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Performance of Wheat under Various Combinations of Phosphorus Application in Rice-Wheat Cropping System in Gobraila, Kailali, Nepal

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ABSTRACT

A field experiment was conducted at Gobraila, Kailali during winter season of 2017/18 to study the performance of wheat under various combinations of phosphorus application in rice-wheat cropping system. The experiment was done in Randomized complete block design having four replications and five treatments. The experiment consisted of various combinations of phosphorus application (kg ha^{-1}) in rice followed by wheat as P_{50-0}, P_{0-50}, P_{50-50}, P_{25-25} and P_{0-0} with recommended dose of nitrogen and potassium fertilizer application. Vijay variety of wheat was used in the study. Phosphorus application in both rice and wheat either full dose or half dose significantly increased plant height, NDVI and number of grains per spike of wheat over control and also caused the early heading of wheat. However, grain yield of wheat was not significantly influenced by various combinations of phosphorus application in R-W cropping system. Indeed, yield advantage of 17.10 percent and 16.45 percent in wheat grain was recorded from 50 kg P ha^{-1} and 25 kg P ha^{-1} application in both rice and wheat over control plot. Similarly, from the comparative economic analysis done between half dose and full dose of phosphorus application, yield obtained from 25 kg P ha^{-1} application in both rice and wheat was found to be economic optimum dose. Hence, half dose of phosphorus application in both rice and wheat exhibited better performance of wheat in Gobraila, Kailali under R-W cropping system.

Key words: *Phosphorus, R-W cropping system, Grain yield, Yield attributes*

INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to family Poaceae and is world's mostly cultivated staple food crop providing 20 percent calories and protein in the world's diet than any other cereals[11]. The cultivated *Triticum* species i.e *Triticum aestivum* with highest chromosome number is hexaploid (48) which is economically by far the most important which fall under the general heading of common wheat, the flour of which is best suited for bread[4]. Nearly 84 % of the total wheat cultivated is cropped under rice-wheat cropping system[16]. The rice-wheat rotation is one of the largest agricultural production of the world, occupying o.5 million ha in Nepal[13]. Major concerns in rice-wheat rotation are being raised as to whether degrading soil and water resources threaten the sustainability of this important production system[12,16].

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Rice- wheat system in Nepal is largely practiced in rainfed or irrigated low land ecosystem where heavier soil texture, excessive soil moisture, and late harvest of rice lead to higher cost and delays in wheat planting[17].

Much of the wheat cultivated under rice-wheat cropping system operates at low yield because of the unbalanced nutrients management and inappropriate water management. The repeated transitions from anaerobic to aerobic and aerobic to anaerobic growing conditions affect soil structure, nutrient relations, the growth of the component crops, and their associated pests and diseases[16]. In rice-wheat system, nitrogen and phosphorus is applied to both the crops[9]. However the utilization of phosphate fertilizer is very low (10-30%) and it's availability increases under submerged conditions[9]. In rice-wheat system of South Asia, long term fertilizer experiments on research stations have indicated that yields and total factor productivity have declined over time for both rice and wheat crops when grown at constant recommended fertilizer levels. Research conducted in different part of the world indicated that application of phosphatic fertilizer during wheat season only could still supply enough available phosphorus sources for crop growth and sustain crop yield compared to phosphorus application during both rice and wheat seasons. The same result was reported by Khattak and Bhatti who conducted research work on the residual effect of phosphorus and potassium on the yield of maize and wheat. They found that P applied to the first crop was sufficient for the subsequent second and third crop. Potassium applied to the first crop may be sufficient up to fourth or even fifth crop.

This study tries to find out whether really the present scenario of use of phosphatic fertilizer in wheat crop in study location is exceeding the crop demand or it is low or optimum in rice-wheat cropping system.

MATERIAL AND METHODS

Experimental site

The research was conducted in farmer's field in Kailari rural municipality-5, Gobraila, Kailali, Nepal during main wheat growing season November 2017 to April 2018. In the experimental site there was clayey type of soil (DADO, Kailali, 2072/73). Geographically, the experimental site falls in the terai region of Far-western Development Region of Nepal.

Soil properties of the experimental site

Soil testing of Kailari rural municipality was done during Jestha 25, 2074 with the mobile van soil testing unit by Khajura, Banke in collaboration with District agriculture development office, Dhangadi, Kailali.

Table 1: Soil test report as presented by DADO, Kailali

S.N	Properties	Average content	Rating
1	Soil pH	6.91	Neutral
2	Soil organic matter (%)	1.48	Low
3	Total nitrogen (%)	0.075	Low
4	Available phosphorus (kg ha^{-1})	55.19	High
5	Available potassium (kg ha^{-1})	216.23	Medium

Climatic condition during experimentation

The experimental site lies in the tropical climatic belt of Nepal which is too often characterized by the three distinct seasons: Monsoon (June to October), winter (November to February) and spring (March to May). The average maximum temperature and average minimum temperature for the cropping duration were 26.55ºC and 11.705ºC respectively. The total rainfall during the cropping period was 27.3 mm. Most of the winter remains generally dry with occasional rainfall, foggy weather with minimum sunshine hours.

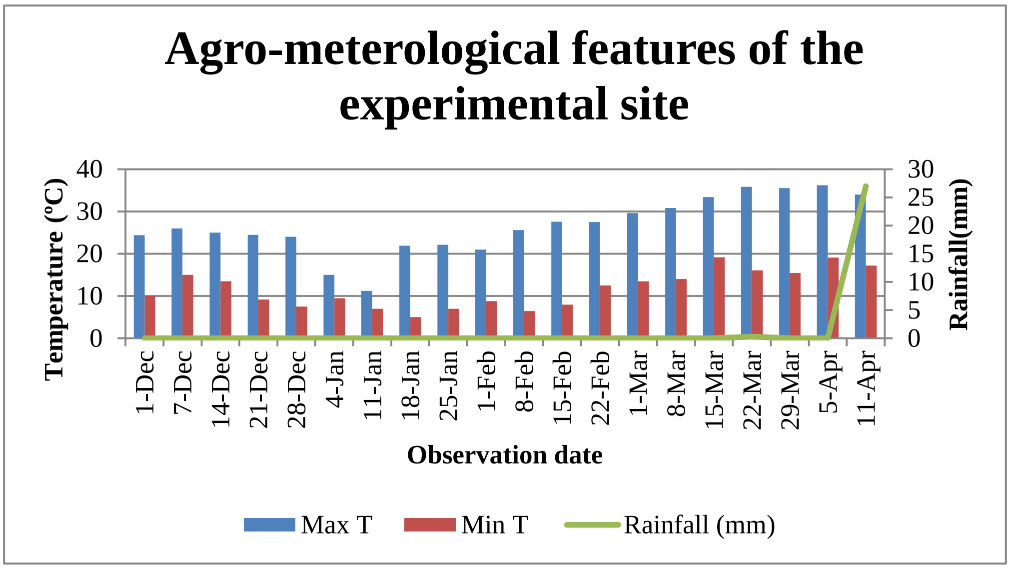

Figure 1: Weather condition during the period of experiment at Gobraila, Kailali

Experimental details: Design and Treatments

The experiment was laid out in Randomized Complete Block Design with five treatments replicated four times. The treatments comprised of 50 kg P_2O_5 ha^{-1} to rice and nil to wheat (T1), 50 kg P_2O_5 ha^{-1} to wheat and nil to rice (T2), 50 kg P_2O_5 ha^{-1} each to rice and wheat (T3), 25 kg P_2O_5 ha^{-1} each to rice and wheat (T4) and check (T5). The fertilizer dose for rice and wheat were 120:50:50 kg NPK ha^{-1} and 150:50:50 kg NPK ha^{-1} respectively. Vijay variety of wheat was used in the experiment.

Table 2: Details of treatment and their symbols in wheat experimentation in 2017-18 at Gobraila, Kailali, Nepal

Treatment details	Symbol
Phosphorus levels	
P_{50-0}	T1
P_{0-50}	T2
P_{50-50}	T3
P_{25-25}	T4
P_{0-0}	T5

Note: Fertilizer dose for wheat: 150:50:50 kg ha^{-1} NPK; rice: 120:50:50 kg ha^{-1} NPK; Figures in subscript of P is phosphorus application (ka ha^{-1}) in rice followed by wheat.

Plot size, layout and crop sowing

The size of individual plot was 10 m x16 m (160 m^2) with total 20 plots. Bund of 0.5 m width separated each plots. Seed sowing was done with the help of seed drill after final land preparation at the row spacing of 20 cm and continuous sowing in the row at seed rate of 120 kg ha^{-1}. Sowing was done in 29th November which is considered as the normal sowing date of wheat.

Crop management

Two light plowing before 15 days of sowing and brought into fine tilth manually one day prior to sowing at the time of final land preparation. FYM was applied on the crops at the rate of 6 mt ha^{-1} at the time of final land preparation and phosphorus was applied as per the treatments imposed along with full dose of potassium with the seed drill at the time of wheat seed sowing. However, the recommended dose of nitrogen was applied in three equal splits; one at the time of sowing with seed drill and remaining two splits at 25 DAS and 50 DAS by topdressing. Nitrogen, phosphorus and potassium was applied through Urea, Di-Ammonium Phosphate and

Muriate of Potash respectively. Weed management was done by spraying 2,4-D at 1.4 kg a.i. ha^{-1} at 30 days after sowing. The wheat crop from 4 m^2 area in each plot was harvested manually using sickles at the stage of physiological maturity. The harvesting was done at four different parts of each plot using 1 m^2 transect. Then the harvested crop was taken to threshing floor and threshed manually by beating with sticks and rubbing in the hand to get grains properly. The threshed grains were cleaned by winnowing and sundried for one day. Rest of the crops were harvested with combine harvester.

Observation recorded

1. Growth parameters of wheat: Plant height,Normalized difference vegetation index (NDVI) and days to 50% heading were recorded. NDVI was recorded with the help of Green seeker hand held crop sensor.

2. Yield attributing characters: Effective tillers per square meter, spike length, number of grains per spike and thousand grains weight.

3. Straw yield, grain yield and harvest index: Grain yield was measured from four random samples of 1 m^2 transect (net area of harvest of 4 m^2) from each plot. Immediately after harvesting total biomass yield was taken and then threshed, cleaned and sundried for one day to maintain moisture content. The grain yield per hectare was computed for each treatment from the net plot yield. The straw yield was obtained by deducting grain yield from the total biomass yield. The grain yield from each net plot was checked for moisture percentage using moisture meter and then the grain yield was adjusted at 12 percent moisture using the formula as suggested by Paudel.

$$\text{Grain yield (kg ha}^{-1}\text{) at 12\% moisture} = \frac{(100\text{-MC})\times\text{plot yield(kg)}\times 10000}{(100-12)\times netplot\ area}$$

where MC=moisture content of the grain

The harvest index was calculated by dividing grain yield with biological yield.

$$\text{HI} = \frac{\text{Grain yield}\times 100}{\text{Grain yield}+\text{Straw yield}}$$

Statistical analysis

Analysis of variance (ANOVA) of the recorded parameters were performed in one way randomized complete block design (RCBD). Means were separated by Duncan's Multiple Range Test (DMRT) at 0.05 level of significance. Regarding the software programs, Microsoft word 2010 was used for word processing, MS excels for tables, graphs and GenStat 15th edition computer programs were used for running statistical analysis.

RESULTS

Effects of phosphorus levels on plant height

The plant height was influenced significantly by various combinations of phosphorus application in rice-wheat cropping system from 55 DAS to 105 DAS except 85 DAS (Table 3).

At 55 DAS, highest plant height (58.1 cm) was found in plot with $P_{50\text{-}0}$ as a treatment which was at par with those plots with $P_{0\text{-}50,}$ $P_{25\text{-}25}$ as a treatment. Along with it, relatively lower plant height was observed in plot with $P_{50\text{-}50}$ as a treatment which was statistically similar to those plots with $P_{0\text{-}50,}$ $P_{25\text{-}25}$ as a treatment. Plant height was found significantly lowest (41.4 cm) in control plot not supplied with phosphorus in both rice and wheat. At 65 DAS, plant height was found highest (71.2 cm) in plot with $P_{0\text{-}50}$ as a treatment which was statistically similar to rest of the plots except the control plot where plant height was found to be lowest (55.9 cm). Similarly, same scenario was found at 75 DAS. At 85 DAS, influence of various combinations of phosphorus application in plant height was non-significant. At 95 DAS, significantly highest plant height was attained in plot with $P_{50\text{-}50}$ as a treatment which was statistically similar to rest of the plots except the control plot. At 105 DAS, plants were significantly taller (108.27 cm) in the plot with P_{50-50} as a treatment than all other plots except the plot with P_{25-25} as a treatment which were at par. The plots with P_{50-0}, P_{0-50}, P_{25-25} and P_{0-0} as a treatment were statistically similar to each other with respect to plant height.

Table 3: Plant height (cm) of wheat as influenced by various combinations of phosphorus application in rice-wheat cropping system in Gobraila, Kailali, 2017-18

Treatment	Plant height(cm)					
	55 DAS	65 DAS	75 DAS	85 DAS	95 DAS	105 DAS
Phosphorus Levels						
P_{50-0}	58.1^{a}	71.2^{a}	86.9^{a}	91.1	102.91^{a}	103.66^{b}
P_{0-50}	50.5^{ab}	66.2^{a}	81.1^{a}	92.2	102.42^{a}	103.54^{b}
P_{50-50}	49.5^{b}	64.9^{a}	80.9^{a}	92.5	106.24^{a}	108.27^{a}
P_{25-25}	51.5^{ab}	66.4^{a}	83.3^{a}	89.9	103.34^{a}	105.06^{ab}
P_{0-0}	41.4^{c}	55.9^{b}	70.8^{b}	82.9	95.25^{b}	101.03^{b}
LSD=(0.05)	7.59	8.55	9.25	ns	4.039	3.932
S.Em(±)	2.46	2.78	3	2.46	1.311	1.276
CV%	9.8	8.5	7.4	5.5	2.6	2.4
Grand mean	50.2	64.9	80.6	89.7	102.03	104.31

Note: LSD, least significant difference; S.Em(±), standard error of mean; CV%, coefficient of variation; ns, non significant; DAS, days after sowing. Figures in subscript of P is phosphorus application (ka $ha^{-1)}$ in rice followed by wheat. Treatment means followed by common letter(s) within column are not significantly different among each other based on DMRT at 0.05 level of significance.

Effects of phosphorus levels on Normalized difference vegetation index

NDVI of wheat was significantly influenced by various combinations of phosphorus application in rice-wheat cropping system at 65, 75 and 85 DAS (Table 4).

At 55 DAS, NDVI of wheat was found non-significant. At 65 DAS, significantly higher NDVI (0.680) was found in plot with P_{0-50} as a treatment as well as in plot with P_{50-50} as a treatment which was statistically similar with the plot with P_{25-25} as a treatment. Lower NDVI was found in control plot not supplied with phosphorus in both rice and wheat which was statistically similar with the plot with P_{25-25} as a treatment. Lowest NDVI (0.573) was found in plot with P_{50-0} as a treatment which was statistically similar with the control plot. At 75 DAS, NDVI was found highest (0.765) in plot with P_{50-50} as a treatment which was statistically similar with plots with P_{0-50} and P_{25-25} as a treatment while NDVI of control plot was found statistically similar with plots with P_{0-50} and P_{25-25} as a treatment. Lowest NDVI (0.696) was found in plot with P_{50-0} as a treatment which was statistically similar with control plot. At 85 DAS, significantly higher NDVI (0.765) was found in plot with P_{0-50} as a treatment which was at par with plots with P_{50-50} and P_{25-25} as a treatment and differed significantly from rest of the plots. Similarly plot with P_{50-50}, P_{25-25} and P_{50-0} as a treatment were at par with each other with respect to NDVI of wheat. Significantly lowest NDVI (0.688) was found in control plot which was at par with plot with P_{50-0} as a treatment.

Table 4: NDVI of wheat as influenced by various combinations of phosphorus application in rice-wheat cropping system in Gobraila, Kailali, 2017-18

Treatments	Normalized difference vegetation index			
	55 DAS	65 DAS	75 DAS	85 DAS
Phosphorus levels				
P_{50-0}	0.434	0.5725^{c}	0.696^{c}	0.703^{bc}
P_{0-50}	0.520	0.680^{a}	0.750^{ab}	0.765^{a}
P_{50-50}	0.545	0.680^{a}	0.765^{a}	0.743^{ab}
P_{25-25}	0.535	0.660^{ab}	0.750^{ab}	0.750^{ab}
P_{0-0}	0.490	0.613^{bc}	0.718^{bc}	0.688^{c}
LSD=(0.05)	ns	0.05596	0.03396	0.04738
SEm(±)	0.0264	0.01816	0.01102	0.01538
CV%	10.5	5.7	3	4.2
Grand mean	0.505	0.641	0.7357	0.7295

Note: LSD, least significant difference; S.Em(±), standard error of mean; CV%, coefficient of variation; ns, non significant; DAS, days after sowing. Figures in subscript of P is phosphorus application (kg ha^{-1}) in rice followed by wheat. Treatment means followed by common letter(s) within column are not significantly different among each other based on DMRT at 0.05 level of significance.

Effects of phosphorus levels on days to 50% heading

Various combinations of phosphorus application in rice-wheat cropping system had significantly influenced on days to 50% heading of wheat (Table 5).

Plot with P_{50-50} as a treatment had significantly came to heading earlier (80 DAS) which was at par with rest of the plots except control plot which came to heading later (84 DAS) which was also statistically similar with plot with P_{25-25} as a treatment .

Table 5: Days to 50% heading (DAS) of wheat as influenced by various combinations of phosphorus application in rice-wheat cropping system in Gobraila, Kailali, 2017-18

Treatments	Days to 50% heading (DAS)
Phosphorus levels	
P_{50-0}	81^{b}
P_{0-50}	81.5^{b}
P_{50-50}	80^{b}
P_{25-25}	82.5^{ab}
P_{0-0}	84^{a}
LSD=(0.05)	2.387
SEm(±)	0.775
CV%	1.9
Grand mean	81.80

Note: LSD, least significant difference; S.Em(±), standard error of mean; CV%, coefficient of variation; DAS, days after sowing. Figures in subscript of P is phosphorus application (kg ha^{-1}) in rice followed by wheat. Treatment means followed by common letter(s) within column are not significantly different among each other based on DMRT at 0.05 level of significance.

Effects of phosphorus levels on yield attributes of wheat

The yield attributes of wheat namely effective tillers per square meter, spike length and thousand grains weight were not significantly influenced by the various combinations of phosphorus application in rice-wheat cropping system except number of grains per spike which was significantly influenced by treatments imposed (Table 6).

The average number of grains per spike was 37.35 ranged from 32.45 to 42.01. Number of grains per spike was significantly influenced by various combinations of phosphorus application in rice-wheat cropping system. Significantly higher number of grains per spike (42.01) was found in plot with P_{25-25} as a treatment which was at par with plot with P_{50-50} as a treatment . Similarly, number of grains per spike were found statistically similar in rest of the plots and lowest (32.45) in plot with P_{50-0} as a treatment.

Table 6: Yield attributes of wheat as influenced by various combinations of phosphorus application in rice-wheat cropping system in Gobraila, Kailali, 2017-18

Treatment	Yield attributes			
	Effective tillers per square meter	Spike length(cm)	Number of grains per spike	Thousand grains weight(g)
Phosphorus levels				
P_{50-0}	329	17.71	32.45^{b}	47.45
P_{0-50}	344	17.78	35.51^{b}	51.77
P_{50-50}	364	18.98	41.52^{a}	48.66
P_{25-25}	335	18.41	42.01^{a}	48.88
P_{0-0}	345	17.06	35.26^{b}	47.25
LSD=(0.05)	ns	Ns	5.782	Ns
SEm(±)	37.3	0.449	1.877	1.156
CV%	21.7	5	10	4.7
Grand mean	343	17.99	37.35	48.8

Note: LSD, least significant difference; S.Em(±), standard error of mean; CV%, coefficient of variation; ns, non-significant. Figures in subscript of P is phosphorus application (kg ha^{-1}) in rice followed by wheat. Treatment means followed by common letter(s) within column are not significantly different among each other based on DMRT at 0.05 level of significance.

Effects of phosphorus levels on yield of wheat

The average grain yield of wheat under various combinations of phosphorus application in rice-wheat cropping system was 4113 kg ha^{-1} which was varied among the treatments (3781 to 4428 kg ha^{-1}). Similarly, average straw yield was 4328 kg ha^{-1}. The entire grain yield, straw yield and harvest index of wheat were not significantly influenced by imposed treatments (Table 7). Highest grain yield (4428 kg ha^{-1}) was obtained in plot with P_{50-50} as a treatment while lowest yield (3781 kg ha^{-1}) was obtained in control plot not supplied with phosphorus in both rice and wheat.

Table 7: Yield (kg ha^{-1}) of wheat as influenced by various combinations of phosphorus application in rice-wheat cropping system in Gobraila, Kailali, 2017-18

Treatments	Yield		
	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index (%)
Phosphorus levels			
P_{50-0}	3956	4303	48.2
P_{0-50}	3997	3912	50.8
P_{50-50}	4428	4659	48.6
P_{25-25}	4403	4334	50.4
P_{0-0}	3781	4431	47.5
LSD=(0.05)	ns	ns	Ns
SEm(±)	269.1	548.5	4.21
CV%	13.1	25.3	17.1
Grand mean	4113	4328	49.1

Note: LSD, least significant difference; S.Em(±), standard error of mean; CV%, coefficient of variation; ns, non significant. Figures in subscript of P is phosphorus application (kg ha^{-1}) in rice followed by wheat. Treatment means followed by common letter(s) within column are not significantly different among each other based on DMRT at 0.05 level of significance.

Economic analysis of phosphorus use in rice-wheat cropping system

Economically optimum yield of wheat was found to be 4403 kg ha^{-1} from the plot supplied with half dose of phosphorus in both rice and wheat instead of the plot supplied with full dose of phosphorus in both rice and wheat, as return per unit phosphorus input is higher in the plot with P_{25-25} as a treatment (Table 8).

As there was no significant difference among the plots with P_{50-50} and P_{25-25} as a treatment with respect to grain yield of wheat, however production cost was found to be higher and net return to be comparatively lower in plot with full dose of phosphorus application in both rice and wheat crop than the plot with half dose of phosphorus application in both rice and wheat crop. So application of 25 kg P ha^{-1} in both rice and wheat crop under R-W cropping system was found to be optimum dose and more economical.

Table 8: Economic analysis of Phosphorus use in wheat under rice-wheat cropping system

Treatments	Yield (kg ha^{-1})	Production cost (NRs. ha^{-1})	Return (NRs. ha^{-1})	Net return (NRs. ha^{-1})
P_{50-50}	4428	60954.50	132840	71885.50
P_{25-25}	4403	58390.53	132090	73699.47

Note: Price of wheat: NRs.30 kg^{-1}; Cost of DAP: NRs.48 kg^{-1}; Cost of Urea: NRs.20 kg^{-1}; Cost of Potash: NRs.25 kg^{-1}

DISCUSSION

Initial plant height was found higher in plot with P_{50-0} as a treatment upto 75 DAS and then it was higher for plot with P_{50-50} as a treatment until final height was attained. This might be due to the residual effect of phosphorus of preceeding rice crop in wheat crop[1] which was completely taken up by the crop as Janssen *et al.*[7], stated that when the supply of the particular nutrient is small compared to those of other nutrients, the whole supply of that nutrient will be taken up by the crop. Later the plant height was higher due to the phosphorus application in both crops which is in line with the result of Khan *et al.*[9], and Bashir *et al.*[2], who reported that increased phosphorus application significantly increased the plant height of wheat.

NDVI was found higher in plot with P_{50-50} as a treatment in all dates of sowing except at 85 DAS when highest NDVI was found in plot with P_{0-50} as a treatment. This might be because of the significant role of phosphorus in increasing the chlorophyll content of leaves and interception of more photosynthetically active radiation (PAR) as concluded by Kolar & Grewal[10]. Shanahan, Schepers, Francis, Varvel, & Wilhelm[15] also found that plant NDVI increased with higher P application was due to increased growth and/or greener plants, because NDVI reflectance in the Near-Infrared (NIR) and red wavelengths is related to plant growth and chlorophyll content. Similarly in the study of Wiatrak[19] also concluded that combination of avail polymer with P fertilizer at higher rates improved wheat plant NDVI, but it did not increase plant NDVI at low P fertilizer application rates. Islam & Muhammad[6] and Pirsabak- *et al.*[14], which stated that phosphorus has the significant potential to cause early heading in wheat as phosphorus influence essentially in all energy requiring processes in plant metabolism[5].

Non significant result in effective tillers per square meter ascribes water stress condition, as only single irrigation was applied in wheat crop. Usman[18] and Bazzaz, Khaliq, Karim, Al-Mahmud, & Khan[3] also reported that phosphorus use efficiency was significantly reduced by water stress condition resulting in reduced effective tillers of wheat. Kaleem *et al.*[8], who studied the effect of phosphorus on the yield and yield components of wheat variety " Inqlab-91 " under rainfed conditions and reported that higher dose of phosphorus application produced maximum number of grains per spike due to maximum accumulation of photosynthates. Grant *et al.*[5], also suggested that P stress reduces the number of seed produced more than seed size.

Non-significant result on grain yield of wheat might be due to the presence of high level of phosphorus already in the soil of experimental site and also low precipitation during the research period might hindered the effective uptake of applied phosphorus. McBeath *et al*. based on the isotopic tracer technique, concluded that P fertilizer uptake in wheat was 3-30% from applied P fertilizer and decreased with decreasing rainfall.

CONCLUSION

From the experimental research, grain yield of wheat was not affected by various combinations of phosphorus application in R-W cropping system. However, yield advantage of 17.11% in wheat grain was recorded from 50 kg P ha^{-1} application in both rice and wheat and 16.45% from 25 kg P ha^{-1} application in both rice and wheat over control. Instead of higher yield advantage from plot with P_{50-50} as a treatment, yield from plot with P_{25-25} as a treatment was found to be economic optimum yield. Similarly, final plant height was 7.166% and 3.948% taller in plot with P_{50-50} and P_{25-25} as a treatment respectively over control. Plant NDVI was 11.27% and 9.09% higher in plot with P_{0-50} and P_{25-25} as a treatment respectively over control. Number of grains per spike was also found 19.14% higher in plot with P_{25-25} and 17.75% higher in plot with P_{50-50} as treatment over control. Therefore it can be concluded that half dose of phosphorus application in both rice and wheat crop exhibited better performance of wheat as well as proved to be more economical under R-W cropping system in Gobraila, Kailali.

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