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Assessment of Physico-chemical Properties of Soil from Different Blocks of Purnea District, Bihar, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was carried out in the Soil Science and Agricultural Chemistry lab at Sam Higginbottom University of Agriculture Technology and Sciences. The sampling location was Purnea district of Bihar. The objective of the study was to analyze the Physico-chemical properties in soil of Purnea district of Bihar, India. Depth wise soil samples were collected from nine different village of 3 blocks of selected spots at 0-15, 15-30 and 30-45 cm. The total no. of 27 samples were collected from several farmer's fields, and composite sampling was carried out. The results revealed that the texture of the soil is sandy loam. The bulk density ranged from 0.95 to 1.29 (Avg. 1.12) Mg m^{-3}, particle density from 2.22 to 2.34 (Avg. 2.28) Mg m^{-3}, pore space from 43.19 to 48.71 (Avg. 45.95) %, water holding capacity from 38.56 to 46.58 (Avg. 42.57) %. The pH ranged from

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6.52 to 6.82 (Avg. 6.68), E.C. ranged from 0.31 to 0.45 (Avg. 0.38) dS m^{-1}. The soil organic carbon ranged from 0.15 to 0.33 (Avg. 0.24) %. Available nitrogen ranged from 162.02 to 255.64 (Avg. 208.83) kg ha^{-1}, available phosphorous ranged from 8.84 to 20.21 (Avg. 14.525) kg ha^{-1}, available potassium ranged from 76.30 to 170.70 (Avg. 123.50) kg ha^{-1}, exchangeable calcium ranged from 3.2 to 4.8 (Avg. 4.00) Meq $100g^{-1}$, exchangeable magnesium ranged from 0.60 to 1.00 (Avg. 0.855) Meq $100g^{-1}$. The Soil has acceptable BD, PD, pore space, and water holding capacity. As a result of the beneficial electrical conductivity for plants, the pH of the soil is slightly acidic to neutral. Available Nitrogen, Phosphorus, Potassium, Exchangeable Calcium and Magnesium are low in macronutrients. The results indicated that overall soils were in moderate conditions and farmers required maintaining soil health card, adopting suitable management practices, and providing proper nutrition to the soil to overcome the pollution effect.

Keywords: Physico-chemical; properties; organic carbon; pH; nitrogen; phosphorus; soil; potassium; analysis.

1. INTRODUCTION

"Soil testing makes complete nutrient control a possibility, fertilizer experiments are being patterned to determine economically optimum rates of nutrients application high yields with low production costs per unit area must in modern farming. Farmers of today are different in the failure is more certain and sooner unless they are obtaining reasonably high yields, improved drainage, many improved cultural practices, better varieties, and control of insects and disease have helped to set the stage for high yields. As a result, the demand on the soil has gradually increased. Soil testing lets farmers know how much and what kind of fertilizer they must apply to be sure of returns from their investments in other improved practices" [1].

"Soil formation is a constructive as well as destructive process. Soil is composed of particles of broken rock that have been altered by chemical and mechanical processes that weathering and erosion. Soil has a complex function which is beneficial to human and other living organism Soil is not merely a group of mineral particles. It has also a biological system of living organism as well as some other components. The climate and other factor largely affect the soil formation. Soil farming factors interaction results into the properties of soil. Physico-chemical characteristics of different soils vary in space and time due to variation in topography, climate, physical weathering processes, vegetation cover, microbial activities, and several other biotic and abiotic variables" [2].

"The physical and chemical properties of the soil and the impact of the pollutants were investigated in the different soil ecosystem" [3]. "Standard soil tests have primary focused on the soil chemical composition. Recommendations generated from these analyses have been applying soil amendments (fertilizers, gypsum, lime etc.) for increasing crop yields, but not for improving intrinsic soil conditions. The biological and physical conditions of the soil are often overlooked. Soil is a living biological ecosystem (habitat for microbes) and the impacts of some soil management activities negatively affect its physical and chemical conditions. Soil biological functions are related to nutrient cycling, soil aggregation and soil water fate, among the soil properties" [4].

"Combined application of manures and fertilizers played a pivotal role in the improvement in soil physico-chemical properties, macro and micronutrients distribution and their transformations under different cropping systems. Intensive cropping systems lead to N, P, K, Zn, Cu, Fe, and Mn deficiencies in surface and subsurface soil, which could be refreshed with combined application of manures and fertilizers. The application of manures and fertilizers controls the pH and electrical conductivity of soil" [5].

"Inclusion of a legume crop in a cropping system can improve soil physical and chemical properties, particularly in predominantly rice cultivating areas" (Kumar et al. 2020). "A balanced application of organic and inorganic fertilizers could be beneficial to both soil nutrient availability, soil health and crop growth" [6].

2. MATERIALS AND METHODS

2.1 Location

Purnea district in Bihar is located on the map with the GPS coordinates of 25° 46' 15.9708'' N and 87° 28' 55.8660'' E.

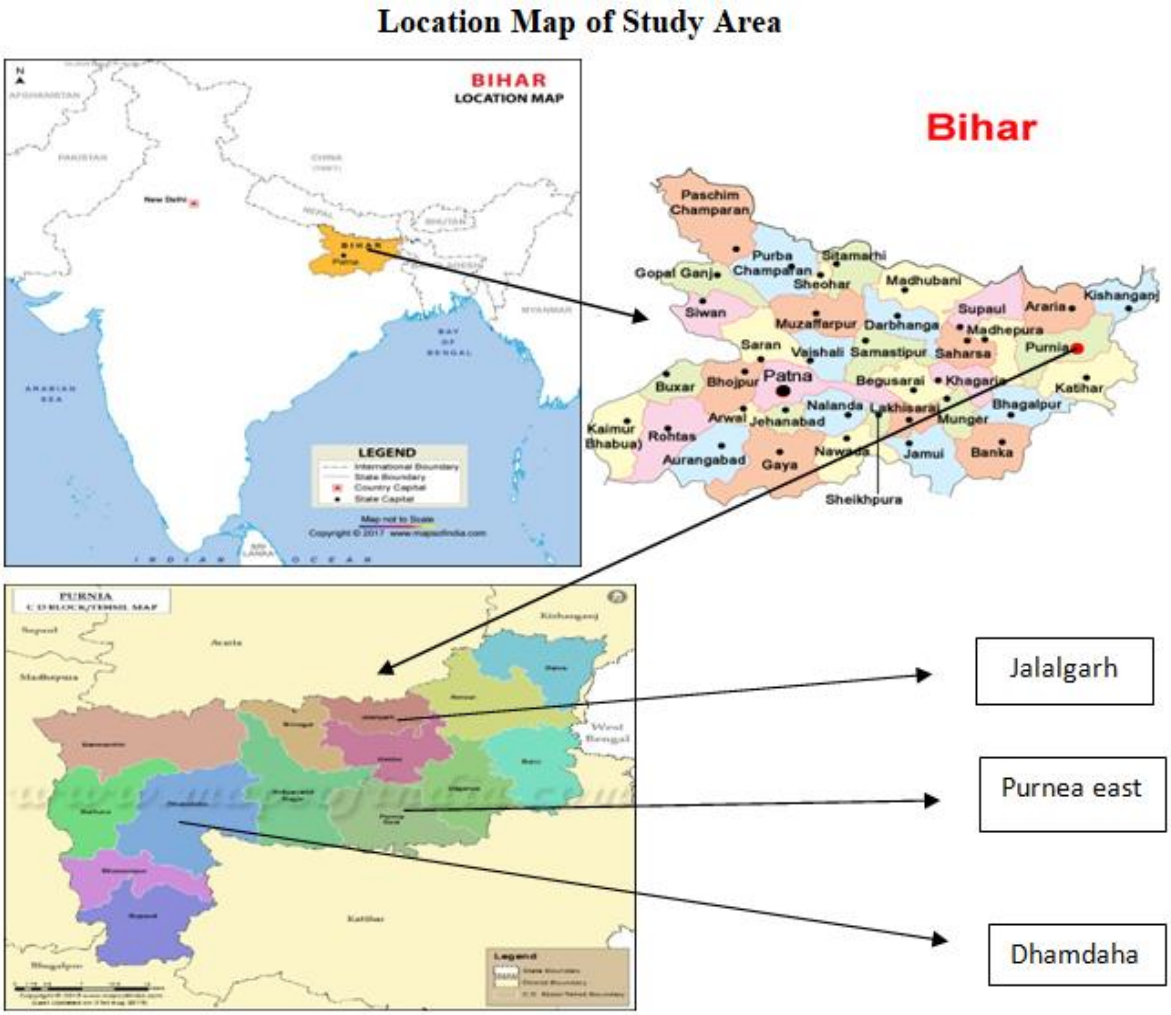

Fig. 1. Location map of Purnea in Bihar, India

2.2 Soil and Climate

Purnea district belongs to monsoonic sub-humid to humid climate with around 1300 mm mean annual rainfall. It falls under Agro-climatic zone II of Bihar. The soils of the entire district have been influenced by Kosi River in the last 50 years or so. The areas, which were directly affected by Kosi have sandy to loamy sand deposits. Climatic conditions are usually suitable for the normal cultivation of paddy, maize, jute, wheat, barley and other crops except in the years of climatic caused by excessive draught or rains. Because of combined influence of sandy to loamy soils, relatively high-water table, different types of natural vegetation, river channel network coupled with geographical location in proximity of the Himalayan foothill, the overall climate is typically congenial for agricultural activities.

2.3 Sampling and Analysis

The soil sample collection is from 3 blocks of Purnea district in the state of Bihar each selecting 3 villages. Samples were collected randomly from a site of each village using soil khurpi by composite sampling method at a depth of 0-15, 15-30 and 30-45 cm**.** "After sampling the samples were air dried in shade and then these samples were processed for various physical and chemical tests" [7].

The data was recorded during the course of investigation were subjected to statistical analysis by analysis of Completely Randomized Design (CRD) as per the method of "Analysis of Variance" (ANOVA) technique.

Table 1. Procedure used for Physico-chemical analysis of soil

A. Physical analysis

S. No.	Parameter	Scientist
1	Soil Textural Class (Sand, Silt, Clay)	Bouyoucos, [12]
2	Bulk Density (Mg m^{-3})	Muthuvel et al. [13]
3	Particle Density (Mg m^{-3})	
4	Pore Space (%)	
5	Water Holding Capacity (%)	

B. Chemical analysis

S. No.	Parameters	Scientist
1	Soil pH	Jackson, [14]
2	Electrical Conductivity (dS m^{-1})	Wilcox, [15]
3	Organic Carbon (%)	Walkley and Black, [16]
4	Available Nitrogen (kg ha^{-1})	Subbiah and Asija, [17]
5	Available Phosphorus (kg ha^{-1})	Olsen et al. [18]
6	Available Potassium (kg ha^{-1})	Toth and Prince, [19]
7	Exchangeable Ca and Mg (Meq $100g^{-1}$)	Cheng and Bray, (1951)

3. RESULTS AND DISCUSSION

3.1 Physical Properties

The Soil Textural class was identified Sandy Loam. The sand, silt and clay percentage varied from 53.50 to 70.10 % sand, 14.90 to 19.80 % silt and 14.30 to 15.60 % clay in Sandy Loam. Bulk Density was varied from the 0.95 to 1.29 Mg m^{-3}. Bulk density was found to increase with the increase soil depth in some sites due to increase in compaction in the subsurface comparatively. Same analysis was done by Jain and Singh, (2013). The Particle Density varied from 2.22 to 2.34 Mg m^{-3}. The particle density did not change with increases in depth in the sites. Same analysis was done by Parmar and Nagi, [8].

The Pore Space (%) ranged from 43.19 to 48.71%. The pore space was found to decrease with increase in depth attributed to increase in compaction in the subsurface. Same result was done by Sahu and David, (2014). "The Water Holding Capacity (%) ranged from 38.56 to 46.58%. These variations were due to the silt, clay and organic carbon content and low WHC in sandy soil due to high sand and less silt content. The irregular trend of WHC with depth due to illuviation and eluviation of finer fraction in different horizons" [7]. Similarly reported by Chaudhari et al. [9].

3.2 Chemical Properties

The pH value ranged from 6.52 to 6.82. The Electrical Conductivity ranged from 0.31 to 0.45 dS m^{-1} and the soil was found to be normal. The value of total Organic Carbon (%) varied from 0.15 to 0.33%. The organic carbon content decreased with depth and this is due to the addition of plant residues and farm yard manures to surface horizons than lower horizons**.** Similar results were reported by Upreti et al. [10]. The available Nitrogen content of soil ranged from 162.02 to 255.64 kg ha^{-1} and nitrogen content was low in all blocks. Similar results were reported by Upadhyay et al. [3]. The available Phosphorus content of soil ranged from 8.84 to 20.21 kg ha^{-1}. All the sites have low to medium phosphorus content. Available Potassium content of soil ranged from 76.30 to 170.70 kg ha^{-1}. All the sites have low to medium potassium content. Similarly results were reported by Patel et al. [11]. Exchangeable Calcium content of soil ranged from 3.2 to 4.8 Meq $100g^{-1}$. Exchangeable Magnesium content of soil ranged from 0.60 to 1.00 Meq $100g^{-1}$. Calcium and Magnesium are low in the soil. Calcium and magnesium both increases the soil pH as its availability increases in soil. Similarly results were reported by Joshi et al. [1,20].

Table 2. Bulk density and Particle density (Mg m^{-3}) of soil in different villages of Purnea at 0-15, 15-30 and 30-45 cm depth

Villages	Bulk Density (Mg m^{-3})			Particle Density (Mg m^{-3})		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Purnea East (B_1)						
V_1	1.02	1.11	1.14	2.30	2.31	2.31
V_2	1.00	1.05	1.17	2.22	2.23	2.23
V_3	1.11	1.17	1.29	2.32	2.31	2.31
Dhamdaha (B_2)						
V_4	1.05	1.11	1.28	2.30	2.32	2.32
V_5	1.00	1.11	1.25	2.35	2.33	2.33
V_6	1.17	1.17	1.26	2.34	2.34	2.31
Jalalgarh (B_3)						
V_7	0.95	1.05	1.11	2.29	2.29	2.30
V_8	1.00	1.11	1.21	2.30	2.31	2.31
V_9	1.00	1.11	1.25	2.33	2.33	2.34
	F-test	**SEm (±)**	**CD at 5%**	**F-test**	**SEm (±)**	**CD at 5%**
Depth (0-15 cm)	S	0.016878	0.050148	S	0.047708	0.141747
Depth (15-30 cm)	S	0.01466	0.043558	S	0.042973	0.127679
Depth (30-45 cm)	S	0.019765	0.058725	S	0.042526	0.126351

Table 3. Pore space and Water holding capacity (%) of soil in different villages of Purnea at 0-15, 15-30 and 30-45 cm depth

Villages	Pore space (%)			Water holding capacity (%)		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Purnea East (B_1)						
V_1	45.11	44.77	43.19	41.23	40.05	38.56
V_2	45.97	45.80	44.53	42.03	40.64	39.23
V_3	46.24	45.88	44.56	45.96	41.20	39.86
Dhamdaha (B_2)						
V_4	45.55	45.11	43.56	41.76	40.29	40.12
V_5	47.05	46.87	43.01	43.51	41.83	40.89
V_6	47.38	47.07	46.28	44.27	43.00	41.26
Jalalgarh (B_3)						
V_7	46.48	45.52	44.13	43.89	42.30	40.97
V_8	47.60	47.31	45.23	45.03	43.25	41.23
V_9	48.71	46.03	45.86	46.58	44.09	42.56
	F-test	**SEm (±)**	**CD at 5%**	**F-test**	**SEm (±)**	**CD at 5%**
Depth (0-15 cm)	NS	0.789786	-	S	0.679181	2.017949
Depth (15-30 cm)	NS	0.806358	-	S	0.57698	1.1714297
Depth (30-45 cm)	NS	0.66642	-	S	0.57466	1.707403

Table 4. Soil pH and EC (dS m^{-1}) of soil in different villages of Purnea at 0-15, 15-30 and 30-45 cm depth

Villages	Soil pH			Soil EC (dS m^{-1})		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Purnea East (B_1)						
V_1	6.57	6.59	6.60	0.36	0.38	0.38
V_2	6.52	6.55	6.55	0.40	0.43	0.44
V_3	6.56	6.53	6.50	0.43	0.45	0.45
Dhamdaha (B_2)						
V_4	6.54	6.56	6.60	0.38	0.39	0.39
V_5	6.62	6.64	6.67	0.35	0.36	0.38
V_6	6.65	6.65	6.69	0.39	0.36	0.38

Villages	Soil pH			Soil EC (dS m^{-1})		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Jalalgarh (B_3)						
V_7	6.83	6.81	6.81	0.34	0.37	0.39
V_8	6.72	6.73	6.73	0.32	0.33	0.33
V_9	6.80	6.82	6.82	0.31	0.32	0.32
	F-test	**SEm (±)**	**CD at 5%**	**F-test**	**SEm (±)**	**CD at 5%**
Depth (0-15 cm)	NS	0.096337	-	S	0.005568	0.016544
Depth (15-30 cm)	NS	0.116799	-	S	0.00577	0.017143
Depth (30-45 cm)	NS	0.088977	-	S	0.006283	0.018668

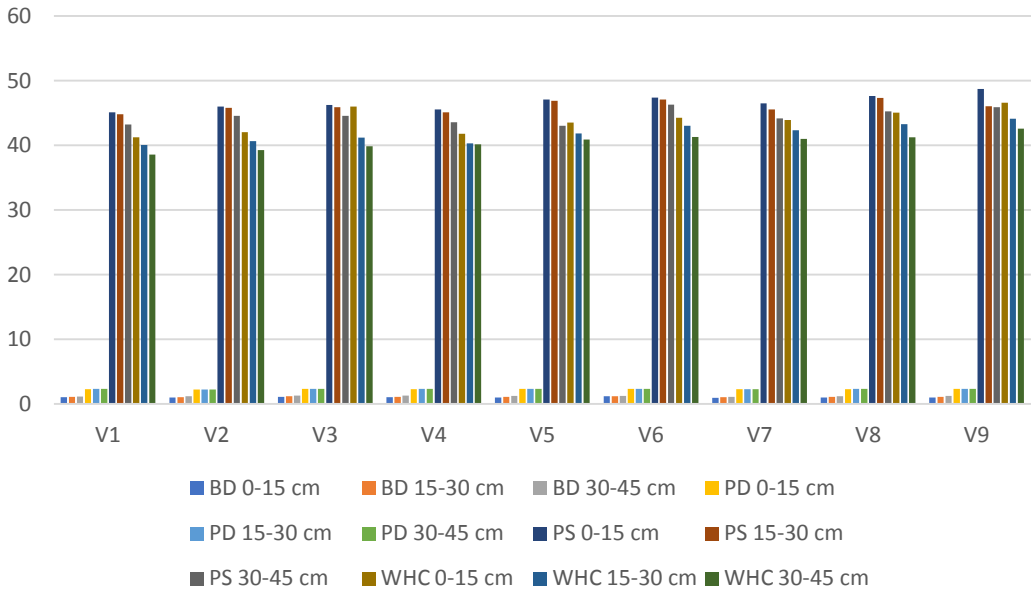

Fig. 2. Bulk density, Particle density, Pore space and Water holding capacity of soil in different villages of Purnea at 0-15, 15-30 and 30-45 cm depth

Table 5. Soil OC and Available Nitrogen of soil in different villages of Purnea at 0-15, 15-30 and 30-45 cm depth

Villages	Organic carbon (%)			Nitrogen (kg ha^{-1})		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Purnea East (B_1)						
V_1	0.23	0.20	0.18	225.31	203.15	195.40
V_2	0.18	0.16	0.15	235.56	198.34	187.65
V_3	0.21	0.19	0.17	247.20	221.74	198.17
Dhamdaha (B_2)						
V_4	0.25	0.22	0.20	255.64	205.73	195.14
V_5	0.31	0.29	0.29	245.41	205.45	189.21
V_6	0.33	0.30	0.29	247.10	223.65	168.47
Jalalgarh (B_3)						
V_7	0.28	0.25	0.25	254.41	179.21	162.02
V_8	0.28	0.23	0.22	243.11	219.45	195.12
V_9	0.30	0.29	0.29	224.32	204.77	173.04
	F-test	**SEm (±)**	**CD at 5%**	**F-test**	**SEm (±)**	**CD at 5%**
Depth (0-15 cm)	S	0.002891	0.008591	S	3.191162	9.481429
Depth (15-30 cm)	S	0.004106	0.012201	S	2.770172	8.249262
Depth (30-45 cm)	S	0.002823	0.008389	S	2.276768	6.764626

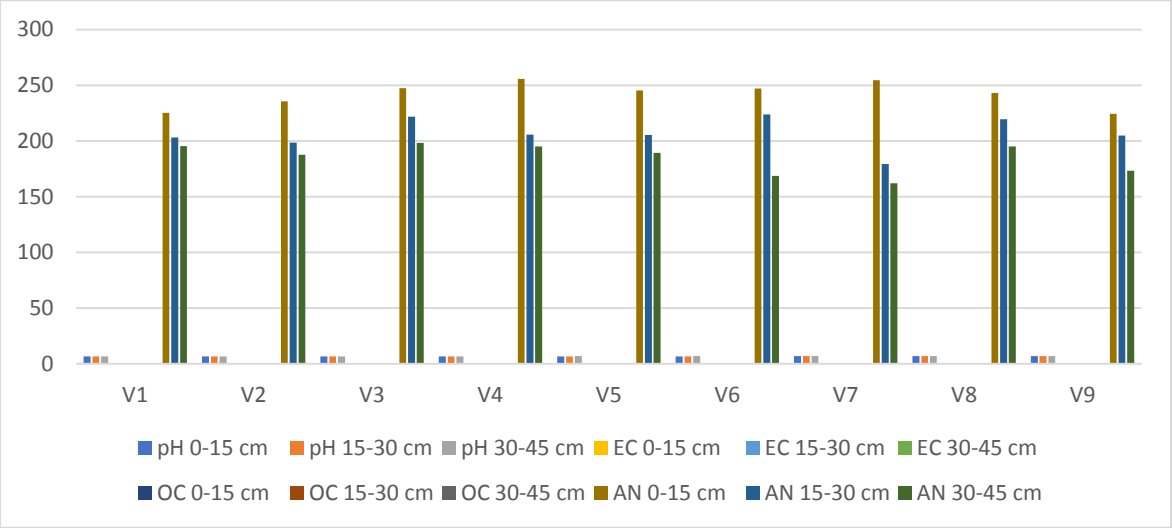

Fig. 3. Soil pH, EC, OC and Available Nitrogen of soil in different villages of Purnea at 0- 15, 15-30 and 30-45 cm depth

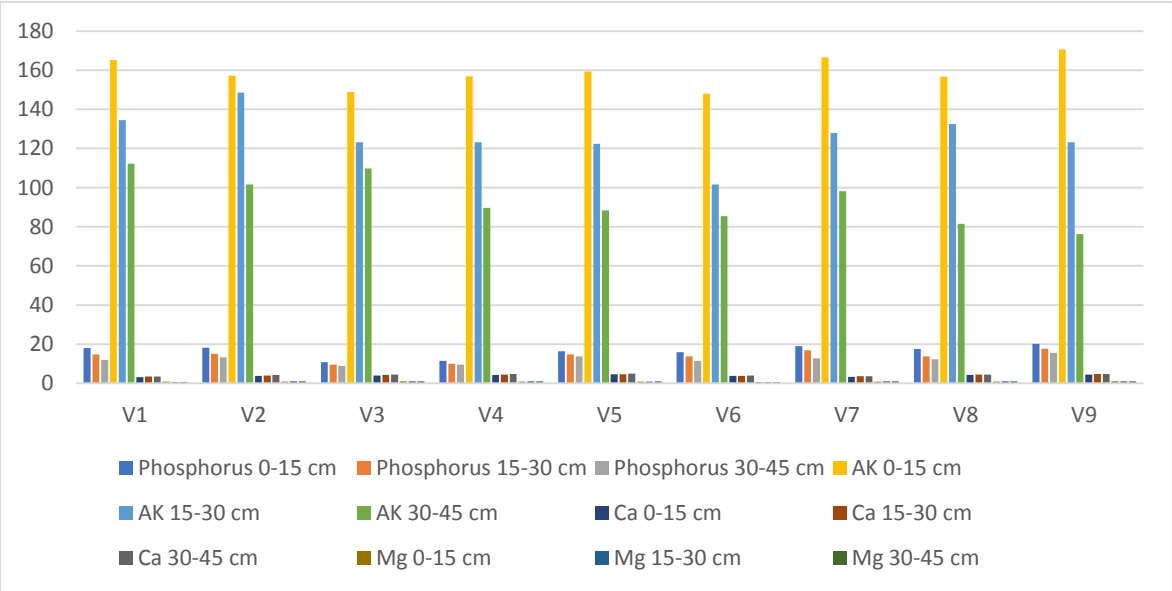

Fig. 4. Available Phosphorus, Potassium, Exchangeable Calcium and Magnesium of soil in different villages of Purnea at 0-15, 15-30 and 30-45 cm depth

Table 6. Available Phosphorus and Potassium (kg ha^{-1}) of soil in different villages of Purnea at 0-15, 15-30 and 30-45 cm depth

Villages	Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Purnea East (B_1)						
V_1	18.00	14.80	12.00	165.20	134.40	112.20
V_2	18.20	15.00	13.30	157.18	148.62	101.54
V_3	10.87	9.52	8.84	148.83	123.20	109.80
Dhamdaha (B_2)						
V_4	11.44	10.02	9.51	156.80	123.20	89.60
V_5	16.45	14.69	13.71	159.28	122.40	88.40
V_6	15.84	13.78	11.41	148.00	101.54	85.32

Villages	Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Jalalgarh (B_3)						
V_7	19.00	16.87	12.83	166.60	128.00	98.20
V_8	17.52	13.47	12.25	156.68	132.51	81.40
V_9	20.21	17.64	15.55	170.70	123.20	76.30
	F-test	**SEm (±)**	**CD at 5%**	**F-test**	**SEm (±)**	**CD at 5%**
Depth (0-15 cm)	S	0.177737	0.528084	S	3.115472	9.256544
Depth (15-30 cm)	S	0.254447	0.756	S	1.771538	5.263509
Depth (30-45 cm)	S	0.185687	0.551705	S	1.513708	4.497458

Table 7. Exchangeable calcium and magnesium of soil in different villages of Purnea at 0- 15, 15-30 and 30-45 cm depth

Villages	Exchangeable Calcium (Meq 100g^{-1})			Exchangeable Magnesium (Meq 100g^{-1})		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Purnea East (B_1)						
V_1	3.2	3.5	3.5	0.90	0.70	0.70
V_2	3.8	4.0	4.2	0.80	1.00	1.00
V_3	4.0	4.3	4.5	0.93	0.98	1.00
Dhamdaha (B_2)						
V_4	4.2	4.5	4.8	0.83	1.00	1.00
V_5	4.6	4.6	4.9	0.79	0.90	1.00
V_6	3.7	3.7	3.9	0.60	0.70	0.70
Jalalgarh (B_3)						
V_7	3.3	3.6	3.6	0.79	0.95	0.95
V_8	4.3	4.4	4.4	0.85	0.92	0.92
V_9	4.5	4.8	4.8	0.98	1.00	1.00
	F-test	**SEm (±)**	**CD at 5%**	**F-test**	**SEm (±)**	**CD at 5%**
Depth (0-15 cm)	S	0.067807	0.201465	S	0.009139	0.027153
Depth (15-30 cm)	S	0.063984	0.190106	S	0.016092	0.047812
Depth (30-45 cm)	S	0.067459	0.20043	S	0.01442	0.042845

4. CONCLUSION

According to the soil test results of villages of Purnea district of Bihar, it clearly shows that the soil is slightly acidic to neutral in condition. Soil samples are in permissible limit of Electrical conductivity and suitable for cultivation of most crops such as Maize, Wheat, Paddy, Moong, Potato, Kalai, Mustard and some vegetables (okra, pointed gourd, bitter gourd, beans etc.) are grown selectively. Organic carbon, Nitrogen, phosphorus and potassium are low due to less organic matter content in the soil. The major reason for lack of macronutrients is low organic matter contents and inappropriate management practices. It suggests that still improvement can be done by improving cropping pattern, decomposition of organic waste, mulching, tillage practices and proper irrigation by management practices with knowledge and experience gained through studies and suggest the farmers to achieve quality produce and high yield through Soil Heath Card report as well as practices of soil conservation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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