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Full Length Research Paper

Assessment of selected soil nutrients and irrigation water quality in the dryland area of Chivi District, Zimbabwe

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The levels of selected nutrients in soils and chemical composition of irrigation water were investigated in 16 villages from the dryland areas of Chivi District in Zimbabwe. The objective was to generate a biophysical knowledge base on the soil fertility status across different villages, and to relate it to site history, management and quality of surface and groundwater used for irrigation. Soil samples were collected from the fields, gardens, cultivated vleis, and virgin land while irrigation water samples were collected from rivers, vlei and shallow wells used to irrigate horticultural crops. Results revealed medium to deficient levels of nitrogen (N) and phosphorus (P) (>75% of the sampled units), and to a lesser degree, potential soil acidity problems on selected fields. The considerably higher soil pH and exchangeable bases in the irrigated gardens and vleis than in the fields and virgin land reflected the impact of management and land utilization. The chemical quality of the sampled water used for irrigation of horticultural crops all showed high chloride hazard. There was need to ascertain the magnitude of crop productivity against applied soil fertility inputs to establish the level and rate of nutrients mining from the soils.

Key words: Soil, fertility, dryland, desertification, irrigation.

INTRODUCTION

The depletion of nutrients from soil through continuous cropping without adequate replenishment has lead to a decline in soil productivity (Kanonge et al., 2009) and in some cases, abandonment of degraded croplands in the communal areas (CAs) of Zimbabwe (Anderson et al., 1993; FSRU, 1993). In the traditional farming systems, nutrient depleted soils were fallowed for about 15 years or more to restore fertility and control erosion (Grant, 1981). However, because of high population pressure on land, the fallowing of nutrient-depleted soils is no longer feasible. The restoration and maintenance of soil productivity require critical assessment of soil fertility variability at field and village levels in addition to the assessment of agro-ecological factors such as soil moisture constraints. When this variability is known technologies that best match specific soil productivity problems and that tally with farmers' available resources can then be targeted (Mtambanengwe and Mapfumo, 2005). This would result in improved soil fertility inputs management and crop yields as it discourages unneeded nutrients application and encourages application of nutrients necessary to allow effective crop responses.

Most CAs in Zimbabwe are found in the drier areas of Natural Regions (NRs) IV and V (mean annual rainfall <650 mm) that are considered too risky for crop production (Vincent and Thomas, 1961). Metelerkamp and Thompson (1967) recommended that commercial crop production in these areas should only be considered in cases where very short-seasoned crop varieties are grown or with irrigation. Horticultural production using

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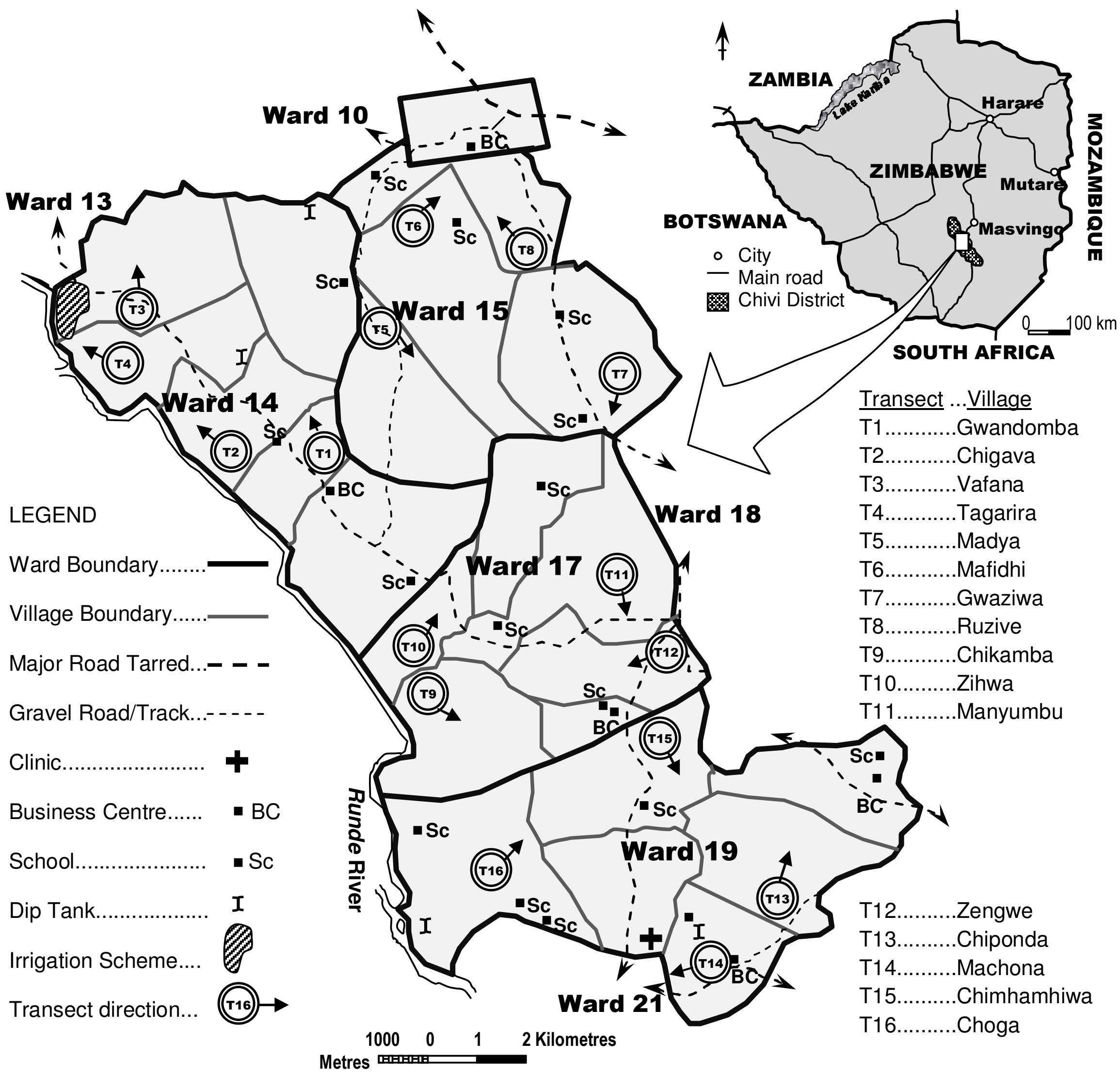

Figure 1. Location and direction of sampled transects in the 16 villages from four in Chivi District, Zimbabwe.

water from rivers, vleis and shallow well for irrigation has contributed to the enhancement of household food security in many CAs in the drylands. To protect these areas from land degradation, resulting from excessive salts (salinity), sodium (sodicity) and toxicity of chemicals found in some irrigation waters, the quality of both surface and groundwater used for irrigation also needs critical assessment.

The objectives of this study were to determine (1) the levels of selected nutrients in soils and their variability across different villages, site backgrounds (field, garden, vlei and virgin land) and previous crops grown (maize, groundnuts, sorghum, vegetables, rice, pear millet, mixed cereals, fallowed and virgin land) in 16 villages from Chivi District, (2) the chemical quality of surface water used for irrigation of horticultural crops to assess its suitability for long-term irrigation. The knowledge generated would guide future agricultural and environmental research on the restoration and maintenance of soil productivity to combat the problems of declining crop yields and desertification in Chivi drylands.

MATERIALS AND METHODS

Study sites

Chivi District is located south central Zimbabwe (Figure 1). The district extends from 20° 14' S to 20° 24' S and lies between 30° 13' E and 30° 57' E. The area receives low and unreliable rainfall (mean annual, 530 mm) and is generally characterized by poor crop productivity and food insecurity. Major soils in Chivi were mainly derived from coarse-grained granite and include the chromic luvisols, ferric luvisols and eutric regosols (Anderson et al., 1993). The study sites were selected from wards 14, 15, 17 and 19 identified by the District Council as the worst in the district in terms of crop yields and food security. From each ward a total of four study villages were selected (Figure 1). Subsistence agriculture was the basis of the economy of people in the selected villages. The major field crops grown were maize (*Zea mays*), sorghum (*Sorghum bicolar*), finger millet (*Eleusine coracana*), pearl millet (*Pennisetum typhoides*) and cowpeas (*Vigna sinensis*). Major horticultural crops grown in individual or cooperative gardens included the leafy vegetables (mostly *Brassica* sp.) and tomatoes (*Lycopersicon esculentum*). Land pressure was high and the average size of arable land holdings was about 2 ha per household, and the land sizes were reported to be declining with increasing family sizes (Mavedzenge et al., 1999). Because of the poor yields attained, people from these villages also relied on food aid from the government and non-governmental organizations working in the area.

Farmer participation

This study employed participatory methodologies. The main participatory tool employed was focus group discussions that were conducted in each village. During these discussions villagers deliberated and agreed upon the soil classes occurring in their area. They also chose the location of transects along which soil and water samples were collected, with assistance of the village agricultural extension staff.

Soil and water sampling

Soil and irrigation water sampling was done in August after the farmers had harvested field crops and before the fields were prepared for the 2004/2005 cropping season. A participatory approach was used in which the farmers were actively involved in the collection of samples and giving background information on the sampled areas. Farmers identified imaginary transect lines (Figure 1) along which all or most of the soil types in their villages could be found within a walking distance of at-least 1 km. A total of 155 composite soil samples were collected from all the 16 villages and the samples were from the farmers' active fields (72%), gardens (8%), indefinitely fallowed fields (7%), cultivated vleis (10%) and virgin land (4%), identified along the transects. The class of indefinitely fallowed fields was defined by farmers as land that had been inactive for at least five years. A composite soil sample (of five sub-samples) was taken from each sampling unit or farmer's field. The sub-samples were collected using a bucket auger at 0 to 0.15 m depths and along independent zigzag paths to achieve randomness.

Nine water samples were collected from shallow wells (5), rivers (3) and vlei (1) used for irrigating horticultural crops at the gardens found along the transects from which soil samples were being collected. The samples were collected from seven villages, namely, Gwandomba (T1), Gwaziwa (T7), Zihwa (T10), Manyumbu (T11), Chiponda (T13), Machona (T14) and Chimhamhiwa (T15) in the four Wards (Figure 1). The water samples were collected at just below the water surface using 1 L polythene bottles, which were filled to the brim.

Analysis of samples

The soil samples were air-dried and ground to pass through a 2 mm sieve prior to determination of pH, mineralizable N, available P, organic carbon, cation exchange capacity, exchangeable bases (Ca, Mg, K and Na) and texture. Soil pH was measured with a pH meter in a 1:5 soil:$CaCl_2$ suspension (McNeal, 1982). The incubation technique (Saunders et al., 1957) was used to estimate mineralizable N that was extracted using KCl solution and determined spectroscopically. Soil-N after a two-week incubation period has for many years been used to predict the optimum N requirements of maize (Fenner and Davidson, 1980), and represents the amount of N that may be available to crops planted early before an appreciable amount of initial N has been leached out (Mapanda and Mugwira, 2009). Available P was extracted by the Resin method (Amer et al., 1955) and determined spectroscopically. The Resin method extract soil-available P in a similar manner as plant roots does, and in contrast to chemical extractants, it can be employed on a variety of soil types, while the resin can be re-used several times without loosing its extraction power (Abdu, 2006).

Organic carbon was estimated by the Walkley-Black method (Nelson and Sommers, 1996), while the exchangeable bases (Ca, Mg, K and Na) and cation exchange capacity (CEC) were determined after extraction with ammonium acetate (Summer and Miller, 1996). The concentrations of exchangeable Na and K were determined by flame emission photometry, while Ca and Mg were determined by atomic absorption spectrophotometry. The relative proportion of sand, silt and clay in the soil was determined using the Bouyoucos hydrometer method (Gee and Bauder, 1986), while a soil texture triangle (FAO, 1990) was used to determine the texture category.

Water samples were analysed for pH, Ca, Mg, Na, carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), chloride (Cl^-), electrical conductivity and total dissolved solids using standard methods (Food and Agriculture Organization (FAO) adopted), described by Abbott and Hasnip (1997). The sodium adsorption ratio (SAR) was derived as the concentration of Na^+ ions relative to the square root of half the total concentrations of Ca^{2+} and Mg^{2+} ions. The bicarbonate hazard (from residual sodium carbonate (RSC) was derived from the difference in concentration (in mmol^c litre^{-1}) between the sum of the HCO_3^- and CO_3^{2-} anions and the sum of the Ca^{2+} and Mg^{2+} cations).

Data analysis

SPSS statistical package (Version 10) was used for statistical analysis of data, including the analysis of variance to test the effects of site (villages), land background (field, garden, vlei and virgin land) and previous crop grown (maize, groundnuts, sorghum, vegetables, rice, pear millet, mixed cereals, fallowed and virgin land) on soil nutrients and pH levels (dependent variables). Bivariate correlation analysis (two-tailed) was performed among the variables using the Pearson correlation coefficients, while regression analysis was conducted to measure the strength of relationships between variables.

RESULTS

Soil textural classes (Farmers' classification)

Farmers from the 16 villages in wards 14, 15, 17 and 19 categorized their soils into six broad groups and 23 sub-groups (Table 1). According to the farmers' information, more than 90% of the sampled units have sandy, loamy and stony soils, while clay soil (<10%) occurs in selected villages from wards 17 and 19. Farmers classified their soils according to the perceived proportions of sand and clay fractions, colour and stoniness, which was indicated in their local system of soil naming. The naming of light textured soils generally reflected some level of grittiness upon hand feeling. It also gave an indication of the poor inherent fertility of the sandy soils which they identified as

Table 1. Soil textural classes (according to farmers), and their relative occurrence frequencies expressed as a fraction of the total sampled fields in each ward.

Category	Sub-category in local vernacular	Ward (W) and % of fields in category			
		W-14	W-15	W-17	W-19
Sand (*Musheche*)	*Musheche* - sand	17	34	26	12
	Musheche muchena - white sand	7	3	–	7
	Musheche mutsvuku - brown sand	13	–	3	5
	Rusekenya - dark grey sand	13	5	3	–
	Gan'a remusheche - loamy sand	–	3	8	5
Loam (*Gan'a*)	*Gan'a* - loam	7	11	27	14
	Musheche gan'a - sandy loam	–	3	–	2
	Rujekese gan'a - stony loam	–	3	11	–
	Gan'a dzvuku - red loam	–	3	–	–
	Gan'a dema - dark grey loam	10	–	–	–
	Gan'a rebwezha - shallow loam	–	3	–	–
	Gan'a regadhi - clay loam	–	–	5	–
Clay (*Chiname*)	*Chiname/Chigadhi* - clay	–	–	3	2
	Chigadhi chitema - heavy clay	–	–	–	2
Stony soil (*Jekese*)	Jekese - stony soil	7	11	5	12
	Doro-jekese - stony soil of vleis	–	–	–	2
	Jecha jekese - stony sand	3	–	–	2
Wetland soil (*Doro*)	*Doro* - wetland/vlei	10	11	5	21
	Jekese doro - stony wetland	–	5	–	–
	Gan'a doro - wetland loam	–	–	–	2
	Guvi - found on waterways	–	–	–	5
Sodic/saline-sodic (*Chimhamhare*)	*Chimhamhare* - sodic/saline-sodic	3	–	–	–
	Rusekenyamhamhare- sodic sand	3	5	5	–

one of the major challenges, together with frequent droughts. Naming of heavy textured soils reflected high stickiness on tillage implements for example, *chiname*. In some cases soils were classified according to their location, for example, in wetlands and waterways. Saline or saline-sodic soils were identified with their exceptionally lighter or pale colours and poor vegetation cover or poor crop performance.

Analytical results of the textural assessment showed that all sampled soils could be classified (FAO, 1990) under five textural classes, namely, sand, loamy sand, sandy loam, sandy clay loam and sandy clay (Figure 2). Of these classes, sands and loamy sands made up 80.6% of the sampled units, while 11.6% were sandy loams and sandy clay loams, and the remaining 7.8% were sandy clays. Soil fertility management in Chivi varied considerably with the textural class of soil. Farmers indicated that they used animal manure, anthill soil, composts and leaf litter on sandy soils while some heavier-textured soils were considered inherently fertile and did not receive any amendments, except at the gardens. The application of organic soil amendments was done in rotations among three or more fields such that most of the fields were fertilized in three or more year intervals. Farmers specified that animal manure, anthill soil and compost were applied for the production of cereals, while leaf litter, poultry and goat manure and ash (considered to be of higher quality, but available in smaller quantities) were mainly reserved for the production of horticultural crops in the gardens.

Soil pH

The topsoil pH differed considerably (P <0.05) among the 16 villages (Figure 3a). The mean pH levels were highest in Machona (T14) and Mafidhi (T6) villages (pH 6.4 and 6.3, respectively), while lowest in Madya (T5) and Choga (T16) villages (pH 4.7 and 4.5, respectively). Soils from cultivated vleis and gardens with generally higher inputs

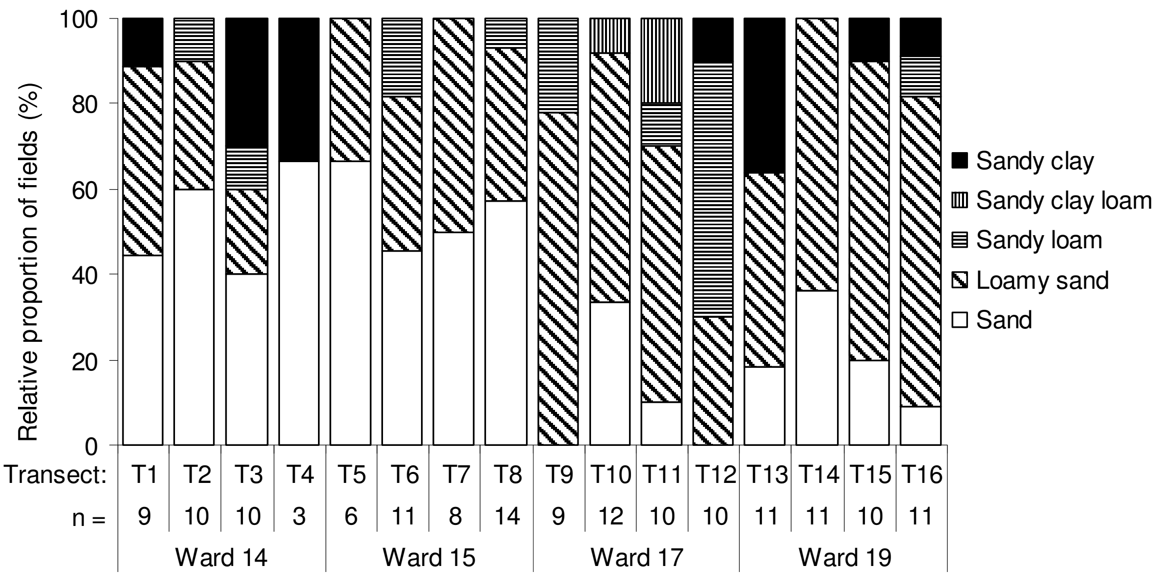

Figure 2. Laboratory based soil textural classes of the sampled fields along the 16 transects in Chivi District.

of manure and other soil amendments had significantly (P <0.05) higher pH (mean, 6.3 and 6.1, respectively) than soils from active fields, indefinitely fallowed fields and virgin land (mean, 4.9 to 5.2). Significant differences (P <0.05) in pH were also found with the previous crops grown and higher pH values were found in the garden soils under vegetables (mean, 6.1) than in soils under other crops (means, 5.3 to 5.8). The soil pH classes given in Figure 3a may suggest that at least 25% of the sampled units in each village, except Mafidhi (T6) and Chikamba (T9), had strongly acid soils.

Available nitrogen and phosphorus

Available N, estimated as mineral N after 14-day incubation (mineralizable N) ranged from 1.0 to 70 mg kg^{-1} (Figure 3b). No significant differences (P >0.05) in available N were found among the 16 villages, among the site backgrounds (active field, cultivated vlei, garden, indefinitely fallowed field and virgin land), or among the previous crops grown. The same variability was observed with available P that ranged from 1.0 to 138 mg kg^{-1} (Figure 3c). Available P was positively correlated with pH and available N (P <0.01), but there were no definite linear relationships (r^2 = 0.33 with pH; and 0.15 with available N). At least 75% of the sampled areas have deficient to marginal levels of N and P.

Exchangeable bases

Total exchangeable bases (summation of exchangeable K, Ca, Mg and Na) in the topsoil of the fields, gardens, cultivated vleis and virgin land from the 16 villages in Chivi are shown in Figure 4a. The total exchangeable bases (means range: 8.7 to 2.0 $cmol^{(+)}$ kg^{-1}) varied considerably (P <0.05) among the villages, and showed significant (P <0.01) positive correlation with soil pH, organic carbon and mineralizable N. Similarly, the base saturation of soils from the 16 villages (means range: 39.5 to 83.4%) (Figure 4b), showed positive correlation with pH and organic C (P <0.01) and with mineralizable N (P <0.05). Among the soils with the highest mean base saturation were those from Zengwe (T12), Machona (T14) and Gwandomba (T1) villages that apparently had 73 to 78% of sampled soils from the category of active fields, and less than 20% from the category of gardens. This could imply that the high base saturation was not only limited to soils from the gardens but was characteristic of the inherent soil properties of a particular village. Among the soils with the least mean base saturation were those from Tagarira (T4), Madya (T5) and Vafana (T3) villages with all samples coming from the category of active fields, except Madya Village that also had 1 garden soil sample from the transect.

Exchangeable sodium percentage (ESP) in the topsoil (Figure 4c) did not reflect potential sodicity challenges in all villages (means, 0.6 to 5.0%), with the exception of specific vleis soils in Gwandomba (T1), Chikamba (T9) and Manyumbu (T11) villages (ESP 21, 24 and 26%, respectively). These soils were also identified by farmers (Table 1) as having an exceptionally lighter colours and giving poor crop performance.

Soil organic carbon

Organic carbon in the topsoil ranged from 0.06 to 2.3% (Figure 5). Significant differences (P<0.05) in organic

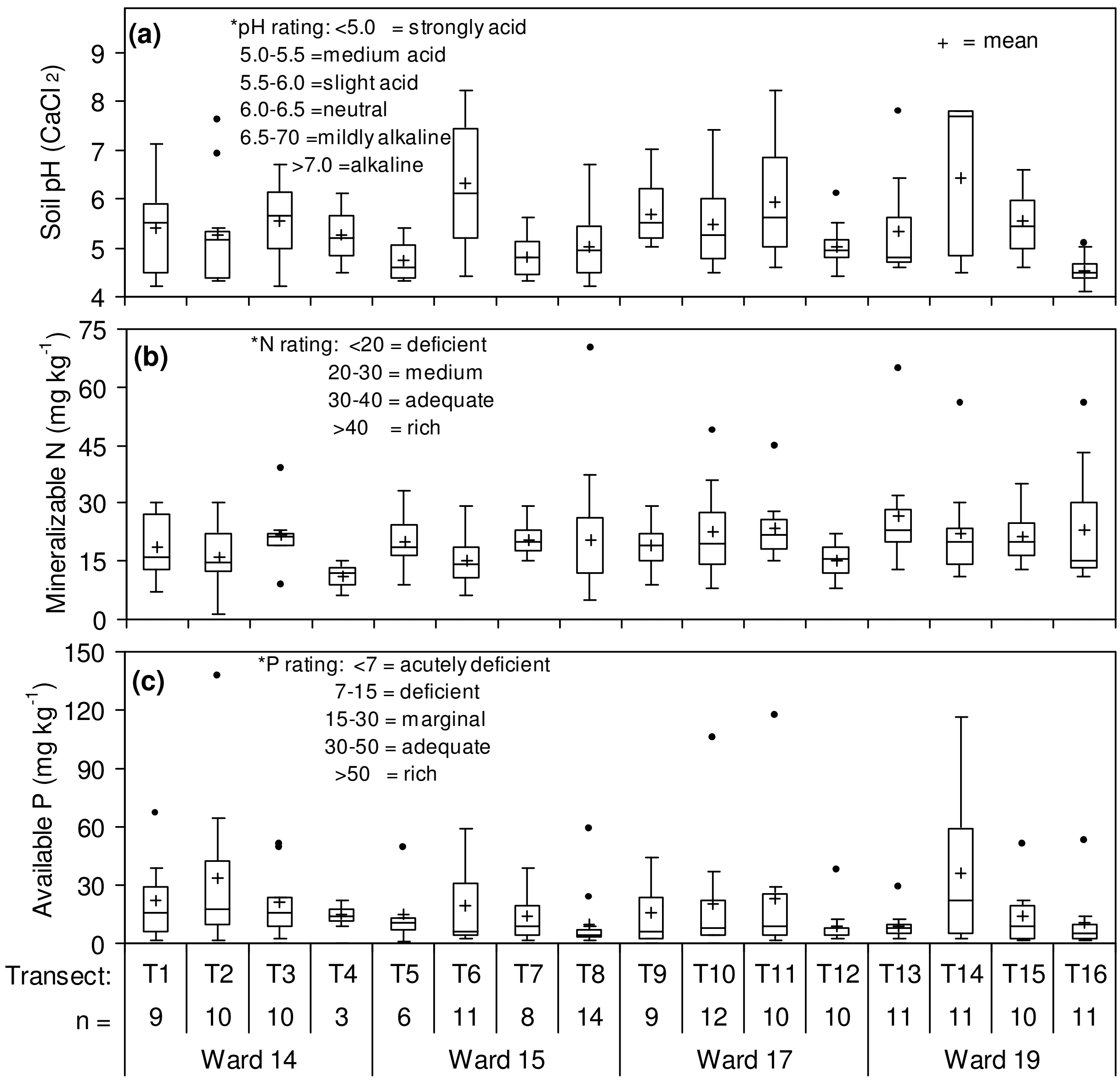

Figure 3. (a) Topsoil pH, (b) mineralizable N (c) available P along the 16 transects in Chivi District (*rating adopted from CSRI, 2005).

carbon were found among the villages (means range: 0.3 to 1.2%). Among the villages with the highest mean soil organic carbon were Gwandomba (T1), Chigava (T2) and Gwaziwa (T7). Higher soil organic carbon was characteristic of the cultivated vleis and gardens encountered along these transects than active fields along transects of the other villages. The lowest mean soil organic carbon were found in Mafighi (T6), Chiponda (T13) and Machona (T14), despite the fact that the soils along these transects had considerably higher proportions of heavier textured soils than in other villages (Figure 2). Mafidhi Village that also had the least soil pH had 27% of the sampled soils coming from the category of indefinitely fallowed land, while Chiponda and Machona Villages had largely active fields.

Chemical quality of irrigation waters

The chemical composition of water from shallow wells, rivers and vlei used to irrigate horticultural crops in selected villages from Chivi are given in Table 2. Water from these villages were largely neutral to alkaline (mean, 7.4), while potential salinity hazard was noted in the shallow well water from Manyumbu (T11) and Chimhamhiwa (T15) villages. However, potential sodicity hazard (from the sodium adsorption ratio) was only apparent in the shallow well water from Manyumbu Village

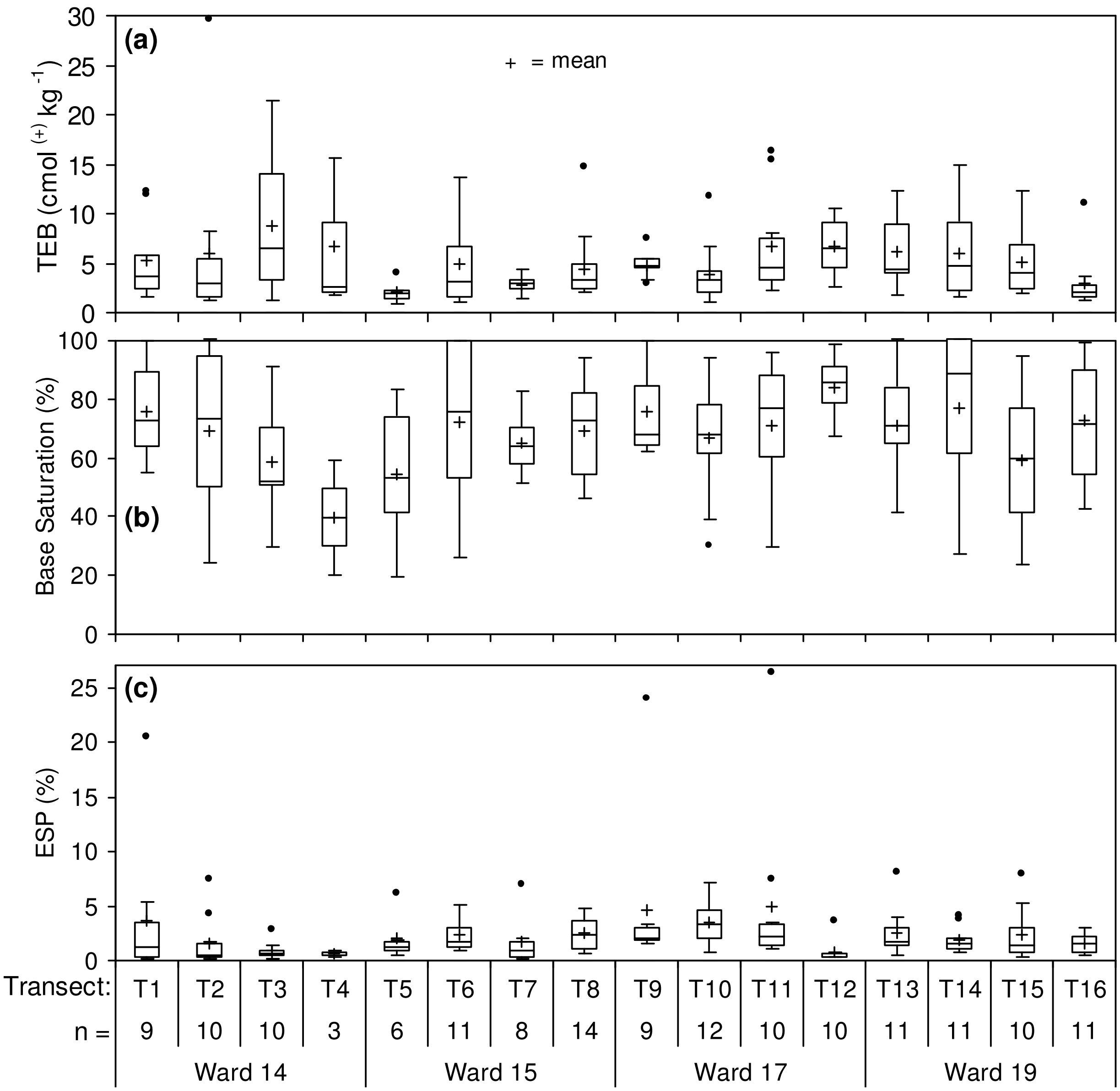

Figure 4. (a) Total exchangeable bases (TEB), (b) base saturation (c) exchangeable sodium percentage (ESP).

that also had high bicarbonate hazard (from residual sodium carbonate). The Ca/Mg ratio (derived using the units mmol^c l^{-1}) was most inverse in the shallow well water from Manyumbu Village, reflecting potential nutrient imbalance challenges. All sampled water sources had high chloride (Cl^-) hazard (mean, 41.2 mg l^{-1}).

DISCUSSION

Farmers from the study villages were knowledgeable about the major factors limiting crop production in their fields, and from their perspective poor soil fertility was the key challenge, together with drought conditions that characterize Chivi District. The farmers were also aware of the variability in soil textures among their fields, hence the variability in soil fertility inputs management between soils considered as light-textured and those considered as heavy-textured. Because of the variability in soil textures among the fields and the variability in farmers' resources-availability within each village, giving a general recommendation on soil fertility inputs allocation might be inappropriate.

Soil nutrients status and variability

The assessment of selected soil nutrients described in this study is based on the criteria described by Mashiringwani (1983), Landon (1984), Nyamangara and

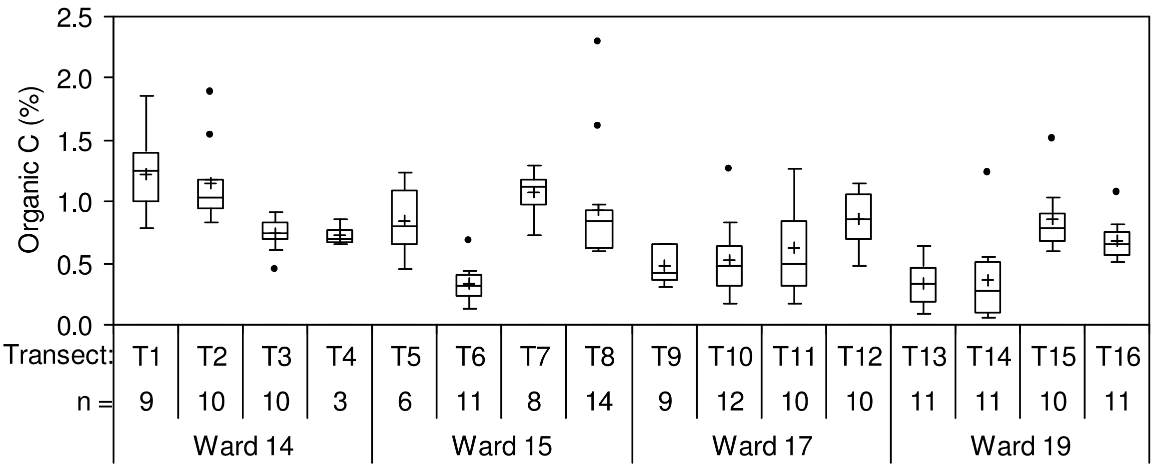

Figure 5. Soil organic carbon in the 0 - 0.15 m depths of the soil sampled along the 16 transects in Chivi Districts.

Table 2. Chemical properties of the irrigation water sampled once from shallow wells, rivers and vlei found along transects (*T*) in 7 villages of Chivi District.

Parameter	**Source of water**								
	Shallow well					**River**			**Vlei**
Transect ID	**T1**	**T7**	**T11**	**T13**	**T15**	**T10**	**T11**	**T14**	**T13**
pH	7.5	6.5	8.3	6.9	7.2	7.3	7.8	7.5	7.4
[a]EC (µS cm^{-1})	316	317	213	1272	999	186	217	427	531
Ca^{2+} (mg l^{-1})	12.8	10.1	4.2	11.9	55.0	8.0	1.6	16.0	8.7
Mg^{2+} (mg l^{-1})	1.5	3.0	6.1	7.9	19.0	0.6	1.5	8.5	9.1
Na^{+} (mg l^{-1})	22.1	18.8	153	14.3	35.3	13.3	14.6	24.4	39.5
CO_3^{2-} (mg l^{-1})	0	0	0	0	0	0	0	0	0
HCO_3^{-} (mg l^{-1})	45.8	30.5	198	54.9	146	46.4	64.1	79.3	97.6
Cl^{-} (mg l^{-1})	46.2	38.1	64.4	42.2	53.0	35.0	44.8	21.0	26.0
[b]TDS (mg l^{-1})	151	101	610	150	482	89	130	204	254
[c]SAR	0.2	1.3	11.1	0.8	1.0	1.2	2.0	1.2	2.2
[d]RSC (meq l^{-1})	0	0	0	2.53	0	0.30	0.80	0	0.41
Ca/Mg ratio	5.1	2.1	0.4	0.9	1.8	8.00	0.6	1.1	0.6
[e]Quality Code:	$C_2S_1R_1X_1Y_3$		$C_3S_2R_3X_2Y_3$		$C_3S_1R_1X_1Y_3$		$C_2S_1R_1X_1Y_3$		$C_2S_1R_1X_1Y_3$
Quality Code:		$C_1S_1R_1X_1Y_3$		$C_2S_1R_1X_1Y_3$		$C_1S_1R_1X_1Y_3$		$C_2S_1R_1X_1Y_3$	

[a]Electrical conductivity; [b]Total dissolved solids; [c]Sodium adsorption ratio; [d]Residual sodium carbonate; [e]Hazard indices where: C, S, R, X and Y denote salinity, sodicity, bicarbonate, Ca/Mg imbalance and chloride hazards, respectively, and subscripts 1, 2, 3 denote low, medium and high hazard according to the rating by de Toit (1970).

Mpofu (1996) and Nyamangara et al. (2000), developed from long-term soil fertility experiments in Zimbabwe. The criteria are general for most crops commonly grown in Zimbabwe and the current fertilizer recommendations given to farmers are also based on these criteria, although special considerations are given to specific nutrient requirements of crops and to site potential or soil moisture adequacy.

Lower pH levels were found in the fields and virgin land where low or no organic soil amendments are applied than in the gardens (where large quantities of 'quality' organic soil amendments are applied) and vleis (which are mainly the zones of accumulation of leached bases and salts in the soil catena). According to Nzuma et al. (2000), the problem of soil acidity in the CAs of Zimbabwe has been worsened by continuous mining of nutrients (cropping with little or no replenishment of nutrients removed at harvesting with the crop) and lack of use of lime. The gardens are generally located closer to the homesteads where the labour of transporting organic soil amendments is minimal in contrast to most fields that are far from the livestock kraals. Results however, reflected that the challenge of soil acidity was largely small.

Medium to deficient levels of N and P were the main potential challenges to soil productivity in the 16 villages studied. The study was however unable to fully attribute the differences in soil fertility to management by individual farmers within each village because of high uncertainty in the management information supplied by the farmers. In addition, the study could neither capture the exact magnitude of crop productivity from the villages nor the exact measure of soil fertility inputs applied in the previous season. These factors would be critical in order to ascertain the levels of and relative rates of nutrients mining from the soil. However, it may be argued that persistent droughts have reduced the number of livestock in these CAs resulting in reduced use of animal manure, and hence a gradual depletion of soil nutrients (Nyamangara et al., 2000), Although it would be anticipated that soils from the fields ought to have lower nutrients levels than soils from the gardens, most farmers indicated that the previous cropping season was exceptionally poor because of limited soil moisture and as such some farmers harvested nothing. This suggests that the soil amendments previously applied in the fields had a residual effect on the levels of N and P in some fields at the time of sampling.

The soils from the 16 villages had generally high base saturation considering that most of them were light textured which would make them more vulnerable to leaching losses. The observation that this high base saturation was not only limited to soils from the gardens reflected that the loss of bases through leaching may have been generally low due to the generally low rainfall received in Chivi District. Both low leaching losses and potentially low crop uptake of bases from the fields, as a result of droughts that may reduce crop productivity, may be important factors in explaining the high base saturation of these soils.

The challenge of sodicity that was testified by the farmers on some cultivated vleis, to some extent, may be attributed to both parent material and poor drainage. Thomson (1968), in his study on soil-profiles of some sodic soils in Zimbabwe, indicated that sodic condition are most commonly found in soils derived from granite, and the sodic horizon, which is dense and relatively impermeable, usually commences very abruptly. He added that when surface horizons have been removed by erosion, the sodic horizon exposed at the surface then appears as a bare patch with a thin layer of coarse surface sand. A 50% yield reduction may be expected with ESP >15% (Landon, 1984), thus, this challenge is likely to be affecting only 3.2% of the sampled areas in the four wards of Chivi District.

Irrigation water quality

The major concern from the chemical composition of all sampled water used to irrigate horticultural crops was the high chloride hazard. The water would add between 84 and 257.6 kg Cl ha^{-1} if applied at the rate of 400 mm ha^{-1} (to irrigate leafy vegetables within a growing period of four months, at the general recommended rate of 25 mm per week). As a general rule <40 kg Cl ha^{-1} may be applied in irrigation of chloride sensitive crops such as tobacco, tomatoes and most legumes, and to achieve that the maximum permissible chloride concentration was set at 10 mg l^{-1} (Zvomuya, 1996; Abbott and Hasnip, 1997), in contrast to the higher chloride concentrations found in the water (Table 2).

Only the shallow well from Manyumbu Village (T11) showed high salinity hazard, sodicity hazard, bicarbonate hazard and an imbalance of Ca and Mg. The gardens irrigated by such water also had the highest pH and exchangeable Na, and second highest ESP, suggesting that this was the main source of soil contamination at the garden. According to Zvomuya (1996), irrigation water with a bicarbonate hazard results in the pH of the soil rising to unacceptable levels. This rise in pH may cause nutritional problems that may manifest as chloroses. The effect of irrigation water quality on the quality of the produce in Manyumbu Village was however not captured in this study although it was noted during the survey that the farmers perceived a challenge with water and quality of their produce. Bicarbonate water may also raise the level of exchangeable Na in the soil because the precipitation of Ca and Mg as insoluble carbonates increases the SAR of the soil solution.

Conclusion

The medium to deficient levels of N and P were the main potential challenges to soil productivity in the 16 villages of study in Chivi, while a small proportion of the fields had the challenge of high soil acidity. The considerably higher soil pH and exchangeable bases in the irrigated gardens and vleis than in the fields and virgin land reflected the impact of management and land utilization, but with very limited confidence. This was largely because of high uncertainty in the management information supplied by the farmers and the lack of data on the exact magnitude of crop productivity and soil fertility inputs applied in the previous season. Soil pH also varied significantly with the previous crops grown, being significantly higher with vegetables than with any other crop. The chemical quality of the sampled water used for irrigation of horticultural crops all showed high chloride hazard, while salinity, sodicity and bicarbonate, hazards were mainly characteristic of the shallow well water from one village.

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