Original Research Article

Understanding Soil Quality Dynamics for Improving Rice Yield in Farmer's Field

ABSTRACT:

A roving survey was conducted during Kharif2023to assess the constraints in rice crop production of district Kaithal, Haryana. A total of 20 soil samples from the surveyed sites were collected in triplicate for further analysis.The $pH_{(1:2)}$ and $EC_{(1:2)}$and OCof the surveyed sites ranged from 7.84 to 8.98, 0.19 to 0.66dS/m and 0.44 to 0.67% respectively. The surveyed soils were non saline in nature. Most of the surveyed sites(around 70%) were found medium in organic carbon status.Soil available nitrogen ranged from 145.36-194.13 kg N/ha, available phosphorus 11.54-19.27 kg P/ha and available potassium 323.2-398 kg K_2O/ha in the surveyed sites. The grain yield of rice varieties ranged from 2.85-8.85t/ha whereas the straw yield of rice varieties ranged from 5.0-12.0t/ha.The commonly grown rice varieties in scented group were PB 1121, PB 1509, PB 1718, PB 1847 and CSR 30 while the common high yielding non-scented variety and hybrid was PR114 and Vnr 2222, respectively. The constraints include low available nitrogen status of soils, high pH and sodicity at some sites, improper and untimely urea (N fertilizer) application. No farmer was applying organic fertilizers.

Keywords:Roving survey, grain and straw yield, soil available nitrogen, urea and varietal spectrum

1. INTRODUCTION:

Haryana, one of the agriculturally important states of India contributes about 7% to the national food grain production with only about 1.33% of geographical area [1]. Agriculture predominates in the Kaithal district of Haryana, India. Within the district, rice and wheat are the most common crops. There isn't much surface water available so aquifer water is mostly used to meet the massive irrigation needs of rice fields. In addition, imbalance application of pesticides and artificial fertilizers such as urea is done to boost output. Assessment of the soil and groundwater quality's appropriateness for sustainable management of these valuable resources is necessary due to the current conditions, which are causing increasing worry about their quality [2,25,26,27]. For over half of the world's population [3], rice (*Oryza sativa* L.) is the primary staple food. The majority of this population resides in less developed nations in Asia, Africa and Latin America. According to current predictions, there will be an additional two billion people on the planet by 2050, bringing the total estimated population to over 9 billion [4]. By 2035, rice output must rise by 26% in order to meet the growing demand for the grain and contribute to global food security [5]. However, with less land, water and labour available, farmers have been experiencing significant constraints in rice production [6]. In the rice fields of district Kaithal, Haryana only one rice crop is generally grown each year from July to November which is followed by wheat. Low soil fertility is widely reported as the major limiting factors for rice productivity in this area. Enhancing the productivity of Kaithal soils is thought to be a practical way to guarantee the state and country's food security because they are among the most significant types of arable soil in North India. Crops produced in most soils experience deficits of one or more micronutrients in addition to primary nutrient deficiencies, despite the fact that the soils frequently have quite adequate overall quantities of the micronutrients [7]. Any soil's potential to provide nutrients to crops growing on it is shown by the status of that nutrient. This is the primary factor of external nutrient input when considered in conjunction with crop demand. Considering that only a small portion of all the nutrients in the soil are readily available, understanding the available nutrient status of soils is crucial for planning agricultural fertilization. The practical goal of soil surveys is to facilitate the making of more numerous, accurate, and valuable forecasts for certain objectives like high yield per acre. A robust data bank on soil qualities and related site features is necessary in order to be able to advise current and future land users on how to use the land efficiently for higher and sustainable production. Soil fertility specialists must characterize and analyze fertility and ecological gaps among sites in order to determine the potential yield from each one. A number of variables, including compaction, salinization, erosion, pollution, a drop in organic content, microbial diversity and sealing, affect the health of the soil. In certain regions of India, soil degradation has increased during the last few decades due to a persistent decrease in fertility [8]. This has reduced the soil's capacity to support agricultural productivity [9]. Due to improper fertilizer and chemical application, soil fertility is degrading and the situation has gotten significantly worse in Punjab and Haryana which are the leading Indian states who revolutionized agriculture through the green revolution [10]. This has converted the fertile land into less fertile and degraded land ultimately leading to crop yield stagnation or reduction. However, some farmers are using recommended dose of fertilizers recommended by state agriculture university i.e. CCS Haryana Agricultural university, however some are using indiscriminately which could have negative impact on soil health and fertility.Accordingly, the Kaithaldistrict of Haryana was selected for a roving survey on the recent limitations in rice production related to soil.Closing current "yield gaps" has been recognized as a critical method to fulfill future rice demand [11]. When comparing mean farm yield to economically sustainable yield through optimal crop management techniques, yield gaps might be a helpful metric [12]. A significant portion of closing production gaps is due to soil-related constraints on output. This kind of research can offer a flexible framing plan in policy [13]. A thorough grasp of rice yield gaps and their causes may result in improved strategies to close the yield gap in a sustainable manner[14]. As a result, a roving study was conducted to identify soil related and management constraints limiting the rice productivity at farmers' fields and provide site specific recommendations to the farmers for higher productivity in Kaithal district of Haryana.

2. MATERIAL METHODS:

Kaithalisthe district of Haryanastate and it aresituated in the northwest region of the Haryana atabout 220 meters above sea level. Kaithalhas a total geographic area of 2317 square kilometers. It is a part of Indus-Ganges plains and has a well spread network of western Yamuna canals. Ghaggar and Markanda rivers are significant seasonal waterways in Kaithal district that run in a westerly direction, spanning the Guhla block. The most significant canal that runs through the Pundri, Kaithal, and Kalayat block areas is the Sirsa branch of the Western Yamuna Canal system.Kaithal district typically receives 511 mm of rain per year[15].Mean maximum and minimum temperature of the Kaithal district is 40^{0}C (May & June) and 7^{0}C (January) [16].The primary crop for Kharif is paddy, whereas the primary crop for Rabi is wheat in this district.There are two types of soils in the Kaithal district: desert and sierozem soils. The majority of the Kaithal district is covered with sierozem soils, whereas desert soils are found in minor areas, mostly in the north of the district[15].

A total of 60 soil samples from the surveyed sites were collected having three replications of each sample. The samples were then air dried and sieved (2 mm) for laboratory analysis. Portable GPS was used for recording the geographic positions (UTM coordinates) of sites.

Soil pH(1:2) and EC(1:2) was determined in soil using EC and pH meter following procedures underlined in USDA Handbook No. 60 [17]. Organic carbon was determined by wetoxidation method [18]. Available nitrogen (N) was determined by alkaline permanganate method [19], available phosphorus (P) content was determined by extracting the soil samples using 0.5M $NaHCO_3$ and analyzed by spectrophotometer

[20] and available potassium was extracted by using neutral normal ammonium acetate and the content was determined by aspirating the extract into flame photometer [21].

The coefficient of variance and range was calculated using MS excel.

3. RESULTS& DISCUSSION:

3.1 Area surveyed: Roving surveys of 20 farmer's field wascarried out duringOctober, 2023.

3.2 Varietal spectrum: The commonly grown rice varieties in scented group werePB 1121, PB 1509, PB 1718, PB 1847 and CSR 30 while the common high yielding non-scented variety and hybrid was PR114 and Vnr 2222, respectively.

3.3 Practices in rice production: In soil, the available nitrogen ranged from 145.36-194.13 kg N/ha, available phosphorus 11.54-19.27 kg P/ha and available potassium 323.2-398kg K_2O/ha in the surveyed sites. Low status of nitrogen in soils is the primary reason for low yield at some sites. Nitrogen being a mobile nutrient in soils leach down below root zone and contaminate ground water. This might be a possible reason for low nitrogen status of the soils. Another reason for depletion of soil nitrogen may be nitrogen loss via NH_3 volatilization from soil or floodwater and denitrification.Unbalanced fertilizer with crop intensification exacerbates the deficiency of this important nutrient [22]. Organic matter increases phosphorus by anion replacement of $H_2PO_4^-$ ion on adsorption sites thereby increasing the quantity of available phosphorus [23]. The soils of these districts are high in potassium content due to alluvial origin and higher micaceous clay content [24]. The grain yield of rice varieties ranged from 2.85-8.85t/ha.The reason for low grain yield in scented genotypes of the surveyed sites may be crop lodging. The straw yield of rice varieties ranged from 5.0-12.0t/ha.Around 70% of surveyed sites were found medium (ranging from 0.5%-0.75%) in organic carbon status.The $pH_{(1:2)}$ and $EC_{(1:2)}$of the surveyed sites ranged from 7.84 to 8.98 and 0.19 to 0.66dS/m, respectively. The surveyed soils were non saline in nature. The probable reason for non saline nature may be low salts in parent material, above average rainfall and good quality irrigation water application due to which salts remains below root zone. Application of sub-optimal doses of herbicides, pesticides and insecticides, raising of nursery in unpuddled fields and rice-wheat sequence were the common practices in all the blocks of surveyed district. The variation in grain yield and soil fertility status might be due to major soil and management related constraints at the sites. Those constraints mainly include low organic carbon (some sites) and nitrogen status of soil, high sodicity at some sites, excessive N dose, improper time of N fertilizer (urea) application and no use of organic source by most farmers.

Table 1: Soil survey report of surveyed sites of Kaithal district of Haryana during *Kharif*, 2023

Site No	Farmers Name	GPS Coordinates		Variety	Grain yield (t/ha)	Straw Yield (t/ha)	$pH_{(1:2)}$	$EC_{(1:2)}$ (dS/m)	Available N (kg/ha)	Available P (kg/ha)	Available K_2O (kg/ha)	Org. Carbon (%)
		Latitude	Longitude									
1	Sh. Dharampal	29.857626	76.647001	CSR 30	2.85	5.1	8.31	0.49	152.09	14.31	328	0.48
2	Sh. Ramesh	29.875852	76.604999	PB 1847	5.5	8.85	8.67	0.22	167.31	12.84	356	0.53
3	Sh. Janesar	29.873293	76.597179	Vnr 2222 (hybrid)	8.85	12.0	8.8	0.57	194.13	11.54	347	0.64
4	Sh. Sukhjeet	29.855438	76.546164	PR 114	6.8	9.65	8.43	0.66	187.28	16.91	398	0.6
5	Sh. Vikram	29.846703	76.52152	PB 1847	5.8	9.0	8.32	0.28	165.49	18.67	378	0.55
6	Sh. Gulab Singh	29.76413	76.410921	PR 114	7.1	10.0	8.54	0.39	176.51	18.99	382	0.59
7	Sh. Balraj	29.716432	76.37073	PB 1718	5.0	7.25	8.89	0.51	193.09	17.17	396	0.67
8	Sh. Sher Singh	29.702489	76.322798	PB 1718	5.2	7.5	8.21	0.55	174.1	15.44	328	0.65
9	Sh. Randhir Singh	29.672769	76.321818	PB 1718	4.85	7.1	8.37	0.34	150.29	14.3	323	0.62
10	Sh. Balbir Bhukal	29.666784	76.275748	PB 1718	4.8	7.35	8.72	0.39	156.42	16.26	355	0.53
11	Sh. Rakesh Kumar	29.812267	76.465702	CSR 30	3.3	5.5	8.24	0.21	152.08	19.27	372	0.51
12	Sh. Manjeet	29.818671	76.498489	CSR 30	3.2	5.0	8.29	0.19	164.77	18.65	326	0.48
13	Sh. Nafe Singh	29.831032	76.313095	PR 114	7.25	9.85	8.31	0.55	169.43	17.42	330	0.46
14	Sh. Dharambir	29.792306	76.321678	CSR 30	3.2	5.4	8.42	0.34	191.74	16.56	341	0.53
15	Sh. Shishpal	29.87391	76.4118	CSR 30	3.55	5.7	8.98	0.52	145.36	13.12	361	0.55
16	Sh. Muktyar Singh	29.651614	76.380955	PB 1718	5.1	7.85	8.13	0.46	178.65	14.87	387	0.59
17	Sh. Jai Bhagwan	29.671717	76.401234	PR 114	7.0	9.6	8.26	0.37	163.94	16.34	395	0.44
18	Sh. Kailash	29.586975	76.490429	PB 1509	4.85	6.8	7.95	0.39	187.44	19.09	358	0.46
19	Sh. Rajender	29.639565	76.506446	PB 1509	5.15	7.5	8.42	0.35	191.03	17.37	347	0.49
20	Sh. Vajir Singh	29.683584	76.523532	PB 1121	5.2	7.85	7.84	0.31	172.84	18.23	344	0.51
	Range				2.85-8.85	5.0-12.0	7.84-8.98	0.19-0.66	145.36-194.13	11.54-19.27	323-398	0.44-0.67
	CV (%)				3.03	2.45	3.49	32.35	9.09	13.85	7.03	12.54

4. CONCLUSION:

Analysis of soil samples revealed pH levels ranged from 7.84 to 8.98 and EC values ranged from 0.19 to 0.66 dS/m indicating the soil were non saline in nature. The organic carbon content varied from 0.44% to 0.67%, with most sites classified as medium in organic carbon status. Soil nutrient analysis indicated varying levels of available nitrogen, phosphorus, and potassium, with deficiencies noted in some sites, particularly in nitrogen content. The study identified common rice varieties grown by farmers, including scented varieties such as PB 1121, PB 1509, PB 1718, PB 1847, and CSR 30, along with high-yielding non-scented varieties like PR114 and Vnr 2222. Grain yields ranged from 2.85 to 8.85 t/ha, while straw yields ranged from 5.0 to 12.0 t/ha. However, certain constraints were observed, such as low soil nitrogen, high pH, sodicity at some sites and improper urea application. Overall, the findings underscore the importance of addressing soil-related constraints to enhance rice productivity in the Kaithal district. Recommendations include optimizing nitrogen management practicesand promoting the use of organic manures to improve soil health and fertility. By implementing targeted interventions informed by these findings, farmers can achieve higher and more sustainable rice yields, contributing to food security and agricultural sustainability in the region.

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