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Assessment of Soil Fertility Status under Different Cropping Sequences in District Kapurthala

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ABSTRACT

The present study was undertaken to assess the fertility status of soil put under various cropping sequences followed in different villages of different blocks in the district. Seven villages namely Bhagwanpur, Bhetan, Boolpur, Kheeranwali, Khukrain, Meripur and Swal, falling under three blocks namely Dhilwan, Kapurthala and Sultanpur were selected. The soil samples were taken from 0-15 cm depth with the help of auger after the harvesting of the *rabi* crops during 2014-15, using the GPS locations. The pH values of soils in all the villages varied from neutral to strongly alkaline (6.79 to 9.87). The pH of all the soil samples of Bhagwanpur and Bhetan villages was neutral to slightly alkaline in nature (<8.7), however, the highest mean pH value was from village Khukrain where 31 per cent of the soil samples were found to be strongly alkaline (>9.3) followed by Kheeranwali village (15 %). The salinity hazard does not exist in village Bhagwanpur, Meripur and Bhetan, however, 42 and 36 per cent samples in village Khukrain and Boolpur showed higher salinity level, respectively. The mean value of EC in Boolpur was 0.76ds/m with a range varying from 0.3 to 1.9ds/m. It was found that organic carbon (OC) status of majority of samples ranged between low to medium. In light textured soils, 54 per cent of samples of Bhetan were found to contain low OC content whereas the soils of Boolpur were found to be rich in OC ranging from 0.32 to 1.07 per cent with mean value of 0.64 per cent and only 12 per cent of samples were under low OC category. The mean values of available phosphorus were 16.7 to 24.2 kg/ha in soil samples of all the villages. The high status of available potassium was found in Khukrain village (92%) followed by Bhagwanpur (72%), Kheeranwali (55%), Swal and Bhetan (45%) and Boolpur (44%). It was interested to note that highest available phosphorus content was found in the soil under potato based cropping sequence due to excessive phosphatic fertilizers application as compared to recommendations of research institutes. However, contrast trends were obtained in case of available potassium status because uptake of potassium was low in paddy-wheat cropping sequence as compared to vegetable and potato based cropping sequence. The OC and available phosphorus exhibited a positive correlation with cropping intensity due to application of higher inorganic fertilizers and incorporation of plant biomass as compared to paddy-wheat cropping sequence. On the other hand, pH, EC and available potassium showed a decreasing trend with the increased crop intensity from paddy-wheat to paddy-potato/vegetable-summer crop.

Key Words: Cropping sequence, pH, EC, Organic carbon, Phosphorus, Potassium, Soil fertility.

INTRODUCTION

The major crop rotation in Punjab is paddy-wheat which has resulted in depletion of underground water as well deterioration of soil health, as result of which agriculture in Punjab is becoming less remunerative due to increased cost of cultivation and unsustainable day by day. In this direction, government is taking number of initiatives like crop diversification to be followed by the farming community of Punjab, in order to maintain crop production and productivity. Fortunately, district Kapurthala having an area of 1.67 thousand hectares, out of which, 1.12 thousand hectares is under cultivation. There are 5 blocks in the district and each block has a particular cropping sequence.

Farmers in the area are cultivating spring maize (*Zea mays*), sunflower (*Helianthus annuus*), summer moong (*Vigna radiata*), seasonal summer

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and winter vegetables, muskmelon (*Cucumis melo*), watermelon (*Citrullus lanatus*) and potato (*Solanum tuberosum*) etc. The success in soil management to maintain the soil quality depends on an understanding of how the soil responds to agricultural practices over time. Majority of the farmers are following three or more crops rotation per year and are using large quantity of fertilizers, insecticides, pesticides in order to harvest maximum gross returns without taking into consideration the soil fertility status. Manan *et al* (2016) reported that farmers applied more quantity of di-ammonium phosphate fertilizer than the recommendations to the spring maize crop, which lowered the net returns. He further suggested that farmers were changing recommendations based on their own assumptions and need to be educated for precise input use.

Soil test data usually are summarized for a respective block and district and on an all India level. Such soil fertility summaries are useful to administrators and planner in deciding the kind and amount of fertilizer most suitable in each area or district and determining the policy of fertilizer, distribution and consumption in different region. The data also are of use to fertilizer association, fertilizer industries and extension workers in promoting their respective programme and to research workers, particularly from the point of view of changes in fertility levels, conditioned by different fertilizer use or by different soil and crop management practices. However, information regarding the effect of various cropping sequences followed by the farmers on the soil fertility status was lacking. Therefore, the present study was undertaken to note down the effects of various cropping sequences followed in different villages of different blocks in the district and its impact on physico-chemical properties of the soil.

MATERIALS AND METHODS

The study was carried out in 7 villages namely Bhagwanpur, Bhetan, Boolpur, Kheeranwali, Khukrain, Meripur and Swal, falling under three blocks namely Dhilwan, Kapurthala and Sultanpur. Selection of the village was based on its soil type, farming situation and crops grown.There are about 20 elements essential for plant growth out of which primary and secondary elements like N, P, K, Ca, Mg, S are involved in major metabolic functions of plants and their deficiency in soil affects crop yields.

The soil samples were taken from 0-15 cm depth with the help of auger after the harvesting of the *rabi* crops during 2014-15, using the GPS locations in all the 7 villages. One hundred sites were randomly selected in each village; soil sampling was done in a zigzag pattern within each field and mixed thoroughly following a standard procedure for soil sampling and sample preparation (Andreas and Berndt, 2005). All the collected samples were air dried in shade, crushed gently with pestle and mortar, and then sieved through 2.0 mm sieve to obtain a uniform soil sample. The processed samples were analyzed for physico-chemical properties by using standard methods of analysis for soil pH and electrical conductivity (EC) were measured in soil: water extract (1:2) according to Rhoades and Oster (1986). Soil organic carbon (OC) was determined by dry combustion using method described by Walkley and Black, (1934), available phosphorus was extracted by 0.5 N sodium bicarbonate solution as described by Olsen *et al* (1954) and thereafter measured using Spectrophotometer. One molar neutral ammonium acetate (pH=7) was used to extract the available potassium using flame photometer (Jackson, 1973). The data were analyzed for correlation coefficient between cropping sequence and all physic-chemical properties of the soil by using SPSS 16.0. A detail of the sampling location and its cropping sequence has been given in Table 1.

Parker's Nutrient Index

In order to compare the levels of soil fertility of one area with those of another it is necessary to obtain a single value for each nutrient. Here the nutrient index introduced by Parker *et al* (1951) is useful. The percentage of samples in each of the three classes, low, medium and high is multiplied

Table 1. Sampling location and cropping sequence of selected sites

Sr. No.	Village	GPS location	Crop sequence (per cent samples)		
			Paddy-wheat	Paddy-Potato-Spring crop	Paddy-Vegetable-spring crop
1	Bhagwanpur	75°20.318'E 31°21.586'N	67	27	6
2	Bhetan	75º38.815'E 31º38.815'N	9	91	0
3	Boolpur	75°14.272'E 31°19.232'N	33	11	56
4	Kheeranwali	75°17.419'E 31°23.443'N	100	0	0
5	Khukrain	75º21.418'E 31º25.353'N	100	0	0
6	Meripur	75°16.746' E 31°15.846' N	52	27	21
7	Swal	75º11.342' E 31º15.498' N	22	0	78

by 1, 2 and 3 respectively. The sum of the figures thus obtained is divided by 100 to give the index or weighted average.

Three Tier System:

$$PI = \frac{\text{No .of samples (low) X 1 + No of samples (medium) X 2 + No. of samples (high) X 3}}{\text{Total number of samples}}$$

Table 2. Nutrient index with range and remarks

Nutrient Index	Range	Remarks (OC, P, K)
I	Below 1.67	Low
II	1.67-2.33	Medium
III	Above 2.33	High

RESULTS AND DISCUSSION

Soil pH

Soil pH or soil reaction is an indication of the acidity or alkalinity of soil and is measured in pH units. Soil pH provides various clues about soil properties and is easily determined. The availability of plant nutrients is considerably affected by soil pH. The effect of soil pH is great on the solubility of minerals or nutrients. Fourteen of the seventeen essential plant nutrients are obtained from the soil. Before a nutrient can be used by plants it must be dissolved in the soil solution. Most minerals and nutrients are more soluble or available in acid soils than in neutral or slightly alkaline soils. A pH range of approximately 6 to 7 promotes the most ready availability of plant nutrients.

The supply of plant nutrients and thus the fertility of the soil are affected by pH. The solubility of most nutrients varies in response to pH. The pH values of soils in all the villages varied from neutral to strongly alkaline (6.79 to 9.87). The data (Table 3) indicated that pH of all the soil samples of Bhagwanpur and Bhetan villages was neutral to slightly alkaline in nature (<8.7), however, the highest mean pH value was from village Khukrain where 31 per cent of the soil samples were found to be strongly alkaline (>9.3) followed by Kheeranwali village (15 % samples in pH 8.7-9.3).

These high values are possibly due to presence of soluble and exchangeable sodium along with HCO_3^- ions, which precipitates calcium and magnesium carbonates during evaporation. Alkalinity problem

Table 3. pH value of soil samples of different villages.

Sr. No.	Village	Per cent samples			Mean ± SD	Range
		pH<8.7	pH 8.7-9.3	pH>9.3		
1	Bhagwanpur	100	0	0	8.13±0.24	7.47-8.42
2	Bhetan	100	0	0	7.48±0.31	6.79-7.94
3	Boolpur	88	12	0	8.21±0.48	7.08-9.87
4	Kheeranwali	85	15	0	8.43±0.24	7.84-8.94
5	Khukrain	42	27	31	8.84±0.56	7.46-9.67
6	Meripur	96	4	0	8.40±0.19	8.09-8.71
7	Swal	91	9	0	8.15±0.45	7.16-9.04

in soils is due to the indigenous calcareous parent material with typical low organic matter content (Brady and Weil, 2005). High pH values are thus indicative of development of salinity in the area. The major crop rotation followed by farmers of these villages was rice–wheat crop rotation so the farmers of these villages were educated for regular soil testing. After soil testing there was sufficient time between harvesting of wheat and transplanting of rice so green manuring followed by gypsum application on the basis of soil test report was recommended in these villages to enhance the crop productivity. Retention of crop residues on soil surface along with fertilization with organic manure and involvement of legumes in crop rotation coupled with minimum/no-tillage practices play an important role to sustain soil fertility, improving fertilizer/water use efficiency, physical conditions of soils and enhance crop productivity (Sainju *et al,* 2008).

Electrical Conductivity

The electrical conductivity (EC) is the measure of the soluble salts present in the soil and is affected by cropping sequence, irrigation, land use and application of fertilizers, manure, and compost. High value of electrical conductivity represents higher degree of salinity. Excessive amount of dissolved salts in soil solutions causes hindrance in normal nutrient uptake process either by imbalance of ions uptake, antagonistic effect between nutrients or excessive osmotic potentials of soil solution or a combination of the three effects (Rahman *et al,* 2010). Data (Table 4) indicate that the salinity hazard does not exist in village Bhagwanpur, Meripur and Bhetan, however, 42 and 36 per cent samples in village Khukrain and Boolpur showed higher salinity level, respectively. The mean value of EC in Boolpur was 0.76ds/m with a range varying from 0.3 to 1.9ds/m.

The variations in the EC could be due to the inherent drainage system of the soils of these villages, the soils of village Bhetan are dominated by sand, therefore, salts leach down easily resulting in low EC, whereas, villages Bhagwanpur, Meripur are surrounded by a drain called *Kali Bhain*, so, resulting in improved drainage of these villages. However, the soils of villages Khukrain and Boolpur are heavy textured and lying in low depression area, resulting high EC values. As salts move with water, low areas, depressions or other wet areas where water accumulates tend to be higher in EC than surrounding higher-lying, better drained areas. To overcome this hazard the farmers were advised to grow salt tolerant crops and use of organic manures in order to get higher crop yield under such situation.

Organic Carbon

Organic matter has a vital role in agricultural soil. It supplies plant nutrient, improve the soil structure, improve water infiltration and retention, feeds soil micro flora and fauna, and the retention and cycling of applied fertilizer (Johnston, 2007). Nitrogen requirements are usually recommended

Table 4. Electrical Conductivity values of soil of different villages.

Sr.No.	Village	Per cent samples		Mean ± SD	Range
		EC<0.8ds/m	EC>0.8ds/m		
1	Bhagwanpur	100	0	0.21±0.07	0.1-0.4
2	Bhetan	100	0	0.17±0.17	0.1-0.7
3	Boolpur	64	36	0.76±0.36	0.3-1.9
4	Kheeranwali	93	7	0.45±0.16	0.2-0.8
5	Khukrain	58	42	0.72±0.43	0.1-1.8
6	Meripur	100	0	0.30±0.08	0.2-0.5
7	Swal	86	14	0.36±0.37	0.1-1.6

by the Soil Testing Laboratories, based on the estimation of nitrogen released by the soil organic matter contents (Cooke, 1982).

The data (Table 5) revealed that OC status of majority of samples ranged between low to medium. Due to light textured soils, 54 per cent of samples of Bhetan were found to contain low OC content. The soils of Boolpur were found to be rich in OC ranging from 0.32 to 1.07 per cent with mean value of 0.64 per cent and only 12 per cent of samples were under low OC category. The high OC level found in both the vegetable growing villages (Boolpur and Swal) can be attributed to *in situ* incorporation of biomass of all the crops in the soil. Crop residue incorporation increased OC content of the soil more significantly than straw burning or removal. Soil OC showed an increasing trend with time in all the residue incorporation (Yadvinder *et al,* 2004). The low OC in villages other than Boolpur and Swal was probably due to burning of paddy and wheat straw residues in paddy-wheat cropping sequence. Therefore, the farmers who have low OC content in soils were encouraged to use organic manures such as green manure and farmyard manure etc. so that the optimum crop productivity can be maintained for a longer period.

Available Phosphorus

Phosphorus has been called the "Master key to agriculture" because low crop production is attributed mainly due to lack of phosphorus than the deficiency of other elements except nitrogen. Phosphorus is essential for growth, cell division, root growth, fruit development and early ripening of the crop. It is also required for energy storage and transfer being a constituent of several organic compounds including oils and amino acids. Phosphate ion enters the soil solution either as a result of mineralization of organophosphates or the

Table 5. Organic Carbon content of soil of different villages.

Sr.No.	Village	Per cent samples			Mean ± SD	Range
		Low (<0.4%)	Medium (0.4-0.75%)	High (>0.75%)		
1	Bhagwanpur	39	61	0	0.42±0.07	0.21-0.56
2	Bhetan	54	46	0	0.4±0.16	0.08-0.68
3	Boolpur	12	54	34	0.64±0.19	0.32-1.07
4	Kheeranwali	48	50	2	0.38±0.09	0.21-0.72
5	Khukrain	44	52	4	0.45±0.14	0.24-0.78
6	Meripur	53	42	5	0.41±0.06	0.35-0.54
7	Swal	32	41	27	0.56±0.25	0.15-1.01

Table 6. Available Phosphorus status of soil of different villages.

Sr. No.	Village	Per cent samples			Mean ± SD	Range
		Low (<12.5 kg/ha)	Medium (12.5-22.5 kg/ha)	High (22.5-50 kg/ha)		
1	Bhagwanpur	20	50	30	19.7±7.2	10.2-35.5
2	Bhetan	9	47	44	23.2±5.2	14.2-34.2
3	Boolpur	2	42	56	24.2±5.5	13.5-37.2
4	Kheeranwali	12	84	4	16.7±3.5	8.5-22.2
5	Khukrain	23	52	25	17.7±5.7	7.0-28.0
6	Meripur	15	80	5	19.2±2.0	15.2-22.2
7	Swal	5	55	40	21.2±5.2	8.7-33.5

application of fertilizers. The plants take available P mostly in the form of H_2PO_4 - from soil solution. Chemisorptions of P occur due to interaction of phosphate ions with the atoms like aluminium (Al), iron (Fe) or calcium (Ca) depending upon soil pH.

The data (Table 6) revealed that mean values of available phosphorus were 17.7 to 24.2 kg/ha in soil samples of all the villages. Similar results were reported by Pathak (2010) who concluded that available phosphorus range from medium to high category in India. In the village Khukrain where 23 per cent samples were under low available phosphorus category might be due to high pH values, whereas, soils of Boolpur, Bhetan and Swal were rich in available phosphorus content probably due to potato and vegetable cropping sequence followed in which farmers apply excessive phosphatic fertilizers as compared to the recommendations made by the research institutes. Hence, farmers of these villages were advised to apply fertilizer only on the basis of soil test report. Similarly, based on soil fertility status, farmers can decide about the cropping sequence as well as its economic output well in advance.

Available Potassium

Potassium exists in K+ form and its function appears to be catalytic in nature. The potassium is important for plant because it participates in the activation of large number of enzymes which are involved in physiological process of plants. It controls the water economy and provides the resistance against a number of pests, diseases and environmental stresses. The high status of available potassium was found in Khukrain village (92%)

Table 7. Available Potassium status of soil of different villages.

Sr. No.	Village	Per cent samples		Mean ± SD	Range
		Low (<137.5 kg/ha)	High (<137.5 kg/ha)		
1	Bhagwanpur	28	72	154.5±39.7	72.5-262.5
2	Bhetan	55	45	155.0±125.7	39.7-883.2
3	Boolpur	56	44	156.7±103.2	34.0-504.0
4	Kheeranwali	45	55	149.2±74.0	28.2-475.7
5	Khukrain	8	92	98.7±143.0	107.5-696.5
6	Meripur	58	42	140.5±49.0	56.7-335.0
7	Swal	55	45	195.0±126.7	90.5-583.2

Table 8. Nutrient Index Value of soils of selected sites.

Sr.No.	Village	Organic Carbon	Phosphorus	Potassium
1	Bhagwanpur	1.61	2.10	2.44
2	Bhetan	1.46	2.35	1.91
3	Boolpur	2.22	2.53	1.88
4	Kheeranwali	1.55	1.91	2.10
5	Khukrain	1.61	2.02	2.83
6	Meripur	1.53	1.90	1.85
7	Swal	1.95	2.35	1.45

followed by Bhagwanpur (72%), Kheeranwali (55%), Swal and Bhetan (45%) and Boolpur (44%) as given in Table 7. Bhatt and Sharma (2011) reported that about 65 per cent samples of district Kapurthala were found to be low in potassium status (Available K<137.5 kg/ha).

However, it is presumed that soils of Punjab are rich in potassium level and there is no need to apply potassium fertilizers. Contrary to this assumption, the soil testing report of 7 selected villages revealed that lowest value for available potassium was 28.2 kg/ha in village Kheeranwali. The reason for this could be lack of farmer awareness about the importance of K indicates need for more education. For example, farmers may not realize the effect of applied K on the size, shape, colour, and quality of produce at maturity, so its need may be overlooked. In contrast, the benefits from N and P are more readily apparent from initial stages of crop growth. Another reason for inadequate use of K fertilizers may be the lack of crop response to applied K, even on low K testing soils. This clearly showed the importance of soil testing while applying fertilizers in growing various cereal, oilseed, pulses and vegetable crops.

Nutrient index value (NIV) is the measure of nutrient supplying capacity of soil to plants. The data (Table 8) implies that the nutrient index of OC was low in all the locations except Swal (1.95) and Boolpur (2.22), where the nutrient index falls under medium category. In case of phosphorus the highest nutrient index was recorded in Boolpur followed by Swal villages, whereas at all other locations it was medium. The villages Khukrain and Bhagwanpur possess high nutrient index in terms of potassium, whereas, Bhetan, Boolpur and Meripur villages have medium values for potassium nutrient index followed by Swal (1.45) with low NIV. The observed difference in the NIV in different village was probably due to difference in the cropping sequence being followed by the farmers.

Effect of cropping sequence on soil fertility

The farmer using vegetables based cropping sequence apply higher doses of fertilizers and generally do *in situ* incorporation of plant biomass, which resulted in increasing the OC content in these soils and found that only 29 per cent soil samples were low in OC content (Table 9). Contrary to this,

Table 9. Effect of different cropping sequence on fertility status.

Cropping sequence	Organic carbon			Av. Phosphorus			Av. Potassium	
	Low	Medium	High	Low	Medium	High	Low	High
Paddy-Wheat	59	39	2	17	64	19	29	71
Paddy-potato- Spring crop	51	49	0	16	54	30	49	51
Paddy-Vegetable- Spring crop	29	53	18	6	59	35	68	32

Table 10. Nutrient index values of the cropping sequences.

Sr.No.	Cropping sequence	Organic Carbon	Phosphorus	Potassium
1	Rice- Wheat	1.44	2.02	2.42
2	Potato based	1.49	2.62	2.02
3	Vegetable based	1.88	2.29	1.65

under potato based cropping sequence, uptake of nitrogen was much higher so, the OC was low in 51 per cent of the samples analyzed. Further, the soils where paddy-wheat cropping sequence was followed, the majority of soil samples were found low in OC mainly due to burning of paddy and wheat stubbles and lower fertilizer application.

Highest available phosphorus content was found in the soil with potato based cropping sequence due to application of excessive phosphatic fertilizers as compared to recommendations of research institutes. However, contrast trends were obtained in case of available potassium status because uptake of potassium was low in paddy-wheat cropping sequence as compared to vegetable and potato based cropping sequence.

It was evident from the data (Table 10) that highest NIV for OC was under vegetable based cropping sequence, for phosphorus it was potato based and for potassium it was rice-wheat cropping sequence.

Correlation of cropping sequence with physico-chemical properties of soil

The cropping sequence followed in district Kapurthala exhibited a significant correlation with the physico-chemical properties of the soil (Table 11). The OC and available phosphorus exhibited a positive correlation with cropping intensity due to application of higher inorganic fertilizers and incorporation of plant biomass as compared to paddy-wheat cropping sequence. On the other hand, pH, EC and available potassium showed a decreasing trend with the increased crop intensity from paddy-wheat to paddy-potato/vegetable-summer crop.

There existed a significant correlation of available phosphorus and potassium with pH and

Table 11. Correlation of cropping intensity with physico-chemical properties of soil.

Particulars	Parameters	Cropping intensity	pH	EC	Organic Carbon	Available Phosphorus	Available Potassium
Cropping sequence	Pearson Correlation	1	-.332**	-.198**	.188**	.315**	-.235**
	Sig. (2-tailed)		.000	.002	.003	.000	.000
pH	Pearson Correlation		1	.481**	-.020	-.186**	.280**
	Sig. (2-tailed)			.000	.758	.003	.000
EC	Pearson Correlation			1	.060	-.123	.509**
	Sig. (2-tailed)				.349	.053	.000
Organic Carbon	Pearson Correlation				1	-.023	.184**
	Sig. (2-tailed)					.720	.004
Available Phosphorus	Pearson Correlation					1	-.152*
	Sig. (2-tailed)						.017
Available Potassium	Pearson Correlation						1
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).							

EC. Although, the negative correlation was observed with available phosphorus be due to fixation of phosphorus under high pH conditions. Similar results were reported by Chawla (1969) that pH and available phosphorus (r=0.362) have negative significant correlation. The organic carbon was found to be non-significantly correlated with pH and EC.

CONCLUSION

The physico-chemical properties of soil were analyzed for 7 villages in district Kapurthala. The parameters such as pH, EC, OC, available phosphorus and available potassium were undertaken for study. Data pertaining to pH revealed villages with pH>9.3 generally follow Paddy-wheat than commercial value crops such as potato and vegetables. Villages with high soil OC generally follow vegetable based cropping system which enriches soil with *in situ* decomposition and high fertilizer use. In case of available phosphorus, Boolpur, Bhetan and Swal showed higher level of values mainly results shift in cropping sequence to intensified cropping including potato and vegetable based cropping sequence. High level of available potassium resulted farmers stick to paddy-wheat rotation cropping sequence. So, both the physical and chemical properties of soil affect the cropping sequence of the area and likewise chemical properties of soil changes with shift in cropping sequence. Selected parameters pertaining to soil testing gave only the level of certain nutrients present in the soil. Hence, in order to advise precise recommendation on soil management for sustaining various cropping sequence in the study area, plant tissue analysis and field experiment on crop nutrient requirement needs to be undertaken.

REFERENCES

Andreas P, Berndt-Micheal W (2005). Soil sampling and storage. In: Margesin R, Schinner F, editors. *Manual for soil analysis monitoring and assessing soil bioremediation*. Springer-Verlag: Berlin Heidelberg: 3–13.

Bhatt Rajan and Sharma Manoj (2011). Potassium Scenario -A case study in the Kapurthala district of Punjab, India. *Journal of Research PAU* **48**(1 &2):24-27.

Brady N C and Weil R R (2005). The Nature and properties of soil (Thirteenth Edition) *Macmillan Publishing Co. New York*.

Chawla V K (1969). Available nitrogen and phosphorus status of saline-sodic soils of Punjab (India). *Agronomy journal* **61**(3):361-362.

Cooke G W (1982). An introduction to soil analysis. *World Crops* **1**: 8-9.

Jackson M L (1973). Soil chemical analysis. *Prentice Hall Inc, Englewood Cliffs*, pp 528.

Johnston A E (2007). Soil organic matter, effects on soil and crop. *Soil use and management* **2**(3): 97-105.

Manan Jatinder, Sharma Manoj, Singh Gurmeet and Singh Gobinder (2016). Effect of application of various inputs by the farmers and the yield of spring maize hybrids. *J Krishi Vigyan* **4** (2): 22-27.

Olsen S R, Cole C V, Watanabe F S and Dean L A (1954). Estimation of available phosphorus in soils by extraction with sodium carbonate. *USDA Circ* 939:1–19.

Parker F W, Nelson W L, Winters E and Miles J E (1951). The broad interpretation and application of soil test summaries. *Agron J* **43**(3): 103–112.

Pathak H (2010). Trends of fertility status of Indian soil. *Current Advances in Agricultural Sciences* **2**(1): 10-12.

Rehman O, Ahmad B and Afzal S (2010). Soil fertility and salinity status of Attock district. *J Agric Res* **48**(4):505-516.

Rhoades D and Oster J D (1986). Methods of Soil Analysis, Part I. Physical and Mineralogical Methods-Agronomy Monograph no. 9 (2nd Edition).

Sainju U M, Senwo Z N, Nyakatawa E Z, Tazisong I A, Reddy K C (2008). Tillage, cropping systems and nitrogen fertilizer source effects on soil carbon sequestration and fractions. *J Environ Qual* **37**: 880–888.

Walkley A and Black CA (1934). An examination of digestion method for determining soil organic matter and the proposed modification of the chromic acid titration method. *Soil Sci* **37**:29–38.

Yadvinder-Singh, Bijay-Singh, Ladha J K, Khind C S, Khera T S and Bueno C S (2004). .Effects of residue decomposition on productivity and soil fertility in rice–wheat rotation. *Soil Sci Soc Am J* **68**:854–864.

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