Indian Journal of Agricultural Sciences **84** (4): 458–60, April 2014/Article
https://doi.org/10.56093/ijas.v84i4.39455

Comparative study of soil fertility status of cold desert Ladakh region before and after cloudburst

S ACHARYA[1], N SINGH[2], S B MAURYA[3] and R B SRIVASTAVA[4]

Defence Institute of High Altitude Research (DIHAR), DRDO, C/o 56 APO, Leh-Ladakh 901 205

Received: 21 April 2012; Revised accepted: 29 January 2014

ABSTRACT

Present study was undertaken to determine loss of soil organic carbon, major and micronutrient status of cold desert Ladakh region as a result of unprecedented cloudburst in August 2010. Heavy rainfall (250 mm) within an hour leading to flash floods resulted in severe loss of standing crops spreading over 1400 ha of agriculture land besides destruction of human, animal lives, infrastructures. In most of the affected areas, top fertile soil completely washed away resulting in severe depletion of various major and micro nutrients essential for good soil health. Soil pH was recorded 8.66 and organic carbon severely depleted from 1.09% to only 0.24% making the soil very loose and poor in WHC. N, P and K (115.4, 1.0 and 103.4 kg/ha respectively) and micronutrient contents were also severely reduced as compared to original soil. These losses have severe long-term effects on crop productivity and economy of the region. Some ameliorative measures have also been mentioned for improving soil health and sustainable crop production.

Key words: Cold desert, Flash flood, Leh-Ladakh, Soil nutrient loss

Soil is a living system that represents a finite resource vital to life on the earth. It forms a thin layer of unconsolidated minerals and organic matter on the earth's surface that performs many processes essential to life. It develops slowly from parent materials and is modified by various soil forming factors like time, climate, macro and microorganisms, vegetation and topography. Soils are complex mixtures of minerals, organic compounds and living organisms that interact continuously in response to natural and imposed biological, chemical and physical activities. It serves as a substrate for plant growth, as a nutrient reservoir, and as the site for many biological processes involved in decomposition and recycling of plant and animal residues (Wienhold *et al.* 2004). People are dependent on soil, and conversely, fertile soils are dependent on people and the use they make of the land. Fertile soils provide starting point for successful agriculture. Rapid increase in world population has increased stress on natural resources, including the soil. Soil degradation adversely affects agricultural production and other interrelated natural resources (Lillesand and Keifer 2000, Brejda and Thomas 2001, Karlen *et al.* 2001).

Climatic factors have become more significant in recent times due to rapid climate changes induced by anthropogenic interventions affecting our ecosystem in various ways. Climate change has become a major, scientific and political issue during the last decade. It is likely to make matters worse with increases in rainfall variability being predicted for the semi-arid tropics and temperate regions. Rising temperatures and unpredictable rainfall patterns would seriously hamper day-to-day decisions to be taken by the farmer (Natarajan *et al.* 2010). On 5 August 2010 night suddenly cloudburst occurred in cold desert trans-Himalayan region of Leh-Ladakh. This does not happen in Himalayan desert altitudes. Leh-Ladakh is an unusual place for a cloudburst because it is a cold desert region where average rainfall is very low. The maximum ever recorded rainfall in Leh was 96.2 mm in a 24 hour period measured in 1933. This cloudburst yielded 250 mm rainfall within an hour resulted a severe flash flood beyond imagination. Due to flash floods and cloudburst, 28 thousand quintals of food grains of different standing crops spread over 1400 ha of agriculture land have been damaged by severe soil erosion and deposition of boulders along the debris. Such types of events have a long-term negative effect on the agricultural productivity and rural livelihood security in the region. Hence, the present study was undertaken to evaluate loss of soil fertility status of the flood affected areas and some recommendations for restoration of soil health and agricultural productivity in these areas.

MATERIALS AN D METHODS

After flash flood devastated several villages of Ladakh region like Choglamsar, Saboo, Phyang, Shey, Nimoo etc.

[1]Scientist 'C' (e mail: someniari@gmail.com), [2]Scientist 'E' (e mail: narendradrdo@yahoo.co.in), [3]STA 'B' (e mail: sbmaurya @gmail.com), [4]Director (e mail: rbs1_cnb@rediffmail.com)

soil samples from those villages were carried out. Sampling was done for both affected and unaffected fields. During sampling time some visible effects were observed like top soil washed away resulting in undulating topography of some cultivated fields. Boulders and stones were accumulated, damage to the irrigation channels, field boundaries, damage to fruit orchards and forest trees and in some of the cases lands became totally unsuitable for cultivation.

Composite soil samples from flood affected fields of Ladakh region were collected and analyzed for various soil physico-chemical parameters. Soil pH and EC was measured in a 1:2 soil to water ratio (Herdershot *et al.* 1993). Organic carbon (OC) was determined by wet oxidation method (Walkley and Black 1934); total N by Kjeldhal method (Subbiah and Asija 1956); available P by Olsen's method (Olsen *et al.* 1954); K by flame photometer; available Zn, Fe, Cu and Mn were determined by DTPA (Diethylene triamine penta acetic acid) extractant method (Lindsay *et al.* 1978) using AAS. Particle size distribution was determined by hydrometer method (Bougoucos 1951) and soil WHC was determined gravimetrically.

RESULTS AND DISCUSSION

Soil nutrient status of Ladakh region before cloudburst has been shown in Table 1. Before flash flood, pH of the surveyed area ranged from 7.89 to 8.32 with average 8.02. Particle size distribution of soils revealed that soils of this cold arid region are mainly sandy-loam in nature (Sand 57%, silt 24% and clay 19%). Soil available nitrogen content was estimated in medium range (350 to 470.4 kg/ha with average 388.9 kg/ha) and rest of the nutrients were estimated to be in lower range. Phosphorus content was found 6.8 to 8.7 kg/ha whereas potassium content was measured 241.5 to 345 kg/ha with average 284.1 kg/ha. Study of some soil micronutrients (Zn, Fe, Cu and Mn) status showed that soil of this region is mainly deficient of these nutrients. Zn content was estimated to be ranged from 0.06 to 0.25 ppm with mean 0.17 ppm; whereas for Fe, Cu and Mn it was 0.8 to 1.9 ppm, 0.52 to 0.85 ppm and 0.6 to 2.3 ppm with average 1.45 ppm, 0.67 ppm and 1.4 ppm respectively.

Unusual changes in some important physico-chemical parameters of soils were observed in Leh-Ladakh before and after flash flood in August 2010 (Table 2). In most of the affected fields, top fertile soil has been completely removed and the fields were full of boulders and debris. One important reason for severity of soil loss is texture of the soil of this region. In Ladakh, soil is mainly sandy-loam in nature which is very susceptible to erosion. Soil pH was found to be increased from slightly alkaline to highly alkaline (8.66) in nature. However range of EC after flash flood was not significantly increased (0.34 to 0.38 mmhos/cm). As top soil completely washed away, OC as well as all macro (N, P and K) and micronutrient contents were severely reduced as compared to original soil. OC content changed from 1.09% to only 0.24%. N, P and K content was recorded 115.4, 1.0 and 103.4 kg/ha respectively. Whereas micronutrient status (Zn, Fe, Cu and Mn) of flood affected soils were found to be 0.09, 0.66, 0.21 and 0.27 ppm only. Particle size distribution showed, nature of soil changed from sandy-loam to sandy soil. Sand content of affected fields increased from 57% to 73% whereas clay content decreased from 19% to only 11%. As a result WHC of the soils was also reduced from 47% to merely 19%. In lower lands also, soils coming from hills deposited and formed very hard pan over the surface soil. The deposition comprising mostly of sand and silt, has caused damage to the standing crops in some areas as well. From overall result it was clear that soil fertility status of flood affected fields were significantly reduced and macro and micronutrient deficiencies were also observed.

After the calamity, it was very difficult to grow any crop in affected fields without soil amelioration. For reclamation of flood affected soils, some recommendation practices may be adopted. In extremely damaged fields where it became undulating topography and full of stones

Table 1 Physico-chemical properties of soils of Ladakh region before flash flood

Parameters	Leh	Choglamsar	Nimmo	Saboo	Phyang	Mean
pH	7.91±0.15	7.88±0.18	8.10±0.21	8.32±0.20	7.89±0.10	8.02
EC(mmhos/cm)	0.36±0.11	0.45±0.13	0.31±0.12	0.26±0.06	0.33±0.10	0.34
OC (%)	1.32±0.14	0.95±0.10	1.15±0.09	1.12±0.15	0.90±0.10	1.09
N (Kg/ha)	397.0±25.3	389.2±30.1	337.9±18.9	470.4±35.4	350.0±20.2	388.9
P (Kg/ha)	8.7±0.6	8.4±0.10	8.3±0.11	7.2±0.08	6.8±0.07	7.9
K (Kg/ha)	345±23.1	262.4±18.8	241.5±21.3	267.3±24.6	304.2±28.0	284.1
Zn (ppm)	0.25±0.05	0.08±0.02	0.06±0.02	0.22±0.04	0.22±0.06	0.17
Fe (ppm)	1.60±0.6	0.80±0.6	1.90±0.12	1.46±0.11	1.50±0.12	1.45
Cu (ppm)	0.85±0.10	0.60±0.06	0.70±0.07	0.52±0.06	0.70±0.06	0.67
Mn (ppm)	0.8±0.05	1.0±0.12	2.2±0.12	0.60±0.05	2.3±0.25	1.4
Sand (%)	60±5	62±7	54±5	53±5	58±6	57
Silt (%)	23±4	20±4	26±5	26±5	22±5	24
Clay (%)	17±4	17±4	20±5	21±4	20±3	19
WHC (%)	47±4	52±4	45±5	44±3	45±3	47

Table 2 Change of physico-chemical properties of soils of affected fields after flash flood

Parameters	Leh	Choglamsar	Nimmo	Saboo	Phyang	Mean
pH	8.85±0.10	8.95±0.12	8.42±0.15	8.57±0.08	8.50±0.14	8.66
EC(mmhos/cm)	0.42±0.08	0.40±0.1	0.35±0.07	0.32±0.05	0.39±0.04	0.38
OC (%)	0.21±0.04	0.22±0.05	0.29±0.06	0.25±0.05	0.21±0.04	0.24
N (Kg/ha)	123.6±10.5	116.9±14.2	130.5±11.1	98.4±10.6	106.1±9.8	115.1
P (Kg/ha)	0.8±0.07	0.9±0.06	1.0±0.12	1.2±0.10	1.1±0.10	1.0
K (Kg/ha)	115.2±8.5	89.5±8.7	95.3±10.5	104.6±11.3	112.4±10.4	103.4
Zn (ppm)	0.08±0.02	0.07±0.03	0.08±0.02	0.12±0.03	0.10±0.04	0.09
Fe (ppm)	0.6±0.08	0.8±0.1	0.7±0.05	0.4±0.05	0.8±0.06	0.66
Cu (ppm)	0.25±0.04	0.15±0.02	0.27±0.08	0.21±0.02	0.15±0.03	0.21
Mn (ppm)	0.30±0.05	0.25±0.05	0.36±0.08	0.18±0.03	0.24±0.03	0.27
Sand (%)	75±7	76±7	70±6	72±5	69±5	73
Silt (%)	15±3	14±2	18±2	17±3	18±2	16
Clay (%)	10±2	10±1	12±1	11±1	13±2	11
WHC (%)	16±4	17±2	21±3	20±2	23±3	19

and boulders, it is very difficult to ameliorate, so if possible compensatory land can be allotted. In moderately affected fields, need removal of big stones, filling with soils, deep ploughing and leveling of the fields. The fields where hard pan has formed need removal of the deposited hard pan, deep ploughing to mix surface and sub-surface soil. Construction of field boundaries and repairing of irrigation channels is necessary. Along the field boundaries planting of trees like willow and poplar which are main dominant tree species of this cold desert region are also recommended. As soils became completely sandy in nature, heavy dose of organic matter in the form of FYM, vermicompost etc. has to be added to enhance soil structure, aggregation, soil WHC, aeration as well as incorporation of major nutrients into the soil. In near future, proper soil and water conservation measures should be adopted for this cold desert region for improving soil health and sustainable crop production for a long period of time. For natural resource conservation, detailed village wise farm level database should be generated on priority basis. Availability of such a database will have an immense utility in undertaking timely restoration and conservation measures in these areas.

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