Int.J.Curr.Microbiol.App.Sci (2019) *8*(6): 150-157

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 06 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.806.019

Performance of Crop Residue Management Practices on Growth and Yield of Wheat (*Triticum aestivum* L.) under Rice- wheat System in *Bastar* Region of Chhattisgarh, India

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A B S T R A C T

A field experiment conducted during the Rabi season, 2016-17 at the Instructional Farm, Shaheed Gundadhoor College of Agriculture & Research Station, Kumhrawand, Jagdalpur District- Bastar (Chhattisgarh). The soil of experimental site was sandy loam; it was low in organic carbon (0.44%) and available nitrogen (235.15 kg ha^{-1}) and medium in available phosphorus (13.10 kg ha^{-1}) and potassium (291.33 kg ha^{-1}) and acidic in reaction (6.2 pH). The experiment was laid out in spilt plot design with three crop residue management practices and four varieties of wheat. Three residue management practices *viz*. Residue burnt + tillage (T_1), Residue incorporation (T_2) and Residue retention (T_3), were applied in main plot and four varieties *viz.* GW- 273 (V_1), Lok- 1 (V_2), Kanchan (V_3) and Sujata (V_4) in sub-plot and replicated 3 times. The results revealed that treatment residue retention recorded relatively higher plant height (16.90 cm) at 15 DAS, whereas treatment residue incorporation recorded relatively higher plant height (26.42 cm) at 30 DAS, (57.51 cm) at 45 DAS and (75.09 cm) at 60 DAS, (93.28 cm) at 75 DAS, (96.74 cm) at 90 DAS and (97.28 cm) at harvest. The varieties GW-273 recorded significantly higher plant height (17.66 cm) at 15 DAS and (26.81 cm) at 30 DAS, variety LOk-1 recorded significantly higher plant height (62.77 cm and 78.24 cm) at (45 and 60 DAS) respectively. Significantly higher plant height recorded of variety Sujata (113.04 cm) at 75 DAS, (113.51 cm) at 90 DAS and (114.06 cm) at harvest. Treatment residue retention recorded relatively higher number of tillers (427.92) at 15 DAS, whereas treatment residue incorporation recorded relatively higher number of tillers (693.75) at 30 DAS, (862.50) at 45 DAS, (618.75) at 60 DAS, (549.08) at 75 DAS, (545.67) at 90 DAS and (544.92) at harvest. The varieties Sujata recorded significantly higher number of tillers (749.44), (901.11) and (652.22) at 30, 45 and 60 DAS respectively, whereas variety Lok-1 recorded significantly higher number of tillers (577.22), (577.00) and (576.44) at 75 DAS, 90 DAS and at harvest respectively. The days to occurrence of crop growth stages more influenced due to varieties and less influenced due to crop residue management practices. Treatment residue incorporation recorded relatively higher grain yield (40.63 q ha^{-1}), straw yield (32.92 q ha^{-1}) and gross return (Rs. ha^{-1} 64,541), whereas treatment residue retention recorded highest net return. (Rs. ha^{-1} 39,308) and B: C ratio (Rs. 2.81). Varieties Lok-1 recorded significantly higher grain yield (43.36 q ha^{-1}), harvest index (61.35%), gross return (Rs. ha^{-1} 66,130), net return (Rs. ha^{-1} 41,452) and B: C ratio (Rs. 2.68). Variety Sujata produces significantly higher straw yield (34.83 q ha^{-1}).

Keywords

Crop residue management, Wheat, Varieties, Growth, Crop stages, Yield, Economics

Article Info

Accepted:
04 May 2019
Available Online:
10 June 2019

Introduction

Rice (*Oryza sativa* L.) - Wheat (*Triticum aestivum* L.) cropping system is a the most predominant production and nutrient exhaustive system occupying about 18 M ha in Asia, of which 13.5 M ha area in Indo-Gangetic Plains of India, Pakistan (2.2 M ha), Bangladesh (0.8 M ha) and Nepal (0.5 M ha) and feeds about 1.3 billion people (20% of the world population) (Farooq *et al.,* 2007, Saharawat *et al.,* 2010). Wheat occupies an area of 0.18 million hectares with the production of 0.28 million tones and average productivity of 1550 kg ha^{-1} during 2017-18 (Anonymous, 2018) in the state and most of the area under rice- wheat system. Farmers normally use wheat straw as animal feed but rice straw is either burnt or used as animal feed and fuel source in rural area or incorporation in the field. Residue retention/incorporation into soil is an essential management practice to handle crop residue. The retention/incorporation of rice residues may affect soil fertility, soil physico - chemical properties and yield of the crop.

Nutrients in crop residues and soil amendments are more available to crops if they are retained/incorporated into the soil rather than burnt, burning of crop residue destroys our precious natural resource (the organic matter) that may adversely affect soil physical, chemical and biological properties (Gangwar *et al.,* 2006). The imbalance use of chemical fertilizers in the last four to five decades has led to the paralleled corresponding decline in the use of cover crops and organic manures. Conventional management practices have led in the decline in soil organic matter, increased soil erosion, and surface and ground water contamination. Until recently, we fail to recognize the consequences of management on the balance and cycling of energy and dry matter and soil productivity. Crop residues are tremendous natural resources not a waste. Residue management is receiving a great deal of attention because of its diverse effects on soil physical, chemical and biological properties (Kumar and Goh, 1999).

Information on the kinetics of decomposition of the crop residues and mineralization, immobilization turnover of different quality crop residues is required to ascertain the actual amount of crop residues needed to maintain the soil productivity and ensure environment protection by minimizing nutrient losses and soil erosion. Addition of soil organic matter to the soil through the return of crop residues, also improve soil structure, influences soil water, air and temperature relations, help control runoff and erosion and makes tillage easier. Crop residue is a good source of plant nutrients and important component for the stability of the agricultural ecosystem. 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 (Dotaniya, 2013). Crop residue and their proper management affect the soil quality either directly or indirectly. Intensive cropping system is very diverse and complex, so no one residue management system is superior under all situations. Ideally crop residue management practices should be selected to enhance crop yields with a minimum adverse effect on environment. It is suggested that in each cropping system the constraints to production and sustainability should identified and conceptualized to guide towards the best option. There is a need to identify and recommend a more productive, profitable and environmentally sound crop residue management system. Objective of this study was to examine the effects of the three crop residue management practices on growth and yield of wheat under rice- wheat cropping system.

Materials and Methods

A field experiment was conducted during the Rabi season of 2016-17, at the Instructional Farm, Shaheed Gundadhoor College of Agriculture & Research Station, Kumhrawand, Jagdalpur District- Bastar (Chhattisgarh). The soil of experimental site was sandy loam; it was low in organic carbon (0.44%) and available nitrogen (235.15 kg ha^{-1}) and medium in available phosphorus (13.10 kg ha^{-1}) and potassium (291.33 kg ha^{-1}) and acidic in reaction (6.2 pH).The experiment was laid out in spilt plot design with three crop residue management practices and four varieties of wheat. Three residue management practices *viz*. Residue burnt + tillage (T_1), Residue incorporation (T_2) and Residue retention (T_3), were applied in main plot and four varieties *viz.* GW- 273 (V_1), Lok- 1 (V_2), Kanchan (V_3) and Sujata (V_4) in sub-plot and replicated 3 times. Recommended dose of nutrients was 100:60:40 kg N: P: K ha^{-1}. Entire quantity of phosphorus & potassium was applied before sowing. Nitrogen applied in three splits i.e. 50% as a basal, 25% at tillering and 25% at panicle emergence stage. Experiment was conducted under irrigated condition and irrigated 5 times in different crop stages. Crop seed sown on 30th November, 2016 with a row spacing of 20 cm. Herbicide pendimethalin 30 EC applied @ 0.75 kg ha-1 in 3rd day. The average maximum and minimum temperature varied between 27.8^0c-33.7^0c and 15.2^0c-26.0^0c respectively.

The plant height was measured randomly of 5 plants of each plot in centimeter from ground surface up to the tip of awn. The number of tillers counted from 0.25 m^2 area by placing a quadrate of 0.5 m x 0.5 m randomly at 4 places in each plot and then number of tillers m^{-2} worked out. Occurrence of crop stages recorded by visited every day at experimental site. The harvest index was calculated by dividing the grain yield with biological yield (grain + straw yield) and multiplied by 100.

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield (q/ha)}}{\text{Biological yield (q/ha)}} \text{X100}$$

Results and Discussion

Plant height

Average plant height increased progressively with increase in the age of the crop. The plant gained height at relatively slower rate between 75 to 90 DAS and accelerated between 15 to 75 DAS. The Plant height of wheat varieties influenced significantly, whereas plant height of wheat did not influenced due to crop residue management practices (Table 1). Among the residue management practices treatment residue retention recorded relatively higher plant height (16.90 cm) at 15 DAS, while treatment residue incorporation recorded relatively higher plant height (26.42 cm) at 30 DAS, (57.51 cm) at 45 DAS, (75.09 cm) at 60 DAS, (93.28 cm) at 75 DAS, (96.74 cm) at 90 DAS and (97.28 cm) at harvest, followed by treatment residue burnt along with tillage (93.01 cm) at 75 DAS, (94.02 cm) at 90 DAS and (94.81 cm) at harvest.

Among the varieties GW-273 recorded significantly higher plant height (17.66 cm) followed by Sujata (16.28 cm) at 15 DAS. Variety GW- 273 recorded significantly higher plant height (26.81 cm), followed by Lok-1 (26.39 cm) at 30 DAS, variety LOk-1 recorded significantly higher plant height (62.77 cm & 78.24 cm) followed by Sujata (56.01 cm & 75.70) at (45 and 60 DAS) respectively. Significantly higher plant height recorded of variety Sujata at 75 DAS (113.04 cm), 90 DAS (113.51 cm) and at harvest (114.06 cm) followed by Kanchan 88.50 cm, 90.18 cm, 90.87 cm at 75 DAS, 90 DAS and at harvest respectively. In case of varieties difference in plant height may be due to their genetic characters.

Number of tillers m^{-2}

The number of tillers m^{-2} increased with increasing the crop age up to 90 DAS, but the number of tillers at maturity slightly reduced. The number of tillers of wheat varieties influenced significantly, whereas number of tillers did not influenced due to residue management practices (Table 2). Among the residue management practices treatment residue retention recorded relatively higher number of tillers (427.92) at 15 DAS, while treatment residue incorporation recorded relatively higher number of tillers (693.75) at 30 DAS, (862.50) at 45 DAS, (618.75) at 60 DAS, (549.08) at 75 DAS, (545.67) at 90 DAS and (544.92) at harvest. Similarly in Dera Ismail Khan (Pakistan) Usman *et al.*, (2014), recorded that rice straw incorporation by tillage resulted the higher number of tillers m^{-2}.

Number of tillers of wheat varieties influenced significantly at all the stages of crop growth except 15 DAS. Among the varieties Sujata recorded significantly higher number of tillers (749.44), (901.11) and (652.22) followed by Lok-1 (685.56), (762.78) and (642.22) at 30 DAS, 45 DAS and 60 DAS respectively, whereas lowest number of tillers recorded with GW-273 at above DAS. Variety Lok-1 recorded significantly higher number of tillers (577.22), (577.00) and (576.44) followed by Kankchan (552.11), (550.56) and (549.78) at 75 DAS, 90 DAS and at harvest respectively, whereas lowest number of tillers recorded with GW-273 at above DAS.

Days to occurrence of crop growth stages

The days to occurrence of crop growth stages more influenced due to varieties and less influenced due to residue management practices. All the varieties start germination in 5 day. Variety Sujata taken more time for 1st true leaf stage (8.67 day), 3 leaf stage (16.33 day), CRI (22.33 day), panicle emergence (67.33 day), 50% flowering (71.33 day), milking (85 day) and maturity (113 day) followed by Kanchan for 1st true leaf stage (8.33 day), 3 leaf stage (16.33 day), panicle emergence (60.67 day), 50% flowering (65.67 day), milking (82 day) and maturity (105 day)

Grain and straw yield and harvest index

The grain and straw yield and harvest index significantly influenced due varieties, whereas grain and straw yield and harvest index did not influenced due to residue management practices (Table 3). Among the residue management practices treatment Residue incorporation recorded relatively higher grain yield (40.63 q ha^{-1}) and straw yield (32.92 q ha^{-1}) followed by treatment Residue burnt along with tillage recorded grain yield (39.96 q ha^{-1}) and straw yield (29.81 q ha^{-1}), whereas treatment residue retention recorded relatively higher harvest index (57.54%) followed by treatment residue burnt along with tillage (56.93%). In Pantnagar, Dotaniya (2013) recorded that rice crop residue incorporation resulted the highest wheat yield (6.35 q ha^{-1}). Similarly in Dera Ismail Khan (Pakistan), Usman *et al.*, (2014) recorded that rice straw incorporation by tillage resulted the highest wheat yield (46.70 q ha^{-1}). Higher grain and straw yield of wheat with treatment Residue incorporation was mainly attributed with higher growth parameters like plant height and number of tillers.

Among the varieties Lok-1 produces significantly higher grain yield (43.36 q ha^{-1}) followed by Kanchan (41.56 q ha^{-1}), GW-273 (40.66 q ha^{-1}), and Sujata (33.07 q ha^{-1}). Variety Sujata produces significantly higher straw yield (34.83 q ha^{-1}) followed by

Kanchan (30.28 q ha^{-1}), GW-273 (30.11 q ha^{-1}) and Lok-1 (27.36 q ha^{-1}). Harvest index significantly higher under variety Lok-1 (61.35%) followed by Kanchan (58.74%), GW-273(58.19%) and Sujata (48.88%). Higher grain and straw yield of wheat variety Lok-1 was mainly attributed with higher number of tillers at reproductive stage and lower plant height (Table 4; Fig. 1 and 2).

Table.1 Plant height of wheat varieties as influenced by crop residue management practices

Treatment	Plant height (cm)						
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**	**At harvest**
Crop residue management practices							
Residue Burnt + tillage	15.36	26.01	55.73	73.41	93.01	94.02	94.81
Residue incorporation	16.44	26.42	57.51	75.09	93.28	96.74	97.28
Residue retention	16.90	25.43	57.35	73.61	91.93	93.49	93.95
SEm±	**1.34**	**1.56**	**3.29**	**1.50**	**2.72**	**1.48**	**1.40**
CD (P = 0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Varieties							
GW-273	17.66	26.81	53.53	69.92	86.68	89.58	90.03
Lok-1	15.50	26.39	62.77	78.24	82.75	85.72	86.41
Kanchan	15.49	26.38	55.14	72.28	88.50	90.18	90.87
Sujata	16.28	24.24	56.01	75.70	113.04	113.51	114.06
SEm±	**0.51**	**0.61**	**1.10**	**1.25**	**1.74**	**1.57**	**1.64**
CD (P = 0.05)	**1.52**	**1.80**	**3.27**	**3.72**	**5.16**	**4.66**	**4.87**

DAS- Days after sowing

Table.2 Number tillers of wheat varieties as influenced by crop residue management practices

Treatment	Number of tillers (m^{-2})						
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**	**At harvest**
Crop residue management practices							
Residue Burnt + tillage	397.92	652.08	816.67	597.08	532.08	521.25	520.83
Residue incorporation	396.25	693.75	862.50	618.75	549.08	545.67	544.92
Residue retention	427.92	677.50	645.83	576.67	509.58	516.17	514.33
SEm±	**25.82**	**65.31**	**43.78**	**53.01**	**23.73**	**24.57**	**24.45**
CD (P = 0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Varieties							
GW-273	413.33	597.78	701.11	515.00	480.00	476.67	475.89
Lok-1	378.89	685.56	762.78	642.22	577.22	577.00	576.44
Kanchan	417.78	665.00	735.00	607.22	552.11	550.56	549.78
Sujata	419.44	749.44	901.11	652.22	511.67	506.56	504.67
SEm±	**18.40**	**27.63**	**20.06**	**28.63**	**22.47**	**24.56**	**25.29**
CD (P = 0.05)	**NS**	**82.10**	**59.59**	**85.06**	**66.77**	**72.97**	**75.14**

Table.3 Occurrence of crop stages of wheat varieties as influenced by crop residue management practices

Treatment	Occurrence of crop stage (Day)							
	Germi nation	1st true leaf	3 leaf	CRI	Panicle emergence	50% Flowering	Milking	Maturity
Crop residue management practices								
Residue Burnt + tillage	5.0	8.0	16.50	21.25	60.50	65.00	80.50	107.0
Residue incorporation	5.0	8.25	15.75	21.25	62.00	65.75	81.00	107.0
Residue retention	5.0	8.50	16.0	21.50	60.50	64.25	80.50	107.0
Varieties								
GW-273	5.0	8.0	15.67	22.33	58.67	62.00	78.33	105.0
Lok-1	5.0	8.0	16.0	20.0	57.33	61.00	77.33	104.0
Kanchan	5.0	8.33	16.33	21.0	60.67	65.67	82.00	105.0
Sujata	5.0	8.67	16.33	22.0	67.33	71.33	85.00	113.0

Table.4 Yield parameters of wheat varieties as influenced by crop residue management practices

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Crop residue management practices			
Residue Burnt + tillage	39.96	29.81	56.93
Residue incorporation	40.63	32.92	55.90
Residue retention	38.40	29.16	57.54
SEm±	**2.40**	**1.45**	**1.93**
CD (P = 0.05)	**NS**	**NS**	**NS**
Varieties			
GW-273	40.66	30.11	58.19
Lok-1	43.36	27.36	61.35
Kanchan	41.56	30.28	58.74
Sujata	33.07	34.83	48.88
SEm±	**2.34**	**2.27**	**2.13**
CD (P = 0.05)	**6.96**	**6.76**	**6.32**

Table.5 Economics of wheat production as influenced by crop residue management practices

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B: C ratio
Crop residue management practices				
Residue Burnt + tillage	26505.00	63345.00	36840.00	2.39
Residue incorporation	26265.00	64541.00	38276.00	2.46
Residue retention	21715.00	61023.00	39308.00	2.81
Varieties				
GW-273	24678.00	62012.00	37334.00	2.51
Lok-1	24678.00	66130.00	41452.00	2.68
Kanchan	24678.00	63386.00	38708.00	2.57
Sujata	25278.00	60349.00	35071.00	2.39

Seed price: Rs. 2600 &3200 q^{-1} (Sujata), Grain sale price: Rs. 1525 & 1825 q^{-1} (Sujata)

Fig.1 Occurrence of crop growth stages of wheat varieties as influenced by crop residue management practices

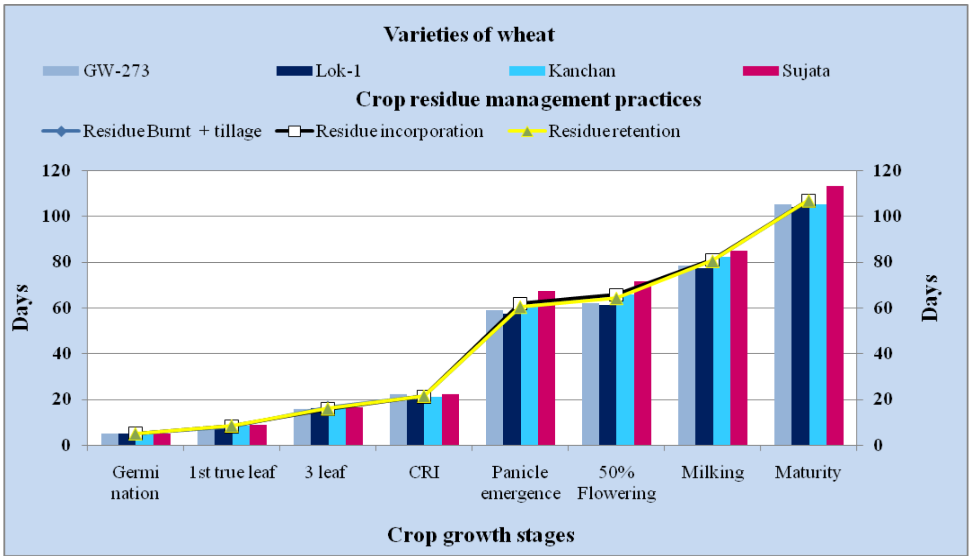
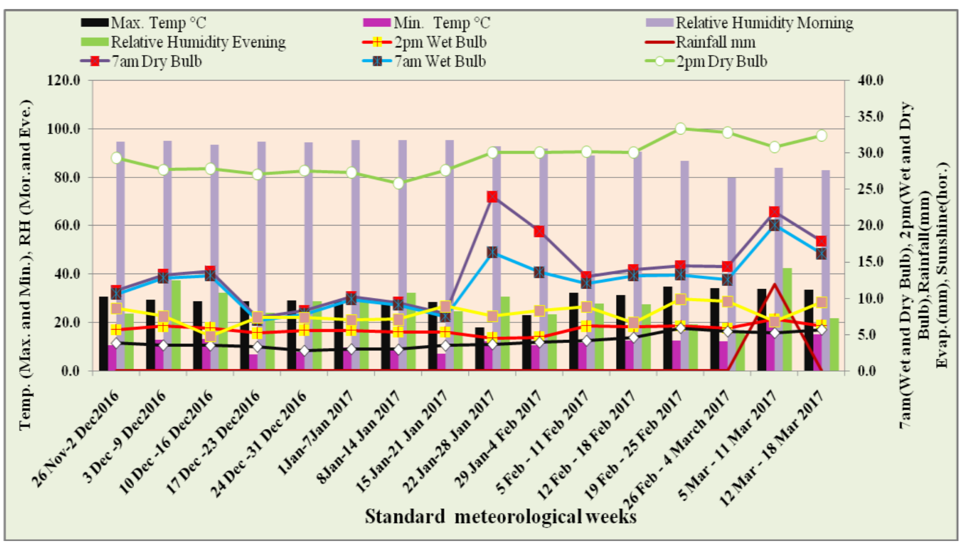


Fig.2 Weekly meteorological data prevailing during crop growth period (Rabi, 2016-17)



Economics of wheat production

Effect of different treatments cannot be assessed without the gross and net return from that treatment. The economics of different treatments have been presented in Table 5. Among the crop residue management practices treatment residue incorporation recorded the highest gross return (Rs. ha^{-1} 64,541) followed by residue burnt along with tillage (Rs. ha^{-1} 63,345), whereas treatment residue retention recorded highest net return. (Rs. ha^{-1} 39,308) and B: C ratio (Rs. 2.81) followed by residue incorporation net return. (Rs. ha^{-1} 38,276) and B: C ratio (Rs. 2.46). Higher net return and B: C ratio was due lowest cost of cultivation. Among the varieties, Lok-1 recorded highest gross return (Rs. ha^{-1} 66,130), net return (Rs. ha^{-1} 41,452) and B: C ratio (Rs. 2.68) followed by

Kanchan with gross return (Rs. ha^{-1} 63,386), net return (Rs. ha^{-1} 38,708) and B: C ratio (Rs. 2.57). In Varanasi, Rakesh *et al.*, (2019) recorded that rice crop residue retention practices resulted higher net return of wheat (Rs. ha^{-1} 20,619) in 2006 and (Rs. ha^{-1} 30, 854) in 2007.

On the basis of experimental findings, it is concluded that wheat should be sown under crop residue incorporation for obtaining higher grain and straw yield and gross return, whereas wheat should be sown under crop residue retention for obtaining higher net return under rice-wheat cropping system. Wheat varieties Lok- 1 and Kanchan should be sown for obtaining higher grain yield, gross and net return in the region.

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How to cite this article:

Anil Kumar Netam, Birbal Sahu, Chainu Ram Netam and Suresh Kumar Markam. 2019. Performance of Crop Residue Management Practices on Growth and Yield of Wheat (*Triticum aestivum* L.) under Rice- wheat System in *Bastar* Region of Chhattisgarh, India. *Int.J.Curr.Microbiol.App.Sci.* 8(06): 150-157. doi: https://doi.org/10.20546/ijcmas.2019.806.019