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A Relationship Study on Soil Characteristics, Crop Output, and Nutrient Absorption for Various Nutrient Fractions

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Abstract - The agricultural yields have been maintained by the application of both organic and inorganic materials. Use of the appropriate amount of nutrients via inorganic fertilisers, although it maintained yields, did not enhance the soil's physical, chemical, and microbiological qualities to the same level as the combined use of the organics and inorganics.

Keywords - Soil characteristics, Crop output, Nutrient absorption, Nutrient fractions

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INTRODUCTION

India's rice-wheat cropping system belt generates a third of the country's cereal output and is a major source of food grain procurement for its public distribution system because of the system's enormous food grain production potential. In spite of these concerns, however, the yield seems to be decreasing. There has also been evidence of deterioration in the factor productivity of fertilisers that need greater amounts of plant nutrients in order to produce the same yield. Soil fertility, particularly the organic matter level, has decreased. On farmland when output is more than 10 t-1 yr-1, the RWCS removes between 300 and 400 kg ha-1 of N+P2O5+K2O yr-1, compared to 6-8 t ha-1 yr-1 at moderate levels of production. Large quantities of secondary and micronutrients are also lost throughout this process (Prasad and Nagarajan, 2004).

There are approximately 13.5 million ha of rice-wheat cropland in India, 0.55 million ha in Nepal, 2.2 millions ha in Pakistan and 0.8 million ha in Bangladesh with the majority of this land lying in the Indo-Gangetic plains (IGP). The RWCS is the world's largest agricultural production system and occupies approximately 85 percent of the IGP (Saharawat et al., 2012). The RWCS in the IGP region of India extends from Punjab in the Northwest to West Bengal in the East (Bhatt et al., 2016). In India, rice and wheat are the two most important food crops, with respective average production levels of 2093 and 2607 kg ha-1. Together, these two crops occupied over 61% of the country's land and produced over 76% of the nation's food grains in 2014-15. (GoI, 2015-16). Over 90% of the entire amount of grains consumed in rural India is made up of these two commodities (Khatkar et al., 2016). Uttar Pradesh (UP) has been using the rice-wheat system since 1872 AD, and approximately half of India's rice-wheat acreage (4.8 million acres) is located in this state. About 22% of the country's total rice-wheat land is located in the eastern part of the state, making it the primary location for the rice-wheat system (Singh, 2012). In the Green Revolution, this approach was essential in boosting food production and making the nation self-sufficient. Its long-term viability has been questioned, and there are already symptoms of exhaustion and a drop in output. There have also been reports of a deterioration in the factor productivity of fertiliser, requiring increasing amounts of plant nutrients to get the same yield. Soil fertility, particularly the organic matter level, has decreased. Crops remove more N, P, K, and micronutrients than they can replace with fertiliser due to over-mining of nutrients. Secondary and micronutrients are also eliminated in substantial quantities. Demand for food is expected to rise, putting a strain on these soils in the future. This tendency is anticipated to lead to degradation in the structure and workability of long-term arable soils in many regions of the globe. Degradation of the soil due to organic matter decomposition in farmed soils in arid and semiarid climates may make it impossible to maintain a sustainable agriculture.

MATERIAL AND METHODS

College of Agriculture, Palampur began a long-term fertiliser experiment in kharif 1991 to study the effects of INM on the long-term nitrogen, phosphorus, and potassium dynamics in rice-wheat systems. This study made use of data from the 2019

Kharif (rice) and 2020-21 Rabi (wheat) agricultural seasons.

- **Soil characteristics**

Alfisols, a taxonomic category, classifies the soil in the study area as "Typic Hapludalf" (Verma 1979). The genetic classification method has categorised the region's soils as "Grey Brown Podozols" since they originated from fluvioglacial parent material. These soils are produced by rocks such as quartzites, gneisses, phyllites, slates, and schists.

The soil was acidic and had a silty clay loam texture when the experiment began in 1991. Nitrogen availability was evaluated as being high on the soil surface, whereas phosphorus and potassium availability were classified as being medium. The level of organic carbon in the atmosphere was equally low. Some of the major physico-chemical characteristics of the surface soil at the experiment location are listed in Table 3.1 (0.15-0.3 m).

- **Experimental details**

With a plot size of 7.0 x 5.1 m2 and a randomised block design that comprised 12 treatments and four replications of each, it was chosen to expand an ongoing long-term field trial. N, P, and K usage recommendations at the state level for rice and wheat were 90:17:33 and 120:26:25, respectively.

Growing and using green manure crops

During the 2019 and 2020 kharif seasons, Sesbania aculeata (Dhaincha) was cultivated as an ex-situ green manure crop. (May to July). The crops were farmed for 60–65 days prior to rice planting, then an electric rotavator crushed them into tiny pieces of 4-6 centimetres.

Field preparation

The individual plots were cultivated with a power-operated rotavator.

Nursery raising, sowing/ transplanting

As of July 4 and 13, 2019, 20 x 15 cm2 rice plantings were made for Kharif 2019. Both spring and fall saw the adoption of the HPR-2143 cultivar, with 1-2 seedlings per hill being transplanted. The fields were watered twice, but received enough precipitation to sustain themselves otherwise. We used butachlor, a pesticide, to kill the weeds. The HPW 155 and HPW-42 wheat varieties were chosen for the first and second year rabi harvests, respectively.

Application of fertilizers and organics

Urea, superphosphate, and muriate of potash were used to provide half of the nitrogen and the remainder phosphorus and potassium, respectively, in rice. Part two of the nitrogen application occurred during tillering. Only one application of organic materials such farmyard manure, wheat cut straw, and green manure were used on the rice crop (Dhaincha). Wheat was given urea, superphosphate, and muriate of potash as its first nitrogen dosage, and the remaining two-thirds of the nitrogen was applied throughout the tillering and grain filling stages. As is common practise among farmers, 5 t ha-1 of FYM and 40% NPK were applied to rice before they were sown, and the same application rate was used for wheat thereafter.

Harvesting and threshing

On October 15 and 20, 2019, over 80% of the kharif 2019 and kharif 2020 rice grains were harvested at maturity. On May 7 and 8, 2020 and 2021, Pakistan harvested wheat for the Rabi 2019-20 and Rabi 2020-21 seasons. The dry product was threshed to remove the straw and expose the grains. Machine threshing was required for wheat, whereas manual threshing was sufficient for rice.

LABORATORY STUDIES

- **Soil studies**

i. **Collection and preparation of samples**

After wheat was harvested, composite soil samples were taken from each plot at 0-15 cm and 0.1-5.30 cm depths (rabi, 2019-20). Soil samples were taken from a depth of 0 to 0.15 metres after the 2019-2020 rabi and kharif harvests of wheat and rice, respectively. For further examination, the soil samples were treated and sieved before being sealed in plastic bags.

ii. **Analysis of soil samples**

Soil samples were analysed for pH, organic carbon, bioavailable N, P, and K after the 2019 and 2020 rice and wheat harvests using standard analytical techniques. (Table 3.2). During the 2019-2020 rabi season, soil samples were taken and analysed for a variety of physical characteristics, including bulk density, particle density, water holding capacity, and porosity, and for a variety of microbiological characteristics, including carbon and nitrogen microbial biomass, and soil respiration.

A variety of nitrogen, phosphorus, and potassium forms were identified by collecting soil samples after the wheat harvest (rabi, 2019-20):

A. **Procedure for determination of N forms**

Just in case you missed it, here's a short rundown of the methods:

Inorganic N: The inorganic N fractions were calculated by combining 3 grammes of soil with 30

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millilitres of 2N KCl and mixing the mixture for 1 hour before filtering. The extracted liquid was stored in the refrigerator for subsequent use. Black's technique was used to extract the inorganic forms of nitrogen (NH4-N and NO3-N) from the aforementioned sample (1965).

Organic N: To extract the organic components of N, 25 g of soil was boiled with 20 ml of 6N HCl and 2 drops of octyl alcohol for 12 hours at reflux. The substance was then filtered via a Buchner funnel and Whatman no. 50 filter paper. The pH was adjusted by adding 5N and 0.5N NaOH to the sample, bringing it to the target range of 6.5–7. Hydrolyzable NH4-N, amino acid-N, serine+threonine N, hexosamine N, and total hydrolyzable N were determined when the final volume was raised to 100 ml, using Bremner's 1965 method.

B. Procedure for determination of P forms

Sequential extraction, as described by Sui et al. (1999), was utilised to probe P fractionation. This technique intends to detect labile and stable organic P, as well as plant-available P (H2O-P or NaHCO3-extractable P), Ca-associated P (HCl-extractable P), Fe-oxide- and Al-oxide-associated P (NaOH-extractable P), and so on. Find a brief outline of the procedure here:

- **Plant studies**

By drying and weighing the whole harvest, we were able to calculate the biological yield. After the grains and straw were separated, the yields from each plot were determined. After the rice and wheat harvests in 2019 and 2020 (kharif), representative samples of grain and straw were collected. They needed to be dried in an oven at 700 degrees Celsius. The parts were reduced to a powder and put away for further analysis. Table 3.3 highlights the many plant analysis techniques that are often used.

Nutrient uptake was determined by combining grain and straw yields with the relevant nutrient concentration percentages. The combined nutrient losses of grain and straw were used to estimate the overall nutrient losses of each crop.

STATISTICAL ANALYSIS

Analysis of variance for randomised block design was used to evaluate the field and laboratory research results, as stated by Gomez and Gomez (1984). Conventional methods were used to determine associations between yield, N, P, and K fractions, proportionate uptake, and soil properties.

RESULTS AND DISCUSSION

The effects of altering N, P, and K fractions on soil pH, organic carbon, CEC, and available nutrients, as well as crop yields and nutrient absorption, were investigated. The data is shown in Tables 4.22 through 4.31; more explanation may be found below.

Nitrogen fractions

i. Correlation with soil properties

Table shows how different amounts of nitrogen affect the properties of soil. To a more or lesser extent, organic carbon, CEC, and accessible nitrogen status were positively related to each of the nitrogen components except for unidentified-N. The correlation between available nitrogen and hydrolyzable ammonical-N was the strongest (r=0.898), followed closely by the correlation between available nitrogen and amino acid-N (r=0.884). Aggarwal et al. (1990) and Sharma et al. (1990) have come to similar conclusions (1991) (1996).

Table 1: Correlation coefficients (r) of different nitrogen fractions (0-0.15 m) with soil properties

N-Fraction	Soil Properties			
	pH	OC	CEC	Available N
Ammonical-N	0.116	0.641**	0.540**	0.615**
Nitrate-N	0.180	0.557**	0.421**	0.564**
Hydrolysable ammonical-N	0.240	0.845**	0.827**	0.898**
Hexosamine-N	0.373**	0.734**	0.652**	0.796**
Amino acid-N	0.418**	0.816**	0.737**	0.884**
Serine + Threonine-N	0.283	0.798**	0.659**	0.835**
Unidentified-N	0.256	0.184	0.193	0.279
Non hydrolysable-N	0.309*	0.470**	0.455**	0.562**

***significant at 5% level, ** significant at 1% level**

ii. Correlation with yield and nitrogen uptake

Table shows the correlation between different nitrogen percentages and the yield and uptake of nitrogen in rice grain and straw. A favourable and statistically significant correlation between rice grain yield and all nitrogen components (excluding unidentified-N) was found. The correlation between rice grain yield and hydrolyzable ammonical-N (r=0.762) and Serine + Threonine-N (r=0.699) was the strongest. On the other hand, hydrolyzable ammonical-N had the strongest correlation between straw yield and amino acid-N (r=0.686), followed by r=0.692 for amino acid-N.

Table 2: Different nitrogen fractions' correlation coefficients (r) with rice yield and nitrogen absorption in 2020

N-Fraction	Yield			N-Uptake	
	Grain	Straw	Grain	Straw	Total
Ammonical-N	0.549**	0.445**	0.634**	0.546**	0.624**
Nitrate-N	0.501**	0.454**	0.528**	0.503**	0.547**
Hydrolysable ammonical-N	0.762**	0.686**	0.875**	0.828**	0.904**
Hexosamine-N	0.608**	0.651**	0.723**	0.765**	0.792**
Amino acid-N	0.687**	0.692**	0.805**	0.817**	0.863**
Serine + Threonine-N	0.699**	0.602	0.811**	0.760**	0.834**
Unidentified-N	-0.535**	-0.547**	-0.601**	-0.604**	-0.641**
Non hydrolysable-N	0.577**	0.576**	0.659**	0.650**	0.696**

****significant at 1% level**

The findings showed that all nitrogen components (apart from unidentified-N) were positively and considerably correlated with rice grain and straw and total N consumption. Grain and straw N absorption were most strongly correlated with hydrolyzable ammonical-N. Total N absorption was shown to be most strongly correlated with hydrolyzable ammonical-N (r=0.904), followed by amino acid-N (r=0.863). Comparable results were discovered by Singh et al. (1999a) and Sarawad et al. (2001)

iii. Relationship between various nitrogen fractions

Table displays data on the correlation between different nitrogen percentages (at a depth of 0.15 m). The data showed a positive and robust relationship between all nitrogen components except for unidentified-N. The strongest association was found between ammonium-N and total hydrolysable-N (0.679), followed by total-N (r=0.678) and hydrolysable ammonical-N (r=0.675). The correlation between nitrate-N and total-N was the greatest (r=0.537), followed closely by the correlation between nitrate-N and hydrolysable-N (r=0.534). Except for unidentified-N, all other forms of nitrogen were positively and significantly linked to HNH4N- Hydrolyzable ammonical N, AAN- Amino acid N, STN- Serine + Threonine N, HAN- Hexosamine N, NHN- Non hydrolyzable N, THN- Total hydrolyzable N, and TN- Total nitrogen. The correlation between hydrolysable-N (r=0.959) and total-N (r=0.958) was the greatest. Total-N had the strongest correlation, same as hexosamine-N, amino acid-N, and serine + threonine-N did.

Table 3: R-values for correlation among nitrogen fractions (0-0.15 m)

N-Fraction	NH_4-N	NO_3-N	HNH_4N	HAN	AAN	ST N	THN	UN	TN
NO_3-N	0.221								
HNH_4N	0.675**	0.521**							
HAN	0.615**	0.457**	0.834**						
AAN	0.634**	0.525**	0.901**	0.876**					
STN	0.661**	0.526**	0.909**	0.822**	0.849**				
THN	0.679**	0.534**	0.959**	0.890**	0.952**	0.919**			
UN	0.169	0.152	0.188	0.192	0.139	0.197	0.215		
TN	0.678**	0.537**	0.958**	0.890**	0.952**	0.927**	0.992**	0.215	
NHN	0.047	0.350*	0.477**	0.443**	0.478**	0.523**	0.461**	0.090	0.776**

* significant at 5% level ** significant at 1% level

Table 4: correlation indices (r) between various nitrogen fractions (0.15-0.30 m)

N-Fraction	NH_4-N	NO_3-N	HNH_4N	HAN	AAN	ST N	THN	UN	TN
NO_3-N	0.502**								
HNH_4N	0.677**	0.762**							
HAN	0.543**	0.676**	0.790**						
AAN	0.634**	0.750**	0.900**	0.819**					
ST N	0.613**	0.759**	0.839**	0.831**	0.847**				
THN	0.669**	0.806**	0.970**	0.843**	0.950**	0.892**			
UN	0.552**	0.734**	0.792**	0.617**	0.707**	0.707**	0.855**		
TN	0.677**	0.801**	0.963**	0.867**	0.944**	0.907**	0.991**	0.823**	
NHN	0.059	0.225	0.367*	0.525**	0.375**	0.458**	0.369*	0.154	0.479**

Hydrolyzable Amino Nitrogen (HNH4N), Amino Acid Nitrogen (AAN), Serine and Threonine Nitrogen (STN), Hexosamine Nitrogen (HAN), Unknown Nitrogen (UN), Nonhydrolyzable Amino Nitrogen (NHN), Total Hydrolyzable Amino Nitrogen (THN), and Total Nitrogen (TN). The significance levels are: * 5% significant ** 1% significant

All percentages of nitrogen, except unidentified-N, were positively and statistically related to depth (0.15-0.30 m) (Table 4.24). The strongest correlation was found between total ammonium-N and hydrolysable ammonical-N (r=0.677), with total hydrolysable-N coming in a close second (r=0.669). The strongest correlation was found between total hydrolysable-N and nitrate-N (r=0.806), followed by total-N and nitrate-N (r=0.801). The strongest correlation was seen between hydrolyzable ammonical-N and both total-N and total-

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hydrolyzable-N (r=0.970) and total-N (r=0.963), respectively. The correlation between amino acid N (r=0.944) and total hydrolysable N (r=0.950) was found to be the greatest. According to Ghosh and Burns, 23 percent of the total N was transformed into amino acid-N and hydrolyzable NH4-N.(1950) (22%). The amino acid-N content of Lantana ranged from 27.1-35.0%, with the remaining N split between hydrolyzable NH4 (25.6-32.9%) and unidentified N. (Sharma & Verma, 2001) (2.2-2.9 percent).

Phosphorus fractions

i. Correlation with soil properties

Soil parameters such as pH, organic carbon, CEC, and accessible phosphorus status were shown to be positively and substantially connected with all the phosphorus fractions studied (Table). NaHCO3-Po (r=0.625) was found to have the best association with soil pH. NaHCO3-Pi (r=0.897) and NaOH-Pi (r=0.894) had the highest connection with organic carbon. For CEC, residual-P (r=0.875) and NaHCO3-Pi (r=0.870) had the strongest correlations. With respect to phosphorus availability, NaHCO3-Pi had the strongest association (r=0.921), followed by residual-P (r=0.891). Similar findings have been found in previous studies by Sood et al. (1992) and Kadrekar et al. (1993). (1992). It has been found that Olsen-P is strongly correlated with all of the inorganic P components, including Chand and Tomar (1992) and Setia and Sharma (2007).

Table 5: Different phosphorus fractions' correlation coefficients (r) with soil characteristics range from 0.00 to 0.15 metres

P-Fraction		Soil Properties		
	Ph	OC	CEC	Available P
$H_2$0-P	0.484**	0.777**	0.692**	0.730**
$NaHCO_3$-P_i	0.359*	0.897**	0.870**	0.921**
$NaHCO_3$-P_o	0.625**	0.817**	0.630**	0.727**
NaOH-P_i	0.365*	0.894**	0.818**	0.866**
NaOH-P_o	0.355**	0.680**	0.626**	0.629**
HCl-P	0.495**	0.854**	0.675**	0.736**
Res-P	0.316*	0.868**	0.875**	0.891**

***significant at 5% level, **significant at 1% level**

ii. Correlation with yield and phosphorus uptake

The relationship between surface layer phosphorus % and subsequent grain and straw yields is shown in Table 4.26. (0-0.15 m). The evaluated data revealed a significant and positive correlation between rice grain and straw yields and all of the phosphorus percentages. The strongest correlation was found with remaining-P and rice grain yield (r=0.756), followed by NaOH-Pi and rice grain yield (r=0.708). The strongest correlations between NaOH-Pi and rice straw yield were found for NaHCO3-Pi (r=0.700) and NaOH-Pi (r=0.704). Olsen-P and all other forms of P were shown to have a positive relationship with rice grain and straw yields, supporting the findings of Sood and Bhardwaj (1992).

The positive and considerable relationship between all P components and wheat grain and straw phosphorus absorption and total P uptake is shown in Table. The strongest correlation was found between remaining-P and rice grain P absorption (r=0.815), followed by NaOH-Pi (r=0.789). The associations with residual-P (r=0.717) and P absorption in straw (r=0.758) were highest for NaOH-Pi and NaHCO3-Pi, respectively. The strongest correlations with total P absorption were found for NaHO-Pi (r=0.822) and NaHCO3-Pi (r=0.819). Sood and Bhardwaj found a strong correlation between the amount of phosphorus absorbed by rice crops and the phosphorus percentages used (1992). Similar to what was shown by Setia and Sharma (2007), it was discovered that wheat's ability to absorb Olsen-P in Punjab's calcareous soils is positively connected with these results. They also claimed that Al-P is responsible for the vast majority of P uptake.

Table 6: Different phosphorus fractions' correlation coefficients (r) with rice production and phosphorus absorption range from 0-0.15 m

P-Fraction	Yield			P-Uptake	
	Grain	Straw	Grain	Straw	Total
$H_2$0-P	0.627**	0.587**	0.682**	0.645**	0.703**
$NaHCO_3$-P_i	0.697**	0.700**	0.779**	0.758**	0.819**
$NaHCO_3$-P_o	0.534**	0.579**	0.619**	0.654**	0.690**
NaOH-P_i	0.708**	0.704**	0.789**	0.758**	0.822**
NaOH-P_o	0.593**	0.615**	0.639**	0.644**	0.689**
HCl-P	0.599**	0.598**	0.690**	0.677**	0.729**
Residual-P	0.756**	0.664**	0.815**	0.717**	0.798**

****significant at 1% level**

iii. Relationship between various phosphorus percentages

Table 7 displays the results of a study examining the correlation between phosphorus percentages (0-0.15 m depth). All of the phosphorus concentrations were found to be positively and strongly associated with one another, as shown by the results. H2O-P had the highest association with residual-P (r=0.826), whereas NaHCO3-Pi had the second highest (r=0.812). While residual-P was the most correlated (r=0.923), NaHCO3-Pi was the most correlated (r=0.931) with NaOH-Pi. The strongest relationship between NaHCO3-Po and HCl-P was observed (r=0.872), followed by NaOH-Pi (r=0.793),

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while the strongest relationship between NaOH-Pi and residual-P was established (r=0.923), followed by HCl-P (r=0.866).

Table 4.307the coefficients of correlation (r) between various phosphorus percentages

P-Fraction	H_20-P	$NaHCO_3$-P_i	$NaHCO_3$-P_o	NaOH-P_i	NaOH-P_o	HCl-P
(0-0.15 m)						
$NaHCO_3$-P_i	0.812**					
$NaHCO_3$-P_o	0.788**	0.799**				
NaOH-P_i	0.773**	0.931**	0.793**			
NaOH-P_o	0.535**	0.709**	0.545**	0.631**		
HCl-P	0.788**	0.822**	0.872**	0.866**	0.500**	
Residual-P	0.826**	0.923**	0.790**	0.923**	0.601**	0.851**
(0.15-0.30 m)						
$NaHCO_3$-P_i	0.776**					
$NaHCO_3$-P_o	0.796**	0.841**				
NaOH-P_i	0.791**	0.926**	0.861**			
NaOH-P_o	0.682**	0.813**	0.584**	0.749**		
HCl-P	0.856**	0.843**	0.878**	0.867**	0.635**	
Residual-P	0.858**	0.894**	0.919**	0.903**	0.646**	0.946**

***significant at 5% level, ** significant at 1% level**

A similar trend was seen between 0.15 and 0.30 m soil depth, where all of the phosphorus percentages were shown to be positively and strongly linked (Table 8). The correlation between H2O-P and residual P was the highest (r=0.858), followed by that between HCl-P and residual P (r=0.856). The two most strongly correlated variables were residual-P and NaHCO3-Pi (r=0.894 and r=0.926, respectively). In contrast, a correlation of 0.919 and 0.903 between NaHCO3-Po and NaOH-Pi, and 0.878 and 0.867 between HCl-P, was established between these two variables and residual-P.

Potassium fractions

i. Correlation with soil properties

All forms of potassium in soil were shown to be significantly and positively correlated with organic carbon, cation exchange capacity, and available potassium (Table 4.28). A favourable and statistically significant connection (r=0.381) was found between soil pH and exchangeable K. Only water-soluble potassium was shown to have a significant relationship to both organic carbon and cation exchange capacity (r=0.715 and 0.678), whereas exchangeable potassium was found to have the strongest relationship (r=0.826 and 0.769). These findings are consistent with those of Tisdale et al. (1995) and Sharma (1996).

Table 8: Different potassium fractions' (0-0.15 m) correlation coefficients with soil

K-Fraction		Soil Properties		
	pH	OC	CEC	Available K
Water soluble-K	0.219	0.715**	0.678**	0.769**
Exchangeable-K	0.381**	0.655**	0.558**	0.826**
Non exchangeable-K	0.174	0.478**	0.471**	0.470**

***significant at 5% level,**

****significant at 1% level**

ii. Yield and potassium uptake: Correlation

Table showing that there is a positive and robust relationship between the quantity of potassium taken up by grain and straw and all of the potassium components. Correlation coefficients for grain production were 0.522, 0.535, 1.481%, and 0.481 for water-soluble, exchangeable, and insoluble potassium, respectively. Most strongly correlated with straw production was exchangeable potassium (r = 0.503), followed by water-soluble potassium (r = 0.530), and then non-exchangeable potassium (r = 0.359).

Table 9: Variable potassium fractions (0-0.15 m) and their correlation coefficients (r) with rice yield and potassium absorption

K-Fraction	Yield			Uptake	
	Grain	Straw	Grain	Straw	Total
Water soluble-K	0.522**	0.503**	0.693**	0.605**	0.622**
Exchangeable-K	0.535**	0.530**	0.691**	0.625**	0.604**
Non exchangeable-K	0.481**	0.359*	0.497**	0.417**	0.430**

***significant at 5% level, ** significant at 1% level**

The data also showed a positive and statistically significant correlation between all potassium fractions and the absorption of potassium in grain, straw, and overall uptake. Water-soluble K (r=0.693 and 0.622) and exchangeable K (r=0.691 and 0.604) had the strongest connection with rice grain K absorption and total K uptake, respectively. Alternatively, exchangeable K (r=0.625) and water-soluble K (r=0.605) showed the strongest connection with K absorption in rice straw. Among all the variables, the non-exchangeable K had the weakest association. The substantial link between water-soluble and exchangeable K and grain production was also observed by Dhanorkar et al. (1994).

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iii. Relationship between various potassium percentages

According to Table, there is a positive and statistically significant relationship between all of the potassium fractions at a soil depth of 0 to 0.15 m. There was a moderate positive correlation between exchangeable-K and non-exchangeable-K (r=0.361) and a moderate negative correlation between exchangeable-K and water-soluble-K (r=0.466). Between 0.15 and 0.30 m, there were no appreciable shifts in potassium concentrations. There was a positive and statistically significant correlation between soil potassium levels that was also discovered by Lal et al (1990).

Table 10: Coefficients of correlation (r) for various potassium percentages (0-0.15 and 0.15-0.30 m)

K-Fraction	Water extractable K	Exchangeable K	Non Exchangeable K
(0-0.15 m)			
Water extractable K	1.000		
Exchangeable K	0.466**	1.000	
Non Exchangeable K	0.385**	0.361*	1.000
(0.15-0.30 m)			
Water extractable K	1.000		
Exchangeable K	0.093	1.000	
Non Exchangeable K	0.190	0.207	1.000

*significant at 5% level, ** significant at 1% level

CONCLUSION

A positive and statistically significant association was found between rice grain and straw yield and all nitrogen fractions except unidentified-N, showing that this fraction is not contributing significantly to yield. All phosphorus fractions showed positive and substantial correlations to each other at soil depths, indicating chemical pool interdependence and indicating dynamic equilibrium. At 0–0.15 m and 0.15-0.30 m soil depth, all potassium fractions correlated positively and strongly with each other, indicating a dynamic equilibrium among these fractions.

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