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# PHOSPHORUS AND POTASSIUM AVAILABILITY AND UPTAKE IN RICE AND WHEAT CROP UNDER CONVENTIONAL AND CONSERVATION AGRICULTURE PRACTICES

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## Abstract

Conservation agricultural (CA) practices prove to be beneficial in terms of resource utilization and maintenance of soil health. Rice-Wheat cropping system (RWCS) is the majorcropping system in Indo-Gangetic plains of India. CA practices are becoming popular in this cropping system as sustainable agricultural management practices. Phosphorus (P) and potassium (K) are important primary nutrients and are required for crop growth. A field experiment was conducted during the period of 2015-2017 at Taraori village of Karnal district in Haryanato study the effects of conservation agricultural practices on P and K availability as well as uptake in rice-wheat cropping system. The experiment comprised of four treatments *i.e.* Transplanted rice + Conventionally tilled wheat ($T_1$), Direct seeded rice + Zero tilled wheat with residue retention ($T_2$), Transplanted rice + Zero tilled wheat ($T_3$) and Transplanted rice + Zero tilled wheat with residue retention ($T_4$). Results showed that P uptake was highest in $T_4$ treatment in wheat crop. P uptake in rice was highest in T4 treatment while direct seeded rice ($T_2$) showed lowest P uptake. CA practices also increased K uptake in both the crops. Practicing zero tillage in wheat increased the availability of soil phosphorus as compared to conventionally tilled treatment with highest value (34 kg $ha^{-1}$) recorded in $T_3$ treatment. But direct seeded rice soil showed lower values of soil available P. Similar to phosphorus, available potassium of soil also increased in all treatments. Highestvalue (341.5 kg $ha^{-1}$) of available K was recorded in $T_4$ treatment while it was minimum (307.2 kg $ha^{-1}$) in $T_1$. Residue incorporation in soil led to more availabilityof K in $T_2$ and $T_4$ treatment. This study features the significance of conservation agricultural practices over conventional practices in terms of increasing the uptake and availability phosphorus and potassium in soil.

***Key words :*** Conservation agriculture, Rice Wheat cropping system, Available Phosphorus (P), Availabe Potassium (K).

## Introduction

Intensive agricultural practices are leading to degradation of natural resources. There is a need to develop sustainable agricultural management practices to conserve the natural resources while maintaining productivity of the crops. Conservation agricultural (CA) practices comprising of minimum soil disturbance, permanent soil cover and crop diversification could help in attaining optimum crop productivity without causing adverse environmental effects (Pramanik *et al.,* 2019). Rice-wheat cropping system (RWCS) is the majorcropping systemin the Indo-Gangetic plains covering 10.3 million haarea (Singh *et al.,* 2011). Im-balanced use of fertilizers and faulty irrigation practices is leading to soil degradation, depletion of water resources as well as environmental pollution which is stagnating yields in this cropping system. The sustainable productivity of this system relies on principle of CA. Adoption of CA based management practices were found to be effective in sustaining the productivity of RWCS while preserving the natural resources like labour, energy, water and also maintaining quality of the environment (Dikgwatlhe *et*

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*al.*, 2014). Sustainable productivity of RWCS could not be achieved unless the declining soil fertility is replenished (Subehia and Sepehya 2012). CA practices like zero tilled wheat, zero tilled wheat with residue incorporation, direct seeded rice (DSR) and mid-season drainage in rice could improve soil physico-chemical properties (Pathak and Aggarwal; 2012, Adhya *et al.*, 2000 and Chakrabarti *et al.*, 2014). There are reports that conservation tillage practices cause more nutrient accumulation in soil surface than conventional tillage practices (Holanda *et al.*, 1998; Lopez-Fando and Pardo 2009). According to Lal *et al.,* (2004), residue incorporation into the field is considered as a source of nutrient availability and soil fertilization. Phosphorus (P) and potassium (K) are important primary nutrients after nitrogen(N) and are required for crop growth. Low yield of crop is attributed to loss of nutrient availability from the soil due to continuous rice wheat cropping system following conventional agriculture practices (Dawe 2000; Shah *et al.*, 2011; Timsina and Connor. 2001). K is required for increasing number of tillers per plant, number of grain per spike and 1000-grain weight in wheat crop whereas P is required for enhancing crop productivity (Polara *et al.*, 2010; Ismail *et al.*, 2007; Rose *et al.*, 2012). According to Damon *et al.,* (2014), P availability in soil could be enhanced with large amount of residue incorporation. More information on soil properties, especially on nutrient availability under different agricultural practices is needed for sustainability of the systems (Singh *et al.*, 2014). Very little information is available on soil nutrient availability as well as crop nutrient uptake under CA based practices in the RWCS. Hence, a study was conducted for 2 years to quantify the P and K uptake and availability of P and K in soil under conservation agricultural practices in rice-wheat cropping system.

## Materials and Methods

The field experiment (29.7° N, 76.9° E) was conducted during the period of 2015-2017 at Taraori village of Karnal district in Haryana. The mean annual maximum and minimum temperature of the region was 35°C and 18°C respectively and annual average rainfall was 700 mm. The soil of the experimental field was sandy clay loam in texture with pH of 8.1. The field was under rice-wheat cropping system for more than 10 years. Rice variety, Pusa 1121 and wheat variety, HD2967 were grown in the fields. The experiment comprised of four treatments *i.e.* Transplanted rice + Conventionally tilled wheat ($T_1$), Direct seeded rice + Zero tilled wheat with residue retention ($T_2$), Transplanted rice + Zero tilled wheat ($T_3$) and Transplanted rice + Zero tilled wheat with residue retention ($T_4$). $T_1$ is conventional agricultural practices whereas $T_2$, $T_3$ and $T_4$ falls under conservation agriculture practices. N, P and K were applied at doses of 120 kg N, 60 kg $P_2O_5$ and 60 Kg $K_2O$ respectively in rice and wheat crop. Each plot size was 7.5m × 6m and the design of the experiment was randomized block design (RBD).

### Collection and analysis of plant samples

Plant samples were collected after harvesting of each crop in both the years. Grain weights of rice and wheat crops were recorded from each treatment. All subsamples were oven dried at 65°C for 72hr and ground in a Wiley mill. Phosphorus concentration in plant samples was determined using vanado-molybdo yellow colour method (Jackson 1956). Potassium concentration in the acid digest was determined by a flame photometer.

### Collection and analysis of soil samples

Initial soil samples were collected from 0-15 cm depth in year 2015 and again samples were collected after 2 years *i.e.* 2017. Collected soil samples were air dried at room temperature and sieved through 0.2 mm screen, mixed and stored in sealed plastic jarsfor analysis of available soil phosphorus and potassium. Available phosphorus content (P kg ha$^{-1}$) in soil was determined by spectrophotometric method by Olsen *et al.,* (1954) whereas Available potassium (K kg ha$^{-1}$) were analyzed by flame photometer method, given by Hanway and Heidel (1952).

### Plant P and K uptake

P and K uptake in rice and wheat grain by multiplying the nutrient concentration (%) in grain with their respective yield.

$$\text{P uptake (kgha}^{-1}\text{)} = [\text{Grain P concentration (\%)}/100) \times \text{Grain yield (kg ha}^{-1}\text{)}] \quad (1)$$

$$\text{K uptake (kg ha}^{-1}\text{)} = [\text{Grain K concentration (\%)}/100) \times \text{Grain yield (kg ha}^{-1}\text{)}] \quad (2)$$

### Statistical analysis

Statistical analysis was performed using analysis of variance (ANOVA) technique recommended for the design to test whether the differences between means were statistically significant or not (Gomea and Gomez, 1984).

## Results and Discussion

### Phosphorus (P) uptake

Results revealed the positive effect of crop residue management practices over phosphorus uptake in both the rice and wheat crops. Higher wheat grain yield resulted in enhance P uptake as compared to rice. P uptake was highest in $T_4$ treatment in wheat (17.7 kg ha$^{-1}$ in first year; 20.1 kg ha$^{-1}$ in second year) and rice crop (13.0 kg ha$^{-1}$ in first year; 14.3 kg ha$^{-1}$ in second year) (Fig. 1a & b). P uptake was lowest (10.9 and 10.6 kg ha$^{-1}$ in first and second year) in direct seeded rice crop. Lower yield of direct seeded rice as compared to transplanted rice resulted in lower P uptake. In wheat crop, zero tillage practice and crop residue incorporation in $T_2$, $T_3$ and $T_4$ treatment resulted enhance phosphorus uptake in both the years. This is attributed to the fact that conservation agriculture increases the nutrients availability to soil and this enhance nutrient uptake in plant tissues (Sharma, 2002).

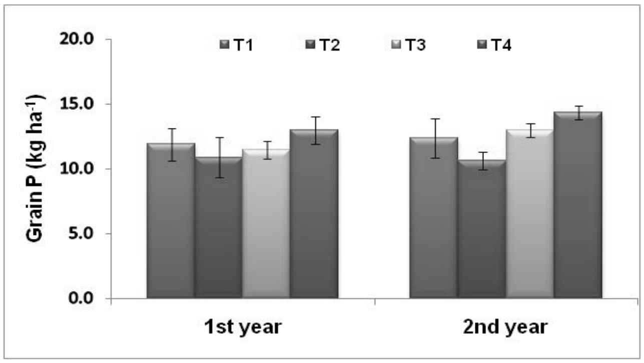


**Fig. 1(a):** Grain phosphorus uptake in rice and crop under conventional and conservation agricultural practices (error bars in figures indicate standard deviation).

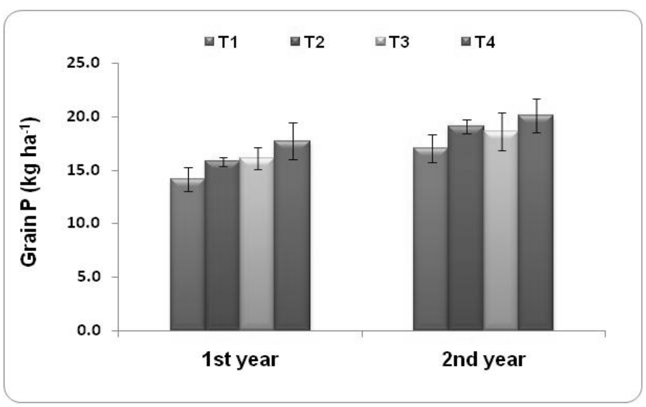


**Fig. 1(b):** Grain phosphorus uptake in wheat crop under conventional and conservation agricultural practices (error bars in figures indicate standard deviation).

## Potassium (K) uptake

Results showed that potassium uptake in rice increased in $T_3$ and $T_4$ treatment as compared to $T_1$ treatment. But lower yield of direct seeded rice resulted in lower K uptake in both the years of study (Fig. 2a & b). $T_2$ treatment with direct seeded rice showed the lowest potassium uptake (12.1 kg ha$^{-1}$ in first year; 12.6 kg ha$^{-1}$ in second year). Potassium uptake in rice was highest (14.2 kg ha$^{-1}$) in $T_3$ treatment in first year while it was highest (17.7 Kg ha$^{-1}$ ) in $T_4$ treatment during second year of study. In case of wheat crop zero tillage practices and crop residue incorporation showed increased K uptake as compared to the conventional tillage practices. K uptake was highest in $T_4$ treatment (20.3 kg ha$^{-1}$ in first year; 23.1 kg ha$^{-1}$ in second year) in wheat crop. Residue retention served as a source of K for the plants leading to higher K uptake in crop residue applied

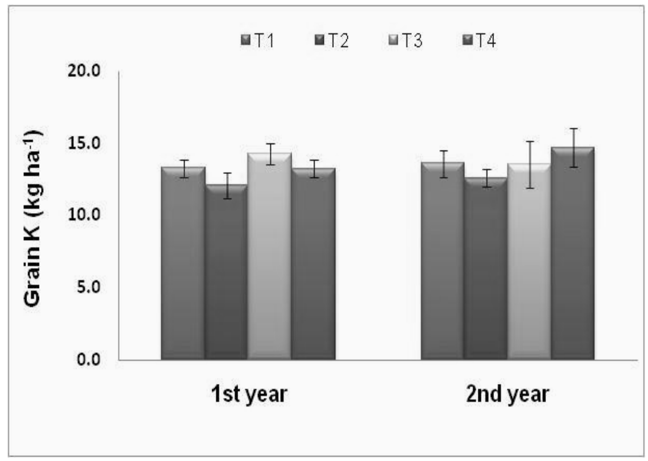


**Fig. 2(a):** Grain potassium uptake in rice crop under conventional and conservation agricultural practices (error bars in figures indicate standard deviation).

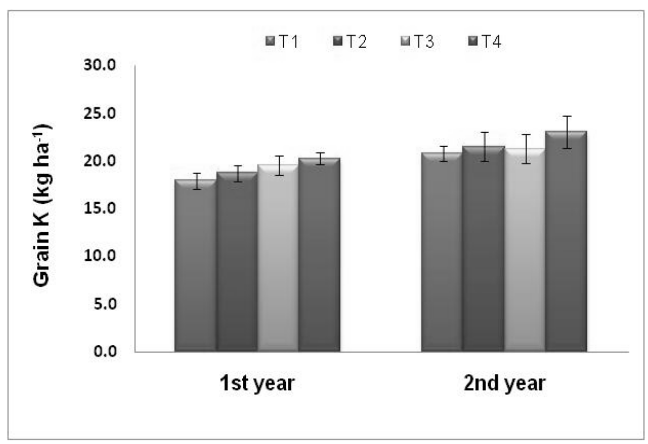


**Fig. 2(b):** Grain potassium uptake in wheat crop under conventional and conservation agricultural practices (error bars in figures indicate standard deviation).

treatments.

## Phosphorus (P) availability

Results showed that Pavailability in the soil increased in all treatments after 2 years of cropping period. In conventional treatment it increased from 28.6 kg ha$^{-1}$ to

29.5 kg $ha^{-1}$ (Fig. 3). Soil available P was significantly higher in $T_3$ and $T_4$ treatment than $T_1$. This shows that practicing zero tillage in wheat has increased the availability of soil phosphorus as compared to conventionally tilled treatment. In residue applied treatments crop residues were a source of organic matter, which when degraded increased nutrient availability in soil. Similar results were reported by Chakrabarti et al (2014) who observed more P availability in zero tillage and residue applied treatment. But treatment with direct seeded rice (DSR) ($T_2$) had lower values of available P than transplanted rice ($T_1$). This is attributed to the fact that continuous submergence of soil in transplanted rice causes convergence of soil pH to neutrality thereby increasing phosphorus availability (Sahrawat, 2005). Jat *et al.*, (2018) also reported that puddling of soil in rice

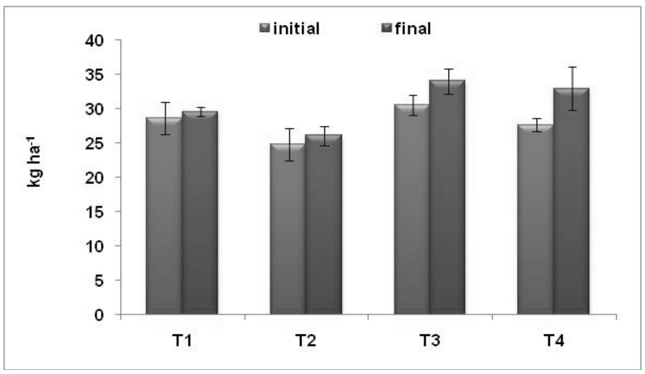


**Fig. 3:** Availability of soil phosphorus under conventional and conservation agricultural practices (error bars in figures indicate standard deviation).

increased the availability of P as reduced soil conditions increased the solubility of Fe, Al and Ca phosphates.

### Potassium (K) Availability

Available K of soil also increased in all treatments after 2 years of cropping period. Maximum value (341.5 kg $ha^{-1}$) of available K was recorded in $T_4$ treatment while it was minimum (307.2kg $ha^{-1}$) in $T_1$ treatment after 2 years of rice-wheat cropping (Fig. 4). Residue incorporation in soilled to more available K in $T_2$ and $T_4$ treatment. Earlier researchers also observed that zero tillage and residue retention in soil led to increased soil available potassium (Jat *et al.*, 2018; Pathak *et al.*, 2017; Malecka *et al.*, 2012). Crop residues contain large amount of potassium which is readily converted to soil available potassium (IRRI 1984).

## Conclusion

Zero tillage and rice residue incorporation in soil improved the uptake and availability of P and K in the rice wheat cropping system. This study highlights the importance of conservation agricultural practices over

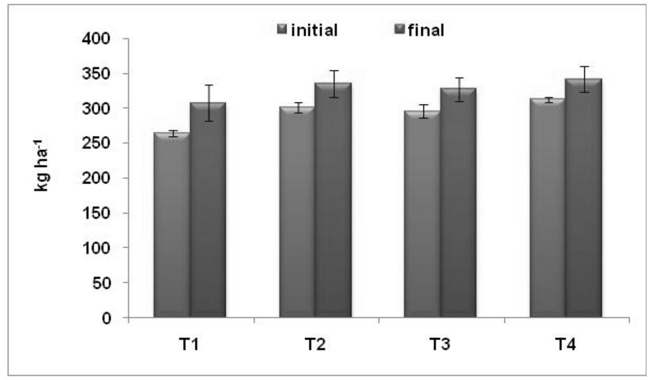


**Fig. 4:** Availability of soil potassium under conventional and conservation agricultural practices (error bars in figures indicate standard deviation).

conventional practices in terms of increasing the availability and uptake of phosphorus and potassium in soil and plant respectively.

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