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Research Article

Spatial Distribution of Nutrients under Cotton-Wheat and Rice-Wheat Cropping Systems in Bathinda District, Punjab

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ABSTRACT

The cotton-wheat cropping system (CWCS) showed higher pH (8.7 and 8.9) than rice- wheat cropping system (RWCS) (8.5 and 8.6) at 0-15 cm and 15-30 cm, whereas electrical conductivity (EC) was higher in RWCS (0.70 and 0.48 dS m^{-1}) than CWCS (0.34 and 0.26 dS m^{-1}) at 0-15 cm and 15-30 cm. RWCS showed higher OC (6.3 and 4.8 mg kg^{-1}) than CWCS (5.2 and 3.7 mg kg^{-1}) at 0-15 cm and 15-30 cm, respectively. Available N (275.9 and 275.9 kg ha^{-1}), P (36.9 and 38.9 kg ha^{-1}), SO_4-S (38.9 and 33.8 kg ha^{-1}) were reported higher in RWCS than CWCS (259.3 and 216.9 kg ha^{-1}), (26.0 and 19.8 kg ha^{-1}), (22.6 and 20.3 kg ha^{-1}) at 0-15 cm and 15-30 cm, respectively. While, K were higher in CWCS (438.2 and 349.0 kg ha^{-1}) than RWCS (283.0 and 211.9 kg ha^{-1}) at 0-15 cm and 15-30 cm. The NIV for both cropping system showed that soil was low in N (1.4 and 1.3), medium to higher in P (2.6 and 2.0) medium in K (2.0 and 2.0) and higher in S (2.6 and 2.4) under CWCS at 0-15 and 15-30 cm, respectively. Whereas, under RWCS soil was low in N (1.6 and 1.2), higher in P (2.9 and 2.7) and S (2.6 and 2.6) and medium in K (2.2 and 1.8) at 0-15 and 15-30 cm, respectively.

Key words: Arid soils, cotton-wheat, rice-wheat, macro-nutrients, nutrient index value

Introduction

Soil nutrients play a vital role in the growth, development and yield of plants and the information on the nutritional status of an area can go for a long way in planning judicious fertilizers and soil management practices to develop economically viable alternatives for the farming community. The major and micronutrients govern the fertility of the soils and control the yield of the crops. Soil fertility evaluation of an area or region is an important aspect in context of sustainable agricultural production, particularly of an arid/semi arid region, where, sparse and highly variable precipitation, extreme variation in diurnal temperature, high evaporation and low humidity, the alluvial and aeolian landforms have given rise to the variability in soils. The Bathinda district is predominately an agriculture oriented and majority of the population depends on agriculture for their livelihood. The soils of the district vary from sandy to clay loam in texture which makes it suitable for cultivation of a wide range of agriculture and fruit crops. Out of total cultivated area, wheat is grown 35.20 lakh ha during 2018-19 (Anonymous, 2020). During *kharif* paddy and cotton is the major cash crop in the district, in which rice occupied an area of 31.42 lakh ha, followed by cotton with an area of 2.45 lakh hectares (Anonymous, 2021). According to crop rotation map there is sequential planting of crops in time which indicates that Bathinda district has moved from the major crop rotations of cotton-wheat to two main crop rotations of rice-wheat and cotton-wheat. Both the rice and cotton crop require application of heavy doses of

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nutrients, particularly nitrogen (N) application, to achieve full yield potential. The indiscriminate use of fertilizers over a period of time has resulted in build up of nutrient elements like phosphorus and deficiency of S in many locations (Sharma, 2004). Hence, for sustainability of the present agricultural system and for management of our soil resources, the fertility status of soil is required. Optimum productivity of any cropping system depends on adequate supply of plant nutrients. When the soil does not supply sufficient nutrients for normal plant development and optimum productivity, application of supplemental nutrients is required (Foth and Ellis, 1997). Therefore, evaluating the fertility status of a soil is important to know the productivity of a soil as soil fertility is one of the parameters of soil productivity. Hence, an investigation was undertaken to assess the spatial distribution of nutrients in arid soils under cotton-wheat and rice-wheat cropping systems of Bathinda district of Punjab.

Material and Methods

Soil sampling and analysis

The soil samples were collected after rice harvesting as well as picking of cotton in different villages of Sangat block, Bathinda (Table 1). 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. Different basic soil chemical properties and available nutrients were analyzed by standard methods as described by Piper (2019). The soil samples were categorized for various classes of soil parameters as per criteria given in Table 2. For further statistical analysis of data, Microsoft Excel (2007) software was used.

Nutrient Index Value (NIV)

Nutrient Index in order to compare the levels of soil fertility of one area with those of another, it is

Table 1. Name of villages under cotton-wheat and rice-wheat cropping system for soil sampling.

Cotton-wheat cropping system		Rice- wheat cropping system	
1. Guru Saniwala (5)	10. Sangat (6)	1. Gehri Buttar (5)	10. Phallar (6)
2. Mehta (5)	11. Koth Guru (7)	2. Sangat (5)	11. Ruldhu Singh Wala (9)
3. Shergarh (5)	12. Mohlan (10)	3. Koth Guru (9)	12. Jai Singh Wala (5)
4. Bhagwangarh (5)	13. Jassi Baghi (3)	4. Mohlan (5)	13. Ghudda (5)
5. Malwala (5)	14. Paka Kala (5)	5. Jassi Bagwali (7)	14. Bajak (5)
6. Dunewala (5)	15. Paka Khurd (8)	6. Machana (6)	15. Nanadgarh (6)
7. Machhana (5)	16. Sakhu (5)	7. Paka Kala (6)	16. Chak Attatrsingh Wala (4)
8. Gurthari (5)	17. Phallar (6)	8. Paka Khurd (7)	17. KalJharani (5)
9. Gehri Buttar (5)	18. Ruldhu Singh Wala (5)	9. Sakhu (5)	

*Figure in parenthesis ( ) denotes the number of samples collected from each village

Table 2. Criteria used to categorize soil parameters into different categories.

Soil characteristics	Categories		
Soil reaction (pH)	Normal (6.5-8.7)	Marginally alkaline (8.7-9.3)	Alkali or sodic (>9.3)
Electrical conductivity (EC) (dSm^{-1})	Normal (<0.8)	Critical for crop production (0.8-2.0)	Injurious (>2.0)
Organic carbon (%)	Low (<0.40)	Medium (0.40-0.75)	High (>0.75)
Mineralizable N (kg ha^{-1})	Low (<271)	Medium (271-543)	High (>543)
Available P (kg ha^{-1})	Low (<12)	Medium (12-22)	High (>22)
Available K (kg ha^{-1})	Low (<136)	Medium (136-333)	High (>333)
Available S (kg ha^{-1})	Low (<10)	Medium (10-30)	High (>30)

necessary to obtain a single value for each nutrient. Here the Nutrient Index (NI) was calculated by following formula suggested by Parker *et al.* (1951).

$$\text{Nutrient Index (NI)} = ((Nl \times 1) + (Nm \times 2) + (Nh \times 3))/ Nt$$

Where

Nt =Total number of samples analyzed in a given area

Nl = Number of samples falling in low category of given nutrient

Nm = Number of samples falling in medium category of given nutrient

Nh= Number of samples falling in high category of given nutrient

Nutrient index value below 1.67, in between 1.67 to 2.33 and above 2.33 has been considered as low, medium and high, respectively (Amara *et al.*, 2017).

Results and Discussion

Soil reaction (pH) under cotton-wheat and rice-wheat cropping system

The data on soil pH under CWCS (Fig. 1) revealed that pH of soils ranged from 8.0-9.5 at surface and 8.1-9.7 at sub-surface, which were normal to marginally alkaline. Higher range of pH were recorded from villages Shergarh, Bhagwangarh, Koth guru, Mohlan and Paka kala (9.0-9.2), (8.8-9.1), (8.6-9.2), (8.8-9.5) and (8.9-9.3) at surface and (9.2-9.5), (8.9-9.2), (8.7-9.7), (8.9-9.7) and (8.9-9.7) at sub-surface soil, respectively. The data showed that 43%, 54% and 3% soils were normal, marginally alkaline and sodic in surface whereas, 30 % samples were normal in pH, 49% samples were marginally alkaline and 21% samples were sodic in nature at sub-surface. Similarly, pH under RWCS ranged from 8.0-9.3 at surface and 8.1-9.4 at sub-surface which was normal to marginally alkaline (Fig. 1). The pH was recorded higher from Bajak (8.7), whereas it was lowest in Jassi Bagwali (8.2). Samples collected from surface, 82% samples were normal, 17% samples were marginally alkaline and 1% sample was sodic in nature. Whereas from sub-surface, 56% samples were normal, 43% were marginally alkaline and 1% sample was sodic in nature. The higher soils pH of the region might be due to low rainfall, and presence of soluble and exchangeable sodium along with HCO^{3-} ions, which precipitate calcium and magnesium carbonates during evaporation. Alkalinity problem in soils is due to the indigenous calcareous parent material with typical low organic matter content (Brady and Weil, 20013). When averages were considered, it found slightly alkaline but free from sodicity in both cropping system. Singh and Sharma (2013) studied the morphological, physical and chemical properties of arid soils of Bathinda district of Punjab and reported that in all the three pedons viz., sand dunes, inter dunal and alluvial terraces soils were alkaline in reaction with pH ranging from 7.9-8.5 with slight trend to increase with depth. Further, Yadav *et al*. (2018), Yadav and Gupta (2019) and Yadav (2020) observed neutral to alkaline soil pH in Bathinda district, which increased with increased in soil depth.

Soil electrical conductivity (EC) under cotton-wheat and rice-wheat cropping system

The EC of soils under CWCS (Fig. 1) ranged from (0.11-1.36 dSm^{-1}) at surface and (0.10-0.83 dS m^{-1}) at sub-surface, which were normal to critical for crop production. 97-99% surface soil samples were recorded normal, where as only1- 3% samples were recorded to be critical for crop production. The average EC (0.34 dS m^{-1}) at surface and sub-surface (0.26 dS m^{-1}) indicated that salinity is not a problem in this area. The data on EC under RWCS (Fig. 1) revealed that soil EC ranged from (0.16-1.86 dSm^{-1}) at surface and (0.13-1.47 dS m^{-1}) at sub-surface. The surface samples from RWCS shown that 65% soils were normal and 35% soils were critical for crop production. Whereas, 88% and 12% soil were recorded as normal and critical for crop production in sub surface under RWCS. The lower EC in the soils may be attributed to leaching of salts, as majority of the soils in the area are light textured. The area from which soil samples collected was light textured having more numbers of macro pores thus resulting easy drainage leading to lower electrical conductivity. Singh and Sharma (2013) reported the EC of arid soils of Bathinda ranged from 0.11-0.18 dS m^{-1} in sand dunes, 0.19-0.27 dS m^{-1} in inter dunal and 0.20-0.31 dS m^{-1} in alluvial terraces soils, indicating thereby that the soils were non saline.

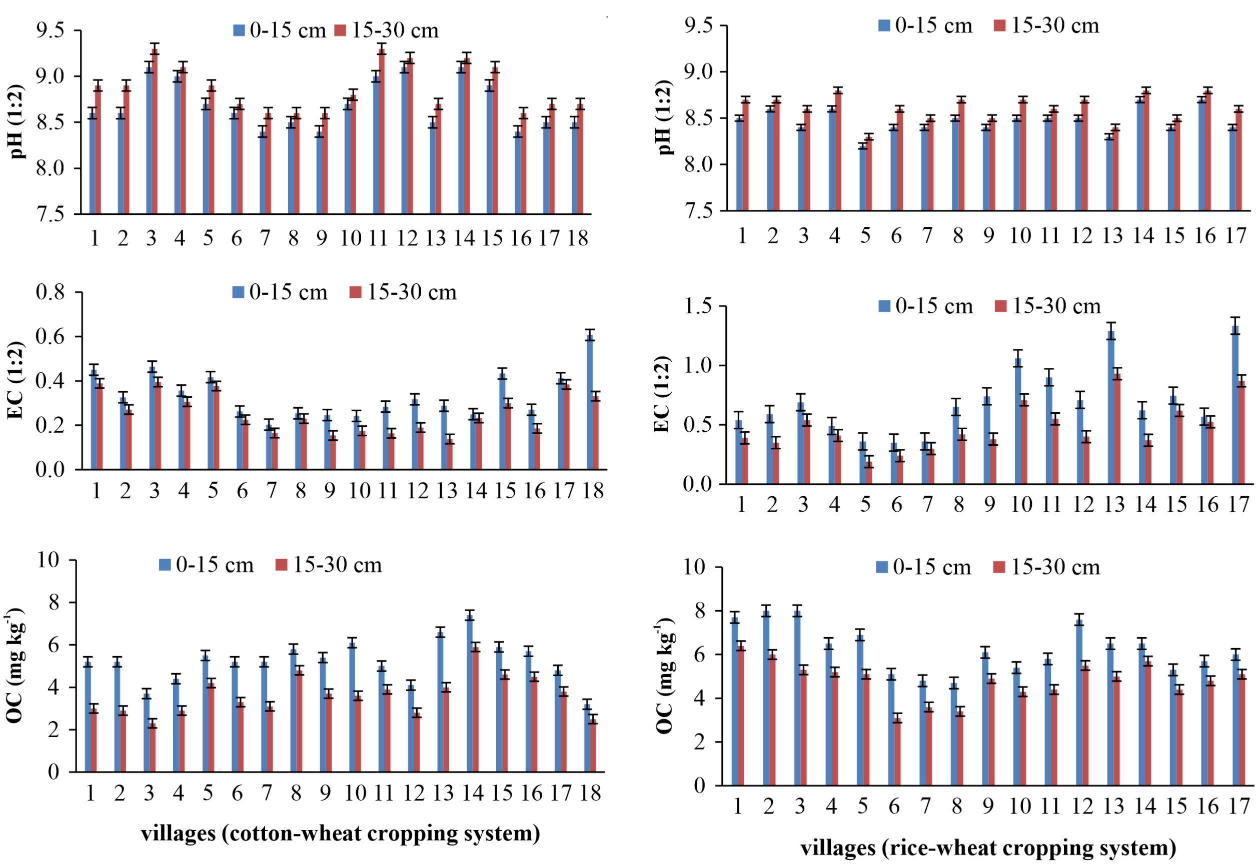


Fig. 1. Soil reaction (pH), electrical conductivity (EC) and organic carbon (OC) of soils under cotton-wheat and rice-wheat cropping system

Moreover, on the basis of 2506 soil samples of Bathinda district, Yadav *et al.* (2018) reported that 85 % soil samples were in normal range (EC < 0.8 dS m^{-1}) and 15% samples had EC > 0.8 dS m^{-1} and recorded increased trend of soil EC with soil depth (Yadav, 2020).

Soil organic carbon (OC) under cotton-wheat and rice-wheat cropping system

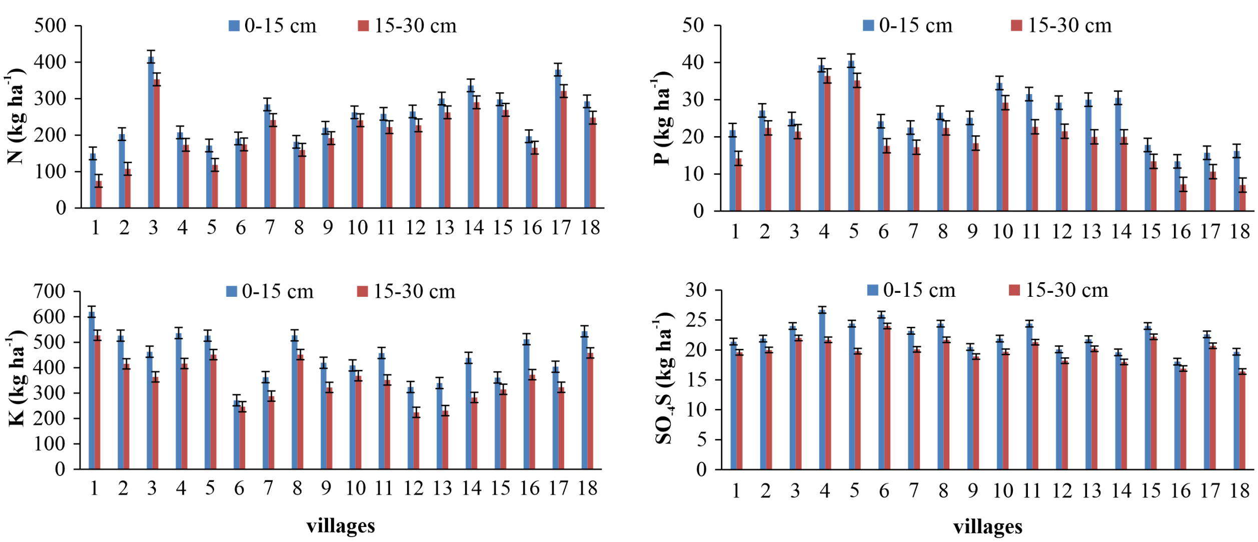
Soil organic carbon under CWCS varied from 1.4-9.6 mg kg^{-1} at surface and 1.0-8.4 mg kg^{-1} at sub-surface (Fig. 1). The OC was highest in Paka Kala (7.4 mg kg^{-1}) at surface and (5.9 mg kg^{-1}) at sub-surface, and was lowest in Ruldhu Singh Wala (3.2 mg kg^{-1}) at surface and Shergarh (2.3 mg kg^{-1}) at sub-surface. On the basis of soil test ratings 25%, 63% and 12 % samples fall under low, medium and high category in OC content at surface, whereas 67%, 31% and 2% samples fall under low, medium and high category at sub-surface. Under RWCS (Fig. 1) OC ranged from 2.8-13.0 mg kg^{-1} at surface and 1.8-12.2 mg kg^{-1} at sub-surface. The mean OC was highest in Koth Guru (8.0 mg kg^{-1}) and Gehri Buttar (6.4 mg kg^{-1}) and was lowest in Paka Khurd (4.7 mg kg^{-1}) and Machana (3.1 mg kg^{-1}). On the basis of soil test ratings, 9%, 65% and 26% samples fall under low, medium and high category at surface, whereas, 28%, 67% and 5% samples fall under low, medium and high category at sub-surface. The low organic carbon content of these soils may be due to high rate of organic matter decomposition under hyper-thermic temperature regime. Singh *et al.* (2014) revealed that SOC density (1.2 ± 0.2 kg m^{-2}) was the lowest in ustic-hyperthermic and highest in udic-mesic (4.2 ± 0.8 kg m^{-2}) and udic-thermic (4.2 ± 0.7 kg m^{-2}) conditions. The OC content was observed low to medium because of higher temperature thus causing rapid burning and decomposition of organic matter resulting in low to medium organic carbon content in areas of these soils. The low OC in case of RWCS was because of burning or removal of rice and wheat straw residues in RWCS. Therefore, incorporation of crop residue enhances crop productivity instead of burning or removing of straw. Singh and Sharma (2013) reported 0.22 %, 0.31% and 0.34% organic carbon in surface horizon of sand dunes, inter dunal and alluvial terraces soils of Bathinda, and decreased with depth. Likewise, Yadav *et al.* (2018) observed variation in OC between 3.1 mg kg^{-1} to 6.2 mg kg^{-1} in different blocks of Bathinda, which decreased with increased in soil depth (Yadav, 2020) and 61 to 70% soils were deficient in organic carbon. Similarly, Kar *et al.* (2020) reported 0.35-0.45% to 0.60-0.65% organic carbon in Nayagarh district of Odisha, India.

Soil nitrogen under cotton-wheat and rice-wheat cropping system

The available N under CWCS (Fig. 2) ranged from 106.7-638.2 kg ha^{-1} at surface with 55%, 41% and 4% samples under low, medium and high category. Whereas, it ranged from 44.8-579.0 kg ha^{-1} with 65%, 33% and 2% samples under low, medium and high category at sub-surface. The nitrogen was highest in Shergarh (384 kg ha^{-1}) and was lowest in Gurusar Saniwala (112 kg ha^{-1}). Similarly, N under RWCS (Fig. 3) revealed that nitrogen of soil ranges from (142.0-362.0 kg ha^{-1}) at surface and (121.2-318.0 kg ha^{-1}) at sub-surface soil layer. It is also observed that in RWCS 40% and 60 % surface soil samples were low and medium N content, whereas, at sub-surface 80% and 20% soil samples were observed low and medium N content. The soil nitrogen was highest in Chak Attatr Singh Wala (300 kg ha^{-1}) and was lowest in Machana (214 kg ha^{-1}) under RWCS. The higher amount of available N was observed in surface soil due to more turnover of organic residues which decreased with soil depth. Bhardwaj *et al.* (2001) observed a decreased trend in available N with increase in soil depth. As organic matter content was an indicator of nitrogen status in soil so nitrogen was also recorded low to medium as organic carbon. Amara *et al.* (2016) reported low to medium nitrogen due to low organic matter content in soils of Karnataka state. The results were also in finding with (Kumar *et al.,* 2015) who observed that available N status ranged from 113-348 kg ha^{-1} with mean value of 245 kg ha^{-1} obtaining 72% low and 48% medium in different blocks of Raipur district of Chhattisgarh.

Soil phosphorus under cotton-wheat and rice-wheat cropping system

The available phosphorus under CWCS (Fig. 2) revealed that soil P ranged from 6.2-52.6 kg ha^{-1} and 3.3-49.2 kg ha^{-1} at surface and sub-surface. At surface 3%, 34% and 63% samples were categorised as low, medium and high in P content, whereas, 20%, 52%



1. Gurusar Saniwala, 2. Mehta, 3. Shergarh, 4. Bhagwangarh, 5. Malwala, 6. Dunewala, 7. Machhana, 8. Gurthari, 9. Gehri Buttar, 10. Sangat, 11. Koth Guru, 12. Mohlana, 13. Jassi Baghi, 14. Paka Kala, 15. Paka Khurd, 16. Sakhu, 17. Phallar, 18. Ruldhu Singh Wal

Fig. 2. Available nutrients (N, P, K and S) of soils under cotton-wheat cropping system

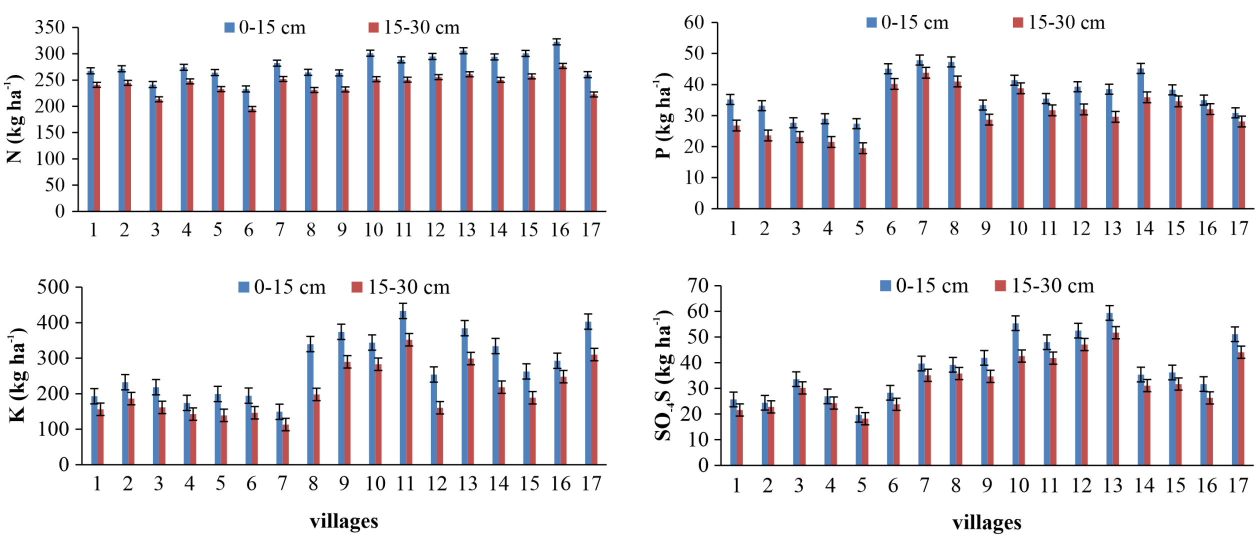
and 28% samples were categorised as low, medium and high P content in sub-surface. The highest P (40.5 kg ha^{-1}) was reported in Malwala and lowest in Sakhu (13.4 kg ha^{-1}) at surface soil. The P under RWCS were represented in Fig. 3 revealed that P ranged from (16.8-57.2 kg ha^{-1}) with 10% and 90% samples under medium and high P soil content at surface. However, it ranged from 12.3-48.3 kg ha^{-1} with 24% and 76% samples under medium and high P soil content at sub-surface. The highest (46 kg ha^{-1}) and lowest (23.5 kg ha^{-1}) P content was reported in Paka Kala and Jassi Bagwali village. The soils of these areas have medium to high P content because of excessive use of phosphatic fertilizers and due to the immobile nature of phosphorus in soils leading to phosphorus accumulation in soils. Similar results were observed by Pathak (2010) in different states of India and Singh *et al.* (2016) in Kapurthala district of Punjab that available phosphorus varied from medium to high category. Yadav *et al.* (2018) also observed higher P content in soils of Bathinda district of Punjab.

Soil potassium (K) under cotton-wheat and rice-wheat cropping systems

The K under CWCS revealed that it ranged from (169.3-848.9 kg ha^{-1}) at surface and (101.9-768.3 kg ha^{-1}) at sub-surface (Fig. 2). At surface 33% and 67% samples were recorded as medium and high K content, whereas, in sub-surface 4%, 47% and 49% samples were recorded as low, medium and high K content. The highest K (573 kg ha^{-1}) was reported in Gurusar Saniwala and lowest K (248 kg ha^{-1}) was recorded in Dunewala. The K under RWCS (Fig. 3) revealed that K ranged from 66.7-792.9 kg ha^{-1} and 49.7-638.4 kg ha^{-1} with 10%, 60% 30% and 32%, 55%, 13% samples were low, medium and high categories at surface and sub-surface, respectively. The K was highest (393 kg ha^{-1}) in Ruldhu Singh Wala and was lowest in Paka Kala (131 kg ha^{-1}). The K content was recorded medium to high in such soils because of K rich minerals such as illite and feldspars (Sharma *et al.,* 2008). Ground waters of Bathinda district have substantial amount of dissolved K and irrigation with such waters results into higher amounts of available K in these soils (Patel *et al.,* 2000). High K was also recorded by Yadav *et al.* (2018) in Bathinda district of Punjab. Moreover, higher value of water soluble, available, exchangeable, non-exchangeable and fixed K in surface soil layer was reported corresponding to their values for sub surface layers (Yadav, 2020).

Soil sulphur (S) under cotton-wheat and rice-wheat cropping system

The S under CWCS (Fig. 2) ranged from 8.1-35.7 kg ha^{-1} at surface and from 7.9-34.2 kg ha^{-1} at



1. Gehri Buttar, 2. Sangat, 3. Koth Guru, 4. Mohlan, 5. Jassi Bagwali, 6. Machana, 7. Paka Kala, 8. Paka Khurd, 9. Sakhu, 10. Phallar, 11. Ruldhu Singh Wala, 12. Jai Singh Wala, 13. Ghudda, 14. Bajak, 15. Nanadgarh, 16. Chak Attatrsingh Wala, 17. KalJharani

Fig. 3. Available nutrients (N, P, K and S) of soils under rice-wheat cropping system

sub-surface with 10%, 87% and 3% samples under low, medium and high categories. The S was highest in Bhagwangarh (26.7 kg ha^{-1}) and was lowest in Sakhu (18.05 kg ha^{-1}). Similarly, the S under RWCS ranged from 8.3-72.7 kg ha^{-1} with 12 %, 33% and 55% samples as low, medium and high categories at surface (Fig. 3). However, it ranged from 8.0-64.4 kg ha^{-1} with 12 %, 39% and 49% samples as low, medium and high categories at sub-surface. The soil S was recorded medium to high in both the cropping system may be due to use of S containing fertilizers and gypsum with poor quality underground water. According to (Dalvinderjit *et al.,* 2001) sulphur was recorded highest in surface layer due to recycling of sulphur over years by higher plants, microbial activity and organic matter accumulation.

Soil nutrient index value (NIV)

According to number of samples in low, medium and high of mineralizable nitrogen, available phosphorus, available sulphur and available potassium, nutrient index value (NIV) was calculated and presented in (Fig. 4). At surface NIV for mineralizable nitrogen under cotton-wheat cropping system (CWCS) was 1.4 which indicated that soils were low in available N, for available P was 2.6 which showed that soils were high in P availability, for available S was 2.6 which showed that soils were high in S availability, for available K was 2.0 which indicated that soils were medium in K availability. At sub surface NIV for mineralizable N was 1.3 which indicated that soils were low in available N, for available P was 2.0 which showed that soils were medium in P availability, for available S was 2.4 which showed that soils were medium in S availability, for available K was 2.0 which indicated that soils were medium in K availability. Similarly, at surface NIV for mineralizable N under RWCS was 1.6 which indicated that soils were medium in available N, for available P was 2.9 which showed that soils were high in P availability, for available S was 2.6 which showed that soils were high in S availability, for available K was 2.2 which indicated that soils were medium in K availability. At sub-surface soil layer NIV for available N was 1.2 which indicated that soils were low in available N, for available P was 2.7 which showed that soils were high in P availability, for available S was 2.6 which showed that soils were high in S availability, for available K was 1.8 which indicated that soils were medium in K availability.

Comparison of soil properties among cotton-wheat and rice-wheat cropping sequences

The highest pH was observed under CWCS (8.7) and (8.9) than RWCS (8.5) at and (8.6) at 0-15cm and 15-30 cm respectively (Table 3) because of flooded conditions in rice that causes reduction leading to low pH conditions in rice-wheat cropping system. Electrical conductivity (EC) was observed to be higher in RWCS (0.70 dS m^{-1}) and (0.48 dS m^{-1}) soil than CWCS (0.34 dS m^{-1}) at surface and

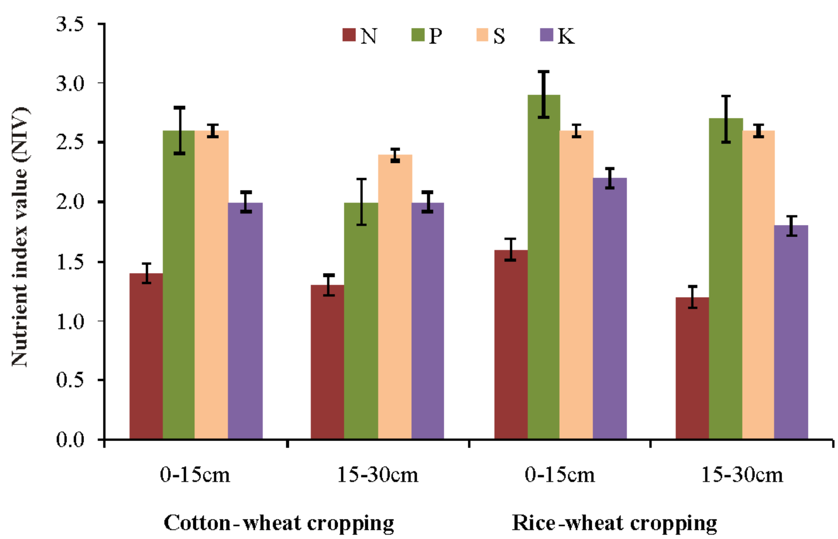


Fig. 4. Nutrient index value of N, P, K and S in cotton-wheat and rice-wheat cropping system

(0.26 dS m^{-1}) at sub-surface because of higher fertilizer addition and application of higher number of irrigation with poor quality groundwater which might have added the salts dissolved in irrigation water under RWCS. The RWCS reported higher OC content at surface (6.3 mg kg^{-1}) and (4.8 mg kg^{-1}) at sub-surface soil layer than CWCS (5.2 mg kg^{-1}) at surface and (3.7 mg kg^{-1}) at sub-surface soil, may be due to addition of rice and wheat stubbles in the field during ploughing and because of flooded condition under rice crops which declines the rate of oxidation of carbon in soils. Under submerged conditions there is lack of oxygen which decreases microbial activity which results in reduced rate of decomposition thus reducing build up of organic matter resulting higher organic carbon content. Available N was also reported higher in RWCS at surface (275.9 kg ha^{-1}) and (240.1 kg ha^{-1}) at sub-surface soil than CWCS (259.3 kg ha^{-1}) at surface and (216.9 kg ha^{-1}) at sub-surface soil because N was related to organic carbon content and higher organic carbon content results into higher available N status in RWCS. Available P was also observed to be highest in RWCS (36.9 kg ha^{-1}) at surface and (31.2 kg ha^{-1}) at sub-surface than CWCS (26.0 kg ha^{-1}) at surface and (19.8 kg ha^{-1}).at sub-surface soil because of excessive use of phosphatic fertilizer in both rice and wheat crop whereas in package of practices developed by university farmers are advised to apply phosphatic fertilizers to only wheat crop (rabi season). Phosphorus fertilizer use efficiency is only 20-30% which is low and the remaining unused P fertilizer accumulates in soil which causes build-up of P in soil. Exchangeable K content was observed to be highest in CWCS (438.2 kg ha^{-1}) at surface and (349.0 kg ha^{-1}) at sub-surface soil layer than RWCS (283.0 kg ha^{-1}) at surface and (211.9 kg ha^{-1}) at sub-surface soil. Available sulphur was highest in RWCS at surface (38.9 kg ha^{-1}) and at sub-surface soil layer (33.8 kg ha^{-1}) than CWCS at surface (22.6 kg ha^{-1}) and sub-surface soil layer (20.3 kg ha^{-1}).

Conclusion

It can be concluded from the present study, that cropping system may influence the soil chemical properties as well as soil macro-nutrients availability. It can also state that surface soils have relative higher nutrients as compare to subsurface soil. The results

Table 3. Comparison of soil properties among cotton-wheat and rice-wheat cropping sequences

Soil parameters	Cotton-wheat cropping system				Rice-wheat cropping system			
	0-15cm		15-30cm		0-15cm		15-30cm	
	Range	Mean± SEM	Range	Mean±SEM	Range	Mean± SEM	Range	Mean± SEM
pH(1:2)	8.0-9.5	8.77±0.03	8.1-9.7	8.97± 0.04	8.0-9.3	8.51± 0.02	8.1-9.4	8.67± 0.02
EC (1:2)	0.11-1.36	0.34±0.02	0.10-0.83	0.26± 0.01	0.16-1.86	0.70± 0.04	0.13-1.47	0.48± 0.03
OC (mg kg^{-1})	1.4-9.6	5.2±0.2	1.0-8.4	3.7± 0.2	2.8-13.0	6.3± 0.2	1.8-12.2	04.8± 0.2
N (kg ha^{-1})	106.7-638.2	259.37±8.66	44.8-579.0	216.98± 9.50	142.0-362.0	275.96 4.34	121.2-318.0	240.10± 3.75
P (kg ha^{-1})	6.2-52.6	26.06±0.92	3.3-49.2	19.80± 0.92	16.8-57.2	36.95± 0.94	12.3-48.3	31.26± 0.95
S (kg ha^{-1})	8.1-35.7	22.60±0.38	7.9-34.2	20.31± 0.36	8.3-72.7	38.94± 1.34	8.0-64.4	33.86± 1.11
K (kg ha^{-1})	169.3-848.9	438.20±16.83	101.9-768.3	349.08± 15.10	66.7-792.9	283.01± 15.39	49.7-638.4	211.90± 12.25

of the present study concluded that both CWCS and RWCS are suitable for the region. However, farmers, of the region are advised to adopt the cropping system according to availability of other resources, in which sufficient good quality irrigation water is most important for adoption of any cropping system.

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