INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 16, No. 1, p. 168-177, 2020

RESEARCH PAPER OPEN ACCESS

Comparative performance of wheat sowing machinery in wheat-rice cropping system

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Key words: Rice Residue, Smog, Sowing Techniques, Happy Seeder, Zero Tillage.

http://dx.doi.org/10.12692/ijb/16.1.168-177 Article published on January 15, 2020

Abstract

Management of combine harvested paddy residue in field though conventional method is becoming an environmental concern to soil health, transport and surrounding population living in the area of wheat-rice cropping system of province Punjab, Pakistan. In common, cultivators prefer to burn their paddy field as an easy and cost effective method of residue disposal. Burning of rice residue in field decreases soil fertility, moisture contents, and dangerous for the life of bio-control microbial insects that are beneficial for crop production.From last few years, issue of smog (mixture of smoke and fog) is rising. When smoke meet with fog, a new heavy smoke is produced called smog causing many road accidents and respiratory diseasesto residents' invicinity. To overcome this problem a new machinewas manufactured at Sharif Engineering Works, Khurrianwala Faisalabad under the joint project of SUMMIT and USDA. Purpose of present study was to compare the performance of newly develop machine Happy seeder (T_1) with zero seed drill (T_2), wheat seed drill (T_3) and conventional broadcasting method (T_4). Experiment was conducted in the combine harvested rice residue field. Each treatment was replicated with three experimental plots for the observation of germination rate, vigor index, number of tillers, spike length, spikelet per spike, 1000 grain weight and yield. Data collected was statistically analyzed at 5% level of significance. It was concluded from the experiment that the treatment T_1Happy seeder had best performance for wheat production in rice-residue field.

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Introduction

In Pakistan handling of combine harvested paddy residue is becoming a major problem to the farmers in rice-wheat cropping. In general, farmers dispose by burn it at farm. Burning results in loss of potential nutrients and great threat to the soil natural environment.

Suitable machinery is not available for sowing of wheat in rice stubble field. Commonly farmers prefer burning/collection of residue from combine-harvested rice harvested field, result in loss of nutrients, moisture and organic matter. To minimize this problem a new machine Happy seeder was introduce for direct wheat sowing (Sidhu *et al.*, 2007).

Happy seeder is a newly concept in Pakistan, it is fabricated at Sharif Engineering Works, Khurrianwala Faisalabad under the joint project of SUMMIT and USDA. Machine was tested in the combine harvested residue field for sowing of wheat. The performance of the machine was compared with zero seed drill, wheat seed drill and broadcasting method. Happy seeder and zero seed drill works on the principle of zero tillage with minimum soil disturbance while sowing with wheat seed drill and broadcasting required other tillage implements (disc plough, Rotavator, cultivator, wooden plank) for land preparation before sowing. Rice and wheat are major source of calories in South Asia for more than a billion individuals (Arshad and Krupnik, 2016). An important part of the rice and wheat cultivated area (57%) is located in Punjab, Pakistan. Punjab region contains rice wheat areas in districts; Gujranwala, Sheikhupura and Sialkot mainly with some parts of the Gujarat and Lahore. Typically, rice-wheat region (Kallar zone) is real home of "Basmati rice", which is famous all over the world as agricultural commodity of Pakistan. It is cooked with stretch and softness which makes it unique in the world (Sheikh and Abbas, 2007).

Combustion of rice residue in the field produces carbon black residues that create smog (the combination of smoke and fog) which is a serious problem for the environment, as it is. Black carbon is now considered the second largest global warming supplier after carbon dioxide. Emissions of black carbon and other forms of aerosols create atmospheric brown clouds (ABC) in Asia. Aerosols in ABCs reduce the amount of sun reaching the earth's surface by 10-15% and increase solar atmospheric heating by up to 50% (Tanvir Ahmed, Rufus Bellamy, 2013). Delay in wheat sowing not only reduces its production, but also reduces the effective use of applied fertilizers. Over 80% of the crop region in Punjab is covered by assortments of Basmati rice which matures in November. Until the start of December, farmers are engaged with expelling rice, stripping and overseeing rice straw. These factors postponed seeding of wheat (Mann, Ramzan, and Munir, 2008).

Combustion of rice residues crops contribute to greenhouse gas emissions, air pollutants, fine dust and smoke, creating a risk to human health. Total quantity of farm waste produced in year 2008-2009 was 621 Mt, of which 15.8% was burned on the farm. Rice chaff added 41% of the total deposit burned, followed by wheat straw (21%) and sugar cane garbage (19%). Emissions of the plants emitted 7.97 Mt CO, 140.85 Mt CO2, 0.047 Mt SOx, 0.22 Mt NOx, 0.11 Mt NH3 and 1.45 Mt NMVOC, were 0.64 Mt NMHC, 1.20 Mt NMHC for 2008-09. From 1995 to 2009 a variation of 20.96% in annual emissions of air pollutants were noted (Jain, Bhatia, and Pathak, 2015). Rota drill was designed to promote line sowing, ensure timely planting of wheat and to save fuel and energy cost as its takes only one pass of a tractor to complete the operation in the field (Muhammad Yasin and Ali, 2009).Happy Seeder is a tractor-mounted machine which cuts and lifts rice straw, drills wheat into the bare soil, and blows the straw as mulch over the sown area. It thus enables farmers to sow wheat instantly after rice harvest without soil preparation and burning of rice residue. First prototype of the Happy Seeder was developed by CSIRO Griffith at Punjab Agricultural University, Ludhiana in July 2001 and first sold to a farmer in 2007 (Ridhima Gupta, Rufus Bellamy, 2012). Rice

straw is considered poor feed for animals due to its high silica content about 8.3%. It has no other economies and remains unutilized in the field after crop harvesting. To vacate fields for the timely sowing of wheat, majority of the rice straw is burnt in situ by the farmers because residues interfere with tillage and seeding operations for the next crop. Burning of rice stubble is rapid and cheap option for farmer, which causes a serious atmospheric pollution as well as dangerous for human health. Due to burning of rice stubbles, another issue of smogis rising in Pakistan and neighboring country India. Smog is basically combination of smoke and fog. When the smoke meet with fog, a new heavy smoke is produced called smog causing many accidents and diseases.Besides, burning of rice stubbles results in the loss of plant nutrients, micro-organism and organic carbon of the soil and thus deteriorates the soil health and texture.Sowing of wheat in stubble field with wheat seed drill requires three extra tillage operation (3Disc plough, 1Rotavator, 1Cultivator and Wooden Plank). Farm Machinery Instiute and Agricultural Mechanization Research Institute introduce zero seed drill while before its operation residue have to collected/burn so that stubbles could not stop sowing process. These wheat sowing methods are not only cost effective but also time consuming, main cause of late sowing and low productivity in wheat-rice cropping system. For timely sowing and to increase wheat yield new innovative techniques like happy seeder is necessary to investigate at reseach institutes before its extensive febrication and extension at farmer field.

Materials and methods

Experiment was conducted to investigate the performance of different sowing machinery in rice-wheat cropping system. Three machines; happy seeder, zero seed drill and indigenously available wheat seed drill commonly known as Wheat-drill were selected during experimentation. Performance of each machinewas evaluated;comparison was made with each other and with conventional broadcasting method. Pakistan covers 2.2 mha area of wheat-rice cropping system. The major districts are Gujranwala, Lahore, Sialkot, Sheikhupura, Gujarat, Mandi-Bhao-Din and Okara. Experiment was conducted in the core area of Central Punjab at Chand Dahir Agri. Farm, village Dahri, tehsil Muridke, District Sheikhupura. During research study, wheat was sown in rice stubble field by adopting four sowing techniques; Happy Seeder (T_1), Zero Seed Drill (T_2), Wheat Seed Drill (T_3) and conventional Broadcasting method (T_4). Happy seeder and zero seed drill works on the principle on minimum tillage, no extra tillage implements were practiced in the experiment of happy seeder and zero seed drill, while for sowing of wheat using conventional wheat seed drill and broadcasting method, additional tillage implements (3Disc plough, 1Rotavator, 1Cultivator and Wooden Plank) were used as primary and secondary tillage to prepare seedbed for proper sowing operation.

Calibration

1. Machine was put up at desirable height to rotate drive wheel freely.
2. Polythene bags were placed under each seed tube.
3. Circumference of dive wheel was measured with the help of formula Circumference = πd
4. Width of machine was calculated by multiplying the number of furrow openers with the distance between two furrow openers.
5. Number of revolution was calculated by the given formula.

$$\text{Number of revolution} = \frac{\text{Area (m}^2\text{)}}{\text{Width(m)} \times \text{Circumference(m)}}$$

6. A point was marked on the drive wheel as starting point.
7. Seed was placed in the seed box.
8. To count number of revolution, drive wheel was rotated from the starting point and end it at the same place.
9. Seed was collected from each seed tube and weight it.
10. Multiply weight of seed collected from each tube to the number of revolution to calculate seed rate per unit area(Jat *et al.*, 2013).

Calculation

Diameter of drive wheel = 0.67 m

Circumference of wheel = πd
= 3.14 × 0.67
= 2.10 m
Area = 4046 m²
Width of machine =2.03 m
Number of revolution = $4046\ m^2/2.03m \times 2.10m$
= 4046/4.263
N = 949 rev.
Weight of seed collected = 52.9 g
Total Seed for an acre = 52.9 × 949
= 50202.1 g/acre
= 50.20 kg/acre

Field efficiency

It is the ratio of effective and theoretical field capacity. To measure it, effective field capacity and the theoretical field capacity were calculated with the help of the formulas (Haque *et al*., 2004).

Total area was one acre and total time (productive +non-productive) required for sowing wheat in T_1 was 45 minutes.

$$EFC=\frac{Total\ Area\ (acre)}{Total\ Time\ (hr)}$$

$$EFC=\frac{1\ (acre)}{0.75\ (hr)}$$

EFC=1.33acre/hour

For the theoretical field capacity width of machine and speed of machine is required.

$$TFC=\frac{Width(ft)\times speed(\frac{mile}{hr})}{8.25}$$

$$TFC=\frac{7.10(ft)\times 1.86(\frac{mile}{hr})}{8.25}$$

TFC=1.60acre/hour

Field efficiency in T_1 was calculated by incorporating the vales of TFC and E F C inthe formula (Haque *et al*., 2004).

$$EF=\frac{EFC}{TFC}\times 100$$

$$EF=\frac{1.33}{1.60}\times 100$$

EF=83.1%

Calibration of Zero Seed Drill
Diameter of drive wheel = 0.61m
Circumference of drive wheel = πd
= 3.14 × 0.61
= 1.91m
Area = 4046m²
Width of machine = 2.48m
Number of revolution =$4046\ m^2/2.48m \times 1.91m$
= 4046/4.736
= 854rev.
Weight of seed collected = 58.8g
Total Seed for an acre = 58.8 × 949
= 50215g/acre
= 50.21 kg/acre

Field efficiency

To calculate field efficiency in T_2 total time (productive +non-productive) required for sowing of one acre wheat was 50 minutes.

$$EFC=\frac{Total\ Area\ (acre)}{Total\ Time\ (hr)}$$

$$EFC=\frac{1\ (acre)}{0.83\ (hr)}$$

EFC=1.20acre/hour

For the theoretical field capacity width of machine and speed of machine is required.

$$TFC=\frac{Width(ft)\times speed(\frac{mile}{hr})}{8.25}$$

$$TFC=\frac{(8.2ft)\times(1.85\frac{mile}{hr})}{8.25}$$

TFC= 1.83 acre/hour

Field efficiency of T_2 was calculated by incorporating the vales of TFC and EFC in the formula (Haque *et al*., 2004).

$$EF=\frac{EFC}{TFC}\times 100$$

$$EF=\frac{1.20}{1.83}\times 100$$

EF=65.5%

Calibration of wheat seed drill
Diameter of drive wheel = 0.71 m
Circumference of drive wheel = πd
= 3.14 × 0.71

= 2.22 m

Area = 4046 m²

Width of machine = 2.28 m

Number of revolution = $4046\ m^2/2.28m \times 2.22m$

= 4046/5.061

= 799 rev.

Weight of seed collected = 62.8 g

Total Seed for an acre = 62.8 × 799

= 50177 g/acre

= 50.17 kg/acre

Field efficiency

To measure field efficiency of T_3total time (productive +non-productive) required for sowing of one acre wheat was 35 minutes.

$$EFC=\frac{Total\ Area\ (acre)}{Total\ Time\ (hr)}$$

$$EFC=\frac{1\ (acre)}{0.58(hr)}$$

EFC=1.72

For the theoretical field capacity width of machine and speed of machine is required.

$$TFC=\frac{Width(ft)\times speed(\frac{mile}{hr})}{8.25}$$

$$TFC=\frac{(8.4ft)\times(2.4\frac{mile}{hr})}{8.25}$$

TFC=2.4 acre/hour

The Field efficiency was calculated by the formula (Haque *et al.*, 2004).

$$EF=\frac{EFC}{TFC}\times 100$$

$$EF=\frac{1.72}{2.4}\times 100$$

EF=71.6%

Result and discussion

Present research was conducted to examine the performance of different sowing methods. In rice stubble field, in wheat rice cropping system, sowing methods plays an important role in seed placement which has direct effect on crop growth. In the wheat-rice cropping zone of Pakistan, after the harvesting of rice, rice residue remains in field and farmer burn it. Due to its burning, a mixture of smoke and fog make smog. To avoid this problem a new machine was manufactured locally in district Faisalabad. Comparison was made between newly developed Happy Seeder, Zero Seed Drill, Wheat Seed Drill and conventional broadcasting method.

Table 1. Mean Germination Count.

Treatments	Mean Germination Count
T_1 Happy Seeder	190.4 a
T_2 Zero Seed Drill	176.1 ab
T_3Wheat Seed Drill	164.3 b
T_4 Broadcasting	164.3 b
LSD	**21.8**

Mean values having same lettering are non-significantly differfrom each other.

Germination Count

Effect of different sowing methods on the germination count is shown in Table 1 indicating the maximum germination count (190.4) was in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed drill) with mean value of 176.1 whileminimum germination count (164.3) was recorded in remaining treatments T_3 & T_4 (Wheat seed drill & Broadcasting). Experiment conducted with the help of happy seeder, the germination count was higher than other methods. Perhaps reason behind isits workingprinciple of zero tillage and additional part is rotor which crushes the rice residue and provide proper placement of seed in soil with higher moisture content then other sowing method.

In zero seed drill, bushes of residue clogged the tines which result in stopping the sowing processthat cause the reduction of germination count. In wheat-seed-drill and broadcasting method, soil have to pulverized before sowing which causes excessive evaporation, results in low productivity of wheat.

Result showed that treatment T_1 is non-significant with treatment T_2 while significantly differ with T_3 and T_4. Treatment T_2 is also non-significant with T_3 and T_4 at 5% level of significance. Present results are in accordance to Iqbal *et al.*, 2017 who reported that maximum germination count was in the field of happy seeder as compared to conventional method (Broadcasting).

Table 2. Vigor Index.

Treatments	Vigor Index
T_1 Happy Seeder	100.8 a
T_2 Zero Seed Drill	93.2 ab
T_3 Wheat Seed Drill	87.0 b
T_4 Broadcasting	87.0 b
LSD	11.47

Mean values having same lettering are non-significantly differ from each other.

Table 3. Number of Tillers.

Treatments	Number of Tillers
T_1 Happy Seeder	299.1 a
T_2 Zero Seed Drill	293.4 ab
T_3 Wheat Seed Drill	287.5 b
T_4 Broadcasting	283.0 b
LSD	11.07

Mean values having same lettering are non-significantly differ from each other.

Vigor Index (%)

Vigor index is basically the index of viable plants have the ability to grow up. Results displayed in Table 2 showed that maximum vigor index (100.8) was recorded in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed drill) with mean value of 93.2. The minimum vigor index (87.0) was recorded in remaining two treatments T_3 & T_4 (Wheat seed drill & Broadcasting).

Table 4. Plant Height.

Treatments	Plant Height (cm)
T_1 Happy Seeder	108.0 a
T_2 Zero Seed Drill	104.1 b
T_3Wheat Seed Drill	102.8 b
T_4 Broadcasting	102.3 b
LSD	3.44

Mean values having same lettering are non-significantly differ from one another.

Number of Tillers

Additional stems that develop from main shoot of plant. Results of present experiment (Table 3) showed that maximum number of tillers (299.1) were recorded in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed drill) with mean value of 293.4. Treatment T_3 gained third position (287.5), whereas minimum germination count (283.0) was observed in T_4 (Broadcasting) respectively.

Result shows that treatment T_1 is non-significant with treatment T_2 while significant with T_3 and T_4. T_2 is

also non-significant with T_3 and T_4 at 5% level of significance.

Plant Height (cm)

Results displayed in Table 4 showed that maximum plant height (108.0) was recorded in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed drill) with mean value of 104.1 cm, while minimum height of plant (102.3 cm) was recorded in treatment T_4 (Broadcasting) respectively.

Table 5. Spike Length.

Treatments	Spike Length
T_1 Happy Seeder	10.1 a
T_2 Zero Seed Drill	8.9 b
T_3Wheat Seed Drill	8.7 bc
T_4 Broadcasting	7.8 c
LSD	1.09

Mean values having same lettering are non-significantly differ from each other.

Plant height depends upon the proper placement of seed at the desired depth having the suitable soil moisture content. Height of plant gives a small increase in the biomass. Results show that T_1 is significant to all other treatments while T_2, T_3 and T_4 are non-significant to each other.

Table 6. Spikelet per Spike.

Treatments	Spikelet per Spike
T_1 Happy Seeder	17.6 a
T_2 Zero Seed Drill	16.2 b
T_3 Wheat Seed Drill	15.6 b
T_4 Broadcasting	15.6 b
LSD	**1.21**

Mean values having same lettering are non-significantly differ from one another.

Spike Length (cm)

Results showed (Table 4.5) that maximum spike length (10.1) was recorded in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed drill) with mean value of 8.9 cm whereas minimum spike length (7.8) was recorded in T_4 (Broadcasting) respectively. Results of experiment shows that T_1 and T_4 are significantly differ while T_3,T_4 and T_2 ,T_3 are non-significant with each other at 5% level of significance.

Table 7. Grain per Spike.

Treatments	Grain per Spike
T_1 Happy Seeder	50.4 a
T_2 Zero Seed Drill	48.5 b
T_3 Wheat Seed Drill	47.3 bc
T_4 Broadcasting	46.8 c
LSD	**1.55**

Mean values having same lettering are non-significantly differ from each other.

Spikelet per Spike

Results showed (Table 6) that maximum spikelet per spike (17.6) was recorded in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed drill) with mean value of 16.2. However the minimum spikelet per spike (15.6) was recorded in remaining two treatment T_3 & T_4 (Wheat seed drill &Broadcasting).

Length of spike was highest in happy seeder. Spikelet per spike depends upon the length of spike, as its length increased number of spikelet per spike will also increase.

Result shown that treatment T_1 is significantly differing with all other treatments while T_2, T_3 and T_4 are non-significant to each other.

Table 8. 1000-Grain Weight.

Treatments	1000-Grain Weight (g)
T_1 Happy Seeder	40.6 a
T_2 Zero Seed Drill	39.6 a
T_3 Wheat Seed Drill	39.0 b
T_4 Broadcasting	38.7 b
LSD	**0.72**

Mean values having same lettering are non-significantly differ from each other.

Grain per Spike

Results displayed in Table 7 showed that maximum grains per spike (50.4 No.) was recorded in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed drill) with mean value of 48.5 whereas minimum grains per spike (46.8 No.) were recorded in T_4 (Broadcasting) respectively.

Grain per spike is an important factor for both spike length and spikelet per spike as they have the direct impact on the grain per spike. Treatment T_1 significantly different with treatment T_4 while T_3 and T_4 are non-significant with each other at 5% level of significance.

1000-Grain Weight (g)

Results displayed in Table 8 showed that maximum thousand grain weight (40.6) was recorded in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed drill) with mean value of (39.6) while the minimum thousand grain weight (38.7) was recorded in T_4 (Broadcasting) respectively.

Table shows that treatment T_1 is significantly different with T_3 while treatment T_4 is non-significant with treatment T_2 at 5% level of significance.

Table 9. Yield.

Treatments	Yield (g/m^2)
T_1 Happy Seeder	333.3 a
T_2 Zero Seed Drill	320.0 b
T_3 Wheat Seed Drill	315.8 bc
T_4 Broadcasting	311.6 c
LSD	7.6

Mean values having same lettering are non-significantly differ from each other

Present results are in accordance to Iqbal *et al.*, 2017; who reported that maximum 1000-grain weight was higher in happy seeder as compared to conventional method (Broadcasting).

Yield (g/m^2)

Results of the experiment (Table 9) showed that maximum yield (333.3) was recorded in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed

drill) with mean value of 320.0 while the minimum thousand grain weight (311.6) was recorded in treatment T_4 (Broadcasting) respectively.

The yield depends upon all the parameters which are studied during the research. Better yield was recorded in happy seeder as compared to zero seed drill, wheat seed drill and broadcasting. Table 4.9 shows that treatment T_1 significantly different with other treatment, while the production of treatment T_2 and T_3 are non-significant at 5% level of probability. Results also show that T_3 and T_4 are non-significant with respect to yield of wheat at 5% level of significance.

Table 10. Yield.

Treatments	Yield (kg/ha)
T_1 Happy Seeder	3333.3 a
T_2 Zero Seed Drill	3200.0 b
T_3 Wheat Seed Drill	3158.8 bc
T_4 Broadcasting	3116.6 c
LSD	76.5

Mean values having same lettering are non-significantly differ from each other.

Present results are in accordance to Singh *et al.*, 2013; Iqbal *et al.*, 2017; who reported that maximum yield (g/m^2) was in happy seeder as compared to conventional method (Broadcasting).

Yield (kg/hectare)

Results shown in Table 10 that maximum yield (3333.3) was recorded in treatment T_1 (Happy seeder) followed by treatment T_2 (Zero seed drill) with mean value of 3200.0 while minimum thousand grain weight (3116.6) was recorded in treatment T_4 (Broadcasting) respectively.

Table shows that the treatment T_1 significantly different with other treatment, while the production of treatment T_2 and T_3 are non-significant at 5% level of probability.

Resultsof experiment shown that treatment T_3 and T_4 are non-significant with respect to yield of wheat at 5% level of significance.

Present results are in accordance to Singh *et al.*, 2013; Iqbal *et al.*, 2017; R.P. Singh *et al.*, 2008; reported that maximum weight was in happy seeder as compared to conventional method (Broadcasting).

Conclusion

It was concluded from the study that highest grain yield was obtained with Happy Seeder in paddy stubble field in rice-wheat cropping system.

Acknowledgment

This research was supported by ENGRO Pvt. Ltd and Dahir Agri. Farms. I am thankful to ENGRO and Dahir Agri. Farms for providing me facilities and infrastructure required during this research. I am also thankful to Sharif Engineering Works Khurrianwala, Faisalabad only manufacture of Happy Seeder in Pakistan.

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