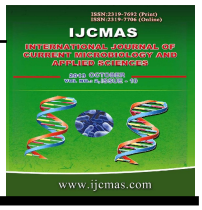
*International Journal of Current Microbiology and Applied Sciences*
***ISSN: 2319-7706*** **Volume 2 Number 10 (2013) pp. 396-405**
**http://www.ijcmas.com**




**Original Research Article**

# Root parameters, weeds, economics and productivity of wheat (*Triticum aestivum* L.) as affected by methods of planting *in-situ* paddy straw

**Avtar Singh*, J. S. Kang, Maninder Kaur and Ashu Goel**

Department of Agronomy, Punjab Agricultural University, Ludhiana-141 004, India
******Corresponding author*

**A B S T R A C T**

On farm trials were conducted in the district of Jalandhar, Kapurthala, Patiala and Fatehgarh Sahib of Punjab during 2008-09. The primary aim of this study was to conduct the evaluation of happy seeder and rotavator for *in-situ* management of paddy straw in comparison with the farmer's practices for the acceleration of happy seeder and rotavator technologies. Data recorded on paddy straw yield from the field of selected farmers during *kharif* of 2008 to know the average straw yield, which was varied from 8.0 to 9.9 $tha^{-1}$ in Fatehgarh Sahib, Patiala, Kapurthala and Jalandhar. Burning of paddy straw is widely practiced for sowing of wheat with conventional tillage and lost with this practice average of 33.48 $kgha^{-1}$ available nitrogen, 7.44 $kgha^{-1}$ available phosphorous and 66.03 $kgha^{-1}$available potassium. The sowing of wheat with happy seeder and rotavator in the combined harvested field can add large amount of nutrients in the soil, which will help to improve the soil productivity. Results of this investigation indicated that similar or slightly higher grain yield can be obtained with the sowing of happy seeder (zero tillage) and rotavator (reduced tillage) as compared to farmer's practice, which are most suitable methods for *in-situ* management of paddy straw and control of weed population. Out of the methods of planting, happy seeder is the most suitable method to reduce the cost of production and to manage the combine harvested paddy straw and ultimately to improve the soil health and productivity. Rotavator sown crop showed shallow root system due to compaction, more weed population as compared to happy seeder, but showed less weed population than farmer's practice. The farmers must used happy seeder for sowing of wheat in the combine harvested fields for *in-situ* management of paddy straw and also to increase the net returns.

**K e y w o r d s**

Districts; Farmer's practice; Happy seeder; Paddy straw; Rotavator; Wheat.

## Introduction

Paddy straw is the only organic material available in significant quantities to the farmers. About 40 percent of the nitrogen (N), 30 to 35 percent of the phosphorus (P), 80 to 85 percent of the potassium (K), and 40 to 50 percent of the sulfur (S) taken

up by rice remains in vegetative plant parts at crop maturity. Straw is removed from the field, burned *in situ*, piled or spread in the field, incorporated in the soil, or used as mulch for the following crop. Burning causes atmospheric pollution and results in nutrient loss, but it is a cost-effective method of straw disposal. Spreading, removal and incorporation of paddy straw, however, are labour-intensive and expensive tasks. The suggested viable methods are *in- situ* management in the field, composting and mulching. Therefore, the *in-situ* management of paddy straw in the field with happy seeder technology has many beneficial effects for preceding crops and also effect on the overall nutrient balance and long-term soil fertility (Bimbraw *et al* ., 2011).

Burning of rice stubbles is widely practiced in Punjab, India, because burning is a rapid and cheap option, and allows quick turn around between crops, it has serious effects on human and animal health due to air pollution, reduced soil fertility due to loss of nutrients and organic matter, and green house gas (GHG) emissions. The Happy Seeder (Singh *et al*., 2008) and rotavator overcomes the technical problems associated with direct drilling into rice residues. The primary objective of the present study was to conduct the evaluation of happy seeder and rotavator for *in-situ* management of paddy straw in comparison with the farmer's practices at farmer's field for the acceleration of happy seeder and rotavator technologies.

## Materials and Methods

On farm trials 10 in each district were conducted in the district of Jalandhar, Kapurthala, Patiala and Fatehgarh Sahib to accelerate technology of happy seeder and rotavator for sowing of wheat in the combine harvested fields for *in-situ* management of paddy straw during 2008-09. In the *Kharif* season of 2008, data was recorded on grain and straw yield of rice from the selected farmers before sowing of wheat. Happy seeder and rotavator machines were used for sowing of wheat in combine harvested paddy fields without any straw burning or removal of paddy straw. The loose straw was uniformly distributed in the field before sowing wheat with happy seeder. In case of sowing with rotavator, the one time it was used in the combine harvested paddy fields to incorporate the paddy straw and second time it was used to mix the broadcasted seed of wheat in the soil. The inputs like one quintal urea and herbicide (Total 75 WP at 40 g/ha) were supplied as an incentive to the selected farmers. The performance of wheat sown with happy seeder and rotavator was compared with farmer's practice followed for sowing of wheat. The observations such as weed count per sq. meter, grain yield, straw yield, root length, root weight per plant, depth of maximum root density were recorded from the demonstration fields to compare the performance of wheat sown with happy seeder, rotavator and farmer's practice. For data collection of root length, depth of maximum root density and dry weight of roots per plant, samples were taken with the help of spade from the demonstration's fields of Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala.

## Results and Discussion

### Grain and straw yield of rice

Data recorded on rice grain and straw yield are presented in the table 1. An average rice grain yield of 7.73, 6.46, 6.35 and 5.45 $tha^{-1}$ and rice straw of 9.9, 9.7,

9.5 and 8.0 $tha^{-1}$ was recorded in the Fatehgarh Sahib, Patiala, Kapurthala and Jalandhar, respectively. Farmers are widely practiced the burning of paddy straw as easy option for disposal of paddy straw before sowing of wheat with conventional tillage. With this practice, lost an average of 3348 $kgha^{-1}$available nitrogen, 744 $kgha^{-1}$available phosphorous and 6603 $kgha^{-1}$available potassium. The zero tillage/ reduce tillage technologies like happy seeder and rotavator with recycling of paddy straw can add considerable quantity of nutrients in soil and this will also help to conserve irrigation water, improve the soil productivity. The long term use of this technology for *in-situ* management of paddy straw reduces the fertilizer requirement and save the environment from pollution by reducing the emission of $CO_2$ with an average 13.0 $tha^{-1}$ (Table 1).

**Grain and straw yield wheat**

Data on grain yield of wheat sown with happy seeder, rotavator and farmer's practice are depicted in table 2. Grain yield in Patiala and Fategarh Sahib was affected significantly by sowing of wheat with happy seeder, rotavator and farmer's practice. In Patiala, wheat sown with happy seeder and rotavator gave significantly similar grain yield, but significantly more than farmers practice. An average 9-15 % higher grain yield of wheat was recorded with the happy seeder sowing in rice residues (Sidhu *et al* ., 2005), with fertilizer broadcast at sowing and before the first irrigation compared with farmer's practice (conventional tillage after burning. Higher wheat yield was also obtained under zero tillage over the conventional tillage (Yadav *et al* .,2005). Average grain yields with no-tillage and conservation tillage were significantly greater than yields using conventional tillage (Ciha, 1982). No tillage increased test weights while reducing tillage operations significantly reduced the number of spikelets per head, but increased the 100-seed weight. However, in Fatehgarh Sahib, significantly equivalent grain yield of wheat was recorded sown with happy seeder and farmer's practice. Zero tillage sowing gave significantly higher grain yield than happy seeder, rotavator and conventional tillage and other three methods of planting were at par with each other (Meenakhi, 2010; Kaushal et al .,2012 a b). Whereas, method of planting did not influence significantly on the grain yield of wheat sown in Jalandhar and Kapurthala district. It is interesting to mention here that the average grain yield of four districts of wheat sown with happy seeder was slightly higher than wheat sown with rotavator (0.7 q/ha) and farmer's practice (0.9 q/ha. This was happened due to the presence of paddy straw on the soil surface resulted in more availability of moisture for longer period during the growing season. Data on straw yield of wheat are given in the table 2. The different methods of planting influenced significantly on straw yield of wheat sown in Patiala and Fatehgarh Sahib. The higher straw yield was recorded from the crop sown with farmer's practice, which was at par with happy seeder and it was significantly lower than rotavator. Straw yield of wheat sown in Fatehgarh Sahib was varied significantly under all the methods of planting. The significantly lower straw yield was recorded from the crop sown with happy seeder and maximum straw yield was recorded from the crop sown with rotavator, which was significantly more than other two methods of planting. The crop sown with different

**Table.1** Effect of different locations on straw yield, Emission of $CO_2$, Organic Carbon and nutrient present in the straw

| Name of district | Grain yield ($tha^{-1}$) | Straw yield ($tha^{-1}$) | Emission of $CO_2$ ($t\ ha^{-1}$) | Nutrient present in the straw | | |
|---|---|---|---|---|---|---|
| | | | | Nitrogen ($Kgha^{-1}$) | Phosphorous ($Kgha^{-1}$) | Potassium ($Kgha^{-1}$) |
| Kapurthala | 6.35 | 9.5 | 13.3 | 34.20 | 7.60 | 67.45 |
| Jalandhar | 5.35 | 8.0 | 11.2 | 28.80 | 6.40 | 56.80 |
| Fatehgarh Sahib | 7.73 | 9.9 | 13.9 | 35.64 | 7.92 | 70.29 |
| Patiala | 6.46 | 9.7 | 13.6 | 34.92 | 7.76 | 68.87 |
| Mean | 6.47 | 9.3 | 13.0 | 33.48 | 7.44 | 66.03 |

Paddy straw contains 0.36 Nitrogen, 0.08 Phosphorous, 0.71Potassium (*Source*: Handbook of Agriculture ICAR)

**Table.2** Effect of plating methods on grain and straw yield of wheat sown in different districts

| Treatments | Grain yield ($qha^{-1}$) | | | | |
|---|---|---|---|---|---|
| | Patiala | Fatehgarh Sahib | Kapurthala | Jalandhar | Mean |
| Happy Seeder | 42.9 | 46.2 | 42.2 | 42.9 | 43.6 |
| Rotavator | 42.9 | 43.3 | 41.3 | 43.9 | 42.9 |
| Farmer's Practice | 41.0 | 45.7 | 41.9 | 42.0 | 42.7 |
| CD (p=0.05) | 1.4 | 1.6 | NS | NS | - |
| Straw yield ($qha^{-1}$) | | | | | |
| Happy Seeder | 67.5 | 52.9 | 64.5 | 66.5 | 62.9 |
| Rotavator | 72.5 | 50.4 | 63.1 | 68.0 | 63.5 |
| Farmer's Practice | 69.6 | 54.6 | 64.1 | 65.1 | 63.4 |
| CD (p=0.05) | 2.9 | 1.2 | NS | NS | - |

**Table.3** Per cent reduction in weed population in happy seeder sown wheat over the rotavator and farmer's practice

| Planting method | Name of District | % reduction in weed population over the rotavator | % reduction in weed population over the Farmer's practice |
|---|---|---|---|
| Happy seeder | Kapurthala | 36.2 | 60.3 |
| | Jalandhar | 28.0 | 53.0 |
| | Fatehgarh Sahib | 21.8 | 33.0 |
| | Patiala | 20.0 | 44.3 |
| Mean | | 26.5 | 47.7 |
| Rotavator | Kapurthala | - | 37.7 |
| | Jalandhar | - | 34.7 |
| | Fatehgarh Sahib | - | 14.3 |
| | Patiala | - | 30.4 |
| Mean | | | 29.3 |

methods in Jalandhar and Kapurthala, the average straw yield was recorded slightly more from the crop sown with rotavator and farmer's practice than happy seeder.

**Weed count in wheat**

Data on weed count before the spray of herbicide collected from the happy seeder, rotavator and farmer's practice sown wheat (Data not given).The highest average weed plants was observed in farmer's practice (23.9, 50.4, 27.9 and 27.3 $m^{-2}$) followed by rotavator (14.9, 32.9, 23.9 and 19 $m^{-2}$) and happy seeder (9.5, 23.7, 18.7 and 15.2 $m^{-2}$) in Kapurthala, Jalandhar, Fatehgarh Sahib and Patiala, respectively. The lowest weed population in the happy seeder sown crop was due to the minimum disturbance of soil but higher weed population in rotavator and farmer's practice sown crop due to creation of favorable environment by pulverization of soil for germination of weed seeds. It shows that the rotavator and farmer's practice encourage the weed population than the zero tillage technology like happy seeder. The data shows that farmer's practice encourage the weed population due to the more disturbance of soil.

Data on per cent reduction in weed population before the spray of herbicide in the happy seeder over the rotavator and farmer's practice, similarly, rotavator over the farmer's practice sown wheat are presented in the table 3. The per cent reduction in weed population in the happy seeder sown crop over the rotavator and farmer's practice was 36.2, 28.0, 21.8 & 20.0 and 60.3, 53.0, 33.0 & 44.3 and rotavator over the farmer's practice was 37.7, 34.7, 14.3 & 30.4 in the district of Kapurthala, Jalandhar, Fatehgarh Sahib and Patiala, respectively. The average reduction in weed population in the happy seeder sown crop over the rotavator and farmer's practice was 26.5 & 47.7 %, respectively. However, the reduction in weed population in rotavator sown wheat crop was 29.3 % over the farmer's practice.

**Root length**

Data on root length of wheat sown with happy seeder, rotavator and farmer's practice are presented in the table 4. For data collection of root length and depth of maximum root density 16 samples were taken with the help of spade from the demonstration's fields of Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala. The average root length of sixteen samples was found maximum in plants of wheat sown with happy seeder (18.1 cm) followed by rotavator (17.7 cm) and farmer's practice (15.5 cm). It might be due to the compaction caused by the rotavator and intensive tillage in case of farmer's practice. It was also found that the bulk density at all the layers under rotavator was generally higher than the conventional tillage and Happy Seeder sown field at all the locations of Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala districts. The lower bulk density values were recorded in happy seeder than rotavator and conventional tillage sown wheat fields. This was due to the presence of paddy straw on the soil surface loosen the soil with the addition of organic matter. Wheat root length is diminished by compaction in the field (Atwell 1990a). Roots are generally short and thick (Goss, 1977; Wilson et al .,1997) and the diameter increase is due to a higher number and size of the cortex cells (Wilson et al .,1977; Goss and Russel, 1980; Atwell, 1990a; Merotto Jr and Mundstock, 1999). Hossain et al .,(2008)

**Table.4** Effect of planting methods on root length and depth of maximum root density of wheat

| Sample No. | Root length (cm) | | | Depth of maximum root density (cm) | | |
|---|---|---|---|---|---|---|
| | Happy seeder | Rotavator | Farmer's practice | Happy seeder | Rotavator | Farmer's practice |
| 1 | 23.0 | 28.5 | 21.0 | 09.0 | 12.0 | 13.0 |
| 2 | 20.5 | 26.0 | 18.0 | 14.0 | 08.0 | 12.0 |
| 3 | 23.0 | 25.5 | 22.5 | 13.0 | 10.0 | 13.0 |
| 4 | 28.0 | 28.0 | 19.0 | 10.0 | 09.0 | 10.0 |
| 5 | 26.0 | 26.0 | 19.0 | 10.0 | 09.0 | 11.5 |
| 6 | 19.0 | 16.5 | 10.5 | 08.0 | 09.5 | 08.0 |
| 7 | 12.0 | 17.0 | 10.0 | 10.0 | 08.5 | 07.0 |
| 8 | 15.0 | 16.0 | 15.0 | 09.0 | 10.0 | 09.0 |
| 9 | 18.0 | 17.0 | 12.5 | 09.0 | 10.0 | 08.0 |
| 10 | 17.5 | 14.0 | 13.0 | 10.0 | 08.0 | 08.5 |
| 11 | 13.0 | 15.0 | 15.0 | 08.0 | 08.0 | 08.0 |
| 12 | 12.0 | 11.0 | 18.0 | 08.0 | 07.0 | 08.5 |
| 13 | 16.5 | 10.0 | 16.0 | 07.0 | 05.0 | 09.0 |
| 14 | 16.5 | 12.0 | 13.0 | 09.0 | 05.0 | 07.0 |
| 15 | 14.5 | 09.5 | 11.7 | 08.0 | 05.0 | 06.0 |
| 16 | 15.0 | 11.0 | 14.0 | 08.0 | 05.0 | 08.0 |
| Mean | 18.1 | 17.7 | 15.5 | 09.4 | 08.1 | 09.2 |

**Figure.1** Roots rotavator sown crop II. Farmer's practice III Happy seeder

**Table.5** Effect of planting methods dry weight of roots/plant of wheat

| Sample No. | Per plant dry weight of roots (g) | | |
|---|---|---|---|
| | Happy seeder | Rotavator | Farmer's practice |
| 1 | 0.97 | 2.26 | 0.65 |
| 2 | 2.65 | 2.48 | 1.72 |
| 3 | 1.03 | 2.12 | 2.10 |
| 4 | 1.58 | 1.25 | 1.01 |
| 5 | 2.49 | 1.06 | 1.29 |
| 6 | 1.68 | 1.60 | 1.40 |
| 7 | 2.49 | 1.57 | 2.08 |
| 8 | 1.90 | 1.81 | 1.66 |
| Average | 1.85 | 1.77 | 1.49 |

**Table.6** Effect of planting methods on bulk density ($gcm^{-3}$) in different districts

| S. No. | **Jallandhar and Kapurthala** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rotavator | | | Happy Seeder | | | Farmer Practice | | |
| | 0-15 | 15-30 | 30-45 | 0-15 | 15-30 | 30-45 | 0-15 | 15-30 | 30-45 |
| 1 | 1.27 | 1.42 | 1.37 | 1.20 | 1.18 | 1.15 | 1.18 | 1.20 | 1.25 |
| **Fatehgarh Sahib** | | | | | | | | | |
| 2 | 1.25 | 1.38 | 1.30 | 1.21 | 1.29 | 1.25 | 1.28 | 1.35 | 1.38 |
| **Patiala** | | | | | | | | | |
| 3 | 1.57 | 1.50 | 1.61 | 1.29 | 1.42 | 1.30 | 1.39 | 1.42 | 1.45 |
| **Mean** | | | | | | | | | |

**Table.7** Comparative fuel, time and monetary gain with the happy seeder over the rotavator and farmer's practice

| Particulars | Fuel (litres) | Time (hours) | Monetary gain (Rs.) |
|---|---|---|---|
| Saving of fuel/time/Monetary gain of Happy Seeder over Rotavator | 0.0 | 4.31 | 2250 |
| Saving of fuel/time/Monetary gain of Happy Seeder over Farmer Practice | 16.03 | 5.38 | 3250 |
| Saving of fuel/time/Monetary gain of Rotavator over Farmer Practice | 16.03 | 1.07 | 1000 |

reported that tillage systems, straw management and nitrogen application have created a remarkable impact on root length density, root weight density and root to shoot ratio of wheat. Root length density and root diameter in the surface layer increased with raised bed, straw mulch and nitrogen application

**Depth of maximum root density**

Data on depth of maximum density of roots of wheat sown with happy seeder, rotavator and farmer's practice are given in the table 4. For data collection of depth of maximum root density 16 samples were taken with the help of spade from the demonstration's fields of Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala. It is interesting to mention here, the maximum density of roots in plants of wheat sown with happy seeder was confined up to 9.4 cm depth followed by farmer's practice (9.2 cm) and rotavator (8.1 cm). It was found that the bulk density at all the layers under rotavator was generally higher than the conventional tillage and Happy Seeder sown field in all the locations of Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala districts. Higher bulk density, which resulted in compaction in lower layers of soil.The lower bulk density values were recorded in happy seeder than rotavator and conventional tillage sown wheat fields. It shows that the roots of wheat sown with rotavator are prevented to penetrate in the deeper layers of soil. It might be due to the compaction caused by the use of heavy machinery (Tractor along with rotavator). Soil compaction is a common problem that affects several soil properties and plant growth (Merotto Jr and Mundstock, 1999). As soil resistance increased, roots showed a reduced length. Soil compaction may change root growth by altering soil aeration (Hanks and Thorp, 1956; Eavis, 1972).

**Per-plant dry weight of roots**

Data on per plant dry weight of roots of wheat sown with happy seeder, rotavator and farmer's practice are depicted in the table 5. For data collection of per plant dry weight of roots 8 samples were taken from the demonstration's fields of Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala. The maximum dry weight of roots per plant was recorded from the plants of wheat sown with happy seeder followed by rotavator and farmer's practice. It was might be due to the more root length and more number of secondary roots and diameter of roots of happy seeder and rotavator sown wheat. Hossain et al., (2008) reported that tillage systems, straw management and nitrogen application have created a remarkable impact on root length density, root weight density and root to shoot ratio of wheat. Root length density and root diameter in the surface layer increased with raised bed, straw mulch and nitrogen application. The lowest dry weight of roots per plant could be due to the lowest root length of plants of the wheat sown with farmer's practice. There was a strong limitation of root growth detected by its dry matter, length and surface at soil resistance of 3.5 and 5.5 MPa as ompared to 1.0 and 2.0 MPa (Merotto Jr and Mundstock, 1999).

**Bulk Density**

The soil samples were taken for determination of bulk density in four districts of Punjab viz; Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala to know the formation of compaction in the

layers of soil by the rotavator, happy seeder and farmer's practice of planting wheat was presented in table 6. The samples were taken from 0-15, 15-30, 30-45 cm soil depth in Jalandhar, Kapurthala, Fatehgarh Sahib and 10-15, 15-20, 20-25 cm soil depth in Patiala for determination of bulk density. It was found that the bulk density at all the layers under rotavator was more than the conventional tillage and happy Seeder sown field at all the locations of Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala districts. The lower bulk density values were recorded in happy seeder than rotavator and conventional tillage sown wheat fields. The average bulk density of soil increased with the increase in soil depth from 0-15 to 15-30 cm in the field of happy seeder and rotavator sown wheat but in case of farmer's practice, the bulk density was increased up to the 30-45 cm soil depth. It shows farmer's practice cause compaction up to the lower depth. In Patiala district, the samples were taken at 5 cm interval of soil depth, the bulk density increased with increase in soil depth from 0-5 cm to 20-25 cm, but in case of happy seeder it was increased up to 15-20 cm after that it was decreased at the soil depth 20-25 cm. Merotto Jr and Mundstock, (1999) reported that the increase in the bulk density from 1.29 to 1.67 kg/dm$^3$ resulted in increase in soil resistance from 1.0 to 5.5 MPa.

## Lodging

On the basis of visual observation, it has been observed that rotavator and conventional tillage sown crop lodged more than happy seeder under adverse weather conditions. Lodging depends upon attaining maximum root length and depth of maximum root density. It was due to depth of maximum root density, which was confined up to 9.4 cm in happy seeder, whereas, it was confined up to 8.1 and 9.2 cm in rotavator and conventional tillage, respectively. So, the roots go deeper and remain intact with soil and therefore, protect the crop from lodging in happy seeder as compared to rotavator and conventional tillage under adverse weather conditions.

## Maturity

It was found on the visual observation basis that wheat sown with happy seeder took the more days to maturity. This might due to availability of soil moisture for longer period with the presence of paddy straw on the soil surface. Wheat sown with rotavator and conventional tillage matures 5-7 days earlier than happy seeder.

## Economics

Sowing of wheat with happy seeder farmers can save time 4.31 hrs and Rs. 2250 ha$^{-1}$ over the rotavator however, fuel 16.03 litres diesel, time 5.38 hrs and Rs. 3250 ha$^{-1}$ over the farmer's practice (Table 7). Similarly, crop sown with rotavator, farmers can save fuel 16.03 litres diesel, time 1.07 hrs and Rs. 1000 ha$^{-1}$ over the farmer's practice. It shows that sowing of wheat with zero tillage technology (Happy seeder) is economical than the rotavator and farmer's practice (Conventional tillage). Meenakhi (2010) reported that net returns varied considerably with the different methods of planting (Table 33). However, zero tillage, happy seeder gave higher net return than conventional tillage and rotavator.

It can be concluded from the results of this study, happy seeder (zero tillage) and rotavator (reduced tillage) gave the similar or slightly higher grain yield of wheat than farmer's practice. Happy seeder and

rotavator are also observed efficient methods for *in-situ* management of paddy straw and control of weed population. However, happy seeder is the most suitable method to produce the wheat at low cost and to manage the combine harvested paddy straw and ultimately to improve the soil productivity. Rotavator sown crop showed shallow root system due to compaction; more weed population than happy seeder sown crop but showed less weed population as compared to farmer's practice.

## References


Atwell, B.J., 1990a. The effect of soil compaction on wheat during early tillering. I. Growth, development and root structure. New Phytol. 115:29-35.

Bimbraw., Avtar Singh, Kang, Jasjit Singh and Kaur, Maninder. 2011. Happy Seeder: A Avenue for crop residue management. *Research Bulletin* 1/2011. Department of Agronomy, Punjab Agricultural University, Ludhiana.

Eavis, B.W., 1972. Soil physical conditions affecting seedling root growth. I. Mechanical impedance, aeration and moisture availability as influenced by bulk density and moisture levels in a sandy loam soil. Plant Soil. 36:613-622.

Goss, M.J., 1977. Effects of mechanical impedance on root growth in barley (*Hordeum vulgare* L.) I. Effects on the elongation and branching of seminal root axes. J. Exp. Bot. 28:96-111.

Goss, M.J., and Rusell, R.S. 1980. Effects of mechanical impedance on root growth in barley (*Hordeum vulgare* L.)III. Observations on the mechanism of response. J. Exp. Bot. 31:577-588.

Hanks, R.J., and Thorp, F.C. 1956. Seedling emergence of wheat as related to soil moisture content, bulk density, oxygen diffusion rate and crust strength. Soil Sci. Soc. Am. Proc., 20:307-309.

Hossain, M.I., Osaki, M., Khan, M.M.H., Rahmatullah, N.M. and Rashid, M.H. 2008. Effect of straw management and nitrogen fertilization on root growth and root characteristics of wheat through raised bed system on a low N calcareous soil of Bangladesh. The Journal of Agricultural Science 41(1-2): 45-52.

Kaushal, Meenakashi, Singh, Avtar and Kang, J.S. 2012a. Effect of planting techniques and nitrogen levels on growth, yield and n recovery in wheat (*Triticum aestivum* L.). J. Res., Punjab Agric. Univ. 49 (1 & 2): 14-16.

Kaushal, Meenakashi, Singh ,Avtar, Kang, J.S. and Kaur, Maninder. 2012b. Influence of direct

drilling and nitrogen levels on wheat grain yield, NPK uptake and soil properties. J. Res., Punjab Agric. Univ. 49 (1 & 2): 9-13.

Meenakshi, 2010. Influence of paddy residue and nitrogen management on the productivity of wheat (T*riticum aestivum* l.). M.Sc. Thesis, Punjab Agricultural University, Ludhiana.

Merotto Jr. A. and Mundstock C.M. 1999. Wheat root growth as affected by soil strength(1). R. Bras. Ci. Solo, 23:197-202.

Sardana, V., Sharma, S.K., Randhawa, A.S. and Mahajan, G. 2005. Zero tillage cultivation of wheat in Rice wheat cropping sequence in sub mountainous region of Punjab. *J Soil and Crop* 15(2): 233-39

Sidhu, H.S., Manpreet-Singh, Humphreys, E., Yadvinder-Singh, Balwinder-Singh, Dhillon, S.S., Blackwell, J., Bector, V., Malkeet-Singh and Sarbjeet- Singh. 2007. The Happy Seeder enables direct drillingof wheat in to rice stubble. Australian. J. Experi.Agricult. 47: 844-854.

Singh, R.P., Dhaliwal, H.S., Humphreys, E., Sidhu, H.S., Manpreet-Singh, Yadvinder-Singh, Blackwell,

John. 2008. Economic evaluation of the Happy Seeder for rice-wheat systems in Punjab, India. http://purl.umn.edu/5975

Wilson, A.J. Robards, A.W. and Goss, M.J. 1977. Effects of mechanical impedance on root growth in barley (*Hordeum vulgare* L.) II. Effects on cell development in seminal roots. J. Exp. Bot. 28:1216-1227.

Yadav, D. S., Shukla, R.P. and Sushant. 2005. Effect of zero tillage and nitrogen level on wheat (*Triticum aestivum*) after rice. Indian J. Agron. 50(1):52-53.