Vol. 50, No. 2, pp 154-158, 2022
Indian Journal of Soil Conservation

Impact of residue management practices of rice on growth, productivity and soil physical properties of barley (*Hordeum vulgare* L.) varieties in Indo-Gangetic plains of India

Kamaljeet Singh[1] and Balwinder Singh Dhillon[2,*]

[1]*Department of Agronomy, College of Agriculture, Guru Kashi University, Talwandi Sabo, Punjab;* [2]*Regional Research Station, Punjab Agricultural University, Ballowal Saunkhri, SBS Nagar, Punjab.*

**Corresponding author:*
E-mail:balwinderdhillon.pau@gmail.com (Balwinder Singh Dhillon)

ARTICLE INFO

DOI : 10.59797/ijsc.v50.i2.171

Article history:
Received : July, 2021
Revised : June, 2022
Accepted : July, 2022

Key words:
Barley
Bulk density
Grain yield
Physical properties
Rice residue

ABSTRACT

Rice residues are important natural resources and recycling of these residues improves the soil physical, chemical and biological properties. Management of rice straw is a major challenge as it is considered to be a poor feed for the animals. The field experiment was conducted on effect of rice residue incorporation on barley productivity and soil physical properties at Research Farm of University College of Agriculture, Bathinda during *rabi* season of 2019-20. The trail was laid out in split plot design with two barley varieties (V_1-'PL 807' and V_2-'DWRB 123') in main plots and five levels of rice residue incorporation (0, 5, 7.5, 10 and 12.5 t ha^{-1}) in sub plots and replicated thrice. Barley variety 'PL 807' recorded higher growth attributes *viz.,* plant height, dry matter, number of tillers, leaf area index and dry matter and yield attributes *viz.,* number of effective tillers, number of grains/ear, 1000-seed weight and grain yield, straw yield and biological yield than 'DWRB 123'. Barley varieties 'PL 807' recorded 17.53% higher grain yield than 'DWRB 123'. Rice residue incorporation of 7.5 t ha^{-1} recorded higher growth attributes *viz.,* plant height, dry matter, number of tillers, leaf area index and dry matter and yield attributes *viz.,* number of effective tillers, number of grains/ear and grain yield, straw yield and biological yield than other treatments of residue incorporations. Grain yield obtained with rice residue incorporation of 7.5 t ha^{-1} found 14.64%, 10.38%, 6.76%, 12.73% higher than 0, 5, 10, 12.5 t ha^{-1}, respectively. The soil water content and saturated soil water content markedly increased with residue incorporation treatments compared with control. Residue incorporation significantly decreased the soil bulk density in all incorporation treatments compared with control.

1. INTRODUCTION

Barley (*Hordeum vulgare*) is a major cereal crop grown in temperate climate regions. It has multifarious importance and besides its potential for use in human food, barley grains have been considered as sacred in many religious functions since ancient times. It grows successfully in a wider range of climatic conditions than any other cereal crops (Dhillon and Ram, 2022). It is more suitable than wheat in India due to hardy nature, can withstand adverse agro-environments like drought, salinity and alkalinity, and performs well in varied topography like plain and hill under both rainfed and irrigated conditions. Globally, about 70% of barley is used for animal feed, 20% for malting and 5% for direct food use. Its straw is also used for making hay and silage (Dhillon *et al.,* 2020).

Recycling of crop residues has the advantage of converting the surplus farm waste into useful products for meeting nutrient requirement of crops, thereby maintaining the soil physical as well as chemical conditions, and improving the overall ecological balance of the crop production system (Singh and Dhillon, 2021). Rice-barley is a nutrient exhaustive cropping system (Dotaniya, 2013). About 25% of N and P, 50% S and 75% of K uptake by cereal crops are retained in crop residue, making them viable nutrient sources. There is a need to identify and recommend highly productive, profitable and environmentally sound residue management systems. Crop residues may be incorporated partially or completely into the soil depending upon methods of cultivation. Ploughing is the most efficient residue incorporation method. Incorporation of rice residues before barley planting is difficult compared to incorporation of barley straw before rice planting due to low temperatures and the short interval between rice harvest and barley planting. Unlike removal or burning, incorporation of straw increases soil organic carbon (SOC) and soil N, P and K contents. It has been observed that incorporation of rice straw three weeks before barley sowing significantly increases barley yields on clay loam and on sandy loam soils.

Paddy straw is considered as a good source of nutrients. As a common practice, about 15 cm of straw is left above the ground level during harvesting of low land rice. Consequently, management of the remaining portion of stubble imposes a serious problem in the field because of the short period available between harvest of rice and sowing of barley, particularly in the rice-barley cropping sequence. Besides, stubble burning results in the loss of organic matter and hence the plant nutrients. However, management of the rice straw is a major challenge as it is a poor feed for the animals owing to high silica content. Combine harvester leaves behind a swath of loose rice residues, which interfere with operations of the seed drill used for planting wheat. To avoid this problem farmers resort to burning of crop residue, which not only leads to loss of huge biomass but also causes environmental pollution. Hence, there is a need to adopt ways and means to manage this valuable resource. Against this background, a field experiment was conducted to study the growth parameters, productivity and soil physical properties under different barley cultivars in relation to different levels of rice residue incorporation.

2. MATERIALS AND METHODS

The field experiment was conducted during 2019-20 on sandy soil at Agronomy Research Farm, University College of Agriculture, Guru Kashi University, Talwandi Sabo, Bathinda, Punjab during *rabi* season of 2019-20. Talwandi Sabo is located at 29°57'N latitudes and 75°7'E longitudes and altitude (213 m above mean sea levels). The experiment was laid out in split plot design with two varieties of barley (V_1-'PL 807' and V_2-'DWRB 123') in main plots and five levels of rice residue incorporation (0, 5, 7.5, 10 and 12.5 t ha^{-1}) in sub plots and replicated thrice. The soil of the experiment field was sandy in texture with slightly alkaline in reaction (pH 8.7) having low organic carbon (0.40) and having low available N (135.0 kg ha^{-1}), P (14.4 kg ha^{-1}), medium K (230.0 kg ha^{-1}). Treatments were allocated randomly to each plot to reduce the experiment errors. One heavy pre sowing irrigation was given to the field. The field was ploughed four times followed by planking at field capacity. After the preparatory tillage the field was divided into 30 different plots of size 2.25 × 3.00 m each. Different levels of rice residue (0, 5, 7.5, 10, 12.5 t ha^{-1}) was incorporated in every plot and irrigation was provided to let the residue to decompose in soil or mix well with soil.

Plant samples were collected 1 week before each crop harvest, but the soil samples were only collected at the time of rice harvest in 2016. The plant sample was divided into grain and straw. Soil samples from 0-30 cm were collected at 10 cm intervals to determine changes in the nutrient content. Soil samples for measuring the soil bulk density properties were collected with steel cutting rings with a volume of 100 cm^3. The soil water content, and soil bulk density were determined using standard methods (Lu, 1999). The SOC was determined following the procedure described by Yeomans and Bremner (1988).

3. RESULTS AND DISCUSSION

Growth Parameters of Barley

The plant height of the crop increased with the progress in crop growth up to harvest, irrespective of treatments

Table: 1
Plant height of barley as influenced by rice residue incorporation and varieties

Treatments	Plant height (cm)				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
Varieties					
PL 807	22.3	44.6	80.4	107.7	107.7
DWRB 123	19.0	40.2	72.5	103.8	103.8
SEm±	0.7	1.3	0.9	0.2	0.1
LSD (P=0.05)	2.2	4.2	2.9	NS	NS
Rice residue incorporation (t ha^{-1})					
0	19.1	40.5	74.4	103.3	103.0
5	20.7	42.0	77.3	106.2	106.2
7.5	22.1	44.7	79.1	109.0	109.0
10	21.0	43.8	76.3	104.9	104.9
12.5	20.4	40.8	75.1	105.4	105.4
SEm±	0.4	0.5	0.6	0.9	1.0
LSD (P=0.05)	1.2	1.6	1.8	3.2	3.2

(Table 1). The maximum gain in plant height was recorded between 60 to 90 days after sowing (DAS). Plant height increases at decreasing rate after 90 DAS and minimum gain in plant height was recorded between 90 to maturity stage. Barley variety 'PL807' recorded significantly higher plant height than 'DWRB 123' at all stages of growth. Plant height was recorded significantly higher with incorporation of rice residue @ 7.5 t ha^{-1} as compared to incorporation of rice residue @ 0, 5, 10, 12.5 t ha^{-1} at every stage of growth after 30, 60, 90, 120 DAS of sowing and after harvesting. The increased plant height can be ascribed to the improvement of physico-chemical properties of soil with the crop residue incorporation.

The number of tillers increased slightly up to 60 DAS and marginal decreased thereafter (Table 2). Among different barley varieties, the maximum tillers were observed in variety 'PL 807' (6-row barley) at all growth stages. Incorporation of rice residue @ 7.5 t ha^{-1} resulted in the highest number of tillers of barley at all the stages of observation (30, 60, 90, 120 and at maturity) which were significantly higher than other treatments. Katiyar (2002), Das *et al.* (2002) and Regar *et al.* (2005) reported that the addition of crop residue which might have improved the soil health and consequently higher uptake of available nutrients from the soil and increased number of tillers.

Yield Attributes of Barley

Tillers bearing panicles were counted and recorded as productive tillers. From the above recorded data in the Table 3 shows significantly higher number of effective tillers in 'PL 807' variety than 'DWRB 123'. Residue incorporation @ 7.5 t ha^{-1} recorded highest number of effective tillers which was significantly higher than control and other treatments of residue incorporations. Incorporation of rice residue results in improvement of spike length (Table 3). The spike length and number of grains / spike were significantly higher in 'PL 807' (6-row Barley) as compared to DWRB 123 (2 row

Table: 2
Number of tillers per meter row length of barley as influenced by rice residue incorporation and varieties

Treatments	Number of tillers per meter row length				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
Varieties					
PL 807	78.1	162.4	143.5	135.5	135.0
DWRB 123	72.1	155.2	126.3	117.5	118.0
SEm±	0.2	0.2	3.0	3.8	3.5
LSD (P=0.05)	0.9	NS	9.5	13.7	13.6
Rice residue incorporation (t ha^{-1})					
0	71.3	137.9	113.0	107.8	108.0
5	74.8	165.2	134.2	125.5	126.0
7.5	79.2	170.5	157.0	146.0	146.0
10	75.9	164.8	144.0	133.0	133.0
12.5	74.5	155.7	126.5	120.2	120.0
SEm±	0.6	4.2	2.8	2.1	2.0
LSD (P=0.05)	1.9	13.1	7.2	6.1	6.1

Table: 3
Yield attributes of barley as influenced by varieties and rice residue incorporation

Treatments	No. of effective tillers m^{-1} row length	No. of grains / spike	Spike length (cm)	1000-grain weight (g)
Varieties				
PL 807	132.0	63.6	7.78	36.2
DWRB 123	115.0	26.7	7.69	53.2
SEm±	3.9	1.3	0.3	0.1
LSD (P=0.05)	14.3	4.0	NS	0.5
Rice residue incorporation (t ha^{-1})				
0	105.0	40.5	6.98	42.9
5	122.0	44.8	7.77	43.8
7.5	143.0	49.7	8.52	47.0
10	130.0	47.1	7.98	46.5
12.5	118.0	43.4	7.43	43.3
SEm±	2.3	0.5	0.5	0.1
LSD (P=0.05)	5.7	1.6	0.15	0.4

barley). Residue incorporation @ 7.5 t ha^{-1} observed highest spike length and number of grains / spike which was significantly higher than control and other treatments of residue incorporations. Singh and Agrawal (2001) reported that rice residue incorporation @ 7.5 t ha^{-1} recorded significantly higher 1000-grain weight than other treatments. Among different varieties 'DWRUB 123' showed significantly higher 1000-grain weight as compared to 'PL 807'.

Productivity of Barley

Among barley varieties 'PL 807' had significantly higher biological yield (157.6 q ha^{-1}) as compared to 'DWRB 123' (143.3 q ha^{-1}) (Table 4). It is evident from the data that significantly maximum biological yield (162.1 q ha^{-1}) was recorded at rice residue incorporation @ 7.5 t ha^{-1}, whereas, at treatment 0 t ha^{-1} rice residue incorporation gave lowest biological yield (141.1 q ha^{-1}). It might be due to the addition of crop residues which might have improved the soil health and consequently higher uptake of available nutrients from the soil and increased the number of total tillers, number of effective tillers, plant height, spike length, number of grains / spike and test weight.

Table: 4
Productivity of barley as influenced by varieties and rice residue incorporation

Treatments	Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Varieties			
PL 807	157.5	61.1	96.4
DWRB 123	143.3	50.4	92.9
SEm±	1.9	1.6	0.3
LSD (P=0.05)	5.4	4.8	1.0
Rice residue incorporation (t ha^{-1})			
0	141.0	52.2	88.8
5	149.3	54.8	94.5
7.5	162.1	61.2	100.9
10	154.7	57.0	97.7
12.5	144.8	53.4	91.4
SEm±	1.1	0.4	0.7
LSD (P=0.05)	3.6	1.4	2.6

There was significant increase in grain yield of barley with the increasing levels of rice residue incorporation up to 7.5 t ha^{-1}. However, numerically significantly higher grain yield was recorded with 'PL 807' (7.5 t ha^{-1} rice residue incorporation) and significantly lower grain yield was recorded with 'DWRUB 123' with treatment (no rice residue incorporation). Crop residues could be better managed; this would directly improve crop yields by increasing soil nutrient availability, decreasing erosion, improving soil structure, and increasing soil water holding capacity. Bhattacharjee *et al.* (2013) reported that crop residue management is agronomically beneficial and environmentally friendly.

The straw yield is the principal criterion for evaluating efficiency of various treatments as it reflects the plant growth. Significant increase in the straw yield was obtained with the application of rice residue incorporation. The increased crop productivity with the crop residue management can be ascribed to the improvement in physical and chemical properties of soils thereby improving the physico-edaphological conditions and nutrient availability in soils. The straw yield was significantly higher with treatment (7.5 t ha^{-1} rice residue incorporation). The straw yield (8.79 t ha^{-1}) was significantly lower in ('DWRB 123' (2-row barley) with treatment (no rice residue incorporation). Tolanur and Badanur (2003) reported that crop residue on decomposition released nutrients slowly throughout the growth period, which resulted better plant growth and higher straw yield.

Physical Properties of Soil

The soil physical properties were significantly affected by residue incorporation treatments, as shown in Table 5. Residue management practices affect soil physical properties

Table: 5
Soil physical properties as influenced by varieties and rice residue incorporation

Treatments	Soil water content (%)	Saturated soil water content (%)	Bulk density (Mg m^{-3})
Varieties			
PL 807	11.4	39.6	1.3
DWRB 123	11.2	39.4	1.3
SEm±	0.01	0.02	0.01
LSD (P=0.05)	NS	NS	NS
Rice residue incorporation (t ha^{-1})			
0	9.4	37.2	1.35
5	11.2	40.1	1.28
7.5	11.5	41.2	1.26
10	12.1	41.6	1.25
12.5	12.2	42.1	1.24
SEm±	0.01	0.6	0.03
LSD (P=0.05)	0.2	1.7	0.1

such as soil moisture content, saturated soil water content and bulk density in soil. Increasing amounts of rice residues on the soil surface reduce evaporation rates and increased duration of first-stage drying. Thus, residue-covered soils tend to have greater soil moisture content than bare soil except after extended drought. The soil water content measured at the end of the experiment markedly increased with incorporation treatments compared with control. The saturated soil water content also notably increased by 13.2%, with residue incorporation @ 12.5 t ha^{-1} compared with control. Residue incorporation significantly decreased the soil bulk density in all incorporation treatments compared with control.

4. CONCLUSIONS

Barley variety 'PL 807' performed better as compared to 'DWRB 123' in terms of growth and yield attributes of barley. Incorporation of rice residue @ 7.5 t ha^{-1} with RDF was the most promising in improving growth attributes, grain, straw and biological yields of barley, besides enhancing soil moisture retention.

REFERENCES

Bhattacharjee, S. 2005. Reactive oxygen species and oxidative burst: roles in stress, senescence and signal. *Curr Sci.,* 89: 1113-1121.

Das, K., Medhi, D.N. and Guha, B. 2002. Recycling effect of crop residues with chemical fertilizers on physico-chemical properties of soil and on wheat yield. *Ann. Agric Res. New Series,* 23(2): 219-222.

Dhillon, B.S. and Ram, H. 2022. Improving nitrogen use efficiency and productivity through sowing environment and cutting stage in dual-purpose barley (*Hordeum vulgare* L.). *Cereal Res. Commun.,* https://doi.org/10.1007/s42976-022-00277-y.

Dhillon, B.S, Uppal, R.S. and Goyal, M. 2020. Forage quality and productivity of barley (*Hordeum vulgare* L.) as influenced by cutting management under staggered sowing in north-west India. *Arc. Agron. Soil Sci.,* 66(9):1244-1258.

Dotaniya, M.L. 2013. Impact of crop residue management practices on yield and nutrient uptake in rice-wheat system, GBPUAT, Pantnagar, India. *Curr. Adv. Agric. Sci.,* 5(2): 269-271.

Katiyar, S.C. 2002. Effect of moisture conservation practices on mustard production under rainfed condition. *Bhartiya Krishi Anusandhan Patrika*, 17(2/3): 81-86.

Lu, R. 1999. Analytical Methods of Soil Agrochemistry; China Agriculture Science and Technique Press: Beijing, China (in Chinese), 85-96 pp.

Regar, P.L., Rao, S.S. and Vyas, S.P. 2005. Crop-residue management for increased wheat (*Triticum aestivum*) production under saline soils of arid fringes. *Indian J. Agric. Sci.,* 75(2): 83-86.

Singh, B. and Dhillon, B.S. 2021. Growth and productivity of wheat (*Triticum aestivum* L.) as influenced by organic manures and residue incorporation. *J. Pharma Phytochem.* 10(3): 529-533.

Singh, R. and Agarwal, S.K. 2001. Analysis of growth and productivity of wheat in relation to levels of FYM and nitrogen. *Ind. J. Plant Physiol.,* 6: 279-28.

Tolanur and Badanur, V.P. 2003. Changes in organic carbon, available N, P and K under integrated use of organic manure, green manure and fertilizer on sustaining productivity of pearl millet-pigeon pea system and fertility of an Inceptisol. *J. Indian Society Soil Sci.* 51: 37-41.

Yeomans, J.C. and Bremner, J.M. 1988. A rapid and precise method for routine determination of organic carbon in soil. *Commun. Soil Sci. Plant Anal.,* 19: 1467-1476.