Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(3): 529-533
Received: 25-03-2021
Accepted: 27-04-2021

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Growth and productivity of wheat (*Triticum aestivum* L.) as influenced by organic manures and residue incorporation

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Abstract
A field experiment entitled "Growth and Productivity of wheat (*Triticum aestivum* L.) as influenced by organic manures and residue incorporation" was conducted during the *rabi* seasons of 2019-20 and 2020-21 at Research Farm, Guru Kashi University, Talwandi Sabo, Bathinda (Punjab). Incorporation of green manuring and crop residue incorporation results in higher growth attributing characteristics namely plant height, tiller density, number of effective tillers, panicle length, number of grains panicle^{-1}, test weight, grain yield, straw yield and physical properties of soil of rice. Crop residue incorporation and green manuring also increased the plant height, tiller density, effective tiller m^{-1} row length, ear length, number of grains ear^{-1}, test weight, grain yield and straw yield of wheat crop.

Keywords: grain yield, green manuring, rice residue, test weight, wheat

Introduction
Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) are the world's two most important cereal crops, Rice is most important *kharif* crop in India and having area of around 44.5 million ha with production of 120 million tonnes. Wheat is the second important staple food crop next to rice with production of 97.5 million tonnes from an area of 29.1 million ha (Anonymous 2020). Crop residues generally left over plant parts of crops after harvest and threshing are important natural resources. The crop residue recycling helps in converting the surplus farm waste into useful products to meet the nutrient requirements of crops apart from improving the ecological balance of crops production system. Rice is most important kharif crop of Punjab and having area about 30.46 lac ha in 2016-17 with 188.63 lac tones production of rice and average yield of 61.93 quintals/ha. About 82 % of rice residue produced is burnt in the field after harvesting rice by combine harvester, resulting in the substantial loss of plant nutrient therein Straw carbon, nitrogen and sulphur are completely burnt and also lost to the atmosphere in the burning process of rice straw. Although the government is trying to find alternative for use of rice straw but at present there is no alternative for use of paddy straw collected from rice harvesting except in-situ management in the field, composting and mulching. The past studies indicates thus grain yield of wheat and following rice have not been adversely effected by in-situ incorporation of rice straw in soil. Walia *et al* (1995) [13] and Singh, *et al*., (1996) [10] reported beneficial effect of rice straw on wheat yield incorporated 3 weeks before sowing of wheat in clay loam soil. Several studies also revealed that incorporation for crop residue improved physical, chemical and biological properties of soil but also increase wheat yield over burning in the long term experiments (Sidhu and Beri 2008) [9]. The burning of crop residue and continuous use of chemical fertilizer may cause environment pollution. Organic manures like farm yard manure (FYM) and green manure (GM) in association with chemical fertilizers would play an important role in quality production of scented rice and maintenance of soil fertility and health (Kumar, R. *et al*., 2018). Basmati rice can successfully be grown with green manuring only or by integration of FYM and reduced dose of chemical fertilizer. Though these are costly options than chemical fertilizer, these improve soil organic carbon and available N, P and K as compared with chemical fertilizer alone and contribute to agricultural sustainability.

Materials and Methods
The present investigation was conducted during two consecutive years (i. e. 2019-20 and 2020-21) at research farm of University College of Agriculture, Guru Kashi University, Talwandi Sabo. Talwandi Sabo is located at 29°-59'N latitude and 75°-4'E longitude and altitude of 213 meters above sea level.

This tract is characterized by semi arid zone, where both winters and summers extreme. A maximum temperature of about 40-41.9 °C is not uncommon during summer, while freezing temperature accompanied by frost occurrence may be witnessed in the months of January and February. The experiment was laid out in a split plot design comprising of four main plot treatments (green manuring options viz., Dhaincha incorporation 40DAS, 60DAS, FYM and control) and four sub-plot treatments (viz., residue incorporation, residue removal, residue burning and standing stubble) replicate thrice. The experimental data was recorded on plant growth and development (Plant height (cm), Number of tillers / m row length, effective tillers, panicle length, number of grains/panicle, yield attributes and yield of rice during both the years of study.

Result and Discussion

Plant height

Plant height is an important index of the plant development. It gives an idea to predict the growth rate and yield of the crop. The periodic plant heights at 30, 60, 90 days after transplanting (DAT) and at maturity have been presented in Table 1. The perusal of data on periodic plant height indicates a progressive increase in plant height with the advancement in age of crop.

Table 1: Effect of crop residues and green manuring on plant height of wheat

Treatments	Plant height (cm)							
	30 DAT		60 DAT		90 DAT		at maturity	
	2019	2020	2019	2020	2019	2020	2019	2020
Green manuring								
Control	15.0	17.5	34.7	35.4	100.7	101.9	102.4	102.4
D_{40}	19.1	21.5	41.2	46.5	104.6	108.8	104.8	104.9
D_{60}	17.7	20.9	38.2	42.4	101.0	106.2	100.3	102.7
FYM_{25}	15.2	17.8	38.4	41.4	103.0	105.6	103.8	102.2
LSD (p=0.05)	0.8	0.7	0.6	1.4	0.4	0.5	2.1	NS
Residue incorporation								
BR-W_{RI}	18.8	20.0	39.5	43.4	102.5	107.3	106.2	105.4
BR-W_{RR}	16.1	19.6	35.5	36.9	102.9	103.2	104.2	102.1
BR-W_{RB}	16.0	18.3	35.6	36.0	102.0	104.5	103.3	101.5
BR-W_{SS}	16.1	19.8	38.0	41.4	101.8	107.5	104.7	103.2
LSD (p=0.05)	0.6	1.0	0.5	0.9	NS	1.2	NS	1.2
Interaction	1.2	NS	1.0	1.8	2.0	2.4	NS	2.3

Plant height of wheat was significantly influenced by green manuring at all stages during both years of study except second year at maturity. Incorporation of dhaincha at 40 DAS recorded the highest plant height, which was significantly higher than control, dhaincha incorporation at 60 DAS and FYM at all 30, 60, 90 DAT and at maturity during both years of study. However at maturity plant height with dhaincha incorporation recorded non significant. Incorporation of dhaincha resulted in the higher plant height which might be due to enhancement of soil fertility and organic matter due to green manuring with dhaincha which in turn influenced plant growth and vigour. Similar, findings were also reported by Singh and Sharma (2001) [11] that plant height was significantly higher under wheat-green manuring-rice sequence. Minimum plant height was recorded in control at all stages of observations during both years of study. Similar findings were also reported by Plant height of wheat was significantly influenced by residue incorporation during both years except 90DAT and maturity during first year, where residue incorporation significantly influenced the plant height of basmati rice. Incorporation of residue resulted in the higher plant height which might be due to enhancement of organic matter, soil fertility and soils physical and biological health due to crop residue incorporation (rice). Similar, findings were also reported by Singh and Sharma (2001) [11] that plant heights were significantly higher under wheat-green manuring-rice sequence. Minimum plant height was recorded in control at all stages of observations during both years of study.

Periodic tiller density

The tiller density indicates about photosynthetic efficiency of crop. The data for periodic tiller density at 60 and 120 DAT have been presented in Table 2.

Tiller density of wheat was significantly influenced by green manuring at all stages during both years of study. Incorporation of dhaincha at 40 DAS recorded the highest tiller density, which was significantly higher than control, dhaincha incorporation at 60 DAS and FYM at 60 and 120 DAT during both years of study. This might be due to increase of soil fertility due to crop residue incorporation (rice) and green manuring with dhaincha which in turn influenced plant growth. Summer green manuring of *Sesbania* before rice transplanting in which residue was incorporated recorded significantly more numbers of tillers was reported by Mukherjee and Singh (2001). Similar, findings were also reveled by Sandeep *et al* (2004) and Arshadullah *et al* (2012) [1] that growth parameters, viz. tillers per hill were significantly higher under wheat-green manuring-rice sequence. Minimum tiller density was recorded in control at all stages of observations during both years of study. Similar research was also reported by Hemalatha *et al* (2000) [3] found that increase in the tillers hill^{-1} of rice, increased the grain and straw yields by about 1001 and 469 kg ha^{-1}, a significant increase in the number of panicles m^{-2} and total and filled grains pancle^{-1} was observed with the incorporation of *Crotalaria* or *Sesbania* in the sandy clay loam soils of Madurai.

Table 2: Effect of crop residues and green manuring on periodic tiller density of wheat

Treatments	Periodic tiller density /m row length			
	60 DAT		120 DAT	
	2019	2020	2019	2020
Green manuring				
Control	105.6	111.7	116.6	118.7
D_{40}	119.0	131.1	129.9	131.0
D_{60}	109.0	120.5	125.8	127.8
FYM_{25}	107.5	117.5	123.6	125.7
LSD (p=0.05)	5.7	3.0	5.2	3.0
Residue incorporation				
BR-W_{RI}	114.0	126.7	124.4	129.7
BR-W_{RR}	108.8	116.6	122.3	125.2
BR-W_{RB}	108.9	117.6	122.1	123.0
BR-W_{SS}	109.3	119.9	125.1	125.3
LSD (p=0.05)	3.4	2.4	NS	3.3
Interaction	6.8	4.8	NS	NS

Periodic tiller density of wheat was significantly influenced by residue incorporation during both years of study at 60 and 120DAT except first year of 120DAT. Significantly higher tiller density was recorded with the treatment residue incorporation than all other treatments during all the stages of observation. Whereas, tiller density during first year at 60 and 120DAT was recorded statistically at par with the treatments

dhaincha incorporation 60 and 120DAS. Incorporation of residue resulted in the higher tiller density which might be due to enhancement of organic matter, soils physical and biological health. Similar, findings were also reported by Singh and Sharma (2001) [11] that plant height was significantly higher under wheat-green manuring-rice sequence. Minimum plant height was recorded in control at all stages of observations during both years of study. Aulakh *et al.* (2001) [2] advocated that incorporating crop residue in a rice-wheat system has likely to improve soil organic matter while maintaining high grain yields and hence its incorporation into the soil can be of immense use in increasing the crop productivity.

Number of effective tillers/ m row length

The data for Effective tillering have been presented in Table 3. Effective tiller of wheat was significantly influenced by green manuring during both years of study. Incorporation of dhaincha at 40 DAS recorded the highest number of effective tillers, which was significantly higher than control, dhaincha incorporation at 60 DAS and FYM during both years of study. This might be due to increase of soil fertility due to crop residue incorporation (rice) and green manuring with dhaincha which in turn influenced plant growth and vigour. Summer green manuring of *Sesbania* before rice transplanting in which residue was incorporated recorded significantly more numbers of tillers was reported by Mukherjee and Singh (2001).

Table 3: Effect of crop residues and green manuring on yield attributing characters of wheat

Treatments	Effective tiller/m row length		Ear length		No. of grains/ear		1000 Grain weight	
	2019	2020	2019	2020	2019	2020	2019	2020
Green manuring								
CONTROL	108.1	110.3	8.1	7.9	41.5	41.5	37.8	37.5
D_{40}	116.1	120.7	8.7	8.7	42.8	42.9	39.1	39.3
D_{60}	113.8	118.0	8.4	8.4	42.9	42.9	38.5	38.6
FYM_{25}	111.6	115.9	8.1	8.1	41.9	42.0	38.8	38.8
LSD (p=0.05)	1.8	1.3	NS	0.2	NS	NS	0.0	0.2
Residue incorporation								
BR-W_{RI}	113.7	117.6	8.5	8.5	42.9	43.0	39.2	39.2
BR-W_{RR}	112.3	117.0	8.2	8.2	42.1	42.1	38.3	38.5
BR-W_{RB}	110.8	114.8	8.2	8.2	41.8	42.0	37.6	37.7
BR-W_{SS}	112.8	115.5	8.4	8.2	42.3	42.3	39.1	38.7
LSD (p=0.05)	NS	1.8	NS	0.2	NS	0.0	NS	0.3
Interaction	NS	3.7	NS	NS	NS	0.2	NS	0.6

Minimum number of effective tillers was recorded with control. Similar, findings were also reported by Neeraj and Binod (2013) revealed that the various rice residue and nutrient management systems significantly influences the plant height and number of tillers per meter and were maximum with 30% additional NPK + recommended NPK over sowing of wheat without incorporation of rice residue and recommended NPK and rice residue incorporation + recommended NPK at wheat sowing during both the years. Among the yield attributes and yield viz. number of effective tillers, length of ear head, numbers of spikelets per spike, grain and straw yield were also recorded maximum with the same treatment.

Effective tillers of wheat were not significantly influenced by residue incorporation during first year. However, during second year of study, number of effective tillers found statistically at par with treatment residue incorporation and residue removal.

Ear length (cm)

The data for ear length have been presented in Table 3. Ear length of wheat was not significantly influenced by green manuring during first year. Incorporation of dhaincha at 40 DAS observed the highest ear length, which was significantly higher than control, dhaincha incorporation at 60 DAS and FYM during second year of study. However the ear length in treatments FYM and control was at par during first year of study. This might be due to enhancement of soil fertility due to crop residue incorporation (rice) and green manuring with dhaincha which in turn influenced plant growth. Minimum ear length was recorded with the control. Similar, findings were also reported by Arshadullah *et al* (2012) [1] found that maximum plant height (135.66 cm) and numbers of grains spike^{-1} (140.33) , spike length (24.66 cm), number of tillers plant^{-1} (40.33) and 1000-grain weight (23 g) were observed at the application of 5 tons wheat straw ha^{-1} along with 90 kg N ha^{-1} rice. Grain yield was the maximum (3.32 t ha^{-1}) at the application of 5 tons wheat straw ha^{-1} along with 90 kg N ha^{-1} and 26% more than control treatment.

Ear length of wheat was not significantly influenced by residue incorporation during first year. However, during second year of study, length of ear found statistically at par with treatment residue incorporation and residue removal and standing stubble.

Number of grains ear^{-1}

Number of grains ear^{-1} of wheat was not significantly influenced by green manuring during both years of study presented in Table 3.

Number of grains ear^{-1} of wheat was not significantly influenced by residue incorporation during first year but, significantly influenced during second year with the residue incorporation. However, treatments standing stubble, residue removal and residue burning recorded statistically at par with each other during second year of study.

1000-grain weight

1000 grain weight of wheat was significantly influenced by green manuring during both years of study presented in Table 3. Incorporation of dhaincha at 40 DAS observed the maximum number 1000 grain weight, which was significantly higher than control, dhaincha incorporation at 60 DAS and FYM during both years of study. However treatment dhaincha incorporation 60DAS and FYM recorded statistically at par with each other during both year of study. This might be due to enhancement of soil fertility due to crop residue incorporation (rice) and green manuring with dhaincha which in turn influenced plant growth and vigour. However, during second year of study the 1000 grain weight was found statistically at par in the treatment FYM and control. Similar, findings were also reported by Arshadullah *et al* (2012) [1]. Minimum number of 1000 grain weight was recorded in control during both years of study. Similar, findings were also reported by Muntasir *et al* (2001) [7] reported that the similar increase in plant height, significant improvement in number of effective tillers hill^{-1}, filled grains panicle^{-1} and 1000-grain weight and straw yield due to *Sesbania* green manuring.

1000-grain weight of basmati rice was not significantly influenced by residue incorporation during first year but, treatment residue incorporation found significantly higher 1000 grain weight than residue burning, residue removal and

standing stubble during second year of study. However, the treatment residue removal and standing stubble recorded statistically at par with each other during second years of study.

Effect of crop residues and green manuring on grain yield, straw yield, biological yield and harvest index

Grain yield (q ha^{-1})

Grain yield of wheat was significantly influenced by green manuring during both years of study presented in Table 4. Incorporation of dhaincha at 40 DAS observed the maximum grain yield (38.1 and 40.1 q ha^{-1}), which was significantly higher than control (30.4 and 30.1 q ha^{-1}), dhaincha incorporation at 60 DAS (31.8 and 35.2 q ha^{-1}) and FYM (32.5 and 34.8 q ha^{-1}) during first and second year respectively. However, grain yield of dhaincha in corporation 60DAS and FYM were statistically at par with each other during both year of study. This might be due to enhancement of soil fertility due to crop residue incorporation (rice) and green manuring with dhaincha which in turn influenced plant growth and vigour. Similar, findings were also reported by Arshadullah *et al* (2012) [1]. Hrusikesh and Prasad, (2016) [4], reported that the Incorporation of *Sesbania* green manure increased plant height, number of shoots and dry matter accumulation per hill in rice. Yield attributes of rice viz number of panicles, number of filled spikelets per panicle; panicle length and 1000 grain weight were maximum with *Sesbania* green manuring. Minimum grain yield was recorded in control during both years of study. Similar, findings were also reported by Similar findings were also reported by Vinay (2006) [12] reported that the *Sesbania* applied with 100 % of recommended dose of NPK fertilizers provided the maximum yield of rice.

Table 4: Effect of crop residues and green manuring on grain yield, straw yield, biological yield and harvest index (%) of wheat

Treatments	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Biological yield (q ha^{-1})		Harvest index (%)	
	2019	2020	2019	2020	2019	2020	2019	2020
Green manuring								
Control	30.4	30.1	67.4	68.5	97.7	98.7	31.4	31.6
D_{40}	38.1	40.1	76.1	77.9	114.2	118.0	33.3	34.0
D_{60}	31.8	35.2	74.3	73.4	106.1	108.6	29.8	30.2
FYM_{25}	32.5	34.8	70.8	71.5	103.4	106.3	31.8	31.9
LSD (p=0.05)	1.9	3.4	5.5	4.8	5.9	5.6	NS	NS
Residue incorporation								
BR-W_{RI}	35.8	38.5	74.9	77.0	110.7	115.4	32.3	33.1
BR-W_{RR}	31.7	33.6	71.9	71.8	103.6	105.4	30.5	30.5
BR-W_{RB}	31.3	33.2	71.1	70.5	102.4	103.7	30.3	30.6
BR-W_{SS}	34.0	34.8	70.6	72.0	104.6	106.8	33.1	33.6
LSD (p=0.05)	1.4	1.5	NS	2.5	3.1	2.5	1.6	1.0
Interaction	NS	3.0	NS	NS	NS	NS	NS	NS

Grain yield of basmati rice was significantly influenced by residue incorporation during both years of study. Significantly higher grain yield was obtained from residue incorporation than standing stubble, residue removal and residue burning respectively during both year of study. Incorporation of residue resulted in the higher grain yield which might be due to enhancement of organic matter, soil fertility and soils physical and biological health. However, treatments residue removal and residue burning observed statistically at par with each other during first year of study. Similar, findings were also reported by Singh and Sharma (2001) [11] that plant height was significantly higher under wheat-green manuring-rice sequence. Minimum plant height was recorded with control during both years of study. Aulakh *et al* (2001) [2] advocated that incorporating crop residue in a rice-wheat system has likely to improve soil organic matter while maintaining high grain yields and hence its incorporation into the soil can be of immense use in increasing the crop productivity.

Straw yield

Straw yield of wheat was significantly influenced by green manuring during both years of study presented in Table 4. Significantly higher straw yield was recorded with the treatment dhaincha incorporation 40DAS than residue burning and residue removal during both year of study. However, the treatment dhaincha incorporation 40 DAS found to be statistically at par with treatment dhaincha incorporation 60 DAS and FYM during both years of study.

Straw yield of basmati rice was not significantly influenced by residue incorporation during first years of study. But during second year significantly higher straw yield was recorded with the treatment residue incorporation than residue burning and residue removal. However, treatment standing stubble found to be statistically at par with treatment residue removal ans residue burning during second year mof study. Incorporation of residue resulted in the higher straw yield which might be due to enhancement of organic matter, soil fertility and soils physical and biological health. Similar, findings were also reported by Singh and Sharma (2001) [11] that plant height was significantly higher under wheat-green manuring-rice sequence. Minimum straw yield was recorded in control during both years of study. Aulakh *et al* (2001) [2] advocated that incorporating crop residue in a rice-wheat system has likely to improve soil organic matter while maintaining high grain yields and hence its incorporation into the soil can be of immense use in increasing the crop productivity.

Biological yield

Biological yield of basmati rice was significantly influenced by green manuring during both years of study presented in Table: 4. Incorporation of dhaincha at 40 DAS observed the more biological yield, which was significantly higher than control and all other treatments. However, biological yield with the treatment dhaincha incorporation 60DAS found to be statistically at par with treatments FYM during both the years of study. This might be due to enhancement of soil fertility due to crop residue incorporation (rice) and green manuring with dhaincha which in turn influenced plant growth and vigour. Similar, findings were also reported by Arshadullah *et al* (2012) [1]. Minimum biological yield was recorded in control during both years of study this was due to not application of any organic manure. Similar findings were also reported by Vinay (2006) [12] reported that the *Sesbania* applied with 100 % of recommended dose of NPK fertilizers provided the maximum yield of rice.

Biological yield of basmati rice was significantly influenced by residue incorporation during both years of study. Incorporation of residue give the significantly higher grain yield than standing stubble, residue removal and residue burning during both year of study Minimum biological yield was recorded in treatment residue burning. Incorporation of residue resulted in the higher biological yield which might be due to enhancement of organic matter, soil fertility and soils physical and biological health. However, treatment standing stubble found to be statistically at par with the treatments residue removal and residue burning during both the years of

study. Similar, findings were also reported by Kharub *et al* (2004) [11]. Rice straw was incorporated in the soil before sowing of wheat, while *Sesbania calillabina* was incorporated before puddling for rice. Wheat yield under straw-incorporated plots was low (6.7- 9.1 %) in the initial 2 years compared to rice residue removal and burning of rice straw treatments, but the yield started improving (4%) in the third cropping season in the straw-incorporated treatment-both in the presence as well absence of green-manure.

Harvest index (%)

Harvest index (%) of basmati rice was not significantly influenced by green manuring during both the years of study presented in Table 4. However with the treatment residues incorporation harvest index was significantly influenced. However, treatment standing stubble found to be statistically at par with residue incorporation. The minimum harvest index was recorded with the treatment residue burning which was statistically at par with residue removal.

Reference

1. Arshad Ullah M, Arshad A, Syed Ishtiaq H, Imdad AM, Badar-uz-Zaman. Integrated effects of wheat residue and phosphorus application on rice productivity and soil health under salt affected soils. Pak. J sci. ind. res. Ser. B: biol. sci. 2012;58(3):117-121
2. Aulakh MS, Khera TS, Doran J Wand, Bronson KF. Managing crop residue with green manure, urea and tillage in a rice-wheat rotation. Journal. Soil Science Society of A lIlerica 2001;65(3):820-7.
3. Hemalatha M, Thirumurugan V, Balasubramanian R. Effect of organic sources of nitrogen on productivity, quality of rice (*Oryza sativa*) and soil fertility in single crop wetlands. Indian Journal of Agronomy 2000;45(3):564-567.
4. Hrusikesh, Prasad. reported that green manuring in rice wheat cropping system, Quartley journal of life sciences, 2016;12(4):800-806.
5. Kharub AS, Sharman RK, Mongin AD, Chhoka RS, Tripathr SC, Sharman VK. Effect of rice (*Oryza sativa*) straw removal, burning and incorporation on soil properties and crop productivity under rice-wheat (*Triticum aestivum*) system., Indian Joul'1Ial of Agricultural Sciences 2004;74(6):295-9.
6. Mukherjee A, Singh Y. Influence of crop residue management and green manuring on growth attributes of transplanted rice (*Oryza sativa* L^.Environment and Ecology 2012;19(4):833-835.
7. Muntasir IM, Tauhiduzzaman S, Ishaque M. Study on the effect of N fertilizer and green manure on the growth and yield of B R 22 rice. Indian Journal of Agricultural Chemistry 2001;XXXIV(1.2):15-21.
8. Sandeep Kumar, Pandey DS, Rana NS. Wheat yield and soil bulk density response to tillage, residue and nitrogen management under rice-wheat system. Annals of Agricultural Research 2008;25(1):113-117.
9. Sidhu BS, Beri. Effect of crop residue management on the yields of different crops and soil properties. Biological Wastes 2008;27:15-27.
10. Singh B, Srivashtava OP, Upadhaya RM. Use of rice straw under submerged conditions. International Rice Research Newsletter 1996;16(6):19.
11. Singh VK, Sharma BB. Productivity of rice (*Oryza sativa*) as influenced by crop diversification in wheat (*Triticum aestivum*)-nce cropping system on Mollisols of foothills of Himalayas. Indian Journal of Agricultural Sciences 2001;71(1):5-8.
12. Vinay Singh. Productivity and economics of rice (*Oryza sativa*)-wheat {*Triticum aestivum*) cropping system under integrated nutrient- supply system in recently reclaimed sodic soil. Indian Journal of Agronomy 2006;51(2):81-84.
13. Walia SS, Brar SS, Kher DS. Effect of management of crop residues on soil properties in rice-wheat cropping system. Environment and ecology 1995;13(3)503-16 ref.