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CROP RESIDUE AND PHOSPHORUS MANAGEMENT FOR SUSTAINED CROP PRODUCTION UNDER DIRECT DRY SEEDED RICE CULTIVATION SYSTEM IN KPK, PAKISTAN

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ABSTRACT

A field experiment was conducted for two years to study the effect of crop residue and Phosphorus management on the growth and yield of direct dry seeded rice cultivation system on farmer's field in village Dhakki, Dera Ismail Khan (KPK) Pakistan during Kharif seasons, 2011 and 2012. Treatments were assigned randomly using Randomized Complete Block Design (RCBD) having three replications. The net plot size was 2.5 x 5m ($12.5m^2$) with 10 rows. IR-6 was used as test variety of rice. Treatments were T_1 = wheat straw @ 5 t. ha^{-1} alone, T_2 = wheat straw @ 5 t. ha^{-1} + P_2O_5 @ 30 Kg .ha^{-1}, T_3 = wheat straw @ 5 t. ha^{-1} + P_2O_5 @ 60 Kg. ha^{-1} and T_4 = P_2O_5 @ 90 Kg. ha^{-1} alone. Effect of wheat residues/straw and different phosphorus levels showed significant variations for plant height (cm), productive tillers m^{-2}, number of grains $panicle^{-1}$, panicle length (cm),1000 grain weight (gm), biomass (t ha^{-1}) and that the treatment T_2 (wheat straw @ 5 t. ha^{-1} + P_2O_5 @ 30 Kg. ha^{-1}) performed the best and gave the maximum rice yield of 6.07 t. ha^{-1}. It was concluded that selection of suitable cultivars, timely planting on loamy soil and accurate use of phosphorus with organic fertilizers, rates of fertilizer can be reduced by 50% thus sustaining the agriculture productivity and reducing environmental degradation.

Keywords: Direct Dry Seeded Rice system, Phosphorus, Crop Residues, Growth, Paddy yield and Economic return.

INTRODUCTION

In Pakistan, rice is an important cereal crop due to its economic importance and food value. Rice is a source of the largest foreign exchange earning and stands next to wheat as a staple food of the people of Pakistan. Rice is one of the most important cereal crops of the world in terms of food, area and production (Niamatullah *et al*., 2010). It occupies a significant position in formulation of agricultural policies but Pakistan is still far behind than other rice producing countries and therefore low paddy yields are serious threats to the sustainability of farmer's livelihood. Pakistan is basically an agricultural country but agriculture in this country suffers from low production due to low yield per unit area (Awan *et al*., 2011). Rice is planted on an area of over 2.31 million hectares with total production of 5.54 million tones and accounts for 17% of the total cereals produced annually. It accounts 2.7% of value added in agriculture and 0.6% in GDP (GOP, 2013). The average rice yield per hectare is only 2400 kg ha^{-1} which is too low as compared with many rice growing countries of the world like Egypt (8.4 t. ha^{-1}) and U.S.A. (6.6 t. ha^{-1}).

Wheat residues are important natural resources, and recycling of these residues improves the soil physical, chemical and biological properties. This paper reviews the potential of wheat residues and its management options, residue effects on soil properties and crop productivity. On the basis of reported research results by different researchers, an analysis has been made. A rice-wheat sequence that yields 7 t. ha^{-1} of rice and 4 t. ha^{-1} of wheat removes more than N 300, P 30 and K 300 kg. ha^{-1} from the soil, the residues of rice and wheat amount to as much as 7-10 t. ha^{-1} yr^{-1}.

Deficiency of phosphorus is of serious concern for agricultural productivity on more than 90% of Pakistani soils. In addition high pH and carbonate contents in the soil may limit its utilization by plants. Application of phosphorus with additional use of wheat crop residues would be a promising strategy for enhancing P use efficiency and productivity of cropping system. Wheat crop residues are a good organic source of nutrients. Now, agriculture has been transformed to mechanized farming. Therefore, most of the wheat growers harvest the wheat crop with the combine harvester before planting rice crop. But instead of incorporating wheat residue/maintain/improve straw into the soil to its fertility status, people generally burn it. There is a need of the time to mould the people to get advantage of this rich source of nutrients. Ghosh and Singh (1998) reported that adequate nutrition, timely planting and proper plant protection are essential for improving the growth variables responsible for high paddy yield.

Direct seeding rice on dry soil has been found most appropriate alternate to transplanting. It not only avoids puddling operation, raising and transplanting of nursery seedlings but also gives better yield than existing manual transplanting. Direct seeding can be done either by drilling or through broadcasting. Drilling is the most efficient method because of lower seed requirement, uniform sowing in lines and uniform crop stand, and it reduces the cost and labour requirements to nearly one-third as compared to transplanting.

Macronutrients play an important role in the production and productivity of the crops. Among major nutrients, phosphorus (P) is one of the most important factor affecting rice growth, yield and profitability. An ample supply of available phosphorus may stimulate growth, result in early maturity and when used in conjunction with other plant nutrients, phosphorus fertilizers greatly increase crop yield and growers net income.

Since phosphatic fertilizes prices are increasing continuously and farmers are unable to afford, there is need to assess the contribution of P coming from crop residues and therefore the present research project was initiated to determine the effect of integrated nutrient management on the growth and yield of direct dry seeding of rice for higher yield under the agro-climatic conditions of D.I.Khan area.

MATERIALS AND METHODS

The present research study was conducted to evaluate the efficacy of wheat crop residue and different rates of Phosphorus application on the growth and yield of direct dry seeded rice cultivation system on farmer's field in village Dhakki, Dera Ismail Khan (KPK) Pakistan during Kharif seasons, 2011 and 2012. The experiments were laid out in Randomized Complete Block Design (RCBD) with three replications. The net plot size was 2.5 x 5m ($12.5m^2$) with 10 rows. IR-6 was used as test variety of rice crop. After chopping and mixing the wheat residues, the seedbed was prepared. A recommended dose of 120 N kg. ha^{-1} as Urea and 70 kg. K_2O ha^{-1} as SOP were applied at the time of final land preparation. Half of the N and full dose of K was applied at the time of sowing and remaining half of N was applied at panicle emergence stage. The treatments included in the experiment were T_1 = wheat straw @ 5 t. ha^{-1} alone, T_2 = wheat straw @ 5 t. ha^{-1} + P_2O_5 @ 30 Kg. ha^{-1} , T_3 = wheat straw @ 5 t. ha^{-1} + P_2O_5 @ 60 Kg. ha^{-1} and T_4 = P_2O_5 @ 90 Kg. ha^{-1} alone. All the agronomic operations except those under study were kept normal and uniform for all the treatments. Irrigation was applied whenever required from seeding till maturity. Last irrigation was applied one week before harvesting.

The soil of the trial was silty clay with a pH of 8.2 and organic matter content of <1% (Table 1). Data on plant height (cm), productive tillers. m^{-2}, panicle length (cm), grains $panicle^{-1}$ (g), 1000 grain weight (g), biomass (t. ha^{-1}) and paddy yield (t. ha^{-1}) were recorded at maturity and statistical analysis of 2 year average data was carried out using MSTATC statistical computer software. When significant F values were obtained then applying Least Significant Difference (LSD) test at 5% probability, compared the treatment means (Steel *et al*., 1997).

Table I. Soil analysis report of experimental area.

Soil Parameters	Concentration	Soil Parameters	Concentration
PH	8.1	P	5.7 mg/kg
EC	0.972 ds/m	K	218 mg/kg
Ca + Mg	6.42 meq/L	Zn	1.228 mg/kg
HCO3	0.82 meq/L	Sand	20%
Cl	1.12 meq/L	Silt	30%
OM	0.82%	Clay	50%
N	0.034%	Textural class	Clay loam

RESULTS AND DISCUSSION

Both phosphorus application and wheat crop residues significantly produced tallest plants and that the plot with the use of P_2O_5 as DAP @ 90 Kg. ha^{-1} resulted in more plant height (124.53 cm) as compared to other treatments. The lowest plant stature (105.73 cm) was recorded in the treatment where wheat straw @ 5 t. ha^{-1} was applied alone. These results are in line with the observations of Byous *et al.* (2004) who found that plant nutrients remain in the wheat straw (approximately 35% N, 30% P, 85% K and 40-50% S) much of this can be recycled for subsequent crop growth after its decomposition.

Tillering capacity of a plant depends on the genotype and environment. The data pertaining to number of tillers revealed that the application of phosphorus in combination with wheat crop residues had significant effect on number of tillers m^{-2}. The treatment of P_2O_5 as DAP @ 90 Kg. ha^{-1} produced more tillers m^{-2} (365.33). The minimum number of tillers. m^{-2} (288.67) was produced in the treatment of wheat straw @ 5 t. ha^{-1} alone. These results are in consonance with the findings of Swarup and Yaduvanshi, (2000) who reported that tillers. m^{-2} increased with the use of phosphorus fertilizers as well as in combination with wheat crop residues.

Phosphorus application alone or in combination with wheat crop residues significantly affected panicle length. Maximum panicle length (28.17 cm) was attained when wheat straw @ 5 t. ha^{-1} with P_2O_5 as DAP @ 60 Kg. ha^{-1} was applied. Minimum panicle length (20.17 cm) was recorded in the treatment where wheat straw @ 5 t. ha^{-1} alone was used. The present results are supported by Tanaki *et al.* (2002) studied the growth and yield of rice with organic farming in comparison with inorganic fertilizers (conventional farming) found that the growth and yield of rice increased with continuous organic farming.

The data showed that soil application of phosphorus (P_2O_5) in combination with wheat residues for producing the number of rice grains $panicle^{-1}$ was significant when seen statistically. The treatment of P_2O_5 as DAP @ 90 Kg. ha^{-1} alone gave the maximum number of rice grains $panicle^{-1}$ (123.27) whereas minimum number of grains $panicle^{-1}$ (93.87) was recorded in the plot where wheat straw @ 5 t ha^{-1} was applied alone. Balamurali *et al.* (2006) claimed that yield attribute (number of grains panicle-1) increased due to the efficacy of organic and inorganic fertilizers which ultimately enhanced rice yield.

Use of organic materials with inorganic fertilizers was found beneficial for 1000 grain weight of rice. It was obvious that maximum weight of 1000 rice grains (23.70 g) was recorded in T_3 (wheat straw @ 5 t. ha^{-1} with P_2O_5 as DAP @ 60 Kg. ha^{-1}) whereas the minimum 1000 weight of rice grains (18.83 g) was found in T_1 when wheat straw @ 5 t ha^{-1} was applied alone. The present findings are in conformity with those of Sarwar (2005) who reported that the grain yield and yield components (plant height, number of fertile tillers and 1000 grain weight) of rice and wheat increased significantly with the application of chemical fertilizers in combination with different organic materials but compost proved the most superior in this regard.

Biological yield of rice was significantly affected by the application of phosphorus (P_2O_5) in combination with wheat residues. Significantly more biological yield was obtained from treated plot with wheat straw @ 5 t. ha^{-1} with P_2O_5 as DAP @ 30 Kg. ha^{-1} (8.66 t ha^{-1}), as compared to T_1 which was recorded (3.76 t. ha^{-1}). All the treatments showed significant effect on the biological yield of rice. These results are in line with the findings of of Swarup and Yaduvanshi (2000) who reported that different yield parameters including total biomass significantly increased with the use of organic and inorganic fertilizers.

Crop productivity is the rate at which a crop accumulates organic matter due to the rate of photosynthesis and conversion of light energy into chemical energy by green plants (Reddy, 2004). The most important parameter and ultimate task of farming is rice yield which was affected significantly with various levels of phosphorus and wheat crop residues. It can be observed from data that the application of wheat straw @ 5 t. ha^{-1} with P_2O_5 as DAP @ 30 Kg. ha^{-1} produced maximum rice yield of (6.07 t ha^{-1}) while the use of wheat straw @ 5 t ha^{-1} alone produced lowest rice yield of (2.49 t. ha^{-1}). The use of wheat straw @5 t. $ha^{-1}$with small quantity of phosphorus fertilizer produced the highest grain yield due to maximum number of tillers m^{-2}, panicle length (cm), grains $panicle^{-1}$ and 1000 seed weight (g). Similar results were stated by Sarwar (2005) who recorded that the grain yield of rice and wheat increased significantly with the application of chemical fertilizers in combination with different organic materials. The findings of Eagle *et al.* (2000) was also in the same direction that crop residues increased the organic carbon and nutrient contents; decreased soil bulk density and increased crop yields.

The past results of many years experimentation on direct dry seeding techniques revealed that this technology has great potential for adoption as substitute for transplanting.

Table 2. Crop residues and Phosphorus application to enhance rice productivity under aerobic culture.

Treatment	Plant height (cm)	Tillers m^{-2}	Panicle length (cm)	Grains $panicle^{-1}$	1000-grain weight (g)	Biomass (t ha^{-1})	Paddy yield (t ha^{-1})
T_1	105.73 d	288.67 d	20.17 d	93.87 c	18.83 d	3.76 c	2.49 d
T_2	114.10 c	342.00 b	24.83 c	118.10 a	22.03 b	8.66 a	6.07 a
T_3	119.57 b	318.67 c	28.17 a	103.80 b	23.70 a	7.99 a	5.13 b
T_4	124.53 a	365.33 a	26.57 b	123.27 a	20.00 c	5.25 b	3.69 c
LSD	4.1612	20.816	1.2221	7.7615	0.8715	0.8244	0.5294

$\mathbf{T_1}$ = wheat straw @ 5 t. ha^{-1} alone; $\mathbf{T_2}$ = wheat straw @ 5 t. ha^{-1} + P_2O_5 @ 30 Kg. ha^{-1}
$\mathbf{T_3}$ = wheat straw @ 5 t. ha^{-1} + P_2O_5 @ 60 Kg. ha^{-1} , **T4** = P2O5 @ 90 Kg. ha-1 alone
LSD = Least Significant Difference

ECONOMIC ANALYSIS

Maximum Net benefit (Rs:62412/ha) was recorded from treatment (T_2) receiving wheat straw incorporation and 30 kg P_2O_5 ha^{-1} followed by T3, T4 and T1 respectively. So our research findings must be based on economic return. The beneficial use of wheat crop residue saved the money, provides more micro & macro nutrients than single/ double nutrient availability by chemical fertilizers. Crop residue increased the soil organic matter by decomposition with the process of microbial activities. This data verified that the application of wheat straw @ 5 t ha^{-1} + 30 kg ha^{-1} not only improved soil productivity but also increased crop production and gained good economic return.

Table 3. Economic analysis of crop residue and Phosphorus application for rice production under aerobic culture.

		T1 5 tons wheat straw ha^{-1}	T2 T_1 + 30 kg P_2O_5 ha^{-1}	T3 T_1 + 60 kg P_2O_5 ha^{-1}	T4 90 kg P_2O_5 ha^{-1}
Price		0	2400	4800	7200
Cost of Input		0	2400	4800	7200
Application Cost		50	60	70	60
Total Cost that Vary		50	2460	4870	7260
Yield Grain	Kg/ha	2490	6007	5130	3690
Yield Adjusted	(10% Low)	2241	5406	4617	3321
Output Price Rs./Kg		12	12	12	12
Gross Field Benefits		26892	64872	55404	39852
Net Benefits		26842	62412	50534	32592

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