land

Article

Comparative Analysis of Soil Quality Assessment and Its Perception by Rice Farmers

Shakeel Ahmad Mir [1], Nasir Bashir Naikoo [2,*], Fehim Jeelani Wani [3], M. H. Chesti [2], Inayat Khan [2], Eajaz Ahmad Dar [4], Bodiga Divya [5], Navaneet Kumar [6], Prashant Kaushik [7], Hamed A. El-Serehy [8] and Muntazir Mushtaq [9,*]

1 Division of Soil Science, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar 190025, J&K, India
2 Division of Soil Science, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore 193201, J&K, India
3 Division of Statistics, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Wadura, Sopore 93201, J&K, India
4 Krishi Vigyan Kendra, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shuhama, Ganderbal 190006, J&K, India
5 College of Forestry, Sam Higginbottom University of Agricultural, Technology and Sciences, Allahabad 211007, Uttar Pradesh, India
6 Division of Soil Science and Agricultural Chemistry, Dr. Rammanohar Lohia Avadh University, Ayodhya 224001, Uttar Pradesh, India
7 Instituto de Conservación y Mejora de la Agrodiversidad Valenciana, Universitat Politècnica de València, 46022 Valencia, Spain
8 Department of Zoology, College of Science, King Saud University, Riyadh l1451, Saudi Arabia
9 Division of Germplasm Evaluation, ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi 110012, Delhi, India
* Correspondence: nasirsoils02@skuastkashmir.ac.in (N.B.N.); muntazirbt@gmail.com (M.M.)

Citation: Mir, S.A.; Naikoo, N.B.; Wani, F.J.; Chesti, M.H.; Khan, I.; Dar, E.A.; Divya, B.; Kumar, N.; Kaushik, P.; El-Serehy, H.A.; et al. Comparative Analysis of Soil Quality Assessment and Its Perception by Rice Farmers. *Land* **2022**, *11*, 1401. https://doi.org/10.3390/land11091401

Academic Editors: Rossana Marzaioli and Gaurav Mishra

Received: 12 July 2022
Accepted: 19 August 2022
Published: 26 August 2022

Abstract: The present study was conducted in three villages of district Budgam in the union territory of Jammu and Kashmir, to find out how farmers differentiate the quality of soils and to determine the level of concurrence between farmers perception and scientific assessment of soil quality. Five fields in each village were selected and ranked on the basis of soil quality indices computed from the minimum data set of indicators, including plant available nutrients N, P, K, Ca, Mg, S, OC, BD, WHC (water holding capacity), CEC (cation exchange capacity) as well as microbial count. The respondents ranked the same 5 selected fields on the bases of their experience and perceptions of soil quality. The study reveals that 58% of farmers ranked the best soils correctly whereas, the percentage of farmers who ranked 2nd, 3rd, 4th and 5th soils correctly was 40, 30, 40, and 45%, respectively. The study found that a greater number of farmers from the remotest village Dalwash were able to judge the soils properly, thereby indicating more profound knowledge and better cognitive abilities to understand soils in the local context. The results divulged by the current study highlight the remarkable local soil knowledge of the farmers and therefore, linking this knowledge system with scientific concepts would prove valuable for sustained land-use management.

Keywords: local knowledge; rice farmers; soil quality; Kashmir

1. Introduction

Soil quality has been defined as the capacity of a soil to function for specific land uses or within ecosystem boundaries. Therefore, innards of soil quality or soil properties and functions that are critical to specific agro-ecosystems may vary. As a cognitive concept 'soil quality' is ingrained in a given socio-ecological context and is associated with farmers perceptions. There has been increasing recognition in the recent past that local knowledge of farmers can yield insight into soil quality [1].

Local soil knowledge has been defined as "the knowledge people living in a particular environment for some period of time have of soil properties and soil" [2]. It has also been described as being "as much a skill as knowledge" and that it is "the heritage of practical everyday life, with its functional demands" [3]. According to Krasilnikov and Tabor [4] the main components of indigenous soil knowledge are local beliefs, perceptions, local cognitive systems, local management and conservation systems. Local or indigenous cultures and people hold significant knowledge of soils and environments, attained by experience and testing through many generations of living close to the land [5]. Smallholder farmers in traditional farming systems are an untapped source of traditional knowledge [6]. These farmers are often confronted with complex and heterogeneous environments, including different soil qualities of which they develop a systematic knowledge [5]. Understanding the local knowledge of soils has come to be seen as essential in understanding the local realities of people, especially farmers. Even United Nations has stressed that traditional and local knowledge systems enhance agricultural soil quality. Many studies have explored soil quality as a cognitive concept that is embedded in a given socio-ecological context and connected to stakeholders' perceptions [2,7,8]. Various studies perceive the local knowledge of farmers as holistic and rather carefully avoid the use of term "simplistic" [3,9–13]. However, the end results of the farmers' judgment of soil quality/fertility vis-à-vis the scientific methods of soil quality assessment is the crux of the matter. This study has sought to address the questions that are the farmers or how much are the farmers, able to figure out about soil quality, through their experience, that the scientists unravel through the application of modern scientific knowledge. In Kashmir the substantive documentation connected to indigenous soil quality knowledge with regard to the production of field crops, in general, and paddy in particular, is meagre. One of the earliest records of the study of folk soil knowledge is that of Sir Walter Lawrence who carried out the land settlement operations for rationalization of land revenue on the bases of fertility, irrigation facilities, and measurement of the land [14] thus, also fulfilling a purpose of a rudimentary ethnopedological survey. According to Lawrence [15] the Kashmiri people recognize four classes of soil, which require peculiar treatment when under rice cultivation. These classes are known as Grutu (clayey), Bahil (loamy), Sekil (light loam with a sandy sub-soil), and Dazanlad (burnt or hot land). However, in addition to these categories, Khanday and Bhat [16] have mentioned that the Kashmiris also recognise some minor types of land and soils such as Nambal (swamps or marshes), Tend Land, (land on the slopes of the mountains, and reclaimed from the forests), Zabal Zamin (land was injured by percolation from irrigated fields), Khar Zamin (Sour soil), Tresh (didn't hold irrigation water.), Ront (land with a stiff, bad clay which often cakes), Shath (stony, pebbly and sandy soil by mountain rivers), Tats Land (land was rendered too warm by the presence of larger stones) and Karewa (elevated table-land).

Lately, rice cultivation in the district is currently facing some challenges such as a decrease in the cultivated area due to rapid population growth and urbanization, land-use change entailing conversion to apple orchards, and other horticultural plantations. The problem is further confounded by the threat to soil quality in terms of physical, chemical, and biological degradation due to intensification of rice production and use of heavy chemical inputs. The major challenge in fragile ecosystems of the Western Himalayan region, such as the study area, is to understand location specificities and translate them into action points [17]. Since local knowledge of soil and other natural resources is the bedrock of sustainable agriculture [18] therefore, it can enhance and complement our scientific understanding of soil quality and its management. Various studies based on different assessment approaches indicate the fertility and quality deterioration of rice soils in the region [19,20]. To address the issue of declining soil quality, there is a need to recognize the value of indigenous soil knowledge, understand local soil quality indicators and the context in which they are used by the local farmers [11]. In this study, effort has been made to identify the knowledge base of farmers regarding the soil quality assessment, and its agreement with the scientifically quantified soil quality index. The main objectives of the study were: to find out how famers differentiate quality of soils and determine the level of concurrence between farmers' perception and scientific assessment of soil quality.

2. Materials and Methods

2.1. Outline of the Study Area

The study was conducted in three villages namely: Chadoora, Dalwash, and Narkura of District Budgam (Table 1). The study sites fall in the central part of the Kashmir valley and the district on the whole forms part of the Jhelum sub-basin of the Indus basin. The climate of the district is Temperate cum Mediterranean type. The average minimum and maximum temperature vary from −11 °C to 33 °C. The winter season starts in the middle of November and severe winter conditions continue till the middle of February/March. The district receives an average annual precipitation of about 660 mm in the form of rain and snow for about 70 days. Soils of the study area are medium-deep to deep with wide ranges of particle size classes, viz., sandy-skeletal, loamy-skeletal, fragmental, coarse-loamy, and fine-loamy. These soils are classified as Typic Udorthents and Dystric Eutrochrepts in the Mesic temperature regime [21]. Rice is a major crop cultivated over 41% of Net area sown in the district Budgam of Central Kashmir. The district produces 45,000metric tonnes of rice with an average productivity of 1845 qt/ha. The problem is further confounded by the threat to soil quality in terms of physical, chemical, and biological degradation due to the intensification of rice production. Compound growth rates of area, production, and productivity of rice have been estimated as −0.2, −1.2, and −1.0, respectively [22]. Most rice farmers are smallholders with a small holding size of less than 0.5 ha. The rice fields are irrigated by snowmelt waters from small streams that originate from mountains, and traverse topographically lower areas. Farmers use organic manure, mainly obtained from domestic Cattle, as well as inorganic fertilizers such as urea, Diammonium phosphate, and Muriate of Potash. The general recommendation of N for paddy varies from 80 to 120 Kg ha^{-1} for different belts of the district, whereas for P and K it is 60 Kg ha^{-1} and 30 Kg ha^{-1}, respectively. Use of machinery, wherever permitted by terrain and is limited to tractors for tillage and almost all farm households rely partly on paid labour for transplanting and harvesting operations. The demand for locally produced rice is generally ample and fetches fair price to farmers. Rice is a staple food of the people in the valley is consumed at a large scale and locally produced medium bold rice is particularly preferred by consumers due to its peculiar organoleptic characters.

Table 1. Site characterization of the study area.

Site Name	Latitude and Longitude	Elevation (amsl)
(Dalwash)	34°00′ 54.82″ N 74°30′ 58.22″ E	1915.668
(Chadoora)	34° 12′ 57″ N 74° 21′ 49″ E	1633.118
(Narkura)	34°15′ 50″ N 74°18′ 18″ E	1583.741

2.2. Criteria for Site Selection

The five fields in each village were selected from a set of 30–40 fields on the basis of various parameters or soil quality indicators. The size of selected fields in different villages varied from 0.85 to 1.10 ha. The care was taken to choose the fields with different values for most of the various soil quality indicators so that they had different Unscreened Additive Soil Quality Indices. The ranking of five fields in villages: Narkura (N_1 to N_5), Chadoora (C_1 to C_5), and Dalwash (D_1 to D_5) was carried out on the basis of the same index.

2.3. Selection of Farmers for Indigenous Soil Quality Assessment

During the field visits and on-farm training conducted by the Krishi Vigyan Kendra (Farm Science Centre) over a period of 2 years, as well as through focus group discussions, 30 key informant farmers from each of the three villages viz., Chadoora, Dalwash, and Narkura were identified and interviewed. Based on the outcome, a semi-structured questionnaire was developed and administered to elicit information on perceptions of soil fertility characteristics and soil quality, from 20 farmers of each village, and in total 60 practicing farmers were chosen for the final study. The villages represent three agro-ecological situations of the district, as well as three locations at increasing distance from the main urban centre. Only those farmers were chosen who own and work themselves in the fields. Moreover, the interviews were conducted on farmers' fields with heads of the households as the respondents. The farmers/respondents were asked to rank the 5 selected fields on the bases of their experience and perceptions of soil quality.

2.4. Soil Sampling and Analysis

Composite soil samples were collected from each of the five fields from every village, with three replicates. Every replicate sample was composited from 20 subsamples randomly collected, pooled, and sieved through a 2 mm mesh. Bulk density and water holding capacity were determined immediately after soil sampling by using separate cores. Water holding capacity was measured by the gravimetric method [23]. Bulk density was estimated by the core method [24]. Total organic carbon in the soil was determined by the wet oxidation method [25]. The percentage of clay, sand, and silt were determined by the hydrometer method [26]. Electrical conductivity and reaction of the soil samples were determined in 1:2.5 soil: water ratio (w/v) with the help of a combined electrode for EC and pH, as per the procedure given by [27]. Available N was determined by the Alkaline Permanganate Method [28]. Olsen's extractant 0.5 M $NaHCO_3$ (pH 8.5) was used for the extraction of available phosphorus. Phosphate in the extract was determined colourimetrically by the ammonium molybdate blue colour method using a spectrophotometer at 760 nm [29]. Available K was determined in the neutral normal ammonium acetate extract of soil with help of a flame photometer [27]. Available Sulphur was determined with 0.15% $CaCl_2$ solution and the S in the extract was estimated turbidmetrically [30]. Exchangeable calcium and magnesium were estimated in the ammonium acetate extract of soil by titration with EDTA [27]. Cation exchange capacity (CEC) was estimated following method of Jackson [27].

2.5. Laboratory Method of Soil Quality Assessment

The unscreened additive index was computed as the summation of scores of all the indicators studied, and the sum was divided by the total number of indicators used [31] which is according to the following formula:

$$\textbf{Soil quality index (SQI)} = \sum_{i=1}^{n} Si/n$$

where, S denotes linear score of observed soil quality indicator and n is the number of indicators included in the index.

Potential SQ indicators (Tables 2–4) were selected based on their sensitivity to management practices, ability to describe major soil processes, ease and cost of sampling and laboratory analysis, and significance in increasing productivity and protecting environmental soil functions. Using Expert Opinion (EO) approach MDS (minimum data set) variables were chosen from the potential indicators based on researcher knowledge and literature recommendations [32,33]. The variables pH and EC were excluded from the data set because these two properties do not limit the soil function as they are always found in the normal range in soils of the study area [19,34]. After identifying the MDS indicators, every observation of each indicator was transformed using a linear scoring method as suggested by Andrew [2]. To assign the scores, indicators were arranged in order depending on whether a higher value was considered "good" or "bad" in terms of soil functions. In the case of "more is better" indicators, each observation was divided by the highest observed value such that the highest score received a value of 1. For "less is better" indicators, the lowest observed value (in the numerator) was divided by each observation (in the denominator) such that lowest observed value received a score of 1. In this study, almost all of the indicators in the MDS were considered good from the viewpoint of soil quality when they are in increasing order, and hence the "more is better" approach was followed, except in the case of bulk density where 'lesser is better' approach was considered [35].

Table 2. Physico-chemical properties of soils in the villages.

Field/Village	EC (dsm^{-1})	pH	BD ($Mg\ m^{-3}$)	Clay %	MWHC(%)	CEC (cmol (+) Kg^{-1})
			Narkura			
N_1	0.23	7.12	1.17	34.76	50.33	22.12
N_2	0.21	6.69	1.21	32.90	47.19	20.11
N_3	0.11	6.77	1.25	32.26	46.93	18.52
N_4	0.19	7.26	1.18	29.33	42.04	16.75
N_5	0.18	7.29	1.29	25.76	40.12	15.28
Mean	0.18	7.03	1.22	31.00	45.32	18.56
SE (Mean)	0.01	0.07	0.01	0.91	1.07	0.70
CD ($p < 0.05$)	0.04	0.23	0.04	2.93	3.45	2.24
SD	0.05	0.28	0.05	3.52	4.15	2.70
CV (%)	24.79	3.97	4.10	11.36	9.16	14.54
			Chadoora			
C_1	0.15	7.22	1.08	37.76	48.66	19.40
C_2	0.28	7.02	1.23	34.76	46.98	18.60
C_3	0.15	6.46	1.24	35.30	48.37	19.55
C_4	0.16	7.37	1.16	33.33	48.10	17.38
C_5	0.20	6.75	1.26	23.93	45.60	16.35
Mean	0.19	6.96	1.19	33.02	47.54	18.26
SE (Mean)	0.01	0.09	0.02	1.37	0.32	0.35
CD ($p < 0.05$)	0.05	0.30	0.06	4.43	1.05	1.14
SD	0.06	0.37	0.07	5.32	1.26	1.37
CV (%)	29.47	5.24	6.20	16.13	2.65	7.50
			Dalwash			
D_1	0.24	6.48	1.10	30.10	56.82	18.34
D_2	0.12	6.70	1.16	29.43	54.34	17.45
D_3	0.31	6.55	1.22	32.00	51.43	16.44
D_4	0.14	7.17	1.23	29.76	47.95	17.42
D_5	0.26	6.76	1.19	21.30	44.85	16.12
Mean	0.21	6.73	1.18	28.52	51.08	17.15
SE (Mean)	0.02	0.07	0.01	1.07	1.24	0.23
CD ($p < 0.05$)	0.07	0.22	0.04	3.46	3.99	0.74
SD	0.08	0.27	0.05	4.16	4.80	0.89
CV (%)	37.91	4.00	4.44	14.57	9.40	5.17

Table 3. Organic carbon and available nutrients in the soils of different villages.

Field/Village	OC %	N ($mgKg^{-1}$)	P ($mgKg^{-1}$)	K ($mgKg^{-1}$)	S ($mgKg^{-1}$)	Ca ($cmolcKg^{-1}$)	Mg ($cmolcKg^{-1}$)
				Narkura			
N_1	1.15	140.61	12.18	177.82	11.52	14.05	3.11
N_2	0.91	132.25	12.14	158.02	11.13	12.81	2.72
N_3	0.75	132.20	11.70	148.05	10.19	11.99	2.65
N_4	0.65	110.70	10.52	135.57	9.60	9.98	2.58
N_5	0.68	97.51	8.54	130.07	8.48	8.72	1.96
Mean	0.83	122.65	11.02	149.91	10.18	11.51	2.60
SE (Mean)	0.05	4.62	0.40	4.91	0.31	0.56	0.11
CD ($p < 0.05$)	0.17	14.88	1.28	15.82	1.01	1.79	0.34
SD	0.21	17.89	1.54	19.02	1.22	2.15	0.41
CV (%)	24.90	14.59	13.96	12.69	11.95	18.68	15.91

Table 3. *Cont.*

Field/Village	OC %	N (mgKg^{-1})	P (mgKg^{-1})	K (mgKg^{-1})	S (mgKg^{-1})	Ca (cmolcKg^{-1})	Mg (cmolcKg^{-1})
				Chadoora			
C$_1$	1.43	180.28	14.68	152.98	12.87	12.77	3.33
C$_2$	1.18	150.56	12.58	140.99	12.05	11.59	3.00
C$_3$	0.77	132.24	11.75	143.12	10.64	11.71	3.13
C$_4$	0.69	102.86	10.01	139.25	11.16	10.79	2.79
C$_5$	0.66	80.85	10.15	142.18	10.71	9.35	2.9
Mean	0.95	129.36	11.83	143.70	11.49	11.24	3.03
SE (Mean)	0.09	10.09	0.50	1.39	0.25	0.33	0.05
CD ($p < 0.05$)	0.28	32.48	1.60	4.48	0.80	1.06	0.17
SD	0.34	39.07	1.93	5.38	0.96	1.27	0.21
CV (%)	36.13	30.20	16.27	3.75	8.33	11.30	6.91
				Dalwash			
D1	1.52	229.38	14.54	229.01	14.13	11.61	4.15
D$_2$	1.26	206.90	13.48	202.53	14.87	10.47	3.88
D$_3$	1.10	181.79	12.35	173.50	13.37	9.73	2.86
D$_4$	0.82	130.83	12.65	146.75	11.98	10.5	2.94
D$_5$	0.71	127.39	11.44	142.43	11.95	9.12	2.97
Mean	1.08	175.26	12.89	178.84	13.26	10.29	3.36
SE (Mean)	0.08	11.72	0.30	9.54	0.33	0.24	0.16
CD ($p < 0.05$)	0.27	37.73	0.98	30.72	1.08	0.78	0.50
SD	0.33	45.38	1.17	36.95	1.30	0.94	0.61
CV (%)	30.33	25.89	9.11	20.66	9.77	9.10	18.06

Table 4. Linear Scores of soil quality indicators and soil quality indices of various fields in the villages.

Village /Field	——————————Score——————————-													
	OC	N	P	K	S	Ca	Mg	WHC	Clay	BD	CEC	BC	FC	AC	SQI
							Narkura								
N$_1$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**1.00**
N$_2$	0.79	0.94	1.00	0.89	0.97	0.91	0.87	0.94	0.95	0.97	0.91	0.94	0.95	0.27	**0.88**
N$_3$	0.65	0.94	0.96	0.83	0.88	0.85	0.85	0.99	0.98	0.94	0.92	0.93	0.81	0.55	**0.86**
N$_4$	0.57	0.79	0.86	0.76	0.83	0.71	0.83	0.90	0.91	0.99	0.90	0.84	0.83	1.24	**0.85**
N$_5$	0.59	0.69	0.70	0.73	0.74	0.62	0.63	0.95	0.88	0.91	0.91	0.80	0.61	0.41	**0.73**
							Chadoora								
C$_1$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	**1.00**
C$_2$	0.85	0.84	0.87	0.92	0.95	0.91	0.88	0.97	0.92	0.89	0.96	0.28	0.40	0.07	**0.80**
C$_3$	0.54	0.73	0.80	0.94	0.83	0.92	0.79	0.99	1.00	0.99	1.00	0.41	0.57	0.08	**0.76**
C$_4$	0.48	0.57	0.68	0.91	0.86	0.83	0.72	0.98	0.94	0.92	0.89	0.75	0.65	0.28	**0.73**
C$_5$	0.46	0.45	0.69	0.93	0.83	0.73	0.67	0.94	0.72	0.92	0.84	0.75	0.82	0.22	**0.70**
							Dalwash								
D1	1.00	1.00	1.00	1.00	0.95	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	0.70	**0.97**
D$_2$	0.83	0.90	0.93	0.88	1.00	0.90	0.92	0.96	0.92	0.95	0.95	0.93	0.83	1.00	**0.92**
D3	0.72	0.79	0.85	0.76	0.95	0.84	0.82	0.91	1.00	0.90	0.90	0.73	0.75	0.28	**0.80**
D$_4$	0.54	0.57	0.87	0.64	0.85	0.90	0.73	0.84	0.93	0.89	0.95	0.68	1.01	0.28	**0.76**
D$_5$	0.47	0.56	0.79	0.62	0.85	0.79	0.68	0.79	0.67	0.92	0.88	0.46	0.48	0.19	**0.65**

BC = Bacterial count, FC = Fungal count and AC = Actinomycetes count.

2.6. Stastistical Analysis

Descriptive statistical analyses were performed in SPSS version 21.0 (SPSS, 2014). Scores were computed in MS Excel ^{TM} spreadsheet using SOLVER Tab for cyclic iteration of 100, precision 0.000001, tolerance 5% and convergence 0.0001. Chi square test was used to find out the agreement/disagreement between rank by farmers and experts.

3. Results and Discussion

3.1. Physico-Chemical Characteristics of Soils

The soils of the different villages did not differ much in terms of their pH values, and it varied from neutral to near-neutral. However, the lower pH values were found to be associated with the fields of Dalwash village which is due to higher precipitation and lower mean temperature associated with higher topographic locations that result in slow decomposition of organic matter that releases acids. The lower pH values in the plots at higher altitudes with higher precipitation may also be associated with the leaching of basic cations and clay fractions as indicated by values of clay and CEC. The percentage of soil clay content in the fields (N_1 to N_5) of Narkura village ranged from 25.76 to 34.76, whereas in the fields of Chadoora (C_1 to C_5) and Dalwash (D_1 to D_5) it varied from 23.93 to 37.76 and 21.30 to 30.10, respectively. SOC (%) varied from 0.65 to 1.15% in the soils of Narkura, 0.66 to 1.43 in Chadoora, and 0.71 to 1.52 in Dalwash soils (Table 2).

3.2. Organic Carbon and Available Nutrients in the Soils of Different Villages

Available N content of soils in the villages varied from 64.68 to 183.50 mgKg^{-1}, relatively higher available N content was observed in soils of Dalwash (high OM, Low temp, High altitude). Available P content in soils ranged from 8.54 to 14.68 mgKg^{-1}, whereas available K was observed in the range of 130 to 229 mgKg^{-1} (Table 3). Highest available S in soil (14.13 mgKg^{-1}) was found in the field D_2 of Dalwash village and lowest value (8.48 mgKg^{-1}) pertained to field N_5 of Narkura. The exchangeable Ca of the soils in different villages varied from 8.72 to 14.05 cmol (+) Kg^{-1}, whereas exchangeable Mg ranged from 1.96 to 4.15 cmol (+) Kg^{-1}. In general, the mean values for OC, available NPKS, and exchangeable Mg are higher in the soils of Dalwash, however, the mean exchangeable Mg level was found to be higher in the soils of Narkura village. Available nutrients of most of the fields fall in the medium range as per the availability indices adopted for this region.

3.3. Soil Quality of Paddy Fields

The Minimum Data Set framed for this study consisted of 14 physical, chemical and biological parameters: OC, N, P, K, S, Ca, Mg, clay%, BD, WHC, CEC, bacterial count (BC), fungal count (FC) and actinomycetes count (AC) as indicators of soil quality. Linear Scores of various soil quality indicators and soil quality indices of the fields in three villages are given in (Table 4). In Narkura village the SQI of the fields varied from 0.73–1.00. In this village the highest ranked field has the greatest values and scores for all the SQ indicators and therefore, the SQ index value of 1, indicating no limitations to soil quality. Subsequently, limitations to soil quality of the rest of the fields increase with decline in scores of one or more indicators and consequently decrease in the SQ index value. The least value for SQ that is 0.73, was recorded in field N_5 which suggests 27% limitation in soil quality in comparison to N_1, the best ranked field. In Chadoora SQ varied from 0.70 to 1.00, whereas in Dalwash it ranged between 0.65–0.97, the variation in SQ of the fields can be interpreted similarly.

3.4. Farmers Cognitive Assessment of Soil Quality

Farmers descriptors of soil quality and preference included mostly the soil colour, physical condition and crop appearance (Figure 1). However, elevation along the slope was also considered an important indicator by many farmers. Colour was found to be the most popular descriptor of good soil. Farmers associated dark black colour with high fertility and water-holding capacity. A perusal of the farmers responses revealed that soil colour, in addition to other parameters was used by 95% of the respondent farmers. Similarly, the physical condition of soils (texture, moisture etc.) and crop appearance as descriptors of soil quality, in addition to other parameters, appeared in 75% of farmers' responses. The location along the slope was used to assess the soil quality by 30% of the respondents. However, when asked the question of 'what case can soil colour be misleading as an indicator of soil quality? Or simply, can a light coloured soil be better than a dark coloured one?', about 61% of respondent farmers pointed to a situation when the soil is dark but may be of bad quality and support poor yield. The most frequent reason cited by the farmers was that a dark colour soil may be exhausted due to continuous cultivation and lack some key elements required for crop growth. Thus, hinting at the low level of micronutrients which indeed, is the case with intensively cultivated, monocropped rice fields of this region. In this case, 55% farmers associated finer texture or 'stickiness' due to higher clay content with better soil water retention and quality. Most farmers used the term *lembil* to refer to soil with this property. Farmers considered slope as an essential factor of soil quality and apparently, they knew that higher quantities of water are required to wet soils with higher clay content. Farmers gave higher ranks to soils on foot slopes as these are regarded as more fertile compared to up-slope and mid-slope soils. Seemingly, farmers knew the difference in fertility due to the removal of soil and nutrient, as well as better moisture availability of the soils at lower topographic positions. Farmers relied on crop production factors such as plant height, colour and firmness to differentiate good soil from bad soil. Crop appearance or yield as the most common benchmark for soil quality in the indigenous approach from various countries has been reported in many studies [36–38].

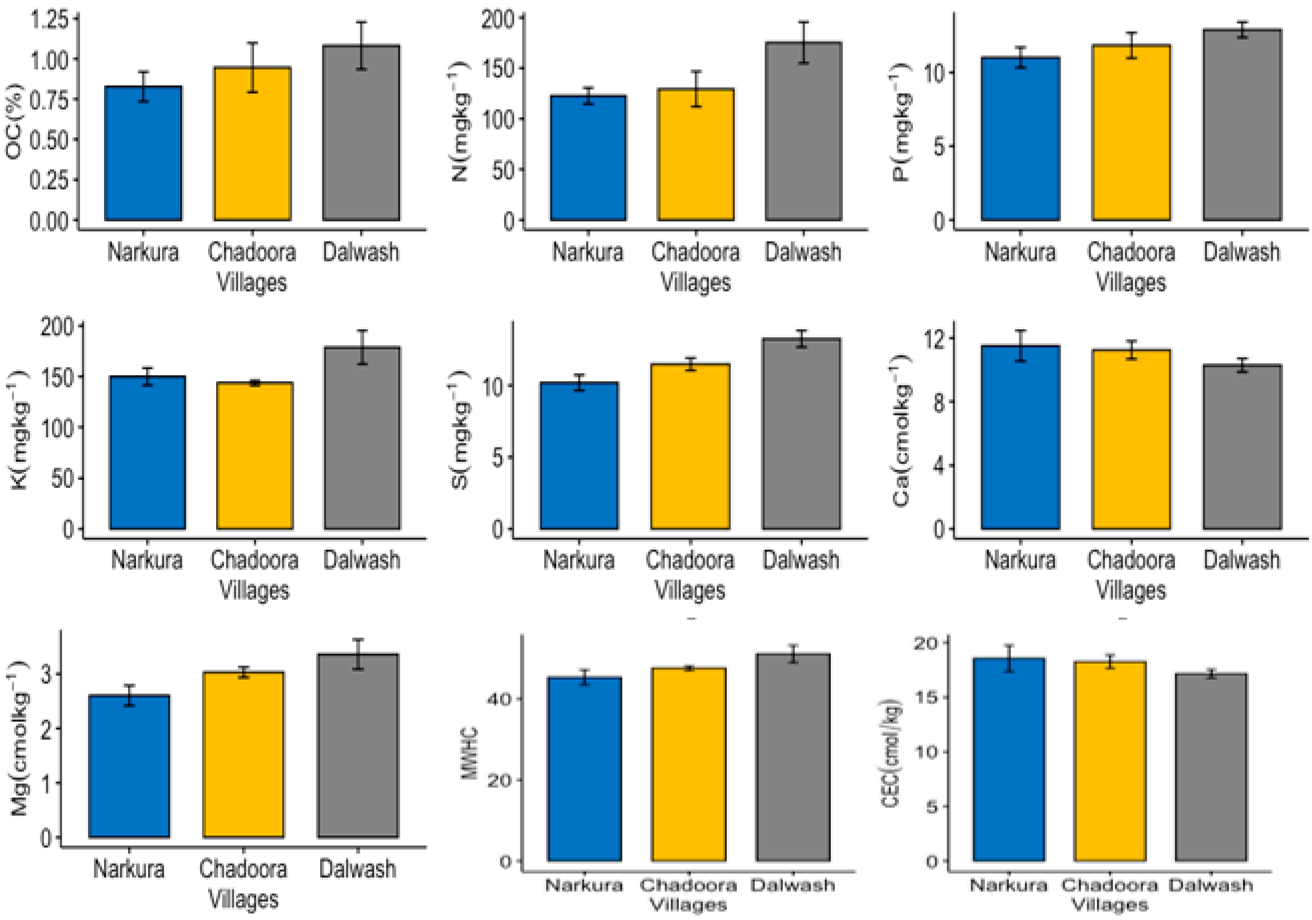

Figure 1. Soil quality indicators of the selected fields in the study villages.

3.5. Comparison of Farmers and Laboratory Assessment of Soil Quality

The selected farmers groups from each village ranked the fields on the basis of their experience and observation. In Narkura, about 50% farmers correctly assigned the Rank 1 to N_1 Field (SQI = 1.0), 40%farmers ranked the N_2 (SQI = 0.88) correctly (Table 5). Similarly, soils from fields N_3 (SQI = 0.86), N_4 (SQI = 0.85) and N_5 (SQI = 0.73) were rightly ranked by 30%, 40% and 45% respondents. Interestingly, the small differences between soil quality indices of soils N_2, N_3 and N_4 as well as N_4 and N_5 are reflected in the farmers response wherein the most farmers have been unable to differentiate and correctly rank those soils. Only 10% farmers judged all the soils (N_1 to N_5) correctly as per their original SQI rank. In the village Chadoora, 55%, 40%, 46%, 40% and 60% farmers assigned the correct ranks to five different fields (C_1 to C_5). In this village 15% farmers judged all the soils correctly as per their original SQI rank. In Dalwash, the remotest village among the three villages, about 70% farmers correctly assigned the Rank 1 to D_1 Field (SQI = 0.97), 40% farmers ranked the D_2 (SQI = 0.92) correctly. Similarly, soils from fields D_3, D_4 and D_5 were rightly ranked by 45%, 40% and 75% respondents. The percentage of farmers who rightly ranked all the soils was found to be 20% which is highest among the villages. Viewed as a whole, the 58% farmers of the study areas ranked the best soils correctly, whereas the percentage of farmers who ranked the 2nd, 3rd, 4th and 5th ranked soils correctly was 40, 30, 40 and 45, respectively. The study reckons that higher number of farmers from the remotest village, that is, Dalwash are able to judge the soils better, thereby indicating more profound knowledge and better cognitive abilities to understand the soils in the local context. The results divulged by this study highlight the remarkable local soil knowledge of the farmers and therefore, linking of this knowledge system with scientific concepts would prove valuable for sustained land-use management.

Table 5. Comparison of farmers' assessment of soils vis-à-vis scientific assessment.

Dalwash						
	Ranks	Rank by Farmers				
		1	2	3	4	5
Rank by Experts	1	14 (70.00)	5 (25.00)	1 (5.00)	0 (0.00)	0 (0.00)
	2	6 (30.00)	8 (40.00)	4 (20.00)	2 (10.00)	0 (0.00)
	3	0 (0.00)	6 (30.00)	9 (45.00)	5 (25.00)	0 (0.00)
	4	0 (0.00)	1 (5.00)	6 (30.00)	8 (40.00)	5 (25.00)
	5	0 (0.00)	0 (0.00)	0 (0.00)	5 (25.00)	15 (75.00)
Chi-square statistic = 115, df = 16, *p*-value < 0.001						
Chadoora						
Rank by Experts	1	11 (55.00)	8 (4.00)	1 (5.00)	0 (0.00)	0 (0.00)
	2	8 (40.00)	6 (30.00)	4 (20.00)	2 (10.00)	0 (0.00)
	3	1 (5.00)	4 (20.00)	12 (60.00)	2 (10.00)	1 (5.00)
	4	0 (0.00)	2 (10.00)	3 (15.00)	8 (40.00)	7 (35.00)
	5	0 (0.00)	0 (0.00)	0 (0.00)	8 (40.00)	12 (60.00)
Chi-square statistic = 101.5, df = 16, *p*-value < 0.001						
Narkura						
Rank by Experts	1	10 (50.00)	6 (30.00)	3 (15.00)	1 (5.00)	0 (0.00)
	2	6 (30.00)	8 (40.00)	5 (25.00)	1 (5.00)	0 (0.00)
	3	2 (10.00)	5 (25.00)	6 (30.00)	3 (15.00)	4 (20.00)
	4	1 (5.00)	1 (5.00)	3 (15.00)	8 (40.00)	7 (35.00)
	5	1 (5.00)	0 (0.00)	3 (15.00)	7 (35.00)	9 (45.00)
Chi-square statistic = 56.5, df = 16, *p*-value < 0.001						

Figures in the parentheses are percent farmers given respective ranks.

4. Conclusions

This study focused on the outcome of farmers judgment of local soil quality and its agreement with the general scientific soil quality assessment method based on analysed soil properties. The study brings to fore the fact that a significant number of respondent farmers were able to figure out the quality of the soils by relying on indigenous knowledge and their cognitive skills. The investigation divulges that farmers' cognitive assessments of soil quality based on specific agro-ecosystems and situations, although not very precise, are remarkable. Local soil knowledge of farmers is an untapped resource that may serve the purpose of overcoming the shortcomings of scientific intervention, Therefore, in this ecologically sensitive Himalayan region, soil and nutrient management interventions based solely on generalized scientific thinking need to reconcile with the rationale of farmers which is related to the compatibility of the recommended technologies with the specific biophysical environment.

Author Contributions: Conceptualization, S.A.M.; methodology, S.A.M. and N.B.N.; validation, M.H.C., P.K., H.A.E.-S. and I.K.; formal analysis, N.B.N., F.J.W. and M.M.; investigation, S.A.M., M.H.C., I.K., P.K. and H.A.E.-S.; software, B.D. and N.K.; resources, N.B.N., F.J.W., N.K., B.D., E.A.D. and M.M.; data curation, F.J.W., E.A.D. and M.M.; writing—original draft preparation, S.A.M., N.B.N., M.H.C. and I.K.; writing—review and editing, F.J.W., E.A.D., B.D., N.K., P.K., H.A.E.-S. and M.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by King Saud University Researchers Supporting Project Number (RSP-2021/19), King Saud University, Riyadh, Saudi Arabia.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data may be made available on request from the corresponding author.

Acknowledgments: The author express the deepest appreciation to Division of Soil Science, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, for providing all the necessary facilities, suggestion, and help to complete the research. The authors also extend their sincere appreciation to the Researchers Supporting Project Number (RSP-2021/19), King Saud University, Riyadh, Saudi Arabia.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Lima, A.C.R.; Hoogmoed, W.B.; Brussaard, L.; Sacco dos Anjos, F. Farmers' assessment of soil quality in rice production systems. *NJAS-Wagening. J. Life Sci.* **2011**, *58*, 1–38. [CrossRef]
2. Andrews, S.S.; Flora, C.B.; Mitchell, J.P.; Karlen, D.L. Growers' perceptions and acceptance of soil quality indices. *Geoderma* **2003**, *114*, 187–213. [CrossRef]
3. Sillitoe, P. Knowing the land: Soil and land resource evaluation and indigenous knowledge. *Soil Use Manag.* **1998**, *14*, 188–193. [CrossRef]
4. Krasilnikov, P.; Tabor, J. Ethnopedology and Folk Soil Taxonomies. In *Soils, Plant Growth and Crop Production*; Verheye, W.H., Ed.; UNESCO EOLSS Publishers: Oxford, UK, 2009; Volume 3, p. 31.
5. Winklerprins, A.M.G.A.; Sandor, J.A. Local soil knowledge: Insights, applications, and challenges. *Geoderma* **2003**, *111*, 165–170. [CrossRef]
6. Das, T.; Das, A.K. Managing Rice Biodiversity by Smallholder Farmers: A Case Study in Barak Valley, Assam. *Indian J. Plant Genet. Resour.* **2006**, *19*, 12–18.
7. Murage, E.W.; Karanja, N.K.; Smithson, P.C.; Woomer, P.L. Diagnostic indicators of soil quality in productive and non-productive smallholders' fields of Kenya's Central Highlands. *Agric. Ecosyst. Environ.* **2000**, *79*, 1–8. [CrossRef]
8. Scalerandi, A. Farmer Perception of Soil Quality as Related to Soil Management for Horticultural Systems; a Case Study of Agroecology Oriented Farms in Piemonte, Italy. Master's Dissertation, Farming Systems Ecology Group—Wageningen University of Research, Wageningen, The Netherlands, 2015.
9. Desbiez, A.; Matthews, R.; Tripathi, B.; Ellis-Jones, J. Perceptions and assessment of soil fertility by farmers in the mid hills of Nepal. *Agric. Ecosyst. Environ.* **2004**, *103*, 191–206. [CrossRef]
10. Barrera-Bassols, J.N.; Zinck, A.; Ranst, E.V. Symbolism, Knowledge and Management of Soil and Land Resources in Indigenous Communities: Ethnopedology at global, regional and Local Scales. *Catena* **2006**, *65*, 118–137. [CrossRef]
11. Barrios, E.; Bekunda, M.A.; Delve, R.J.; Esilaba, A.O.; Mowo, J.; Zapata Sánchez, V. *Identifying and Classifying Local Indicators of Soil Quality: Methodologies for Decision Making in Natural Resource Management: Eastern Africa Version*; CIAT: Cali, Colombia, 2000.
12. Douglas, E.; Romig, M.; Jason, G.; Robin, F.H.; Mc Sweeney, K. How farmers assess soil health and quality. *J. Soil Water Conserv.* **1995**, *50*, 229–236.

13. Ingram, J.; Fry, P.; Mathieu, A. Revealing different understandings of soil held by scientists and farmers in the context of soil protection and management. *Land Use Policy* **2010**, *27*, 51–60. [CrossRef]
14. Shiekh, A.R. Changing Agrarian Landscape of Kashmir: A Case Study of Lawrence Settlement. In Proceedings of the Indian History Congress; Indian History Congress: New Delhi, India, 2012; Volume 73, pp. 844–852.
15. Lawrence, W.R. *The Valley of Kashmir*; H. Frowde: London, UK, 1895.
16. Khanday, S.A.; Bhat, J. Shaping of Peasant Economy: Classification of Land and Agricultural Technology in Kashmir during Dogra's 1885–1925 A.D. *Int. J. Curr. Res.* **2014**, *6*, 5119–5122.
17. Barah, B.C. Hill Agriculture: Problems and Prospects for Mountain Agriculture. *Indian J. Agric. Econ.* **2010**, *65*, 584–601.
18. Leopold, A. *For the Health of the Land: Previously Unpublished Essays and Other Writings*; Island Press: Washington, DC, USA, 2001.
19. Nisar, M.; Lone, F.A. Effect of Land use/Land cover Change on Soils of a Kashmir Himalayan Catchment-Sindh. *Int. J. Res. Earth Environ. Sci.* **2013**, *11*, 13–27.
20. Sofi, J.A.; Bhat, A.G.; Kirmai, N.A.; Wani, J.A.; Lone, A.H.; Ganie, M.A.; Dar, G.I.H. Soil quality index as affected by different cropping systems in northwestern Himalayas. *Environ. Monit. Assess.* **2016**, *188*, 1–13. [CrossRef] [PubMed]
21. Sidhu, G.S.; Surya, J.N. Soils of North-Western Himalayan eco-system and their land use, constraints, productivity potentials and future strategies. *Agropedology* **2014**, *24*, 1–19.
22. Rather, S. Production and Productivity Trends of Paddy Cultivation in Jammu&Kashmir. *Indian J. Res.* **2014**, *3*, 42–44.
23. Allen, S.E. *Chemical Analysis of Ecological Materials*; Blackwell Scientific Publications: Oxford, UK, 1989.
24. Blake, G.R.; Hartge, K.H. Bulk density. In *Methods of Soil Analysis. Part I. Physical and Mineralogical Methods, Agronomy Monograph No. 9*, 2nd ed.; Klute, A., Ed.; American Society of Agronomy: Madison, WI, USA, 1986; pp. 363–375.
25. Walkley, A.J.; Black, C.A. An estimation of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* **1934**, *37*, 9–38. [CrossRef]
26. Piper, C.S. *Soil and Plant Analysis*; Hans Publisher: Bombay, India, 1966.
27. Jackson, M.L. *Soil Chemical Analysis*; Prentice Hall of India Pvt. Ltd.: New Delhi, India, 1973.
28. Subbiah, B.V.; Asija, G.L. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.* **1956**, *25*, 259–260.
29. Olsen, S.R.; Cole, C.V.; Watanabe, F.S.; Dean, L.A. *Estimation of Available Phosphorus in Soils by Extraction with Sodium Carbonate*; USDA: Lola, KS, USA, 1954; p. 939.
30. William, C.H.; Steinbergs, A. Soil sulphur fractions aschemical indices of available sulphur in some Australian soils. *Aust. J. Agric. Res.* **1959**, *10*, 340–352. [CrossRef]
31. Velmurugan, A. Assessment of Soil Quality Parameters for Sustainable Production in Rice-Wheat Cropping System. Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi, India, 2000.
32. Doran, J.W.; Parkin, T.B. Defining and assessing soil quality. In *Defining Soil Quality for a Sustainable Environment*; Doran, J.W., Bezdicek, D.F., Coleman, D.C., Stewart, B.A., Eds.; American Society of Agronomy: Madison, WI, USA, 1994; pp. 3–21.
33. Tandon, H.L.S. *Methods of Analysis of Soils, Plants, Waters, Fertilizers and Organic Manures*; Tandon, H.L.S., Ed.; Fertilizer Development Consultation Organization: New Delhi, India, 2005; pp. 152–182.
34. Ramzan, S.; Bhat, M.A.; Kirmani, N.A.; Rasool, R. Fractionation of Zinc and their Association with Soil Properties in Soils of Kashmir Himalayas. *Int. Inv. J. Agric. Soil Sci.* **2014**, *2*, 132–142.
35. Harris, R.F.; Karlen, D.L.; Mulla, D.J. A Conceptual Framework For Assessment and Management of Soil Quality and Health. In *Methods for Assessing Soil Quality*; Soil Science Society of America: Madison, WI, USA, 1996; pp. 61–82.
36. Mairura, F.S.; Mugendi, D.N.; Mwanje, J.I.; Ramisch, J.J.; Mbugua, P.K. Assessment of farmers' perceptions of soil quality indicators within smallholder farms in the central highlands of Kenya. In *Advances in Integrated Soil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities*; Springer: Dordrecht, The Netherlands, 2014; pp. 1035–1046.
37. Schmidhuber, J.; Tubiello, F.N. Global food security under climate change. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 19703–19708. [CrossRef] [PubMed]
38. Tesfahunegn, G.B. Soil Quality Assessment Strategies for Evaluating Soil Degradation in Northern Ethiopia. *Appl. Environ. Soil Sci.* **2014**, *2014*, 1–14. [CrossRef]