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Correlation coefficient between soil properties and Nutrient uptake without potassium by upland paddy

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Abstract
The paddy crop was harvested at 100% flowering. The initial soil analysis for physico-chemical properties of the soils were determined. The concentration and uptake of nutrients (N, P, K, Fe, Mn, Zn and Cu) by upland paddy (Cv. Bhogavati) were determined at 100% flowering. Correlation coefficient between initial soil chemical properties and nutrients uptake without K showed that, the soil potassium was significantly positively correlated with all nutrients uptake without potassium. The soil nitrogen was positively correlated to plant N, P, K, Zn uptake and negatively correlated to plant Fe, Mn, Cu uptake. The soil phosphorus was significantly positively correlated to plant N, Fe, Zn, Cu uptake and positively correlated to plant P, K, and Mn uptake. The soil electrical conductivity, soil calcium carbonate and soil zinc were positively correlated and soil pH, exchangeable calcium were significantly positively correlated to all nutrients uptake by paddy plant. Soil organic carbon significantly positively correlated with plant P, Mn uptake and positively correlated with plant N, K, Fe, Zn, Cu uptake. Soil Fe and Mn were negatively correlated and soil Mg and Cu were significantly negatively correlated with all nutrients uptake by paddy plant.

Keywords: Soil properties, nutrient uptake, Potassium, upland paddy

Introduction
Rice (Oryza sativa L.) is a major Kharif crop of India. Rice is foremost cereal crop of the world and is the staple food of over 60 per cent of the world's population. In India, particularly Southern and Western India, rice is the main constituent of the daily diet. Other rice products of common importance are parched rice (Murmura), beaten rice (Poha) and parched paddy (Lahi). Most of the paddy is consumed by human being after cooking as whole rice or by preparing products like Bhakri, Idali, Dossa or Uttappa. Rice cultivation in India is traditionally confined to the areas of high rainfall, where it is grown under lowland conditions. But with the use of irrigation resources and introduction of high yielding cultivars, rice is being cultivated under upland conditions in nontraditional areas in Maharashtra. Upland rice is grown on soils that are aerobic or oxidized for the greater part of the growing season (Ponnamperuma, 1975) [11].

Rice occupies 23.3 per cent of gross cropped area of the country, contributes 43 per cent of total grain production and 46 per cent of total cereal production. Considering worldwide distribution India has the largest area under rice cultivation (42.49 m. ha) and has occupies second position in production (88.28 m.t) next to china. In India, as far as area concerned under rice, Uttar Pradesh ranks first (58.39 lakh hectares.) followed by West Bengal (54.36 lakh hectares) and Orissa (44.34 lakh hectares). In terms of production, West Bengal ranks first (124.28 lakh tones) followed by Uttar Pradesh (115.40 lakh tones) and Andhra Pradesh (114.48 lakh tones).

According to agricultural statistical information of Maharashtra, rice is second important crop, grown over an area of 15.35 lakh hectares. The average productivity of the state is 1.85 tones per hectare. Area under rice crop in Kolhapur district is 1.10 lakh hectares with average productivity of 2.35 tons per hectare. The position of Maharashtra in rice production is comparatively poor. In the state, rice is grown in the districts with varying extent. However, the major rice growing districts are Raigad, Thane, Ratnagiri and Sindhudurg of Konkan region, Kolhapur district of western Maharashtra region and Bhandara, Chandrapur and Gadchiroli of Vidharbha region. (Anonymous, 2006) [1]

Materials and Methods
A pot culture experiment was conducted in wire house of Division of Soil Science and Agricultural Chemistry, College of Agriculture, Kolhapur during *kharif* season 2012. The College of Agriculture, Kolhapur comes under the Sub-montane Zone, with annual rainfall ranging from 700 to 2500 mm.

Preparation of soil samples

The collected surface soil samples (0-15 cm) were air dried. Out of the bulk samples collected, representative sample of 1 kg was obtained by quartering technique. Each sample was pounded with the help of a wooden mortar and pestle, sieved and stored in cotton bags and used for analysis.
The remaining bulk samples were pounded, passed through 2 mm sieve and were used for conducting pot culture experiment.

Filling of pots

The 72 pots were filled with 10 kg of soil and moisture was maintained to field capacity with deionized water for all the collected eighteen samples with two treatments and two replications. The experiment was conducted in Factorial Completely Randomized Design.

Details of treatments are as below

Table 1: Symbol of treatment

Treatment symbol	Treatment details
K0	0 kg K_2O ha-1 (Control)
K75	50 kg K_2O ha-1 (Optimum dose)

Analysis of soil

The collected soil samples were analyzed for physico-chemical properties by using standard methods as given in Table 2.

Table 2: Methods used for soil analysis

Sr. No.	Parameters	Methods	References
A.	Physical properties:-		
1.	Soil Texture	International Pipette	Piper (1966)
B. Chemical properties			
1.	pH (1:2.5 Soil: Water)	Potentiometric	Jackson (1973)
2.	EC (1:2.5 Soil: Water)	Conductometry	Jackson (1973)
3.	Calcium Carbonate	Rapid Titration	Piper (1966)
4.	Organic Carbon	Walkely-Black	Jackson (1973)
5.	Available Nitrogen	Alkaline Permagnate	Subbiah and Asija (1956)
6.	Available Phosphorus	0.5 M NaHCO3 pH 8.5	Watanabe and Olsen (1965)
7.	Available Potassium	1 N Ammonium Acetate (pH – 7.0)	Knudsen and Peterson (1982)
8.	Available Micronutrients (Fe, Zn, Mn and Cu)	Atomic Absorption Spectrophotometry	Lindsay and Norvell (1978)
9.	Exchangeable Calcium and Magnesium	EDTA Titration	Jackson (1973)

Preparation of plant samples for analysis

After harvesting plant samples were washed with distilled water. The roots were removed by cutting. The shoot samples were air dried under shade for 5 days. After air drying samples were dried in oven at 60^0C ± 2^0C temperature by putting them into paper bags till constant weight. After oven drying the dry matter weight of samples were recorded. Plant samples were ground in grinding mill to pass through 2 mm sieve. The powdered samples were stored in airtight butter paper bags and used for analysis of N, P, K and hand crushed samples were used for micronutrients (Fe, Mn, Zn and Cu) analysis.

Plant analysis

The processed plant samples were digested in Diacid mixture (H_2SO_4: 30 % H_2O_2) for nitrogen content. The triacid mixture (HNO_3: H_2SO_4: $HClO_4$) was used to digest the plant samples for estimation of phosphorous, potassium and micronutrients.

Methods used for plant analysis

The analysis of powdered plant samples were carried out by using standard methods as given below

Table 3: Methods used for plant analysis

Sr. No.	Parameters	Methods	References
1.	Total N	Micro-kjeldhal (Diacid Digestion)	Parkinson and Allen (1975)
2.	Total P	Vanadomolybdate Yellow colour in Nitric Acid System (Triacid Digestion)	Jackson (1973)
3.	Total K	Flame Photometry (Triacid Digestion)	Chapman and Pratt (1973)
4.	Micronutrients (Fe, Mn, Zn and Cu)	Atomic Absorption Spectrophotometry	Zoroski and Burau (1977)

Results and Discussion

Initial soil analysis of collected soil samples for pot culture experiment.
The 18 soil samples were collected from 18 different locations of Agriculture College Farm, Kolhapur and analyzed for the soil properties such as pH, EC, soil texture, calcium carbonate, organic carbon, available nitrogen, available phosphorus, available potassium, exchangeable calcium, magnesium and available micronutrients *viz*. iron, manganese, zinc and copper and the data presented in Table 4.
These results revealed that the pH of experimental soils ranged from 6.80 to 8.20. Electrical conductivity ranged from 0.12 to 0.35 dS m-1. The sand content ranged from 32.50 to 65.10, silt from 6.70 to 38.70 and clay from 15.00 to 38.20 per cent with textural class from sandy clay loam to clay. The calcium carbonate of the soils ranged from 1.55 to 7.95 per cent. Organic carbon content ranged from 0.68 to 1.14 per cent. The available nitrogen ranged from 150.53 to 250.88 kg ha-1. The available phosphorus ranged from 11.20 to 32.94 kg ha-1. The available potassium ranged from 78.40 to 358.40 kg ha-1. The six soil samples were low in available potassium (<125 kg K2O ha-1), six soil samples were medium in available potassium (125-250 kg K2O ha-1) and six soil samples were high in available potassium (>250 kg K2O ha-1). The exchangeable calcium and magnesium content ranged from 21.80 to 36.80 and 6.20 to 15.90 me 100 g-1 of soil, respectively. The micronutrients content ranged of soils *viz*. Fe 1.03 to 2.46 ppm, Mn 1.60 to 4.91 ppm, Zn 0.33 to 0.88 ppm and Cu 1.62 to 3.69 ppm.
The above results indicated that, the soils were neutral to alkaline in reaction, low in electrical conductivity, moderately high to very high in organic carbon, slightly calcareous to

calcareous, low in available nitrogen, low to high in available phosphorus and very low to very high potassium content. The values for chemical properties were comparable to those reported by Borate, 2010 and for physical properties it was comparable to values reported by Pathak, 2011.

Table 4: Physico-chemical properties of the soils (Initial soil analysis)

Sr. No.	Survey No.	pH (1:2.5)	EC (dSm^{-1})	Partical size distribution (%)			Textural Class	$CaCO_3$ (%)	Organic Carbon (%)	Available nutrients (Kg ha^{-1})			Exch. cations (me $100g^{-1}$ of soil)		Avail. Micronutrients (ppm)			
				Sand	Silt	Clay				N	P	K	Ca^{2+}	Mg^{2+}	Fe	Mn	Zn	Cu
1	343B/25B	7.10	0.24	60.10	18.50	21.40	Scl	2.15	0.93	206.98	17.92	78.40	29.80	13.80	1.16	2.62	0.45	3.69
2	360/29	7.20	0.23	58.20	9.50	32.30	Scl	1.55	1.05	175.62	13.44	89.60	25.00	12.60	1.77	3.60	0.82	2.84
3	343B/26A	6.80	0.13	47.20	20.60	32.20	Scl	2.25	0.83	225.79	15.68	100.80	29.60	15.90	1.47	3.13	0.51	3.10
4	343B/26C	6.90	0.12	58.10	16.20	25.70	Scl	1.85	0.68	206.98	17.02	100.80	26.00	13.40	2.46	1.90	0.42	3.64
5	368/58	7.00	0.28	63.90	21.10	15.00	Sl	2.20	1.07	235.20	20.16	100.80	27.60	13.00	1.58	2.93	0.52	3.11
6	360/30	7.50	0.35	59.80	22.10	18.10	Sl	1.65	0.89	244.61	11.20	100.80	23.40	12.80	1.68	2.74	0.65	1.84
7	368/67	6.90	0.17	65.10	12.40	22.50	Scl	1.75	1.14	247.74	12.32	145.60	29.60	13.20	1.52	1.67	0.40	2.92
8	343B/26A	6.80	0.16	56.30	11.20	32.50	Scl	2.35	0.98	213.25	23.52	145.60	29.80	8.00	1.08	1.37	0.72	3.34
9	368/65	7.40	0.15	58.20	25.10	16.70	Sl	2.45	1.05	247.74	17.92	156.80	30.60	9.50	1.37	1.60	0.34	3.26
10	365/51	6.80	0.19	63.20	12.30	24.50	Scl	1.75	0.99	250.88	20.16	190.40	21.80	7.60	1.34	2.98	1.15	3.01
11	358A/9C	8.00	0.22	62.40	19.00	18.60	Sl	1.75	1.05	175.62	15.68	190.40	29.60	10.00	1.23	3.21	0.54	2.35
12	350/58	7.10	0.19	55.10	6.70	38.20	Scl	2.40	1.13	219.52	21.28	201.60	36.80	9.00	1.08	4.91	0.35	2.57
13	368/65	7.20	0.18	40.00	25.70	34.30	Cl	7.95	1.14	241.47	21.28	268.80	32.80	8.80	1.57	1.41	0.69	2.61
14	368/65	7.30	0.12	59.10	9.50	31.40	Scl	6.75	0.98	222.66	13.44	268.80	30.20	6.40	1.25	4.01	0.57	2.54
15	368/67	7.10	0.28	64.30	19.30	16.40	Sl	7.25	1.02	213.25	14.56	280.00	36.80	13.60	1.03	3.69	0.33	3.13
16	358A/9A	7.90	0.21	38.10	38.70	23.20	L	2.00	1.13	150.53	15.68	336.00	30.20	6.20	1.47	2.10	0.78	1.62
17	358A/5A	8.20	0.32	32.50	34.10	33.40	Cl	1.65	0.98	219.52	29.12	336.00	28.00	9.00	1.34	1.24	0.74	1.98
18	358A/5E	8.10	0.33	57.20	11.10	31.70	Scl	2.35	1.05	250.88	32.94	358.40	35.80	8.40	1.50	1.61	0.88	1.82
	Range value	6.80-8.20	0.12-0.35	32.50-65.10	6.70-38.70	15.00-38.20		1.55-7.95	0.68-1.14	150.53-250.88	11.20-32.94	78.40-358.40	21.80-36.80	6.20-15.90	1.03-2.46	1.60-4.91	0.33-0.88	1.62-3.69

Correlation coefficients between initial soil chemical properties and nutrients uptake by upland paddy

Correlation coefficients between initial soil chemical properties and nutrients uptake (without K) by paddy plant at 100% flowering was worked out and reported in Table 5.

The soil pH was significantly positively correlated to plant uptake of N (0.612**), P (0.475*), K (0.505*), Fe (0.630**), Mn (0.567*), Zn (0.723**) and Cu (0.663**). The soil Electrical Conductivity, soil calcium carbonate and soil Zinc were positively correlated to all nutrients uptake by paddy plant. The soil organic carbon was significantly positively correlated with plant P (0.559*) and Mn (0.487*) uptake and positively correlated with plant N, K, Fe, Zn and Cu uptake. The soil Fe was negatively correlated to all nutrients uptake by paddy plant. The soil nitrogen was positively correlated to plant N, P, K and Zn uptake and negatively correlated to plant Fe, Mn and Cu uptake. The soil phosphorus was positively correlated to uptake of P, K and Mn, while significantly positively correlated to uptake of N (0.478*), Fe (0.511*), Zn (0.555*) and Cu (0.545*) by paddy plant.

The soil potassium was significantly positively correlated to plant N (0.947**), plant P (0.906**), plant K (0.925**), plant Fe (0.974**), plant Mn (0.875**), plant Zn (0.956**), plant Cu (0.985**) uptake i.e. all nutrients uptake by paddy plant. The exchangeable calcium was significantly positively correlated to all nutrients uptake by paddy plant. The exchangeable magnesium and soil Cu were significantly negatively correlated to all nutrients uptake by paddy plant. The soil Mn was negatively correlated to all nutrients uptake by paddy plant.

Table 5: Correlation coefficients between initial soil chemical properties and nutrients uptake (without K) by upland paddy at 100 per cent flowering.

Soil chemical properties Plant nutrients uptake	pH	EC (dSm^{-1})	Organic Carbon (%)	$CaCO_3$ (%)	Available nutrients (Kg ha^{-1})			Exch. Cations (me 100 g^{-1} of soil)		Micronutrients (ppm)			
					N	P	K	Ca^{2+}	Mg^{2+}	Fe	Mn	Zn	Cu
N (g pot^{-1})	0.612**	0.200	0.467	0.323	0.047	0.478*	0.947**	0.475*	-0.744**	-0.308	-0.157	0.255	-0.651**
P (g pot^{-1})	0.475*	0.104	0.559*	0.407	0.087	0.432	0.906**	0.582*	-0.726**	-0.463	-0.128	0.167	-0.517*
K (g pot^{-1})	0.505*	0.153	0.347	0.399	0.074	0.457	0.925**	0.524*	-0.630**	-0.264	-0.110	0.169	-0.595**
Fe (mg pot^{-1})	0.636**	0.271	0.392	0.333	-0.001	0.511*	0.974**	0.516*	-0.647**	-0.283	-0.136	0.266	-0.640**
Mn (mg pot^{-1})	0.567*	0.014	0.487*	0.260	-0.410	0.307	0.875**	0.477*	-0.695**	-0.328	-0.150	0.227	-0.552*
Zn (mg pot^{-1})	0.723**	0.409	0.409	0.311	0.010	0.555*	0.956**	0.507*	-0.594**	-0.332	-0.135	0.205	-0.663**
Cu (mg pot^{-1})	0.663**	0.275	0.370	0.321	-0.057	0.545*	0.985**	0.529*	-0.627**	-0.281	-0.162	0.254	-0.641**

** Significant at 1 per cent level of significance.
* Significant at 5 per cent level of significance.

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