a nine tyne zero till ferti seed drill having invested-T tyne furrow opener for timely sowing of wheat after the harvest of rice. The performance of the machine was evaluated in combine harvester rice field during growing seasons 1991/92 and 1992/93. The results have indicated that the crop sown by zero till ferti seed drill gave almost equal yield as compared to the conventional method of wheat sowing. The zero till sowing technique was found to be more time and energy efficient, wheat sowing was reported to be advanced by 10-15 days. The performance of the drill was found more satisfactory in burnt rice residue field. Verma (1986) obtained similar establishment of wheat under conventional and no-tillage conditions following transplanted rice indicated that wheat can easily be stabilized without ploughing the land by 4 to 6 times. Yan et al. (1986) while studying no-tillage technique for wheat in rice stubbles field have reported that root number and root length of wheat did not differ significantly with ploughing experiment. Considering the above points, feasibility testing of Pantnagar zero-till drill was done at farmer's fields during last two years (2012/13). he comparison was made between Pantnagar zero-till drill, reduced tillage and conventional method of sowing (broadcosting). Reduced tillage not only conserves the time and energy, but also reduces the cost of cultivation, improves soil environment for better crop yield and increased water availability for plant growth Sandhu, 1981 reported that wheat could be grown after paddy without any tillage operations. Shukla (1987 and 2001), Shrivastava (2005) and Choudhary (2002) reported that the performance of strip, zero and conventional till system for wheat cropping gave better results in the light soil.

2. Materials And Methods

2.1 Laboratory Testing

The eleven furrows tractor mounted Pantnagar zero-till drill seed cum ferti-drill of "National" make was tested in laboratory before taking to actual field conditions. PBW-343 variety of wheat was selected for the study. The seed were passed through the groves of the fluted roller to check the regularity of flow and damage. Due to smooth and shining surface the flow was regular and no damage either internal or external was found in the germination test. The line to line spacing of zero-till drill was adjusted at 20 cm. The machine was calibrated for 100 kg/ha normal conditions. The calibration for fertilizer (100) kg DAP + 20 kg sulphur per hectare was also done.

2.2 Calibration of zero-till drill

The seed-drill was calibrated for wheat sowing using the metering mechanism. The seed-drill was placed on a level ground and jacked up to facilitate the rotation of ground drive wheel freely. Laboratory test was carried for ten revolution of ground drive wheel for each exposure length of fluted rollers. The following equation was used to determine the seed rate.

$$W = \frac{q\left(1-\frac{S}{100}\right)}{\pi D n d} \times 100000$$ Where, W = Seed rate, kg/ha

q = Quality of seed dropped from all furrow opener per revolution of ground drive wheel, g n = number of furrow openers

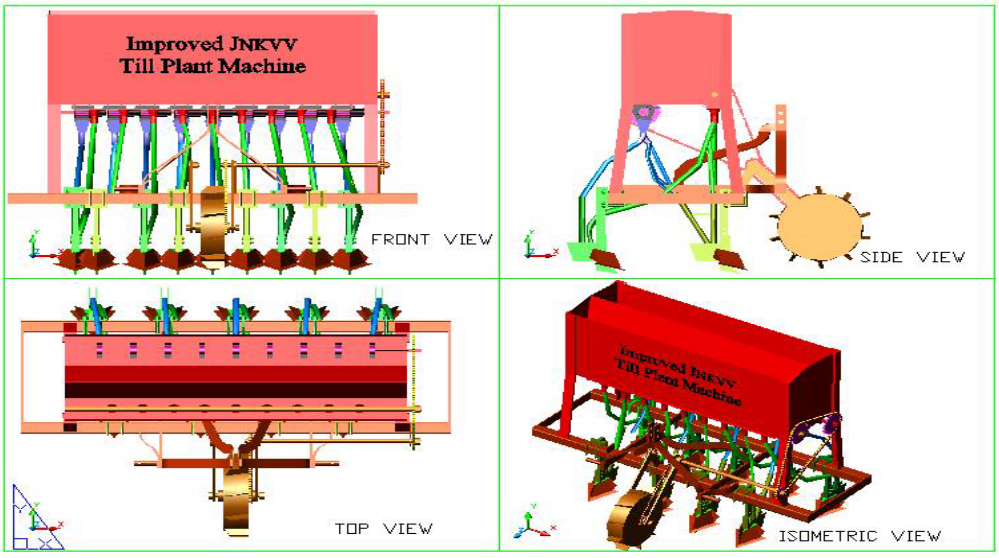
d = distance between two successive openers, cm

S = slip, (%)

D = diameter of ground drive wheel, cm



Figure 1: Zero-Till Ferti Cum Seed Drill Macine



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2.3 Field Testing

The Pantnagar zero-till ferti-seed drill (Fig.1 and 2) was developed by the Department of Farm Machinery and Power Engineering, College of Technology, G.B.Pant University of Agriculture and Technology, Pantnagar, Uttaranchal. The zero-till ferti seed drill was made of mild steel angle iron of size 68.0 x 68.0 x 8 mm with square cross-section. Spacing between two furrow openers was 22.5 cm having nine furrows. The seed and fertilizer box of existing zero-till ferti seed–drill was made by using mild steel sheet. The capacity of seed and fertilizer boxes was 50and 40 kg, respectively. The slope provided in seed and fertilizer boxes were about 23 to 28 degree and 62 degree, respectively. The seed metering device used in drill was of fluted roller type having 10 numbers of groves fitted in 16mm size shaft. These rollers are especially suitable for seeding wheat crop the metering mechanism for fertilizer was of hole mesh type. Star type agitators were provided in the fertilizer box to avoid bridging of fertilizer. The special feature of the Pantnagar zero-till ferti seed-drill was that it utilizes a different type of furrow opener termed as inverted –T type furrow opener which makes slit in untilled soil without much disturbing it. Fig 1 and 2 shows the details of an inverted-T type furrow opener. The blade of furrow opener was made of 8mm thick mild steel plate having hardness of 116 RHN. The rake and relief angles had been kept at 20 degree and 5 degree, respectively. The power to the seed and fertilizer metering device is transmitted through a 380 mm diameter. Lugged ground drive wheel and chain sprocket system. The zero-till ferti-seed drill was field evaluated in comparison to different tillage and seeding systems for raising wheat crop during the Rabi season over an area of 0.20 ha at farmer's field and Ambedker Nagar district of Uttar Pradesh. The average height of paddy stubbles was 5.03 cm and average moisture content and bulk density of soil were 17.25% and 1.62 gcm-3, respectively. The test field was devided into twelve equal plots of size 25m x 6m. The experiment was laid out in a randomized block design with replications. The performance evaluation of Pantnagar zero-till seed cum ferti drill was tested in field conditions having organic carbon 0.25%, pH 7.0, bulk density (0-12 cm depth) 1.39 g/cc and cone index 4.20 kg/cm^2 (at 7.2 cm depth). Three treatments of four replications were considered in RBD statistical design in 50m × 3m^2 plot size to run the machine easily. The different treatments adopted for the study were as follow:

S.N.	Plot	Tillage and seeding operation	Sowing date
1.	T_1	Disc harrowing × 2 + cultivating with planking × 1 + planking × 1 + seeding by seed-cum ferti drill	30.11.2012
2.	T_2	Disc harrowing × 1 + cultivating with planking × 1 + planking × 1 + seeding by seed-cum ferti drill	30.11.2012
3.	T_3	Power tiller rota tilling × 1 = tractor planking × 2 + seeding by tractor drawn seed-cum ferti drill	30.11.2012
4.	T_4	Zero-till ferti drill machine	30.11.2012

The rice field was harvested on 10th Nov., 2012 and left the crop for drying in field for three days and then removed on 13th Nov., 2012. The plots were irrigated on 14th Nov., 2012 due to depleting moisture and were not suitable for seeding directly after harvesting. The sowing was done on 30th Nov., 2012 by zero till drill in first treatment, Table 1.

Table 1: Performance results of Pantnagar zero-till ferti drill machine in comparison to other systems of wheat crop production at Farmer's fields

S. N.	Particular	Treatments			
		T_1	T_2	T_3	T_4
1.	Testing date	30.11.2012	30.11.2012	30.11.2012	30.11.2012
2.	No. of replication	3	3	3	3
3.	Test conditions				
	(i) Name of seed	Wheat	Wheat	Wheat	Wheat
	(ii) Varity	PBW-343	PBW-343	PBW-343	PBW-343
	(iii) Wt. of 1000 grains, gm	41	40	41	40
	(iv) Laboratory germination %	85	85	85	85
4.	**Condition of fertilizer**				
	(i) Name of fertilizer	(Urea+DAP)+MOP*			
	(ii) Shape of fertilizer	Granular, *Powder form			
5.	**Condition of field**				
	(i) Location	Farmer farm, Baghpat			
	(ii) Area of plot, m^2	50×6	50×6	50×6	50×6
	(iii) Shape of plot	Rectangular	Rectangular	Rectangular	Rectangular
	(iv) Type of soil	Lomay	Lomay	Lomay	Lomay
6.	**Condition of power source**				
	(i) Power source	Tractor	Tractor	PT& Tractor	Tractor
	(ii) Make & model	MF 1035	MF 1035	VST & MF	MF 1035
	(iii) Rated engine power, hp	35	35	1035	35
	(iv) Selected gear	IV Low	IV Low	10 & 35	IV Low
				II & IV Low	

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7.	**Condition of operator**				
	(i) Skill	Good	Good	Good	Good
	(ii) Wage, Rs./day	100	100	100	100
8.	**Field performance test**				
	(A) Tillage				
	a) Soil moisture content before tillage, %	17.20	17.20	17.25	17.30
	b) Soil moisture content after tillage, %	16.05	16.10	15.95	17.30
	(B) Bulk density				
	a) Soil bulk density before tillage, g/cc	1.35	1.30	1.40	1.62
	b) Soil bulk density after tillage, g/cc	1.46	1.40	1.40	1.62
9.	**Size of tillage equipment**				
	i) PT Rotavator, cm	-	-	60	-
	ii) Cultivator , cm	9×20	9×20	9×20	9×20
	iii) Disc harrow, cm	6×30	6×30	-	-
10.	**Speed of tillage equipment**				
	i) PT Rotavator, km/h	-	-	2.15	-
	ii) Cultivator, km/h	4.5	4.5	-	-
	iii) Disc harrow, km/h	4.5	4.5	-	-
11.	**Field capacity of tillage equipment**				
	i) PT Rotavator, ha/h	-	-	0.10	-
	ii) Cultivator+Planker, ha/h	0.50	0.50	-	-
	iii) Disc harrow, ha/h	0.80	0.80	0.80	0.80
	iv) Planker, ha/h	0.80	0.80	0.08	0.80
12.	**Field efficiency of tillage equipment**				
	i) PT Rotavator, %	-	-	77.50	-
	ii) Cultivator, %	61.72	61.72	-	-
	iii) Disc harrow, %	61.72	61.72	-	-
	iv) Planker, %	88.80	88.80	-	-
13.	**Time required for seed bed preparation, h/ha**	7.25	5.25	10.00 (PT) + 2.50 (Tractor)	-
14.	**Cost of seed bed preparation, Rs/ha**	1812	1312	1625	-
	(A) Tillage				
	i) Tractor@250				
	ii) PT@100				
	(B) Sowing seed rate				
	i) Calibrated, kg/ha	100	100	100	100
	ii) Actual, kg/ha	98	97	98	97
	(C) Fertiloizer rate, kg/ha				
	i) (Urea:DAP), 1:1.64	210	210	210	210
15.	Size of sowing equipment, cm	9×20	9×20	9×20	11×18.50
16.	Speed of sowing equipment, km/h	4	4	4	4
17.	Field capacity of sowing equipment, ha/h	0.5	0.5	0.5	0.48
18.	Field efficiency of sowing equipment, %	69.44	69.44	69.44	62.96
19.	Time required for sowing, h/ha	2.00	2.00	2.00	1.96
20.	Total time for seed bed preparation and sowing, h/ha	9.25	7.25	14.50	1.96
21.	Depth of seed placement, cm	4.00	4.00	4.00	4.00
22.	Depth of fertilizer placement, cm	4.00	4.00	4.00	4.00
23.	Fuel consumption (in tillage and seeding), lit/ha	27.75	21.75	23.50	5.88
24.	Cost of sowing, Rs./ha	500	500	500	450
25.	Total cost of seed bed preparation and sowing, Rs/ha	2312	1812	2125	450
26.	Total cost of 4 irrigation, Rs/ha	3500	3200	2800	2600
27.	All other inputs (Fertilizers, weeding, harvesting and threahing etc.), Rs./ha	8000	8000	8000	8000
28.	Cost of cultivation, (25+26+27), Rs./ha	13812	10132	10925	11050
29.	Net saving over convectional, Rs./ha	-	600	585	2200
30.	Percent saving, %	-	4.62	4.32	15.69
31.	Time saving, w.r.t., T_1 h/ha, %	-	+2(+21.6)	-5.25(-56.75)	(+78.80)+22.9
32.	**Direct energy use, mJ/ha**				
	a) In tillage	1245.32	903.54	1014.82	-
	b) In sowing	345.70	345.70	345.70	338.78
33.	Total direct energy use, mJ/ha	1591.02	1249.24	1360.52	338.78
34.	Percent energy saving w.r.t., T_1, %	-	21.48	14.48	78.70
35.	Grain output cost @1000 Rs./q	40300	39600	40400	40200
36.	Straw output cost@ 200 Rs./q	12446	11880	11626	11958
40.	Total income (35+36), Rs./ha	52746	51480	52026	52158
41.	Net benefit, (25+28), Rs./ha	38934	41348	41101	41108
42.	Benefit-cost ratio, (BCR)	1.36	1.41	1.42	1.76

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2.4 Field preparation

Field preparation under conventional tillage seeding system (T_1) was done by harrowing twice using twelve disc trailed type off set disc harrow operated by 35 hp tractor followed by single cultivating using nine tyne spacing loaded cultivator with planker operated by 35 hp tractor followed by one planking using tractor drawn planker of two meter size. After the field preparation wheat seeding was done by tractor drawn eleven rows seed cum ferti drill. In reduced tillage system (T_2) field preparation was done by single harrowing following by single cultivating with nine tyne cultivator with planker followed by one planking using the tractor drawn planker. After the field preparation wheat seeding was done by tractor drawn eleven rows seed cum ferti drill. In minimum tillage system (T_3) field preparation was done by single rota tilling using 8 hp power tiller rotavator followed by twice planking using tractor. Wheat seeding was done by tractor drawn eleven rows seed cum ferti drill. In zero-till system (T_4) wheat seeding was done by inputs like fertilizers, irrigation were used in same quantity as per recommended package of practice for wheat crop production.

3. Result and discussion

3.1 Comparative Performance of Different Treatments

The performance results of the experiment conducted at different farmer's fields have been given in Table 1. The average value of two years has been tabulated and the last year data of seeding and field preparation has been recorded. The total numbers of weeds were recorded as 3, 10 and 25 weeds/m^2 in T_1, T_2, T_3 and T_4 respectively. The weeds found were *Chenopodium album* and *Phalaris Minor* only. The saving in man hour per hectare was recorded as 15 and 32 in T_1 and T_3 respectively.

3.2 Effect of Different Treatments on Yield Attributes

Different parameters which effects the yield of wheat crop for various treatments are given in Table 2. The data in Table 2 indicates that germination count at 21 DAS in T_1, T_2, T_3 and T_4 were 160, 148, 168 and 160 numbers per square meter.

Table 2: Effect of different treatments on yield attributes

S. No	*Particulars*	*Treatments*			
		T_1	*T_2*	*T_3*	**T_4**
1.	Germination counts at 21 DAS*, no/m^2	160	148	168	160
2.	Plant population at maturity (no./m^2)	543.33	540.33	545.33	565
3.	Crop stands	Good	Average	Average	Good
4.	Colour of crop	Dark green	Yellowish green	Yellowish	Dark green
5.	Tillering, no/plant	8.8	8.6	9.1	8.7
6.	Plant height, cm	81.0	88.7	89.4	89.9
7.	Length of ear head, cm	10.7	10.5	10.8	10.4
8.	No of grains per ear head	53.73	52.33	52.80	52.06
9.	Grain yield, q/ha	40.30	39.60	40.40	40.20
10.	Straw yield, q/ha	62.23	59.40	58.13	59.79

*DAS: Days after saving

3.3 Feasibility testing of zero-till ferti drill for wheat sowing at Farmer's Fields

Pantnagar zero-till ferti drill was also field evaluated at farmer's fields for raising wheat crop after paddy and toria crops in comparison to conventional method wheat seeding after seedbed preparation. Average effective field capacity of eleven rows zero-till ferti drill was 0.4 to 0.52 ha/h. Data related to machine performance, crop growth and yield are presented in table 1. Data showed that average tillering (no/plant) and plant population (no/m^2) of wheat crop at maturity were 8.85 and 575.71 under zero-till ferti drill and 7.14 and 577.57 under conventional system. This showed that tillering and plant population was approximately same in both the systems average wheat grain yield (q/ha) was 44.42 in zero-till ferti drill and 44.08 in conventional method, which showed grain yield of 0.76% through it was statistically non-significant.

3.4 Effect of the farmers after crop establishment

Wheat seed germinated uniformly in the rows without any gap using zero-till ferti drill. Incidence of Phalaris minor (Gehun ka Mama or Gulli Danda) was reported minimum. Numbers of weeds in general were reported to be lesser in zer-till ferti drill than conventional system. About 25% water saving was observed in first irrigation in zero-till ferti drill with that of conventional system. The farmers reported saving in time of sowing as well as in cost of cultivation as the expenditure incurring on field preparation was saved to the extent of Rs. 2000.00 /ha. There was saving of 50-75 kg/ha seed @150-175 kg ha while zero-till ferti drill machine needed only 100 kg seed/ha. Numbers of plants with zero-till ferti drill machine sowing were 576.00 plants/m^2 which were at a with seed drill sowing 577 plants/m^2. Numbers of tillers reported with zero-till ferti drill machine sowing were 8.75/plant while they were 7/plant with seed drill. The grain yield received with zero-till ferti drill machine was about 44.55 q/ha that was slightly higher than convectional system in which it was about 43.98 q/ha. Thus farmers appreciated the machine and sowed interests in its use. They wanted to use the machine for large area seeding in the next rabi season.

The performance evaluation of 9 rows zero till ferti seed drill was conducted by rising of wheat crop in field during rabi season. It is evident from table 1 that initial moisture content was maximum in T4 system and bulk density also. The field capacity of zero till ferti seed drill was found slightly higher than other treatments but field efficiency was less due to presence of crop residue and no seed bed preparation. Fuel consumption in tillage and seeding system was very less i.e. 5.88 Lha-1 in T4 system in comparison to other treatments which indicates much saving of fuel in zero till ferti seed drill system. The data pertaining to germination count collected at 21 (DAS) showed (Table2) that the plant establishment was satisfactory in zero till ferti seed drill system and only 4.76 per cent less than maximum plant establishment T3 system. The maximum plant height in treatment T1 that was 1.24 percent higher than zero till ferti seed drill system. The maximum tillering in treatment T3 was (3.9%) higher than zero till ferti seed drill system which was statistically non-significant. The data revealed that the

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grain yield under zero till ferti seed drill system was only 0.50 per cent lower than treatment T3 which gave highest yield (4.040 t ha-1).

The data regarding direct energy use under different systems of wheat crop seedbed preparation and seeding are given in table 1 the total direct energy use for seedbed preparation and sowing of wheat crop was 1591.02, 1249.24, 1360.52 and 338.78 MJha-1 under T1, T2, T3 and T4 systems, respectively. The saving in direct energy use in zero-till ferti seed-drill (T4) system was 78.70, 72.88 and 75.10 percent in comparison to T1, T2 and T3 systems, respectively. Data related to economic aspects under different tillage and seeding system for raising wheat crop are given in table 4.Total cost of seedbed preparation and seeding (Rsha-1) was 1665, 1305, 1610 and 353 under treatments T1, T2, T3 and T4 systems, respectively. Data showed that zerotill ferti seed-drill (T4) system gave 78.79, 72.95 and 78.10 per cent saving with that of T1, T2 and T3 systems, respectively. The average cost of irrigation (Rsha-1) was 3159.50, 2937.00, 2670.00 and 2492.00 under treatments T1, T2, T3 and T4 systems, respectively. This showed that in zerotill ferti seed-drill (T4) system also gave 21.13, 15.15 and 6.67 per cent saving over T1, T2 and T3 systems, respectively in irrigation. The total net benefit (Rsha-1) under different systems T1, T2, T3 and T4 was Rs. 16984.50, Rs. 16818.00, Rs. 17177.00 and Rs. 18662.00, respectively. Data showed that zero-till ferti seed-drill (T4) system gave highest benefit, which was 10.96, 9.9 and 9.03 % higher than T1, T2 and T3, respectively.
The benefit cost ratio was 1.35, 1.40, 1.42 and 1.75 under different treatments T1, T2, T3 and T4 , respectively. The benefit cost ratio was also highest in zero-till ferti seed-drill system as there was no expenditure on seedbed preparation with less expenditure in irrigation. This system also gave approximately the same yield in comparison to other treatments. Thus zero-till ferti seed-drill system was found most economical and gave highest benefit cost ratio than conventional wheat crop raising system and other reduced tillage systems studied under this investigation. It can be concluded that the intensive tillage may not be necessary for wheat crop in paddy-wheat rotation and there is sufficient scope to reduced tillage operations for seed bed preparation of wheat crop. There is no effect of stubble on the performance of zero till ferti seed drill. However, the loose straw spread on the surface offers some hindrance in the working of drill. The zero tillage sowing was found to be most time, energy saving and reduces cost of production as compare to conventional method of sowing. Wheat crop can be grown 10-15 days early that will result in timely sowing of wheat crop and increases in yield. Another advantage of zero tillage is that it reduces the cost of irrigation which was more economical in comparison to conventional method of sowing.

4. Conclusions

The following conclusions were drawn from this study:

- There is no effect of stubble on the performance of zero-till ferti drill. However, the loose straw spread on the surface offers some hindrance in the working of the drill.
- The zero-till ferti drill sowing was found to be most time (88%) and energy efficient (79%) as compared to conventional method of sowing.
- Wheat crop can be 10-15 days earlier as compared to conventional method of sowing. This result in timely sowing of wheat crops and increase in yield.
- In zero-till ferti drill system the average cost of irrigation 2592.0 Rs./ha which was 667.5 Rs./ha lesser in comparison to convectional system and give 21% saving.
- The zero-till ferti drill sowing was more economical (79%) in comparison to conventional method of sowing.
- The zero-till ferti drill work satisfactory and gab no trouble in the field while operating.
- It was observed that zero-till ferti drill system was found an acceptable machine by the farmers of district Baghpat, (U.P.) because the zero-till ferti drill system gabe highest benefit cost ratio (1.76) in comparison to conventional system.

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