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Baseline Soil Information and Management of a Salt-Tolerant Forage Project Site in Pakistan

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Abstract

The International Center for Biosaline Agriculture (ICBA), Dubai is implementing a salt-tolerant forage project in Pakistan in collaboration with Nuclear Institute for Agriculture and Biology Faisalabad. Pakistan is one of the seven partner countries (Tunisia, Palestine, Syria, Jordan, United Arab Emirates and Oman) where this project is implemented. Prior to any agricultural project initiation, it is essential to establish baseline soil information to understand soil conditions to prepare management plans to utilize the site optimally to achieve the objectives. It is also important to assign internationally recognized soil name to the experimental site for the wider acceptance of project findings /results by the international scientific community. This paper presents soil assessment results and management options of a project site at Shorkot, Pakistan. Specifically it presents physical and chemical characteristics, soil classification and management issues, as well as highlighting the limitations and constraints inherent at the site and suggests recommendations needed to overcome or reduce the limitations. The site presents variable texture at different depths, the ***argillic*** horizon (at 15-35 cm depth) is 20 cm thick silty clay (49% clay). The entire profile is calcareous and saline-sodic, surface salinity is the highest (ECe 64.2 dS/m). The soil type as per USDA Soil Taxonomy is coarse-loamy, mixed, hyperthermic Typic Natrargid. To offset high sodicity addition of soil amendment such as gypsum is required, as well as leaching of soil salinity from root zone. This paper is unique in its scope and purpose. The researchers may use the results of the forage project to apply in other areas where such a type of soil will occur with great confidence and avoids conducting long term experiments.

Keywords: Soil information; Soil management; Salt-tolerant forage; Soil taxonomy; Pakistan.

1. Introduction

The International Center for Biosaline Agriculture (ICBA) Dubai has started a salt-tolerant forage project jointly funded by International Fund for Agriculture Development (IFAD), Arab Fund for Economic and Social Development (AFESD) & OPEC Fund for International Development (OFID) in collaboration with national agricultural systems of Jordan, Syria, Palestine, Oman, UAE, Tunisia and Pakistan.

On a worldwide basis, national and international research centers involved with agricultural research routinely have detailed soil mapping made for their experimental sites (Kamara & Haque 1987 & 1990; Ryan et al, 1997). Once the soil information is documented, these sites are used to conduct applied research transferable to, and beneficial for, scientists and the farming community through the establishment of guidelines for sustainable farming (SFRI, 1995). It is difficult to imagine any national agricultural research system (NARS) without complete knowledge of the soil conditions within which field experimentation is conducted. The value of any experimental site, however, is limited by the extent to which the site is representative of the agro-ecological conditions of the surrounding environment. Therefore, initial and final site assessment is necessary to provide an overview of field conditions and the impact of interventions on soil environment.

1.1. Why a Site Assessment is Required?

The purpose of site assessment and sampling is to observe and quantify what is at a prescribed experimental site. The observed data combined with knowledge of landscape development , soil development and processes allows the assessor to predict its behavior for future experiments. Therefore, site assessment is believed to be pre-requisite in any agricultural project activities to understand soil conditions to prepare experimental plans, to forecast responses of soil to various treatments, and for the wider acceptance of project findings by the international scientific community when an internationally recognized name is given to the soil type.

The authors strongly believe on the fact that the lack of initial soil related information usually leads to failure many projects particularly the soil and irrigation management, because the soils were not studied systematically prior to implementing the project, and the responses of soil to project treatments were merely ignored. Therefore, a preliminary site assessment is must to achieve successful results from the project activities.

Particularly for this nature of the project initial salinity measurement and monitoring through out the course of the project is very important. Firstly, it provides salinity status that can be correlated to the "***threshold salinity values***" of the selected forages and provides important information to base their selection or rejection on the selected site, and/or to adopt certain management practices (leaching requirement, amendment use) to improve experimental conditions. Secondly, the salinity monitoring during the course of the project will provide information to adjust experimental plan to best suit the project needs.

1.2. Why Soil Taxonomic Name of Project Site?

If an internationally recognized soil classification system is used, international technology transfer is possible as similar soils anywhere in the world can be easily identified and successful management practices can be copied without the need for extensive local trials. In this assessment the latest norms and standards of the United States Department of Agriculture Soil Taxonomy, 2006 revision (USDA-NRCS, 1999, 2006) have been used for soil classification. Although this was first developed for use in United States, it is now considered to be an international soil classification. Worldwide more than 75 countries have assessed their soils at national level using USDA System. As an example in the Gulf Cooperation Council Countries, Kingdom of Saudi Arabia completed soil assessment in 1985

(Ministry of Agriculture and Water, 1985), Sultanate of Oman in 1990 (Ministry of Agriculture and Fisheries, 1990); State of Kuwait in 1999 (KISR, 1999); State of Qatar in 2005 (Ministry of Municipal Affairs and Agriculture, 2005); and recently Abu Dhabi Emirate has started Emirate wide scientific soil inventory which will be completed over a period of 42 months (EAD-ICBA, 2006). Shahid et al (2004) have completed *state-of-the-art* Soil Survey for the Coastline of Abu Dhabi Emirate using the USDA System of Soil Classification. The USDA Soil Taxonomy is based on soil properties observed in the field or inferred from those observations and conformed by laboratory measurements. The project site is classified and taxonomic name given to remember and communicate their significant characteristics. Classification enabled the project team to assemble knowledge of site to develop principles that help the team to understand their behavior to project treatments.

1.3. Specific Objectives

Specific objectives of site assessments are; to complete site assessment at ICBA-forage experiential sites designated by NIAB at Shorkote, Pakistan; to bring together soil information and their properties with special emphasis on salinity and other aspects that would remain valid in the years ahead; designate soil class name using USDA System of Soil Taxonomy; develop site assessment model to be followed by other NARS; and build capacity of project staff.

1.4. Indicators used for Soil Quality Assessment

Soil quality is an assessment of how well soil performs all of its functions now and how those functions are being preserved for future use. Soil quality cannot be measured directly, so we evaluate indicators. Indicators are measurable properties of soil that provide clues about how well the soil can function. Indicators can be physical, chemical, and biological properties, processes, or characteristics of soils. They can also be morphological or visual features of plants. Natural Resource Conservation Service (NRCS) of the United States Department of Agriculture (USDA) present useful indicators, which are: easy to measure; measure changes in soil functions; assessed in reasonable amount of time; encompass chemical, biological, and physical properties; are accessible to many users and applicable to field conditions, and are sensitive to variations in climate and management; assessed by qualitative and/or quantitative methods (a qualitative assessment is the determination of the nature of an indicator. A quantitative assessment is the accurate measurement of an indicator.

To assess experimental site at Shorkot, soil morphological, physical and chemical properties are used as indicators. **Morphological properties**– field soil description of soil pits; **physical** – soil texture, stoniness, occurrence of clay pan; **chemical properties** – EC (salinity), Sodium Adsorption Ratio-SAR (sodicity), ionic composition (soluble and extractable cations); plant nutrients (N, P, K), organic matter, cation-exchange capacity, base saturation, and pHs directly affect plant production and the ability of the plants to provide soil cover. The indicators help to determine the effects of management on the site. Often, these are the primary causes for changes in soil quality. Indicators (Table 1) can be assessed by qualitative or quantitative techniques. Qualitative assessments have an element of subjectivity; indicators measured with a quantitative method have a precise, numeric value.

Table 1: Examples of soil quality indicators in relation to soil health (NRCS-USDA) as used in the present study:

Indicator	**Relationship to Soil Health**
Soil organic matter (SOM)	Soil fertility, structure, stability, nutrient retention, and available water capacity
Physical: texture, depth of soil (hardpan), structure	Retention and transport of water and nutrients; water movement; porosity; compaction; workability
Chemical: pH; electrical conductivity (soil salinity); extractable N-P-K; Sodium Adsorption Ratio-SAR (soil sodicity); Cation exchange capacity; gypsum; $CaCO_3$ equivalents;	Salinity thresholds (salt tolerance); plant available nutrients and potential for N and P loss; soil dispersion & sealing; nutrient holding capacity; soil subsidence

2. Procedures used to Quantify Soil Quality Indicators

2.1. Soil Morphological Description

Soil morphology was described (Soil Survey Division Staff, 1993; USDA-NRCS, 2002) and soils classified using Soil Taxonomy (USDA-NRCS, 1999) and Keys to Soil Taxonomy (USDA-NRCS, 2006), a taxonomic system based on the physical and chemical soil properties within genetic horizons and the arrangement of those horizons in the profile, which is based mainly on the kind and character of soil properties and the arrangement of horizons in the profile. Field characteristics utilized in the description include Munsell Color Notation (dry and moist) texture, structure, consistence, excavation difficulty, roots, cementation, toughness, stickiness, segregation, plasticity, effervescence and boundary, where appropriate. Samples were collected from each horizon and returned to the NIAB soil laboratories for further processing. The soil profile in association with the landscape is presented below (Figure 1). The samples were air-dried, processed to passed through a 2 mm sieve at NIAB laboratories at Faisalabad Pakistan. Subsequent determinations were made on soil material less that 2mm in diameter (called fine earth fraction) at NIAB and soil laboratories of the International Center for Biosaline Agriculture (ICBA) Dubai, United Arab Emirates. No fragments were found to exceed 2 mm diameter.

2.2. Laboratory Analyses

The primary methods used for laboratory analyses are those of the USDA-NRCS (2004), however, soil texture was determined using the modified hydrometer method (Shahid, 2006) supplemented with wet sieving. Laboratory analyses of soil samples include pH of the soil saturated paste (pHs), electrical conductivity of the soil saturation extract (ECe) and water-soluble calcium (Ca^{2+}), sodium (Na^+) and potassium (K^+) using flame photometer and Mg^{2+} by Atomic Absorption Spectrophotometer (AAS), and bicarbonates (HCO_3^-) ions using acid titration, chlorides by silver nitrate titration, and sulfate by difference between total cations and HCO_3^- and Cl^- ions. Sodium Adsorption Ratio (SAR) was calculated from water extractable elemental data using the formula [SAR = Na/[(Ca + Mg)/2]$^{0.5}$ with results recorded as (mmoles/l)$^{0.5}$. Calcium carbonate equivalent was determined using standard Calcimeter and the presence/absence of gypsum was tested by acetone precipitation test.

3. Results and Discussions

3.1. Formation of Soils

A ***soil*** is a ***3-dimensional*** natural body made up of mineral and organic materials. The nature of any soil at a given site is the result of the interaction of five interrelated factors-parent material, climate, plants and animals, relief, and time. The climate, animals and plants have an effect on parent material that is modified by relief over a period of time. Theoretically, if all these factors were identical at different sites, the soils at these sites would be identical. In practical identical soils are rarely found, the differences being caused by variations in one or more factors.

3.1.1. Factors of Soil Formation

Parent material is the raw material acted on by the soil-forming processes (*addition, losses*, *transformation* and *translocation)*. It largely determines soil texture, which, in turn, affects other properties, such as natural soil drainage and permeability. The physical and chemical composition of parent material has an important effect on the kind of soil that forms. The parent material in the study site as assessed through field observation is mainly ***mixed calcareous alluvium*** derived originally from variety of rocks (calcareous sandstone, shales and clays, granites, schists, gneisses and slates etc) in the Hamalayas. ***Climate*** is semi-arid subtropical continental. The rainfall varies between 200 and 350 mm per annum. Climate influences the formations of soils in many ways, particularly in the study area the low rainfall in winter moves (in dry season) the salts to the surface through capillary action, and to lower depths in monsoon when there is relatively high rainfall. The temperature in association with high salts affects the growth of vegetation, activity of microorganisms and chemical reactions, and rate of parent material weathering. The slope determines the soil moisture and rate of runoff. ***Relief*** of the Shorkote site is level or nearly level. The ***Plants and Animals*** life are important factors of soil formation. Animals affect soil formation, in particular, the remains of plants are added to soil, and a number of living organisms convert these remains into organic matter, and many kinds of micro-organisms are needed to transform organic remains into stable humus, however, it seems they have insignificant affect on soil formation in the study area. ***Time*** is important for soil development, generally older soils have well developed horizons, however, the younger soils show little or no horizon development. In general in arid region soils, due to less precipitation, soil development is very slow compared with high precipitation areas (humid). The soil at the Shorkote site is formed in the old and young flood plains and is of late Pleistocene age.

3.1.2. Processes of Soil Formation

An important feature of the soil is that it is not static, rather it is a dynamic natural body interacting in a complex manner with its environment. As a consequence, the soil changes through time and in space as a response to environmental changes. The soil is result of the complex interaction of the processes of soil formation in the environmental context, particularly climate, parent material and topography. These processes have operated over varying time periods. In the world soil literature a number of soil formation processes have been reported. Some processes are unique to some areas and occur under the influence of specific soil formation factors. In the study area following were observed.

Salinization is a process of soluble salts accumulation. This was recognized by the presence of surface salt enriched zone (0-15 cm) presenting an ECe of 64.2 dS/m, however, it lacks the salic horizon requirement (Figure 1). ***Sodication*** is a process of the accumulation of sodium on the soil exchange complex. The soils become sodic when exchangeable-sodium-percentage (ESP) reaches 15 or more. The ESP in the entire profile is in excess of 15. In the field it was not possible to identify sodication, however, laboratory analysis revealed the process. Soft segregation of carbonates at 105-145 cm depth was observed during field investigation. This segregation development is result of dissolution of carbonates from above soil horizons "***decalcification"*** and subsequent precipitation (segregation) at greater depth in the soil profile ***"calcification***". The distribution and the morphological form of the carbonate accumulation at 105-145 cm depth indicate that these are pedogenic phases (Shahid et al, 2004). The zone 105-145 cm lacks the diagnostic properties of the calcic horizon by being low in carbonate contents (less than 15%). The direct source of calcium carbonate in soil is calcareous parent material. Almost all horizons contain carbonates to a varying extent. In these soils, carbonates were disseminated or finely dispersed throughout the soil matrix such that specific carbonate features were not visible. In the soil profile at Shorkot site a Chrotovina was observed, this may be due to a filled burrow hole of an animal activity (rodent). Otherwise a clear differentiation of sediment deposition at different depths indicates insignificant ***homogenization*** due to biological activity. ***Illuviation*** is the process of clay enrichment in the subsurface horizon through translocation and deposition. This was very well recognized in the Shorkot soil profile where 49% clay was recorded through laboratory analysis, the clay rich horizon meets the requirement of argillic as well as natric diagnostic horizons which helped in naming soil class according to USDA soil classification system, (USDA-NRCS, 1999; USDA-NRCS, 2006).

Site and Morphological Description of Typical Soil Profile

Site No	: Skot01
Observation type	: Soil profile
Described by	: Dr. Shabbir Shahid - Salinity Management Scientist (ICBA)
Geographic Coordinate	: 72°.14.748 E 30°.52.118 N

Physiography		**Soil Properties**	
slope	: < 1 %	*surface condition*	: salt crust furrows
slope class	: nearly level	*Microrelief:*	: smooth
slope morphological type	: flat	*drainage class*	: poorly drained (argillic horizon)
landform pattern	: alluvial plain	*permeability class*	: very slow (argillic horizon)
relief/modal slope class	: level plain	*Ksat class*	: very low (argillic horizon)
water table depth	: not reached	*root restriction depth*	: very deep
erosion	: none	*moisture condition*	: moist
runoff	: Slight-north to south	*Surface rock fragments*	: none
Land use/cover	: NIAB salt tolerant forage project (2005 – 2009)		

Morphological Description

Horizon	**Depth (cm)**	**Description**
Apkz	0 – 15	10YR 6/2 (light brownish gray) dry; 10YR 4/3 (brown) moist; loose single grain; sandy texture; strongly saline (ECe 64.2 dS/m); moderately alkaline (pHs 8.43)
Bptk	15 – 35	10YR 6/3 (pale brown) dry; 10YR 4/2 (dark grayish brown) moist; non-gravelly silty clay texture; strong medium to coarse sub-angular blocky structure (moist); argillic horizon; firm moist consistence; moderate excavation difficulty; medium to coarse moderately few roots; non-cemented; medium toughness; very sticky; no segregation; very plastic; strongly effervescent; wavy irregular boundary; moderately saline (ECe 9.75 dS/m); strongly alkaline (pHs 8.72).
Bk1	35 – 105	10YR 6/3 (pale brown) dry; 10YR 4/3 (brown) moist; non-gravelly sandy loam; massive structure; slightly hard dry consistence; moderate excavation difficulty; medium to coarse moderately few roots; non-cemented; low toughness; slightly sticky; common medium rounded soft carbonates segregation; slightly plastic; strongly effervescent; clear smooth boundary; slightly saline (ECe 6.92 dS/m); moderately alkaline (pHs 8.15).
Bk2	105 – 145	10YR 6/3 (pale brown) dry; 10YR 5/2 (grayish brown) moist; non-gravelly sandy loam; massive structure; slightly hard dry consistence; moderate excavation difficulty; non-cemented; low toughness; slightly sticky; common medium rounded soft carbonates segregation; slightly plastic; strongly effervescent; clear smooth boundary; slightly saline (ECe 6.00 dS/m); strongly alkaline (pHs 8.87).
Ck	145 – 210+	10YR 6/3 (pale brown) dry; 10YR 4/2 (dark grayish brown) moist; non-gravelly loamy sand; massive structure; slightly hard dry consistence; low excavation difficulty; non-cemented; low toughness; slightly sticky; no-segregation; non-plastic; strongly effervescent; moderately saline (ECe 8.79 dS/m); very strongly alkaline (pHs 9.9).

Figure 1: Typical soil profile and associated landscape of coarse loamy, mixed,hyperthermic Typic Natrargid

3.2. Soil Taxonomic Name

The NIAB through its ***Farmer Participatory Program*** acquired this piece of land (2 ha) from a farmer. Prior to NIAB experiments the piece of land was barren and unused. It is situated in Shorkot. The 2 ha site was rapidly assessed through hand auguring, and this enabled to select a representative site where a deeper than 2 meters profile was dug for in depth soil description, soil classification and sample collection for laboratory characterization. The site and profile description was completed using Soil

Survey Manual (USDA, 1993) and Fieldbook for Describing and Sampling Soils (USDA-NRCS, 2002) and soils classified according to USDA Soil Taxonomy (USDA-NRCS, 1999; 2006).

3.2.1. Coarse Loamy, Mixed, Hyperthermic Typic Natrargid

The *coarse loamy, mixed, hyperthermic Typic Natrargid* soil type consists of about 15 cm surface salt rich horizon, and well developed *argillic* horizon at 15-35 cm depth which also has properties of a *natric* horizon. The profile is very deep (hardpan and water table not found within the upper 225 cm depth), excessively drained below the argillic horizon. Argillic horizon presents very low saturated hydraulic conductivity and is very slowly permeable due to combined effect of high clay contents and exchangeable sodium percentage.

3.2.2. Argillc/Natric Horizon

An argillic horizon is normally a subsurface horizon with a significant higher percentage of phyllosilicate clay than the overlying material (in Shorkot site clay % in the argillic horizon is 49% compared to surface material 21%). Figure 1 shows evidence of clay illuviation, where the argillic horizon is formed below the soil surface, however, in Figure 1 it is exposed at surface due to seed bed preparation using the upper 15 cm surface soil. Pale brown (dry) and dark grayish brown (moist) ***Argillic*** diagnostic horizon (20 cm thick with 49% clay) was identified at 15-35 cm depth in the Shorkot site. The horizon was moist due to earlier heavy rain and perhaps through seepage from nearby irrigated plots. Field observation shows that eluvial horizon and perhaps partially the argillic horizon has been mixed into an ***Ap*** horizon during seed bed preparation. This was evidenced through surface accumulation of clay through water ponding and cracking after drying. The argillic horizon also meets the properties of a ***Natric*** horizon. The natric horizon has ESP of 15 or more in one or more horizons within 40 cm of its upper boundary.

3.2.3. What the Soil Taxonomic Name "*Coarse Loamy, Mixed, Hyperthermic Typic Natrargid*" of Site Means?

The soil belongs to order ***Aridisol*** as indicated by the formative element "***id***"; it belongs to suborder "***Argid***" because profile has argillic horizon (enriched with clay); it also presents ***Natric*** horizon due to more than 15 ESP in argillic horizon; ***coarse loamy*** is family textural class; ***Mixed***, is the mineralogy class; it has ***hyperthermic*** soil temperature regime, in which the mean annual soil temperature is 22 ^{o}C or higher, and the difference between mean summer and winter soil temperature is more than 6 ^{o}C at a depth of 50 cm; ***Natrargids*** is the Great Group name – Argids that have a natric horizon; ***Typic Natrargids*** is the subgroup name showing that the profile has typical soil properties to qualify as Natrargids.

3.3. Physical and Chemical Characteristics

Table 2 shows important physical and chemical characteristics of Shorkot site. The pHs values ranged between 8.15 (moderately alkaline) to 9.9 (very strongly alkaline), suggesting buffering influence in the soil. The relatively high ECe at surface is related to the capillary movement of water and subsequent evaporation. The ECe of the profile is primarily related by the presence of different electrolytes, and is in excess of 4 dS/m at all depths (saline category). The ionic composition of the saturation extract indicates the dominance of Na^+ and Cl^- + SO_4^{2-}, with variable concentration of other cations (Ca^{2+}, Mg^{2+}, K^+) and HCO_3^{2-} anion, CO_3^- were absent in all horizons. Carbonate equivalents are relatively higher at 105-145 cm depth (15.60%) where soft segregation was observed during field investigation. This segregation development is result of carbonates dissolution in the upper horizons and subsequent accumulation at lower depth "decalcification". The ESP calculated from the SAR values is in excess of 15 in all depths (sodic category), minimum was recorded at 35-105 cm (29%) and maximum (56.5%) at the lowest depth. Both ECe and ESP values of the entire profile classify the profile as ***saline-sodic.*** The bulk density is higher (1.4 g cm^{-3}) in the argillic horizon due to relatively higher clay contents, which corresponds to 47% porosity. Other depths present slightly low bulk density values (1.33-1.35 g cm^{-3}). The organic matter is in general less than 1% though out the profile. General features of the Shorkot site are presented in Figure 2.

Table 2: Laboratory characteristics of coarse loamy, mixed, hyperthermic Typic Natrargid (Shorkot site)

Physical Data

Horizon	Depth cm	Total -			Silt		-Sand					Textural Class
		Clay <.002	Silt .002-.05	Sand .05-2	Fine .002-.02	Coarse .02-.05	Very fine .05-.1	Fine .1-.25	Medium .25-.5	Coarse .5-1	Very Coarse 1-2	
		% of <2mm -										
Apkz	0-15	21.0	53.6	25.4	47.0	06.6	13.4	06.0	5.3	0.7	0.0	Silt Loam
Bptk	15-35	49.0	41.8	09.2	39.5	02.3	03.7	05.0	0.2	0.3	0.0	Silty Clay
Bk1	35-105	15.5	23.5	61.0	12.3	11.2	27.8	30.0	2.7	0.5	0.0	Sandy Loam
Bk2	105-145	16.8	26.0	57.2	18.2	07.8	24.0	31.2	1.7	0.3	0.0	Sandy Loam
Ck	145-210+	15.5	02.9	81.6	00.5	02.4	38.6	40.0	2.5	0.5	0.0	Sandy Loam

Analytical Data

Horizon	Depth cm	ESP*	$CaCO_3$ % eq. <2mm	H_2O content W15	Bulk Density g/cm^3	Porosity	Organic carbon	Organic matter
						%		
Apkz	0-15	42.34	09.21	6.75	-	-	0.39	0.67
Bptk	15-35	39.86	15.13	8.79	1.40	47	0.19	0.32
Bk1	35-105	29.03	12.38	6.58	1.33	50	0.43	0.74
Bk2	105-145	44.66	15.60	4.60	-	-	0.51	0.87
Ck	145-210+	56.67	13.85	4.98	1.35	49	0.45	0.77

Analytical Data

Horizon	Depth Cm	ECe dS/m	pHs	SP	Water extractable from saturated soil paste							
					Ca	Mg	Na	K	HCO_3	SO_4	Cl	SAR
					meq/L							(mmole/L)$^{0.5}$
Apkz	0-15	64.2	8.43	42.75	36.23	145.45	478.7	39.5	5.25	263.78	430.85	50.23
Bptk	15-35	9.75	8.72	55.66	3.30	4.50	90.30	1.10	4.25	62.57	32.38	45.72
Bk1	35-105	6.92	8.15	41.69	3.15	5.71	60.20	1.00	3.00	42.42	24.64	28.59
Bk2	105-145	6.00	8.87	29.13	1.44	1.04	61.90	0.90	5.50	34.08	25.70	55.57
Ck	145-210+	8.79	9.9	31.55	1.74	0.03	84.30	1.00	14.00	41.39	31.68	89.54

pHs = pH of soil saturated soil paste; ECe = electrical conductivity of soil saturation extract; CEC = Cation Exchange Capacity; ESP*=Exchangeable Sodium Percentage calculated from SAR;
SAR=Sodium Adsorption Ratio; SP = Saturation Percentage

Figure 2: General Features of Experimental Site at Shorkot and capacity building

a. Clay rich argillic/natric horizon and chrotovina

b. Core sampling – bulk density

c. Clay rich argillic horizon f

d. Training of project staff on profile description

e. On-site capacity building of project staff

f. On-site briefing to farmers by NIAB staff

3.4. General Characteristics and Management Issues

The soil profile presents strongly saline conditions at surface (0-15 cm where ECe is 64.2 dS/m) and the salinity decreases significantly down the profile. Such a relatively high salinity level at the surface is due partially to the capillary action of the subsurface water that brings salts to the surface and after evaporation leave the salts at the surface, and partially due to the hindrance caused by the argillic horizon (20 cm thick with 49% clay) in water movement, that to a certain extent kept the water above this clay zone and hot dry climate developed the surface salt crust through evaporation. The salts enriched zone as observed during the field investigation was hard at surface and if not broken can cause hindrance in seed germination. Under such saline conditions following are suggested for a better seed germination.

When seeds are sown in the shoulder of raised beds (which has low salinity level), enough water should be applied to offset seed germination requirement and to avoid salt build up near the seed and crust formation. Otherwise seed germination may be restricted. Under such conditions salts accumulate at the top of the raised beds and this can be scrapped off to minimize its further effects, particularly when rain. This requires extra labor, but may reward at later stage.

If due to uncertainties there is heavy rain after sowing the seeds, this may cause crust formation due to raindrop impact and seed may not break it to germinate, but turned down due to hard crust and dies. The Shorkote soil contains upto 49% clay in the argillic horizon, which is highly prone to crust formation and cracking on drying. Under such crust formation conditions the crust must be broken by rakes to allow aeration and seed to emerge from soil. The lack of such practice may lead to poor germination and subsequent decline in final production.

Regularly irrigate to meet plant water requirements and to avoid build up of salts in the root zone. The concept of leaching requirement (LR) should be used to keep the rootzone below the salinity threshold level (critical stage where plant starts declining yields compared to non-saline conditions) of the concerned plant.

Argillic horizon (Fig. 2c, see top 20 cm clay rich horizon) need to be mixed with upper soil through tillage implements, this will help in the improvement of water holding capacity of the upper soil material and keep the salinity to a lower level due to dilution affect; in addition this activity will improve water infiltration (argillic horizon itself controls water movement) and avoid ponding, that ultimately leads to surface salinization through evaporation.

To offset soil sodcity, gypsum amendment should be applied. The gypsum application will bring the soil ESP to a required level and also decrease soil pHs. Placing gypsum in water channels may reduce water sodicity (SAR) and Residual Sodium Carbonates (RSC), that will ultimately improve soil properties.

4. Capacity Building

One of the objectives was to build capacity of project staff working at NIAB Faisalabad and affiliated to project activities. The project staff received on-the site training on different aspects of site, profile description and soil classification. The staff also received relevant material and handouts for site and profile description.

5. Conclusions

Site assessment prior to implementation of salt-tolerant project activities has highlighted the presence of very high salinity and sodicity levels at the surface, which will be the root zone of the salt tolerant forages to be tested. Without removing these salts the soil medium may not be conducive for seed germination. Therefore, salts must be leached down. The study also revealed occurrence of a clay pan that will restrict roots to limited soil medium to explore nutrient and to flourish freely, and also affect water movement (physical barrier). The study provides baseline soil information as a starting point, under such soil condition there is always a need to regularly monitor salinity build up and take necessary action to remove salts from the root zone during the course of crop period. Final soil assessment after the project completion will be required to assure that the soil properties are conserved or degraded, in the latter case the salt tolerant forage production system is not sustainable.

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References

[1] EAD-ICBA. 2006. Soil Survey for Emirate of Abu Dhabi. Agreement and Terms of Reference Document. Jointly prepared by Environment Agency – Abu dhabi and the International Center for Biosaline Agriculture Dubai, United Arab Emirates.

[2] Kamara, C. S., and I. Haque. 1987. Characteristics of vertisols at ILCA research and outreach sites in Ethiopia. Plant Science Division (PSD) Working Document No. B5. International Livestock Center of Africa (ILCA), Addis-Ababa, Ethiopia.

[3] Kamara, C. S., and I. Haque. 1990. Characteristics of Lowland Soils of Melka Sede State Farm and Melka Water Research Center in the Harerge Region of Ethiopia. Working Document No. B11. Soil Science and Plant Nutrition Section . International Livestock Center of Africa (ILCA), Addis-Ababa, Ethiopia.

[4] KISR. 1999. Soil Survey for the State of Kuwait. 5 Volume. Kuwait Institute for Scientific Research, Kuwait.

[5] Ministry of Agriculture and Fisheries Oman. 1994. General soil map of the Sultanate of Oman.

[6] Ministry of Agruculture and Water. 1985. General Soil map of the Kingdom of Saudi Arabia.

[7] Ministry of Municipal Affairs and Agriculture. 2005. The Atlas of Soils for the State of Qatar. Soil Classification and Land Use Specification Project for the State of Qatar.

[8] Munsell. 1994. Munsell Soil Color Charts, Revised Edition. New Windsor, New York Macbeth Division of Kollmorgen Instruments Corporation.

[9] Ryan, J., S. Mesri, S. Garabet, J. Diekmann and H. Habib. 1997. Soils of ICARDA'S Agricultural Experimental Stayion and Sites: Climate, Classification, Physical and Chemical Properties, and Land Use. International Center for Agricultural Research in the Dry Areas, Aleppo, Syria, VI + 107pp.

[10] SFRI. 1995. From soil survey to sustainable farming. Proceedings of the conference to 35th Anniversary of the Soil Fertility Institute Bratislava. Organized within the ENCY activities. October 3-5, 1995, High Tatras, Stara'Lesna – 2 Volumes 461 p.

[11] Shahid, S. A. 1992. An uptodate precise stage by stage textural analysis of soil profiles.Pakistan Journal of Soil Science, 7(3-4):29-34.

[12] Shahid, S. A. 2006. Soil Textural Analyses. ICBA Soil Procedures (Draft) – Soil and Water Analytical Laboratory. International Center for Biosaline Agriculture, Dubai.

[13] Shahid, S. A., and S. A. S. Omar. 1999. Order 1 soil survey of the demonstration farm sites with proposed management. Kuwait Institute for Scientific Research, KISR 5463. viii + 144pp.

[14] Shahid, S. A., S. A. S. Omar, M. E. Jamal, A. Shihab, and H. Abo-Rizq. 2004. Soil survey for farm planning in northern Kuwait. Kuwait Journal of Science and Engineering, 31(1):43-57.

[15] Shahid, S. A., M. A. Abdelfattah, K. R. Arshad & Others. 2004. Soil Survey for the Coastline of Abu Dhabi Emirate. 2 Volumes (Volume 1: Reconnaissance Survey and Volume II: Soil maps). Environmental Research and Wildlife Development Agency, Abu Dhabi, UAE.

[16] Soil Survey Division Staff. 1993. Soil Survey Manual. United States Department of Agriculture Handbook No. 18, Washington D.C., US Government Printing Office.

[17] USDA-NRCS. 1995. Soil Survey Investigations Report 45, Soil Survey Laboratory Information Manual, USDA, NRCS. US Government Printing Office.

[18] USDA-NRCS. 1999. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Agricultural Handbook 436, Second Edition. Soil Survey Staff, USDA, NRCS; and all Amendments. US Government Printing Office.

[19] USDA-NRCS, 2002. Field Book for Describing and Sampling Soils, (version 2) USDA, NRCS. US Government Printing Office.
[20] USDA-NRCS. 2004. Soil Survey Investigations Report 42, Soil Survey Laboratory Methods Manual, (Version 4 November 2004), USDA, NRCS. US Government Printing Office.
[21] USDA-NRCS. 2004. National Soil survey Handbook. Title 430-VI-2004, USDA-NRCS. US Government Printing Office.
[22] USDA-NRCS. 2006. Keys to Soil Taxonomy, Soil Survey Staff, (2006 Tenth Edition), USDA, NRCS. US Government Printing Office.