EVALUATION OF SOIL FERTILITY/SALINITY STATUS OF THE TUTUDAWA MAIN CANAL OF THE WURNO IRRIGATION SCHEME IN SOKOTO STATE OF NIGERIA, AFTER SEPTEMBER 2010 FLOOD

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ABSTRACT
This research was carried out to evaluate the fertility and salinity status of the soil and pattern of its variations with depth along Tutudawa main canal of the Wurno Irrigation Scheme. The Wurno irrigation scheme is located in the Sudan Savannah, situated 45km north of Sokoto town. The Irrigation scheme is located on latitude 13^{o} 20΄N and longitude 4^{o} 55΄E, within the agro-ecological zone D designated dry sub-humid Illela-Sokoto-Yelwa Plain (Ojanuga, 2006).The climate consists of a long dry season (October to May) and a short wet season June to September (Ojanuga, 2006). The nature of rainfall in the area is poor in distribution, scanty in quantity and erratic in behavior with its peak in August with average of 704.2.mm per anum. The temperature ranges from a minimum of 17^{o}C recorded in December/January to 40^{o}C in April/May (NAERL and FDAE, 2014).Wurno irrigation scheme comprises of a storage reservoir with design capacity of 19,501,200 m^3 supplied from Goronyo dam(Wurno Irrigation Management Manual WIPMM,1994).The reservoir is linked to two main canals, namely; Lugu main canal that passes through Lugu village and Tutudawa main canal that passes through Tutudawa village, a main drain and a number of secondary canals (WIPMAM, 1994). Four transects were purposively chosen and soil samples were collected from three sampling spots in each transects. The samples were taken at the 0-15cm and 15-30cm depth respectively. Soil fertility and salinity parameters such as p^H, Total N, Organic Carbon, available P, CEC, Exchangeable bases, were determined using standard methods. While PBS, ESP, EC and SAR were calculated. The findings of the study revealed that Ca^{2+}, K^+ and Na^+ ions were all high across the sampling locations and depths. Periodic monitoring is proposed as a means of ensuring that proper soil quality for effective plant growth performance is maintained.

Keywords: Evaluation, Fertility, Salinity, Tutudawa, Flood

1. INTRODUCTION

One of the most important natural resources that cover much of the land surface is soil. It is crucial to life, most life on earth directly or indirectly depends upon soil as a source of food. To a great extent, soil quality determines the nature of plant-ecosystem and capacity of land to support biotic life. As human societies become increasingly urbanized, fewer people have intimate contact with the soil, and individuals tend to lose sight of the many ways in which they depend upon soils for their prosperity and survival (Brady and Weil, 2010). Soil fertility decline is naturally more alarming in intensively cultivated areas where nutrients uptake by crop is high and replenishment is not only inadequate but also unbalanced (SFE, 2014). Continuous cropping without adequate nutrient restorative practices may endanger the sustainability of agriculture (FAO, 2014).

Soil nutrient depletion has grave implication in terms of more acute and widespread nutrients deficiencies, weakened the foundation for high yielding sustainable farming and escalating remedial cost for re-building depleted soils (SFE, 2014). The selection of the proper rate of plant nutrient depends on the knowledge of nutrient supplying power of the soil on which the crop is to be grown (Tisdale *et al.*, 1985). Proper soil testing would help reach the goal of sound soil management decision, that best meet crop needs and maintain the nutrient supplying power of the soil, while making the most efficient use of fertilizer and avoiding environmental problems (FAO, 2014). Indeed many government and private farming activities failed due to inadequate understanding of the values and significance of soil evaluation and monitoring through proper sampling and testing techniques. This being the bedrock of sound soil management decision while making the most efficient use of environmental resources (FAO, 2003).

Irrigation has contributed significantly to poverty alleviation, food security, and improving the quality of life for rural populations of some developed countries. However, the increased dependence on irrigation has not been without its negative environmental effects. Inadequate attention to soils salinization factors and projected economic implications of large-scale irrigation schemes like the Wurno irrigation project has frequently led to great difficulties in soil management decisions. The sustainability of irrigation projects depends on taking into consideration of environmental effects as well as on the fertility status of soils. Negative impacts of soil salinization could have a serious effect on the investments in the irrigation farming (Elke, 1998). Thousands of hactres are going out of production worldwide each year due to salinity problems. On irrigated land, soil salinization is the major cause of land being lost to production and is one of the most prolific adverse environmental impacts associated with irrigation.

Despite the immense importance of Wurno Irrigation Scheme, the yield obtained in recent years by farmers from most cultivated crops in the scheme (rice, onion, tomatoes, pepper and potato) is low compared to the previous years especially before the September 2010 flood. This could be due to low level of soil management which may lead to the preponderance of sodium ions in the soil and or substantial concentration of soluble salts in irrigation water. The September 2010 flood has washed and changed the whole physiographic features of the terrain. This could have a serious implication on soil production potential of the area. With the current trend of population growth, mostly at geometric progression, while food production is only increasing at an arithmetic progression (Anonymous, 2013), These trend therefore raises the need for measures that would increase the yield and good performance of food crops to meet up the demand for the ever growing population.

Continuous research in relation to salinity management is lacking or rather scanty in Wurno Irrigation Scheme. However, studies conducted by Dikko *et al. during 2000/2001 dry season on soil fertility assessment of Lugu Main Canal* has proved that the soil at some part of the irrigation scheme were generally low in fertility status and had high concentration of salts. Ibrahim *et al., (*1998) also recommended periodic monitoring of water from the Wurno irrigation project as a means of ensuring its quality status for use.

Quantitative estimation of soil nutrient status and salinity related parameters of the Wurno Irrigation Scheme would be a useful devise for comprehending the state of soil richness and for devising corrective measures needed. The need for this cannot be over- emphasized especially when viewed against the realization that such information forms the background to an efficient and holistic use of soil and water resources (Elke, 1998).Ojanuga (2005) also reported that information about the land base of Nigeria is required for land use and land management decisions at several levels of natural resources development.

The foregoing therefore highlights the need to generate recent information on soil quality of the Wurno irrigation scheme with a view to foster correct management. The broad objective of this research is to provide the scientific knowledge on the current status of soils quality along Tutudawa Main Canal of the Wurno Irrigation after September 2010 Flood Scheme with a view to offer suggestions on appropriate management strategies for sustainable utilization of the soils of the study area.

2. MATERIALS AND METHODS

2.1 Study Area

The Wurno irrigation scheme is located in the Sudan savannah, situated 45km north of Sokoto town. The Irrigation scheme is located on latitude 13^o 20´N and longitude 4^o 55´E, within the agro-ecological zone D designated dry sub-humid Illela-Sokoto-Yelwa Plain (Ojanuga, 2006). The climate consists of a long dry season (October to May) and a short wet season June to September (Ojanuga, 2006). The nature of rainfall in the area is poor in distribution, scanty in quantity and erratic in behavior with its peak in August with average of 704.2.mm per annum.The temperature ranges from a minimum of 17^{o}C recorded in December/January to 40^{o}C in April/May (NAERL and FDAE, 2014). Wurno irrigation scheme comprises of a storage reservoir with design capacity of 19,501,200 m^3 supplied from Goronyo dam (WIPMM, 1994). The reservoir is linked to two main canals, namely; Lugu main canal that passes through Lugu village and Tutudawa main canal that passes through Tutudawa village, a main drain and a number of secondary canals (wurno irrigation management manual (WIPMAM, 1994).

2.2 Soil Sampling

Four transects were purposively chosen along Tutudawa main canal and three sampling spots were identified on each transect and soil samples were taken at 0-15 cm and 15-30 cm depth from each sampling spot making a total of 24 soil samples. These were taken to the laboratory, air dried and crushed using pestle and mortar and sieved through 2 mm sieve mesh. The soil samples were finally stored for subsequent analyses to determine the various chemical properties. Sampling locations are shown below:

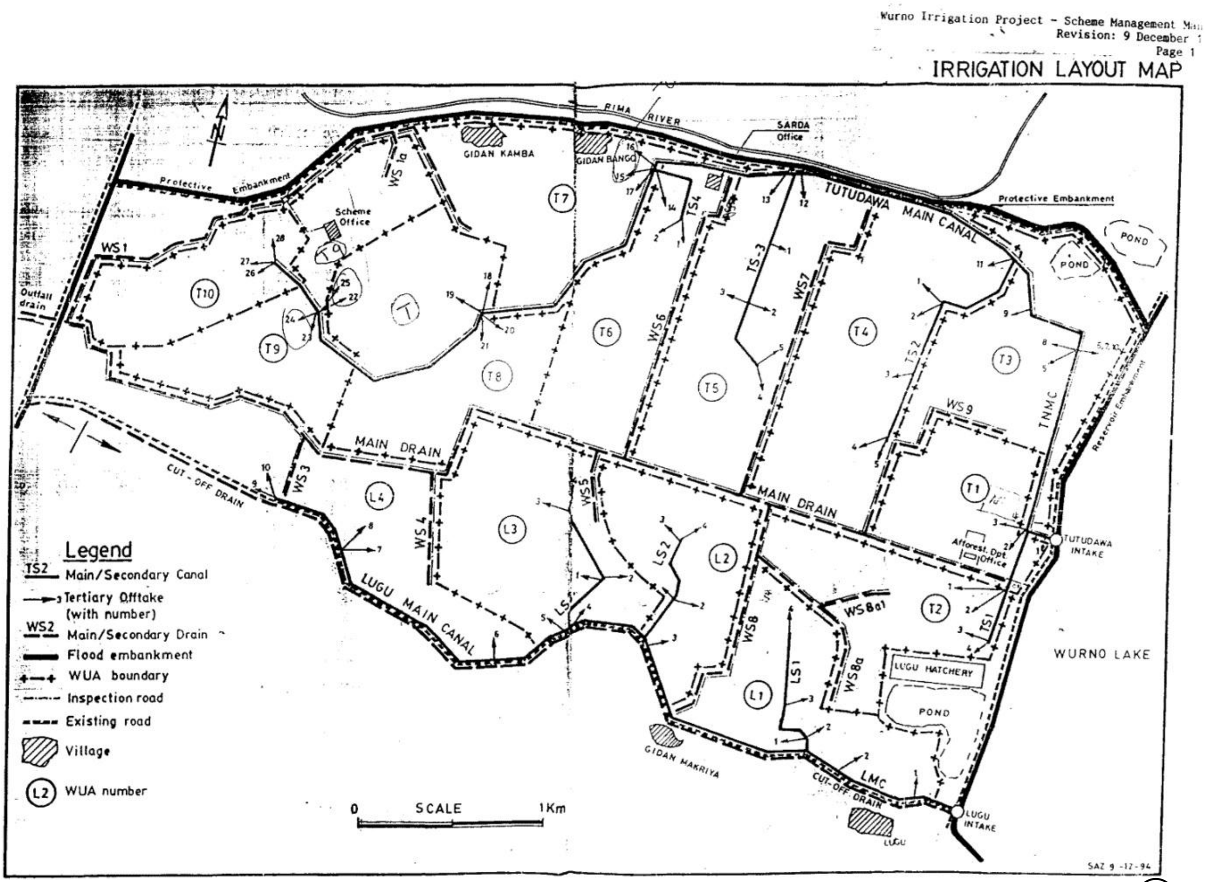

Figure 1: Map of Wurno Irrigation Scheme showing sampling locations tagged with letter (T)

2.3 Analytical Methods

The soil pH was determined both in water and in calcium chloride ($CaCl_2$) solution using a pH meter. Organic carbon was determined by Walkley and Black method (1934). The cation exchange capacity was determined using ammonium acetate saturation method as described by Hesse (1957).Exchangeable bases were extracted by the ammonium acetate extraction technique and determined by flame photometry (Adepetu *et al.*, 2000). The extract was analyzed for calcium (Ca) and magnesium (Mg) by atomic absorption spectrophotometry method while potassium (K) and sodium (Na) by flame photometer (Maclean, 1965). Total nitrogen (N) was determined by macro- Kjeldahl digestion distillation method (Jackson,1962). Available phosphorus was determined using Bray No. 1 method (Bray and Kurtz, 1945).Electrical conductivity (ECe) was determined using conductivity meter, The percentage base saturation, the sodium adsorption ratio (SAR) and the exchangeable sodium percentage (ESP) of the sample were computed using the following expressions;

(i) $$PBS = \frac{\sum Exchangeable\ Bases}{CEC} \times 100$$ (ii) $$ESP = \frac{Na^{+}}{CEC} \times 10$$

(iii) $$SAR = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{2+} + mg^{2+})}}$$

2.4 Statistical Analysis

The data collected were analyzed with the aid of analysis of variance (ANOVA) using statistical analysis system (SAS, 2002).

3. RESULTS AND DISCUSSION

The results of the chemical properties of the soils in the Tutudawa main canal of the Wurno Irrigation scheme after the September 2010 flood is presented in table 1-4

Table 1 Chemical properties of soil at Tutudawa Main canal of the Wurno irrigation scheme after September 2010 flood (0-15cm)

Location	p$^{H}_{H20}$	p$^{H}_{Cacl2}$	EC	SAR	ESP %
Tt1D1	6.83±0.58^{abcde}	6.16±0.58^{abcd}	0.50±0.10^{bc}	0.60±0.00^{abc}	7.83±0.62^{bcd}
Tt$_2$D1	6.33±0.42^{def}	5.83±0.35^{bcde}	0.03±0.02^{c}	0.64±0.10^{ab}	7.83±0.34^{bcd}
Tt$_3$D1	6.30±0.17^{ef}	5.87±0.58^{bcde}	0.3±0.00^{c}	0.60±0.02^{abcd}	9.3±0.66^{a}
Tt$_4$D1	6.40±0.17^{cdef}	6.03±0.15^{abcde}	0.03±0.01^{c}	0.50±0.00^{cd}	8.03±0.73^{abcd}
SE	0.5	0.06	0.01	0.01	0.11
Sig	*	*	Ns	*	*

Means followed by the same letters within a treatment column are not significantly (ns) different at 5% level of probability using Duncan multiple range test (DMRT) ns-not significant (P<0.05).

Table 2 Chemical properties of soil at Tutudawa Main canal of the Wurno irrigation scheme after September 2010 flood (15-30cm)

Location	p$^{H}_{H20}$	p$^{H}_{Cacl2}$	EC	SAR	ESP %
Tt1D2	7.10±0.36^{a}	6.63±0.46^{a}	0.03±0.02^{c}	0.56±0.06^{abcd}	8.58±1.66^{abc}
Tt2D2	6.30±0.17^{a}	5.80±0.17^{a}	0.03±0.00^{c}	0.60±0.06^{abcd}	7.52±0.41^{cd}
Tt$_3$D2	6.63±0.21^{abcdef}	6.06±0.15^{abcde}	0.02±0.02^{c}	0.60±0.05^{abcd}	8.50±0.16^{abcd}
Tt4D2	6.87±0.15^{abcd}	6.30±0.00^{abcd}	0.02±0.01^{c}	0.50±0.04^{d}	07.23±0.15^{d}
SE	0.05	0.06	0.01	0.01	0.11
Sig	*	*	Ns	*	*

Means followed by the same letters within a treatment column are not significantly (ns) different at 5% level of probability using Duncan multiple range test (DMRT) ns-not significant (P<0.05)

Table 3: Chemical properties of soil at Tutudawa Main canal of the Wurno irrigation scheme after September 2010 flood (0-15cm)

Location	O.C	Total N	AV. P	Ca	Mg	K	Na	PBS %	CEC
	→ g.kg^{-1} ←		Mg/kg	→	Cmol.kg^{-1} ←				
Tt1D1	0.35±0.16	0.07±0.00	1.20±0.13^{ab}	1.90±0.23^{cde}	1.80±0.11^{cde}	1.00±0.12^{abcd}	0.78±0.04^{cde}	54.56±2.65^{bcdef}	10.03±0.44^{bc}
Tt$_2$D1	0.23±0.18	0.07±0.01^{ab}	1.30±0.00^{a}	1.81±0.43^{cde}	1.60±0.30^{de}	1.13±0.08^{ab}	0.82±0.9^{cde}	49.01±84^{ef}	10.54±0.63^{abc}
Tt$_3$D1	0.37±0.06	0.07±0.00^{abcde}	1.20±0.12^{ab}	2.86±50^{a}	3.28±0.30^{a}	1.06±0.18^{abc}	1.00±0.09^{a}	75.73±7.88^{-}	10.80±0.57^{ab}
Tt$_4$D1	0.23±0.8	0.07±0.00^{abcde}	1.20±.13^{ab}	2.60±0.20^{abc}	2.83±0.05^{ab}	0.92±0.15^{abcd}	0.80±0.02^{cde}	72.05±5.50^{a}	9.94± 0.54^{bc}
SE	0.02	0.00	0.01	0.07	0.09	0.02	0.01	1.53	0.09
Sig	ns	*	*	*	*	*	*	*	*

Means followed by the same letters within a treatment column are not significantly (ns) different at 5% level of probability using Duncan multiple range test (DMRT) ns-not significant (P<0.05).

Table 4: Chemical properties of soil at Tutudawa Main canal of the Wurno irrigation scheme after September 2010 flood (15-30cm)

Location	O.C	Total N	AV. P	Ca	Mg	K	Na	PBS %	CEC
	→ g.kg^{-1} ←		Mg/kg	→	Cmol.kg^{-1} ←				
Tt1D2	0.36±0.22	0.06±0.00^{abcde}	1.09±0.25^{ab}	1.72±0.30^{de}	1.80±0.15^{cde}	0.93±0.13^{abcd}	0.74±0.09^{de}	53.54±3.48^{cdef}	9.63±0.29^{c}
Tt2D2	0.23±0.15	0.07±0.00^{abcde}	1.30±0.05^{ab}	1.63±0.43^{de}	1.62±0.29^{a}	1.00±0.08^{abc}	0.75±0.06^{de}	50.55±4.04^{def}	10.05±0.33^{bc}
Tt$_3$D2	0.42±0.07	0.06±0.00	1.14±0.96^{ab}	2.50±0.51^{abcd}	2.40±0.45^{bc}	0.94±0.18^{abcd}	0.89±0.06^{abcd}	64.01±3.00^{abc}	10.42±0.58^{abc}
Tt4D	0.23±0	0.06±0.00	1.16±0.	2.30±0.	2.40±0.3	0.92±0.13^{a}	0.70±0.0	65.60±2.2	9.62±0.4

2	.06	de	05ab	10abcde	0bc	bcde	4c	0abc	4c
SE	0.02	0.00	0.01	0.07	0.09	0.02	0.01	1.53	0.09
Sig	Ns	*	*	*	*	*	*	*	

Means followed by the same letters within a treatment column are not significantly (ns) different at 5% level of probability using Duncan multiple range test (DMRT) ns-not significant (P<0.05)

The pH values were slightly acidic to neutral and ranged from 6.30 to 6.83 and 6.30 to 7.10 at 0-15cm and 15-30cm soil depth respectively. These trends indicates a slight decrease in pH which could be attributed to seasonal leaching of basic salts due to poor soil management and over use of acid forming fertilizers. However, the observed pH values across the sampling locations are within the optimum value required for best performance of most tropical crops, (pH 6.0-7.0) where most essential nutrients are available at adequate amounts (Brady and Weil, 1999). The values are similar to what was previously reported by Yacouba, 1996, Singh, 1997 while working on soils of Sokoto Rima River Basin and Kandoli Shela stream valley. Irrigation practices significantly affected the distributions of pH values across the locations and soil depths (P<0.05) the electrical conductivity (ECe) values for the soils ranged from 0.03 to 0.5 dS/m and 0.02 to 0.03 dS/m at the 0-15cm and 15-30cm depths. The result of the study indicates a significance difference in the mean values of (ECe) across the sampling locations and depths. In general the ECe values suggest that there is no accumulation of soluble salts to the depth sampled to such an extent to limit crop production. This was supported by FAO, (2014) who reported ECe of (<0.8 dS/m) as low in range, to cause any salinity hazards.

Sodium adsorption ratio ranged from 0.50-0.64 at both 0-15 and 15-30cm depths and do not pose any threat to salinity build up. Increasing sodicity hazards may be associated with values exceeding 6, additionally, irrigation practices and soil depths significantly affected the distributions of SAR values across the sampling locations (P<0.05). The results also agree to rule that values of SAR should always be lower than the values of ESP (%).Values of ESP is presented in (Table 1 and 2). It ranged from 7.83 to 9.3 (%) and 7.23 to 8.58(%) for 0-15cm and 15 -30cm depths. The highest numerical mean values of ESP occurred at 15-30cm. There is also significant difference between the ESP values across all the sampling locations, and depth (P<0.05).Graham and Singh (1997) reported ESP range of 4-12 (mean 7) for soils of the same study area (WIP). An ESP value of 15 is considered as critical limits for salt affected soils. (Brady and Weil, 2002).

Organic carbon ranged from 0.23 to 0.37 g/kg at (0-15cm) depth and 0.23 to 0.42 g/kg at (15-30cm) depth respectively (Table 3 and 4).Organic carbon levels were generally low across all the sampling locations and depths (<1.00) Also, there was significant difference between the values of organic C across all the sampling locations and depth due to irrigation practices. It was observed that, the distribution of organic carbon was irregular, across the location, but at (Tt_3D_2) the value was relatively higher. This could be attributed to the anaerobic condition of the subsurface layer, as poorly drained soil are typically known to accumulated higher levels of organic matter than well-drained soil, (McCauley et al; 2003) or may be due to differences in organic matter content of alluvial materials deposited during seasonal flooding (Ojanuga, 2006).

On the general assessment, the low organic C observed in the study area could be due to intensification of cultivation (Greenland et al, 1994) or due to rapid decomposition and subsequent mineralization of organic matter owing to high temperatures which speed-up microbial activities. Total Nitrogen ranged from 0.7 to 0.07 By fertility rating of Nigerian savannah soil, (Esu 1991), the values of the were all within the class of low range. The low values could be attributed to leaching process of N especially under flooded situation. In addition, the finding confirms the fact that the total N decrease with soil depth (Brady and Weil, 1999). Also, the total N values observed were somewhat higher than those reported by Graham and Singh (1997) who reported value of N as high as 0.4 – 0.6gkg^{-1} at 0-15cm depth. The finding also agrees with the work of Mustapha and Nnalee (2007) who reported low nitrogen levels obtained from Fadama soils in Bauchi state. Irrigation practice and Soil depth also affected the distributions of Total Nitrogen levels significantly across all the locations (P<0.05). The values of Available phosphorus ranged from 1.20 to 1.30 mg/kg and 1.09 to 1.16g/kg at (0-15cm) and (15-30cm) depth respectively. Esu (1999) reported that soils with available P level of <10mg/kg as rated low, 10.0 – 20.0 mg/kg as medium and > 20mg/k is rated high.

Therefore, this qualifies the soils of Tutudawa study sites to be within the low range of available P. The exchangeable bases were generally high except calcium which was found to be low across all the sampling points and depths. The values ranged from 1.81 to 2.86 cmol (+)/kg^{-1}, 1.63 to 2.50 cmol (+)/kg^{-1} and 1 .60 to 3.28 cmol (+)/kg^{-1}, 1.62 to 2.40 cmol (+)/kg^{-1} for calcium and magnesium at 0 -15 cm and 15-30cm soil depths respectively. The values of exchangeable K^+ and Na^+ values ranged from 0.92 to 1.13 cmol (+)/kg , 0.92 to 1.00cmol (+)/kg and 0.78 to 1.00 cmol(+)/kg and 0.74 to 0.89cmol(+)/kg at 0 -15 cm and 15-30cm depths respectively. Percent base saturation ranged from 49.01 to 75.73% and 50.55 to 65.60% at 0-15cm and15-30cm soil depths. The values obtained could means that over 50% of the cations could be exchanged into the soil solution for root uptake. Esu, (1991) reported soils with base saturation of <50% (as low), 50-80% (medium) and (>80%) as high and therefore the soil is within the medium range of base saturation. Cation exchange capacity values ranged from 9.94 to10.80 cmol (+)/kg^{-1} and 9.62 to10.24 cmol (+)/kg^{-1} at 0-15cm and15-30cm) depth respectively. The distribution of the mean values were irregular and were significantly affected by irrigation practices ($P<0.05$). This also translated the soil into a very good index of percent base saturation (PBS).

4. CONCLUSION

Soil of the Tutudawa main canal of the Wurno irrigation scheme are generally within the range of low to medium level of fertility. The pH was slightly acidic to neutral in range .Organic Carbon, available P and Calcium was generally low. Except calcium, all the exchangeable bases were high and this signal the tendency for salinity build up. Percent base saturation and CEC were all moderate. Although the soil has not yet indicated clear symptoms of salt build up, periodic monitoring of soil should be done so as to protect the soil from deterioration. Adoption of proper manure application and controlled irrigation should be encouraged. Government should as a matter of urgency rehabilitate the damaged water conveyance structures so as to reduce unnecessary soil water lodging and salt build up.

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