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Effect of Tractor Forward Speed on Field Performance of Zero Till Seed-cum Fertilizer Drill in Tilth and un-tilth Sandy Loam Soil

DHARMENDER*, SUBHASH CHANDRA, AMIT KUMAR AND NIRAJ KUMAR

ABSTRACT

The zero till seed-cum-ferti-drill was assessed for field performance in sandy loam soil under tillage and no-tillage soil conditions at variable forward speed of tractor. With increase in forward speed of tractor, field capacity of the machine was in increasing order in all treatments, in tilth and un-tilth soil. Field efficiency of machine in tilth soil was initially increasing with tractor speed with maximum value 94.71% at 3.39 km/h. However, in un-tilth soil, it was highest (94.17%) at slowest speed i.e. 1.73 km/h and remained almost constant around 92% upon increase in tractor speed up to 4.32 km/h. The tractor wheel slip percentage started decreasing with increase in tractor speed and was in minimum range between 6.35-7.59% in tilth soil and between 16.03-15.55% in un-tilth soil in treatments at rated speed of the tractor between 3.62-4.77 km/h. Drive wheel skid in no-tillage condition of soil was found minimum at 5.69 km/h forward speed of tractor for zero till-seed-cum-ferti-drill and the same was observed to be in decreasing order with increase in tractor forward speed. However, in tilth soil, drive wheel skid was remained in between 14.94%-19.05% with increase in tractor forward speed. Seeding efficiency of zero till-seed-cum-ferti-drill was observed to have been influenced by the drive wheel skid, and had direct as well as inverse co-relation with increase in tractor forward speed in un-tilth and tilth soil, respectively. Obviously, design characteristic of zero till-seed-cum-ferti-drill is better suited for its use in no-tillage soil condition to achieve higher seeding efficiency, field capacity and field efficiency.

KEYWORDS

Field efficiency, tilth soil, untilth soil, wheel slip, zero tillseedcumferti drill

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INTRODUCTION

Wheat is the second most important stable food grain of the country as well as of Bihar. It is cultivated in 30.42 million hectares in India with production, 98.38 million tonnes. The area and production of wheat in Bihar is 21.01 lakh hectares and 61.04 lakh tonnes, respectively (Kumar and Chandra, 2019). Broadcasting of seeds in ploughed field is still a popular method of wheat cultivation in the state being, adopted by the majority of farmers. Although line sowing of wheat seeds has been found to be advantageous from yield point of view (Lathwal and Malik, 2005), very few farmers are using seed drill/Zero till seed-cum-ferti drill for wheat cultivation. Even the line sowing under no tillage condition with zero till drill has been found giving higher yield in another crop like chickpea also as compared to the conventional practices with additional gain in saving of the cost of cultivation (Shrivastava *et al*, 2012). Adoption of zero till-cum-ferti-drill is governed by many parameters including the field condition (Kumar and Chandra, 2019). Mishra (2015) had also reported about the effect of tillage system on seeding performance of seed drill for wheat crop. The seeding behaviour of seed drill/ zero till-cum-ferti-drill is greatly influenced by the soil condition and tractor speed attributing to the tractor wheel slip as well as drive wheel skid of the equipment. According to (Choudhary and Singh, 2002) the performance of zero till system in wheat cropping gives better results in light soil. The slippage of drive wheel has been found a factor of tractor forward speed in a study conducted by Ramesh et al (2016). Therefore, the present study relates to the assessment of impact of tractor forward speed on field performance of zero till seed-cum-fertilizer drill in tilth and un-tilth sandy loam soil of Pusa.

MATERIALS AND METHODS

The experiment was carried out in research farm of Dr. Rajendra Prasad Central Agricultural University, Pusa in the year 2016. The experimental plot was located at an altitude of 52.99 m above the mean sea level with $25^0$59′ N latitude and $85^0$48′ E longitude. The climate was sub-tropical with the average rainfall 1234 mm. the characteristics of the experimental plot is described in Table 1.

Treatments and Replications

The experiment was conducted with 6 treatments and in 5 replications for both types of field conditions i.e. field with tillage and no-tillage. Special device was made to fix the throttle at 3-different positions. The tractor was operated in high and low gear positions at every position of throttle. The description of forward speed of tractor and engine RPM at different throttle position is given in Table 2 .

[1] Deptt. of Farm Machinery & Power Engg., College of Ag. Engg., Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar- 848125, India
*Corresponding author email: amitcae02.13@gmail.com

Table 1: General information aboutexperimental plot

S. No.	Particulars		Numerical value
01	Bulk density of soil, g/cc	Before tillage	2.28
		After tillage	1.33
02	Moisture content of the soil, %	Before tillage	14.45
		After tillage	8.76
03	Soil composition, %	Sand	43
		Silt	46
		Clay	11
04	Soil texture	Silty loam	-
05	Status of crop residue in un-tilth plot	Previous crop	Paddy
		Average height of residue, cm	19.33
		Average no. of hills, per sq m	33

Experimental design

The experiment was conducted in randomized block design (RBD).

Determination of various parameters

Forward speed of tractor

The forward speed of tractor was determined with implement under mounted position (no load) as well as with implement in working condition in field (load) respectively at different throttle positions both in high and low gears on straight track of 60 m length in tilth and un-tilth soil. The speed of tractor with implement under mounted condition was termed as rated speed. The speed of operation was determined by formula.

$$Speed\ of\ operation\ (km/h) = \frac{Dis\tan ce\ travelled(m)}{travel\ time\ (s)} \times \frac{3600}{1000} \text{ (Eq.1)}$$

Calibration of zero till-cum-ferti-drill

The zero till-seed-cum-ferti-drill was calibrated for delivery of seed at rate 64 kg/ha by using standard method of calibration as being usually used for scientific purposes.

Table 2: Forward speed (S) of tractor and engine RPM at different throttle position

S. No .	Throttle position	Gear position	Treatments	Rated tractor Speed, in km/h		Engine RPM of Tractor
				Tillage	No-tillage	
1	1^{st}	1^{st} low	S1	2.26	2.04	780
		1^{st} high	S2	3.22	3.02	780
2	2^{nd}	2^{nd} low	S3	3.62	3.68	1280
		2^{nd} high	S4	4.74	4.79	1280
3	3^{rd}	3^{rd} low	S5	5.37	5.46	1650
		3^{rd} high	S6	7.03	7.16	1650

Bulk density

The bulk density of the experimental plot before and after tillage was determined by using core soil sampler through formula:

$$Bulk\ Density\ (D_b\ in\ gcm^{-3}) = \frac{M_s}{V_t} \quad \text{(Eq.2)}$$

Where,

M_s= M_f-M_c = Mass of soil, in g

M_c = Initial mass of core sampler, in g

M_f = final mass of core sampler (mass of soil+ core sampler), in g

V_1= $3.141r^2l$= Volume of core, in cm3

Where, r and l are radius and length of the core in cm, respectively.

Moisture content of the soil

Moisture content of soil was determined by using formula:

$$Soil\ Moisture\ content(\%) = \frac{M_2 - M_3}{M_3 - M_1} \times 100 \quad \text{(Eq.3)}$$

Where,

M1= Mass of empty soil moisture box (g)

M2= Mass of moisture box + moist soil (g)

M3= Mass of moisture box + dry soil (g)

Seeding efficiency (%)

Seeding efficiency zero till-seed-cum-ferti-drill was determined by formula.

$$Seeding\ \eta\ (\%) = \frac{Actual\ seed\ rate\ delivered\ by\ machine}{Calibrated\ seed\ rate} \times 100 \text{ (Eq.4)}$$

Wheel slip (%)

$$Wheel\ Slip(\%) = \frac{SR - SL}{SR} \times 100 \quad \text{(Eq.5)}$$

Where,

SR= Rated tractor forward speed corresponding to different gear settings with seed drill, as attachment in mounted position.

SL= Actual forward speed of tractor, corresponding to different gear settings with seed drill, as attachment in working condition.

Drive wheel skid (%)

$$Drive\ wheel\ skid(\%) = \frac{DsT - DsA}{DsT} \times 100 \qquad \text{(Eq.6)}$$

Where,

DsT= Theoretical distance covered by the seed drill in known number (say, N) of revolution of drive wheel of seed drill.

DsA= Actual distance covered by the seed drill in the same number (say, N) of revolution of drive wheel of seed drill.

RESULTS AND DISCUSSION

The tractor operated zero till-seed-cum-ferti-drill was operated in tilth and un-tilth soil at variable forward speed. The tractor wheel slip, drive wheel skid of seed drill and their impact on field efficiency as well as seeding efficiency were determined to judge the performance of machine in light textured soil under tillage and no-tillage condition.

Table 3: Field capacity and field efficiency of machine at different tractor forward speed

Treatments	Actual tractor forward speed while seeding by seed drill, km/h		Width of machine, m	Theoretical field capacity, ha/h		Actual field capacity, ha/h		Field efficiency (%)	
	T	NT		T	NT	T	NT	T	NT
S_1	2.12	1.73	2.07	0.44	0.36	0.372	0.339	84.55	94.17
S_2	3.02	2.56	2.07	0.63	0.53	0.541	0.477	85.87	90.00
S_3	3.39	3.09	2.07	0.70	0.64	0.663	0.588	94.71	91.88
S_4	4.38	4.02	2.07	0.91	0.83	0.821	0.771	90.22	92.89
S_5	4.95	4.32	2.07	1.02	0.89	0.917	0.812	89.90	91.24
S_6	6.41	5.69	2.07	1.33	1.18	1.166	0.979	87.67	82.97

T= Tillage, NT= No-Tillage

The data on field capacity and field efficiency, presented in Table 3 shows that the maximum field efficiency (94.71%) of machine in tilth soil is achieved at forward speed of tractor 3.39 km/h. In tilth soil, field efficiency of machine was initially increasing with increase in forward speed of tractor upto 4.38 km/h and thereafter started decreasing with increase in forward speed. However, in un-tilth soil the field efficiency was maximum (94.17%) at minimum tractor forward speed of 1.73 km/h. With increase in tractor forward speed, field efficiency slightly decreased and remained between 90%-92.89% upto 4.32 km/h. upon increase in speed of tractor beyond 4.32 km/h, field efficiency of machine started decreasing further.Similar trend were reported by Dauda *et al* (2013); Kankal *et al* (2016) in their studies where the effective field capacity increase with increases of tractor forward speed and also field efficiency. Initially increase in field efficiency of machine with increase in speed of tractor may be because of the fact that upto certain limit of tractor speed, its control on turning at turns in the field was easy and turning loss time was not increasing in spite of having increased theoretical field capacity accounted by the increased speed. However, upon increase in speed beyond 3.39 km/h, time for turning loss was increasing, as the tractor operator was taking extra precaution in controlling the speed of tractor before reaching the headland area and turning time was increasing also due to skid of front wheel of tractor in loose soil. In un-tilth soil, soil was hard and tractor front wheel grip on soil was better to control the skid at turns and that had accounted to lesser time loss in turning of machine at turns and accordingly, even upto the tractor forward speed of 4.32 km/h, the field efficiency of machine was above 90.0%. When the speed of tractor exceeded beyond 5.69 km/h in un-tilth soil due to issue of speed control at turns, turning time was increased and field efficiency decreased.

The data of tractor wheel slip at different forward speed has been complied in Table **??** and perusal of data shows that both in tilth and un-tilth soil, the wheel slip of tractor was increasing with increase in forward speed. In tilth soil the wheel slip was in minimum range between 6.19%-8.82% at forward speed of tractor between 2.26-7.03 km/h. In un-tilth soil the tractor wheel slip was varying between 15.19%-16.07% in the speed range of tractor between 2.04-4.79 km/h. However, in un-tilth soil upon increase in forward speed of tractor beyond 4.79 km/h, there was sudden increase in wheel slip of tractor and that showed an increasing trend with the increase in forward speed. The similar trend was reported by Askari and Abbaspour (2016).

Table 4: Tractor wheel slip during seeding at different tractor forward speed

Treatments	Rated tractor forward speed corresponding to different gear settings at no load situation, km/h		Tractor speed under seeding by seed drill under load condition, km/h		Tractor wheel slip during seeding by seed drill (%)	
	Tillage	No Tillage	Tillage	No Tillage	Tillage	No tillage
S_1	2.26	2.04	2.12	1.73	6.19	15.19
S_2	3.22	3.02	3.02	2.56	6.21	15.23
S_3	3.62	3.68	3.39	3.09	6.35	16.03
S_4	4.74	4.79	4.38	4.02	7.59	16.07
S_5	5.37	5.46	4.95	4.32	7.82	20.88
S_6	7.03	7.16	6.41	5.69	8.82	21.37

In tilth soil due to better penetration of tyre in soil, traction increases. Secondly, the loose soil does not offer much resistance to the furrow opener of the zero till-seed-cum-ferti-drill and thus wheel slip does not vary much even at increased forward speed of tractor. Contrarily, in un-tilth soil the surface remains hard and soil offers higher resistance to the furrow openers of the machine at higher velocity and there by causes more and more wheel slip of tractor with increase in its speed beyond the threshold limit.

Observation of data of drive wheel skid of zero till-seed-cum-ferti-drill presented in Table 5, indicates that in un-tilth soil the drive wheel skid of the machine had inverse co-relation with the forward speed of tractor and it was maximum (8.69%) and minimum (1.0%) at forward speed of 1.73 km/h and 5.69 km/h, respectively. However, in tilth soil there was no definite pattern in variation of drive wheel skid of the machine. It was fluctuating in nature, and was increasing and decreasing in the range of 14.94%- 19.05%, with increase in forward speed of tractor between 2.12 km/h-6.41km/h. With increase in speed of tractor, drive wheel of machine was rolling upon the ground with impact action. In un-tilth soil, the soil was compact and therefore was exerting reaction force on drive wheel to rotate it and thereby it was causing minimum skid with increase in speed. However, in tilth soil due to impact action of drive wheel on soil, there was displacement in the soil and this was causing the drive wheel to travel a short distance without causing rotation. Obviously, skid was more. Since, this skid was being attributed by the field condition, soil properties and soil condition the same was fluctuating due to undulation in field as well as variation in moisture within the field.

The seeding efficiency of zero till-seed-cum-ferti-drill calculated on the basis of calibrated seed rate and delivered seed rate both in tilth and un-tilth soil is presented in Table 6. Critical observation of data shows that, the seeding efficiency of the machine was ranging between 91.31%-99.0% in un-tilth soil with maximum value (99.0%) corresponding to the forward speed in treatment S6 (5.69 km/h).

Table 5: Drive wheel skid of seed drill at different tractor forward speed

Treatments	Tractor speed under seeding by seed drill, km/h		Theoretical distance covered by drive wheel in 35 revolutions, m	Actual distance covered by drive wheel in 35 revolutions, m		Drive wheel skid of seed drill, %	
	Tillage	No-tillage		Tillage	No-tillage	Tillage	No-tillage
S_1	2.12	1.73	49.46	57.63	53.76	16.52	8.69
S_2	3.02	2.56	49.46	58.88	52.96	19.05	7.07
S_3	3.39	3.09	49.46	56.85	53.18	14.94	7.52
S_4	4.38	4.02	49.46	57.57	50.98	16.27	3.07
S_5	4.95	4.32	49.46	58.88	50.47	19.04	2.04
S_6	6.41	5.69	49.46	58.19	49.95	17.65	1.0

Table 6: Seeding efficiency of seed drill in different treatments in tilth and un-tilth soil

Treatments	Tractor speed under seeding by seed drill, km/h		Calibrated seed rate (kg/ha)	Seed loss percentage expressed in terms of drive wheel skid (%)		Delivered seed rate of machine (kg/ha)		Seeding efficiency (%)	
	Tillage	No-tillage		Tillage	No-tillage	Tillage	No-tillage	Tillage	No-tillage
S_1	2.12	1.73	64	16.52	8.69	53.43	58.44	83.48	91.31
S_2	3.02	2.56	64	19.05	7.07	51.81	59.48	80.95	92.93
S_3	3.39	3.09	64	14.94	7.52	54.44	59.19	85.06	92.48
S_4	4.38	4.02	64	16.27	3.07	53.59	62.04	83.73	96.93
S_5	4.95	4.32	64	19.04	2.04	51.81	62.69	80.96	97.96
S_6	6.41	5.69	64	17.65	1.0	52.70	63.36	82.35	99.0

In tilth soil, the seeding efficiency of the machine was maximum (85.06%) for treatment S3 corresponding to the forward speed 3.39 km/h. With increase in a speed, the seeding efficiency was found to be in decreasing order further. The fluctuation in seeding efficiency in tilth soil is attributed by drive wheel skid may be because of undulation in field accounted by improper operation of tillage equipments in course of land preparation and land preparation also due to variation in soil moisture at different locations in the field. In un-tilth soil, as tractor speed was increasing, drive wheel skid was decreasing and ultimately seeding efficiency was increasing. However, for speed range between 1.73-5.69 km/h, seeding efficiency ranged between 91.31%-99%.

CONCLUSIONS

On the basis of experiment conducted for field assessment of zero till-seed-cum-ferti-drill in local soil condition of Pusa the following conclusions were drawn. With regards to field efficiency, the machine performance was found superior in un-tilth soil for wide range of tractor forward speeds, as compared to the tilth soil. The tractor wheel slip was found to be minimum and ranging between 6.19-8.82% in tilth soil for tractor speed upto 6.41 km/h. However, under no-tillage condition, the wheel slip was comparatively more and ranging between 15.19-16.07%, for tractor speed from 1.7-4.02 km/h. The wheel slip started increasing upon increase in tractor speed beyond this limit in un-tilth soil. The drive wheel skid of zero till-seed-cum-ferti-drill was varying between 14.94%-19.05% in tilth soil without following a definite trend. However, in un-tilth soil it was decreasing with increase in tractor forward speed with minimum value 1% at maximum forward speed 5.69km/h. Seeding efficiency of machine was superior under no-till condition of soil as compared to the tilth soil for different ranges of tractor speeds. Maximum efficiency was achieved at highest forward speed of tractor i.e. 5.69km/h. Overall, suitability of zero till-seed-cum-ferti-drill was established for light textured un-tilth sandy loam soil condition from field efficiency and seeding efficiency point of view, over its use in tilth soil, of same category.

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