Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
www.phytojournal.com
JPP 2020; 9(3): 958-962
Received: 08-03-2020
Accepted: 12-04-2020

**Vinay Singh**
Assistant Professor, Punjab Agricultural University, Krishi Vigyan Kendra, Bathinda, Punjab, India

**Gurmeet Singh Dhillon**
Associate Professor, Punjab Agricultural University, Krishi Vigyan Kendra, Bathinda, Punjab, India

**Parkash Singh Sidhu**
Senior Research Fellow, Punjab Agricultural University, Krishi Vigyan Kendra, Bathinda, Punjab, India

**Corresponding Author:**
**Vinay Singh**
Assistant Professor, Punjab Agricultural University, Krishi Vigyan Kendra, Bathinda, Punjab, India

# Effect of various rice residue management practices on performance of wheat in south-western region of Punjab

**Vinay Singh, Gurmeet Singh Dhillon and Parkash Singh Sidhu**

**Abstract**
On-farm trials were conducted during three consecutive *Rabi* seasons from 2016-2019 to evaluate the influence of different paddy straw management practices on productivity and yield attributes of wheat. Besides these, effects on soil fertility were also observed. Rice straw was managed by harvesting of crop using straw management system (SMS) fitted combine, then wheat was sown with different methods like happy seeder, mulcher, reversible mould board plough, zero till drill and conventional method. The results revealed a significant improvement in productivity of happy seeder sown wheat. The maximum grain yield was recorded when wheat was sown with happy seeder machine as compared to the treatment where it was sown after incorporating straw with mulcher and RMB plough. The yield attributes of wheat like numbers of effective tillers, plant height, ear length, number of grains per ear and test weight were also found to be significantly higher in happy seeder sown wheat. Significantly higher soil pH, available phosphorus and potassium status was observed in happy seeder sown wheat. Whereas, OC was significantly higher in RMBP followed by happy seeder sown wheat. The average higher net returns and benefit: cost ratio were also found to be maximum under wheat sown with happy seeder as compared with other methods.

**Keywords:** Happy seeder, RMB plough, mulcher, wheat, zero till, crop, residue, management

## Introduction

Punjab is a leading state in production of rice and wheat in India. The state has 30.65 lakh ha under rice cultivation with production of 199.72 lakh tones and average yield of 65.16 quintals per hectare. The area under wheat cultivation is 35.12 lakh ha with a production of 178.30 lakh tones and average yield of 50.77 quintals per hectare (Anonymous, 2019a) [2]. In the state, 90% of area under rice is machine harvested (Lohan *et al.* 2018) [13]. Based on harvest index, 18-20 million tones of rice-straw production is estimated. Approximately 95% of paddy straw is burnt every year in Punjab, making the state the major culprit for greenhouse gas emission (Singh *et al.* 2018) [16]. According to a study conducted by Lohan *et al.* (2018) [13], the central and southern districts of Punjab are involved in severe burning activities. According to state Department of Agriculture and Farmers Welfare (Anonymous 2019b) the paddy including basmati was cultivated in Bathinda district in the area of 1,60,000 ha during the last year. Out of this 70% area is under crop residue management practices and remaining 30% is still unmanaged. In 294 villages of Bathinda district, 80-100%, 60-80%, 40-60%, 20-40% and 0-20% area is under crop residue management in 27, 99, 126, 41 and 1 villages, respectively (PRSC, 2019).

The scarcity of labour for manual harvesting, use of combine harvester with the growth of farm mechanization, timeliness in operation and cleaning of fields etc. are some major reasons behind in-situ burning of paddy straw (Lohan *et al.* 2018, Singh *et al.* 2018 and Shyamsunder *et al.* 2019) [13, 16]. This incineration of crop residue has become an essential source of atmospheric pollution in the NW India during paddy harvesting seasons (Sarkar *et al.* 2018) [19]. This also leads to health hazards to human and animals (Gupta and Sahai 2005, Aggarwal 2006 and Lal 2006) [7, 12]. Besides these, this in-situ burning of rice residue also results in deterioration in soil health and fertility through loss of soil nutrients like 89% N, 5.5% P, 20% K, and more than 50% S (Singh *et al.* 2007 and Singh *et al.* 2010) [23, 26]. Such beneficial nutrients can be conserved and recycled in soil by incorporating crop residues in it (Singh *et al.* 2008) [24]. Therefore, residue management is receiving a great deal of attention now a day, due to this positive and diverse effect of soil physical, chemical and biological properties. Previously, many researchers have studied effects of rice residue management on performance of wheat and found positive effect on yield and uptake of N and K (Mandal *et al.* 2004, Kahloon *et al.* 2012, Dotaniya 2013, Dhillon 2016 and Iqbal *et al.* 2017) [14, 10, 6, 5, 8].

Though there are many such studies have been conducted across India and Punjab, but there was lack of such information from district Bathinda of Punjab. The district has sandy loam to loamy sand type of soil properties. So, keeping in view such points the present investigations were planned to study the effect of various rice residue management techniques on performance of wheat in south-western region of Punjab.

## Materials and Methods

The present on-farm trials were conducted during three consecutive *Rabi* seasons (2016-17, 2017-18 and 2018-19) to evaluate the influence of different rice residue management practices on wheat productivity, yield attributes and fertility status of the cropped soil. All the demonstrations sites were kept same for the three experimental years. The investigations were conducted at five different locations, one at farm of Krishi Vigyan Kendra, Bathinda and four at farmers' fields of villages namely Mehraj, Killi Nihal Singh wala, Mehma sarja and Bir Behman. There were three replications of each treatment at all the locations. Details of the treatments are given in Table 1.

**Table 1:** Details of Treatments

| Sr. no. | Treatment* | Details of treatments |
|---|---|---|
| 1. | HS | Harvesting of rice with PAU Straw Management System (SMS) attached combine. Then sowing of wheat with happy seeder in standing stubbles of rice. |
| 2. | M | Mulcher was used to cut and spread the straw from stubbles of paddy after combine harvest then sowing of wheat with happy seeder or zero till drill |
| 3. | RMBP | Harvesting of rice with PAU Straw Management System (SMS) attached combine and the stubbles were cut with cutter cum spreader and mixed in soil with the help of Reversible Mould Board Plough. After this operation leveling of field was done and wheat was sown with seed cum fertilizer drill. |
| 4. | ZTD | Harvesting of rice with PAU Straw Management System (SMS) attached combine and manual/ mechanical removal of loose straw. Sowing of wheat was done with zero till drill. |
| 5. | CM | The field was well prepared by use of disc harrow, cultivator and, planker after burning of paddy straw. Wheat was sown with ferti-cum seed drill |

* HS= Happy seeder; M= Mulcher; RMBP= Reversible MB Plough; ZTD= Zero till drill;
CM= Conventional Method

Varieties of rice and wheat namely PR-122 and HD-3086 respectively, were used for the experimentation. The rice crop was harvested and wheat sowing was done on dates given in Table 2.

**Table 2:** Dates of harvesting rice and sowing wheat during different *rabi* seasons

| Particulars | 2016-17 | 2017-18 | 2018-19 |
|---|---|---|---|
| Rice harvesting | 25 Oct – 30 Oct, 2016 | 25 Oct –30 Oct, 2017 | 1 Nov – 10 Nov, 2018 |
| Residue management treatment | 1 Nov - 10 Nov, 2016 | 15 Nov–20 Nov, 2017 | 15 Nov–30 Nov, 2018 |
| Wheat sowing | 15 Nov–25 Nov, 2016 | 20 Nov–25 Nov, 2017 | 20 Nov–30 Nov, 2018 |
| Time interval between rice harvest and wheat sowing | 25 days | 25 days | 20 days |

### Soil analysis

The soil of experimental area was sandy loam to loamy sand. The soil samples were collected from the fields in the month of May, after wheat harvest. The samples were grounded to pass through 2.0 mm stainless steel sieve and stored in polyethylene bottles with tight lids. Soil reaction (pH) and electrical conductivity (EC) were determined by using 1:2 soil: water (w/v basis) ratio (Jackson, 1967) [9]. Soil organic carbon (OC) content was determined by method of Walkley and Black (1934) [28]. The Olsen-P (Av-P) content in the soil samples was determined as described by Olsen *et al.* (1954) [17]. Available-K was determined using 1N, $CH_3COONH_4$ (pH=7.0) followed by flame photometric estimation.

## Results and Discussion

### Crop yield

Data presented in Table 3. revealed that the average yield obtained from happy seeder (HS) sown wheat for the three years was maximum (60.4 q/ha) amongst all the treatments. Remaining treatments namely M, RMBP, ZTD and CM were found to be at par to each other in terms of yield of wheat. Though the order of yield obtained was HS>ZTD>RMBP>CM>M. A significant increase of 2.7% in average yield of wheat was also observed during the three cropping years. Though, the interaction effect of cropping years on yield was found to be non-significant. A numerical increase in yield was observed in all the treatments during the three cropping years. The average enhancement in yield to the tune of 3.60%, 3.95%, 4.31% and 5.22% in happy seeder practice over zero till drill, reversible mould board plough, conventional method and mulcher respectively was also observed. The present investigations find support from Singh *et al.* 2009 who also observed a higher yield in happy seeder sown wheat compared to conventional tillage. Sidhu *et al.* (2007) [22] and Naresh *et al.* (2011) [15] recorded an average 9-15% higher grain yield of wheat sown with happy seeder in rice residues. The surface retention practice of straw may maintain better temperature and moisture regimes of soil which may result in higher grain yield.

**Table 3:** Yield of wheat sown with various RRM techniques during different years

| RRM techniques | Yield (q/ha) | | | Average (q/ha) |
|---|---|---|---|---|
| | 2016-17 | 2017-18 | 2018-19 | |
| HS | 59.2±1.15* | 60.9±2.20 | 61.2±2.15 | 60.4 |
| M | 56.7±0.40 | 57.2±1.95 | 58.5±1.70 | 57.4 |
| RMBP | 57.4±0.80 | 58.1±0.90 | 58.9±1.90 | 58.1 |
| ZTD | 57.6±1.30 | 58.4±1.30 | 59.0±1.85 | 58.3 |
| CM | 57.1±1.35 | 58.1±1.10 | 58.7±1.65 | 57.9 |
| Average Yield (q/ha) | 57.6 | 58.5 | 59.2 | |

*Values indicate standard error
CD ($p$=0.05)
A (Cropping years) : 0.71
B (RRM techniques) : 0.92
A×B : NS

**Yield attributes**

Data on effect of various rice residue management practices on yield attributes are presented in Table 4. The results revealed that the plant height, number of effective tillers, ear length and test weight remained significantly higher in HS sown wheat. Higher numbers of grains per ear were observed in HS and ZTD which remained on par to each other. HS being significantly maximum in plant height was followed by ZTD, M and CM which were at par to each other. Significantly, minimum plant height was evident in treatment RMBP. Treatments namely M and CM were found to be significantly best in terms of number of effective tillers after HS. Both the treatments were found to be on par to each other. Significantly, less number of effective tillers were observed in treatment ZTD. Treatment RMBP was found to be significantly best after HS and ZTD in terms of ear length. Whereas, minimum ear length was recorded in treatment M. Ear length in treatment CM remained at par to RMBP and M. Similar trend of number of grains per ear was found amongst various treatments. Treatment ZTD was found next to HS. This was followed by RMBP. Significantly, minimum number of grains per ear was found in M and CM which were on par to each other. Treatment RMBP followed the treatment HS in terms of test weight. This was followed by ZTD and CM. Significantly, minimum test weight was observed in treatment M.

Maximum plant height, effective tillers, ear length, grains per ear and test weight observed in treatment HS was attributed due to better root development and maximum uptake of nutrients as observed by other researchers like Soomro *et al*., (2009) [27], Nasurullah *et al.* (2010), Zamir *et al.* (2010) [29].

**Table 4:** Effect of various rice residue management practices on yield attributes

| Treatments | Plant height (cm) | No. of effective tillers (per $m^2$) | Ear length (cm) | No. of grains per ear | Test weight (g) |
|---|---|---|---|---|---|
| HS | 96.17±0.345* (9.86) | 372.33±4.74 (19.32) | 9.70±0.043 (3.27) | 79.89±0.588 (68.99) | 54.56±0.245 (7.45) |
| M | 93.67±0.097 (9.73) | 343.67±4.35 (18.56) | 9.05±0.012 (3.17) | 68.33±0.771 (8.33) | 48.46±0.099 (7.03) |
| RMBP | 91.37±0.371 (9.61) | 346.67±8.47 (18.64) | 9.24±0.047 (3.20) | 73.44±0.678 (8.63) | 49.42±0.091 (7.10) |
| ZTD | 94.11±0.294 (9.75) | 351.67±8.76 (18.78) | 9.64±0.062 (3.26) | 76.33±0.510 (8.79) | 49.17±0.166 (7.08) |
| CM | 93.35±0.176 (9.71) | 343.67±6.27 (18.56) | 9.16±0.110 (3.19) | 70.11±0.890 (8.43) | 48.72±0.307 (7.05) |
| Average | 93.73 | 351.60 | 9.35 | 73.62 | 50.06 |
| CD ($p$=0.05) | 0.05 | 0.19 | 0.02 | 0.12 | 0.04 |

*Values indicate standard error

Figures in parentheses are the $\sqrt{x+1}$ transformed values

**Soil Health Parameters**

Soil analysis of the experimental plots before initiation of the investigations revealed values of pH, OC, available P and K to be 8.1, 0.35%, 18.25 kg/ha and 373.70 kg/ha, respectively. Data pertaining to effect of different rice residue management practices on soil health after three years of experimentations are presented in Table 5.

After three years of the experimentations, a significantly higher pH value (8.41) was recorded from treatment HS amongst all. 3.82 % increase in pH from the initial value was observed in treatment HS. This was followed by CM which was on par to treatment HS. Significantly, minimum pH value was observed in soils of treatment RMBP (8.16) with only 0.74 % increase from the initial value.

After three years, the buildup of OC was found to be significantly maximum in treatment RMBP (0.58%) with 65.71 % increase from the initial value (0.35%). This was followed by treatments HS, M, ZTD and CM with 3.57, 23.4, 38.0 and 61.1 % increase in percent OC from the initial value. Due to microbial decomposition it converted into different easily mineralizable form of soil organic matter (Brady and Weil, 2005). Plants directly and indirectly take up the mineralized form of plant nutrient from the soil solution. The incorporation of crop residues can recycle nutrients and increase soil organic matter content (Kone *et al*., 2010). Significant difference in available P content was also observed across the treatments with maximum and minimum corresponding to treatments HS (25.18 kg/ha) and CM (18.90 kg/ha). 37.9 and 3.56 % increase from the initial value of available P content (18.25 kg/ha) was evident from these treatments respectively. The solubility action of organic acids produced during decomposition of crop residues resulted in the more release of native and applied phosphorus.

Almost similar trend was observed in case of available K content in soils after 3 years. Significantly maximum available K content was observed in treatment HS (419.60 kg/ha) with 12.28 % increase from initial available content (373.70 kg/ha). This was followed by RMBP, M ZTD and CM with 3.67, 7.89, 11.19 and 12.16 % available K content. This might be due to the decomposition of crop residues which led to mineralization of the fixed potassium and increased the availability of potassium. The increase in total K uptake on addition of crop residues and application of inorganic N and K fertilizer might be due to increase in the availability of plant N and K nutrient in the soil (Sharma, 2002) [20].

**Table 5:** Effect of various rice residue management practices on soil health after three years

| Treatments | pH | Available P (kg/ha) | Available K (kg/ha) | OC (%) |
|---|---|---|---|---|
| HS | 8.41±0.030 (3.07) | 25.18±4.032 (5.11) | 419.60±0.292 (20.51) | 0.56±0.007 (4.28) |
| M | 8.25±0.036 (3.04) | 21.18±0.567 (4.71) | 388.89±0.278 (19.75) | 0.47±0.007 (3.94) |
| RMBP | 8.16±0.038 (3.03) | 23.65±3.876 (4.97) | 404.74±0.169 (20.14) | 0.58±0.006 (4.37) |

| | | | | |
|---|---|---|---|---|
| ZTD | 8.22±0.049 (3.04) | 19.92±1.811 (4.57) | 377.34±0.093 (19.45) | 0.42±0.003 (3.68) |
| CM | 8.30±0.033 (3.05) | 18.90±1.551 (4.46) | 374.10±0.138 (19.37) | 0.36±0.006 (3.44) |
| Average | 8.268 | 21.766 | 392.934 | 0.478 |
| CD ($p$=0.05) | 0.01 | 0.05 | 0.12 | 0.04 |

*Values indicate standard error

Figures in parentheses in the last column are arc sine and in the rest are $\sqrt{x+1}$ transformed values

## Economics

The observed data were analyzed for economics of returns from various rice residue management practices on performance of wheat in south-western region of Punjab (Table 6). The data revealed highest gross returns (Rs. 1,11,136/-) under wheat sown with happy seeder due to higher grain produce (60.4 q/ha) then sold at MSP rates in market. The average cost of cultivation of wheat sown with conventional method (Rs. 31542/-) was recorded highest as compared with other methods of wheat sown like RMB plough (Rs. 25575/-), Mulcher (RS. 24075/-), happy seeder (Rs. 21420/-) and zero till drill (Rs. 20850/-). This might be due to the field preparation operations under conventional method consumes high fuel, more labor and herbicides for weed management. The average higher net returns (Rs. 89716/-) was recorded under happy seeder after excluding the gross cost from gross returns as compared to other methods. The benefit: cost ratio was found to be maximum (4.18) under wheat sown with happy seeder as compared with other methods. Results of the present studies are also in line with the results obtained by Kahloon *et al.* (2012) [10], Dhillon (2016) [5] and Iqbal *et al.* 2017 [8] who found highest increments B:C ratio in happy seeder compared to normal sowing of wheat.

**Table 6:** Cost analysis of various rice residue management practices

| Wheat sown method | Avg. Yield (q/ha) | Cost of cultivation (Rs/ha) | *Gross return (Rs/ha) | Net return (Rs/ha) | B:C ratio |
|---|---|---|---|---|---|
| Happy seeder | 60.4 | 21420 | 111136 | 89716 | 4.18 |
| Mulcher | 57.4 | 24075 | 105616 | 81541 | 3.38 |
| RMB Plough | 58.1 | 25575 | 106904 | 81329 | 3.18 |
| Zero till Drill | 58.3 | 20850 | 107272 | 81422 | 3.90 |
| Conventional Method | 57.9 | 31542 | 106536 | 74994 | 2.37 |

*Latest MSP rate of wheat= Rs.1840/qtl

It is concluded that among machinery available for paddy straw management, happy seeder is a better option to manage paddy straw for the sowing of wheat crop. The surface retention of paddy straw by use of happy seeder not only enhanced the wheat yield but also improved the soil fertility. The study finds that the Happy Seeder technology is a viable alternative to open-field burning of rice residue in the *Malwa* region of Punjab. This technology is also time saving because the Happy Seeder can be brought into the field immediately after the rice harvest and is environment friendly.

## Acknowledgment

The authors sincerely acknowledge the necessary facilities provided by Dr Jitender Singh Brar, Associate Director (Trg.), Krishi Vigyan Kendra, Bathinda during the studies.

## References

1. Agrawal S, Trivedi C, Sengupta R. Air pollution due to burning of residues. In: Proceeding of the Workshop on Air Pollution Problems Due to Burning of Agricultural Residues, held at PAU, Ludhiana organized by the Indian Association for Air Pollution Control in collaboration with the Punjab State Pollution Control Board, Patiala and the Central Pollution Control Board, New Delhi, 2006.
2. Anonymous. Packages of practices for field crops during Rabi. Punjab Agricultural University, Ludhiana, Punjab, India, 2019a.
3. Anonymous. Current scenario of rice residue management in Bathinda district. Department of Agriculture and Farmers Welafare. Official Report, 2019b, 1.
4. Brady NC, Weil RR. The Nature and properties of soil. 881 (Thirteenth Edition). Macmillan Publishing Co., New York, 2005.
5. Dhillon GS. Comparative evaluation of happy seeder technology versus normal sowing in wheat (*Triticum aestivum*) in adopted village Killi Nihal Singh of Bathinda district of Punjab. Journal of Applied and Natural Science. 2016; 8(4):2278-2282.
6. Dotaniya ML. Impact of crop residue management practices in rice-wheat system. Current Advances in Agricultural Sciences. 2013; 5(2):269-271.
7. Gupta PK, Sahai S. Residues open burning in rice-wheat cropping system in India: an agenda for conservation of environment and agricultural conservation agriculture. in 'Conservation Agriculture – Status and Prospects', ed. by I.P. Abrol, R.K. Gupta and R.K. Malik. Centre for Advancement of Sustainable Agriculture, National Agriculture Science Centre: New Delhi, 2005, 50-54.
8. Iqbal MF, Hussain M, Faisal N, Iqbal J, Rehman AU, Ahmad M *et al*. Happy seeder zero tillage equipment for sowing of wheat in standing rice stubbles. International Journal of Advanced Research in Biological Sciences. 2017; 4(4):101-105.
9. Jackson ML. Soil chemical analysis, Prentice Hall of India Pvt Ltd, New Delhi, 1973, 186-196.
10. Kahloon MH, Iqbal MF, Farooq M, Ali L, Fiaz M, Ahmad I. A comparison of conservation technologies and traditional techniques for sowing of wheat. J Anim. Plant Sci. 2012; 22(3):827-830.
11. Kone FJ, Kouadio Y, Yapo ES, Visser M. Effects of spontaneous plant residues and rice straw incorporated in soil on growth and yield parameters of a lowland rice cultivar (*Oryza sativa* L.) in sub humid Tropical area, Côte D'ivoire. Journal of Applied Sciences Research. 2010; 6:1581-1588.
12. Lal MM. An Overview to Agricultural Burning. In: Proceeding of the Workshop on Air Pollution Problems Due to Burning of Agricultural Residues, held at PAU, Ludhiana organized by the Indian Association for Air Pollution Control in collaboration with the Punjab State Pollution Control Board, Patiala and the Central Pollution Control Board, New Delhi, 2006.
13. Lohan SK, Jat HS, Yadav AK, Sidhu HS, Jat ML, Choudhary M *et al*. Burning issues of paddy residue management in northwest states of India. Renewable and Sustainable Energy Reviews. 2018; 81:693-706.

14. Mandal KG, Misra AK, Hati KM, Bandyopadhyay KK, Ghosh PK, Mohanty M. Rice residue management options and effects on soil properties and crop productivity. Food, Agriculture & Environment. 2004; 2:224–231.
15. Naresh RK, Gupta RK, Parakash S, Kumar A, Singh M, Misra AK. Permanent beds and rice residues management for rice wheat systems in the North West India. International Journal of Agricultural Sciences. 2011; 7(2):429-439.
16. Nasrullah MH, Cheema MS, Akhtar M. Efficacy of different dry sowing methods to enhance wheat yield under Cotton-Wheat cropping system. Crop and Environment. 2010; 1(1):27-30.
17. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. In: USDA Circ. 939, United States Department of Agriculture, Washington DC, 1954.
18. PRSC. Present burning scenario in district Bathinda. Punjab Remote Sensing Centre. Official Report, 2019, 4.
19. Sarkar S, Singh RP, Chauhan A. Crop residue burning in Northern India: increasing threat to greater India. Journal of Geophysical Research: Atmospheres. 2018; 123(13):6920–6934.
20. Sharma SN. Nitrogen management in relation to wheat residue management in rice-wheat cropping system. Indian Journal of Agricultural Sciences. 2002; 72:449-452.
21. Shyamsundar P, Springer NP, Tallis H, Polasky S, Jat ML, Sidhu HS *et al*. Fields on fire: Alternatives to crop residue burning in India. Science. 2019; 365(6453):536-538
22. Sidhu HS, Singh M, Humphreys E, Singh Y, Singh B, Dhillon SS *et al*. The Happy Seeder enables direct drilling of wheat into rice stubbles. Australian Journal of Experimental Agriculture. 2007; 47:844-854.
23. Singh B, Shan YH, Johnson-Beebout SE, Singh Y, Buresh RJ. Crop residue management for lowland rice based cropping system in Asia. Advance in Agronomy. 2007; 98:118-186.
24. Singh B, Shan YH, Johnson-beeebout SE, Yadvinder-Singh, Buresh RJ. Crop residue management for lowland rice-based cropping systems in Asia. Advance in Agronomy. 2008; 98:118-199.
25. Singh R, Mahajan G, Kaur S, Chauhan BS. Issues and strategies for rice residue management to unravel winter smog in North India. Current Science, 114(12):2419.
26. Singh Y, Singh M, Sidhu HS, Khanna PK, Kapoor S, Jain AK *et al*. Options for effective utilization of crop residues. Directorate of Research, Punjab Agricultural University, Ludhiana, India, 2010.
27. Soomro UA, Rehman MU, Odhano EA, Gul S, Tareen AQ. Effect of sowing method and seed rate on growth and yield of wheat (*Triticum aestivum*). World Journal of Agricultural Sciences. 2009; 5(2):159-162.
28. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934; 37:29–38.
29. Zamir MSI, Ahmad AH, Nadeem MA. Behavior of various wheat cultivars at tillage in Sub-tropical conditions. Cercetări Agronomice în Moldova. 2010; 4(144):13-19.