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FARMERS' PERCEPTION ON THE EFFECTS AND MANAGEMENT OF SALINE WATER ON SOIL AND CROPS WITHIN KILIFI AND KWALE COUNTIES

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ABSTRACT

Coastal Kenya is arid and semi-arid. Farmers in coastal Kenya use saline borehole irrigation water for crop production. There is limited information regarding the perception of farmers on effect and management of salinity on crop production. This study assessed farmers' perception on effects and management of saline water on soil and crops in coastal Kenya. The study was carried out in Kilifi County (Kaloleni, Magarini and Kilifi sub-Counties) and Kwale County (Msambweni and Matuga sub-Counties). A purposive sampling procedure was used to select farmers from the two study sites. Farmers owning boreholes and practicing irrigated agriculture for at least three calendar years were selected per site resulting in a sample size of 30 farmers from each county. Data were obtained from sampled farmers through interviews and structured questionnaires. The farmers' survey was undertaken using a single - visit survey approach. Data collected were divided into four subsections, which include, socio-demographic profiles, farmers' sources of information on crop production, history of borehole water, crops grown and soil and water management. Survey data were coded and analyzed using SPSS software, version 14. Data were analyzed using descriptive statistics. Results revealed that all (100 %) household size in Kilifi County and 92.2 % of Kwale County consisted of four or less members, showing that the smaller household sizes depended on irrigated crop production either for food or income generation. Radio was the most common means of communication (Kilifi 90 % and Kwale 87.5 %) through national and vernacular languages. Farmers in Kilifi County (93.3 %) and Kwale County (86.7 %) did not belong to any agricultural society. This meant that some farmers lacked information on the advantages and how agricultural societies are formed. Farmers growing crops under irrigation in Kwale County obtained water from boreholes. Farmers in both counties never tested the quality of borehole water used to irrigate their crops. All farmers (100 %) in Kwale County and 86.7 % in Kilifi County reported gradual decline in yield, 13.3 % of famers in Kilifi County reported stunted growth, 84.6 % of farmers from Kilifi County and 78.6 % from Kwale County reported that salts in irrigation water (indicated by white residues on soil after irrigation) accumulate in soil over time that degraded the soil and harmed plants. Farmers in both counties (Kilifi 84.6 % and Kwale 64.3 %) use manure during planting to manage their soils.

Key words: Salinity, Farmers' perception, Soil and water management, Irrigation water quality ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 23 No. 5 May 2023 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

The beginning of the 21st century is marked by global water shortage, increased water and soil salinization, increasing human population, and reduction of available land for cultivation [1]. World population is projected to reach 9.7 billion people by 2050 [2]. Despite the increased population, the rate of food production has remained low leading to food insecurity problems worldwide [3]. Curbing the global food insecurity requires adoption of sustainable food production technologies that can optimize production with the limited available resources. Irrigation is one of the technologies that can improve sustainable dryland agricultural production [4, 5]. Coastal Kenya is arid and semi-arid, and most farmers in the region are forced to use borehole irrigation water which is saline [6].

Kilifi County experiences unreliable rainfall with frequent drought [7]. Areas like Bamba, Ganze, and the western part of the county experience about 5-6 months of continuous dry weather. The average temperature is 27 ºC (and it is 4.78 % higher than Kenya's averages). Kilifi typically receives about 102.1 mm of precipitation and has about only 187 rainy days (51.2 % of the time) annually. Therefore, groundwater contributes nearly 50 % of the water used in the area through boreholes [8]. Kwale County on the other hand, which lies on the southern part of the Kenyan coastal line is also dry, and experiences unreliable rainfall. Commercial agriculture mainly relies on groundwater to complement surface water sources from the few rivers around. The Mkurumudzi and Ramisi rivers are the major rivers in the county. The Ramisi River is however highly salinized (high levels of chloride), and unfit for domestic use and agricultural production. During high tides the Ramisi River also experiences seawater intrusion [9].

Irrigation water quality is depended on the type and quantity of dissolved salts [10]. Salinity of the soil reduces uptake of plant phosphorus, causes toxicity of ions, osmotic stress, and deficiency of nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), iron (Fe) and zinc (Zn), which limit plant water uptake [11]. The presence of salts in the soil affects interaction among physiological, morphological, and biochemical processes like germination of seeds, growth of plant, nutrient and water uptake by plants [12, 13]. Saline growth medium has adverse effects on plant growth, osmotic stress, salt stress, nutrition imbalance or combination of the factors [14]. Accumulation of salts in the soil is known to cause metabolic and physiological disturbance in crop affecting growth, yield and crop quality [15, 16]. Salt accumulation around the root zone prevents plant roots from absorbing water from the surrounding soil, decreasing available water for plant, causing stress to plant [17]. Soil salinity causes flocculation, which promotes soil

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aeration and growth of roots. However, its increase to high level is lethal to plant growth [18]. Sodium salts accumulation in soil has contrary effects of salinity in soil. High concentration of sodium salts causes dispersion, which leads to reduced infiltration, surface crusting and reduced hydraulic conductivity [19]. A clay soil high in sodium concentration causes aggregation and swelling [20].

Despite the negative effects of saline irrigation water on crop growth and soils, limited research has been carried out on the farmers' perception on soils and saline irrigation water management especially within the Kenyan coastal region. The objective of this study was to assess farmers' perception on the effect of saline water management on soils and crops in coastal Kenya.

METHODS

The study was carried out in Kilifi County (Kaloleni, Magarini and Kilifi sub-Counties) and Kwale County (Msambweni and Matuga sub-Counties). A purposive sampling procedure was used to select farmers in the study [21]. Farmers owning boreholes and practicing irrigated agriculture for at least three calendar years were selected per location, resulting in a sample size of 30 farmers from each county. Data were obtained from sampled farmers through interviews and structured questionnaires. The farmers' survey was undertaken using a single visit survey approach [22]. Data collected was divided into four subsections, which include socio-demographic profiles, farmers source of information on crop production, history of borehole water, crop grown and soil and water management. Survey data were coded and analysed using SPSS software, version 14 [23]. Data was analysed using descriptive statistics. Data were presented as percentages in Tables.

RESULTS AND DISCUSSION

Socio-demographic profiles

Young adults (31 to 56 years) were the main age group growing crops with saline borehole irrigation water in both Kilifi County (53 %) and Kwale County (50 %) (Table 1). The largest percentage of the farmers who produced their crops with borehole water were men in both counties. There were 80 % male farmers in Kwale County and 93.3 % male farmers in Kilifi County (Table 1). All household sizes in Kilifi County (100 %) and Kwale County (92.9 %) consisted of four or less members. Farmers in Kilifi County (60 %) and Kwale County (73.3 %) had four acres of land or less each. Then smaller sizes of farmland in both counties pushed farmers to adopt irrigation technology to improve crop production. The adoption of irrigation technology could also be the result of land segregation due to growth in human population causing land scarcity and subsequent conversion of virgin lands to agriculture [24]. Farm size influences the level of agricultural technology adopted on the farm. Therefore, farm size is one of the most important factors affecting the adoption of new technologies, with a positive relationship with adoption [25]. The level of education varied across the counties. In Kilifi, County, 60 % of the farmers had primary education, 26.7 % had secondary education, and only 13.3 % had college or university education. In Kwale County, 40 % of the farmers had primary education, 53.3 % had secondary education and only 6.7 % of the farmers had college or university education. Generally, education tends to create suitable mental attitude for adoption of new technology, more management-intensive, and information-intensive practices [26]. Formal training is also reported to improve yield and socio-economic development [27].

Information sourcing and trainings on agriculture

Farmers in Kilifi County (86.7 %) had no formal training on agricultural production, however, 60 % of the farmers had training in agribusiness related issues compared to crop production (40 %) (Table 2). In Kwale County, 66.7 % of the farmers had no formal training in agricultural production; however, 66.7 % of the farmers had training in crop production related issues compared to agribusiness (33.3 %). Formal training is reported to improve yield and socio-economic development [28]. Training positively contributed to crops and livestock, as well as socio-economic development [29]. Agricultural training resulted in an increase in the yields of crops and livestock [30]. Some crops exhibit tolerance to salt and it would be expected that different results would be obtained for different crops. Therefore, educated and enlightened farmers would be more likely to carefully select the crops in this situation.

Farmers in Kilifi County (90 %) and Kwale County (87.5 %) obtained agricultural information through radio. This could be attributed to radio being the commonest means of communication through the national and vernacular languages. Similar studies also indicated radios to be most important communication media in agricultural information dissemination [31, 32]. In Zambia, it was found out that farmers acknowledged radio to be a good tool for the dissemination of information since it was relevant to their information needs [31]. Another study showed that radio was the most available, and accessible mass medium for obtaining agricultural information as most of the respondents indicated its availability and accessibility [32]. The use of community radio to communicate agricultural information to peasant farmers in Zimbabwe was investigated and the study found that community radio service was the most preferred medium of communication

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with rural peasant farmers, since farming radio programs were in their language and dialects. Radio provides agricultural information relevant to farmers, and it also gives them opportunity to contribute to the program content. Farmers in Kilifi County (93.3 %) and Kwale County (86.7 %) did not belong to any agricultural society. This meant farmers lacked information on how to form agricultural societies and the benefits of such groups as indicated in the study.

In another study, it was observed that agricultural cooperative system is an important avenue for farmers to improve their economic status and the economic benefits arising from the cooperative [33]. However, in another study, it was found that there was no difference between participants and non-participants of the cooperative in terms of net income from rice production [34]. The difference in the results observed by the researchers was brought about by the dynamics of farmers used in the study areas in terms of economic status, level of education and types of agriculture.

Use of borehole water

Most boreholes in Kwale County were older compared to the ones in Kilifi County (Table 3). In Kwale County, 60 % of the borehole were drilled in the 1990s while in Kilifi, 46.7 % of the boreholes were drilled between the year 2000 - 2010. Most boreholes in Kilifi (60 %) and Kwale (73.3 %) Counties were drilled to a depth above 25 feet, and majority of boreholes in Kilifi (60 %) and Kwale (53.3 %) Counties had a yield capacity of over 10,000 liters of water per cropping season (4 months).

In Kilifi and in Kwale Counties, 71.4 % and 78 % of farmers, respectively, paid less than Ksh. 100,000.0 to install their borehole. In another study, it was reported that decision by farmers to invest and produce depends on the financial instrument and farmers are discouraged to adopt better technologies if the available financial instruments do not match their needs [35]. In Kwale and Kilifi Counties, 60 % and 50 % of farmers, respectively, use borehole water for both irrigation and domestic purposes. This could be attributed to the reliability and accessibility of borehole water which is a groundwater source more so in arid and semi-arid areas. All the farmers interviewed in the study growing crops under irrigation in Kwale County obtained water from boreholes compared to 93.3 % in Kilifi County. All the boreholes in both counties did not have uniform flow throughout the year and majority (86.7 %) in Kilifi County and 66.7 % in Kwale County attributed the lack of uniform flow of borehole water to drought. A study reported that 80 % of the country is categorized as arid and semi-arid region with unreliable rainfall patterns and high evapotranspiration rates [36]. Another study also found that recharge was negligible in semi-arid environments when precipitation rates were below 500 mm per annum [37]. All farmers in both counties reported the quality of water to vary throughout the year, with 53.3 % associating it with high salinity in the area. All farmers in both counties reported that their borehole water had not been tested for quality (Table 3). This was mainly indicated by white residues on the soil after irrigation.

Soil and water management

Farmers in Kilifi and Kwale Counties had varied responses concerning crops grown and soil and water management (Table 4). One of the profitable crops grown in both counties was Amaranthus, which was reported by 73.3 % and 80 % of farmers in Kwale and Kilifi Counties, respectively. This is attributable to Amaranthus' ability to withstand drought, saline and acidic soil conditions [38]. Most farmers (66.7 to 73.3 %) grew their crops using overhead irrigation (using watering can) method, while 13.3 % and 20 % of them in Kilifi and Kwale Counties, respectively used drip irrigation and 13.3 % of farmers in both Kilifi and Kwale Counties used surface irrigation. Most of the farmers (53.8 to 61 %) preferred the overhead method of irrigation because it was simple and easy to use and an appropriate smaller land size irrigation method. A study found that watering can be used to successfully irrigate very small plots of land like vegetable gardens which are close to the water source [39]. All farmers (100 %) in Kwale County and 86.7 % in Kilifi County reported gradual decline in yield of the crops grown using borehole water when using overhead irrigation (watering manually using watering cans or horse pipes). Irrigation method was observed to affect soil salinity through evapotranspiration [40]. Only 13.3 % of farmers in Kilifi County reported stunted growth. This finding could be attributed to the saline irrigation water. A study indicated higher levels of chloride salts (33.5 to 37.1 meq/L) of borehole water samples collected form the study area [41] which was higher than the recommended rate for crop production (0-30 meq/L) [42]. However, none of the farmers interviewed had carried out water and soil testing in both counties. Saline water was reported to affect soil properties, nutrient absorption, physiology of the plant and finally plant growth in the study area [43]. Salts cause deterioration in the physical structure like water permeability and reduction in soil aeration [40]. An increase in osmotic potential of soil solution reduces plant available water and nutrient uptake, increase concentration of ions that inhibit plant metabolism and physiology, resulting in poor growth. Saline soil conditions affect stomatal aperture and reactive oxygen species that hinder activities of the enzymes and membranes related to photosynthesis [40]. Most of the farmers in Kilifi (92.9 %) and Kwale (86.7 %) Counties lacked information on soil testing. Most farmers from both counties (Kilifi 60 %, Kwale 73.3 %) had no idea that salts in irrigation water accumulate in soil over time, to be detrimental to the soil and plant. Farmers in both counties (Kilifi 84.6 %, Kwale 64.3 %) used manure during planting as a plant nutrient source. All farmers in Kwale County and 86.7 % in Kilifi County used DAP/CAN as the main fertilizer (Table 4). This means that farmers in Kilifi County understood the importance of fertilizer to supply nutrients needed for plant growth than farmers in Kwale County.

CONCLUSION

It can be concluded from this study that borehole water within the study area has high levels of salinity as supported by the secondary data from the study area [42], and farmers in Kilifi County (92.9 %), and Kwale County (86.7 %) have limited knowledge on the effect of water salinity on soil fertility and crop growth. For enhancement of dry land irrigation, farmers should carry out soil and water analysis so as to come up with sustainable soil management practices like planting salt tolerant crops such as amaranthus and irrigation management system like using drip irrigation and enhancing drainage system. Based on the research findings, there is need for further studies on the effect of saline soils on various crops grown in the coastal region of Kenya.

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Table 1: Socio-demographic profiles of farmers interviewed in Kilifi and Kwale county (n = 60)

Variable	Categories	Response (%) Kilifi county	Kwale county
Age (years)	18 – 30	13.3	7.1
	31 – 43	33.3	50.0
	44 – 56	53.3	42.9
Gender	Male	93.3	80.0
	Female	6.7	20.0
Household size (number)	0 – 4	100.0	92.9
	5 – 9	0.0	7.1
Farm size (acres)	0 – 4	60.0	73.3
	5 – 9	40.0	26.7
Education level	Primary education	60.0	40.0
	Secondary education	26.7	53.3
	College/University education	13.3	6.7

Table 2: Farmers response on their source of information regarding crop production (n = 60)

Variable	Categories	Response (%) Kilifi county	Kwale county
Agricultural trainings attended by the respondent in the past	Yes	13.3	33.3
	No	86.7	66.7
Nature of agricultural trainings attended in the past	Crop	40.0	66.7
	Agribusiness	60.0	33.3
Respondent's major source of agricultural information	Radio	90.0	87.5
	Internet	10.0	12.5
Membership to agricultural group	Yes	6.7	13.3
	No	93.3	86.7

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Table 3: Farmers response concerning use of borehole water (n = 60)

Variable	Categories	Response (%) Kilifi county	Kwale county
Date when the borehole was drilled (years)	2000- to date	46.7	40.0
	1990-2000 (10 years)	33.3	60.0
	1980-1990 (10 years)	20.0	0.0
The depth of borehole (feet)	0-25	40.0	26.7
	above 25	60.0	73.3
Capacity of the borehole (liters)	less 10000	40.0	46.7
	10000 and above	60.0	53.3
Approximate cost of borehole installation	less Ksh.100,000	71.4	78.6
	Ksh.100,000 and above	28.6	21.4
Use of borehole water	Domestic and irrigation	50.0	60.0
	Domestic	40.0	40.0
	Irrigation	10.0	0.0
Source of water for irrigation	Borehole	93.3	100.0
	Tap water	6.7	0.0
The cause of non-uniformity of the flow of borehole water	Drought	86.7	66.7
	Evaporation	13.3	33.3
Does water quality remain the same throughout the year?	Yes	0.0	0.0
	No	100.0	100.0
Reason(s) of lack of uniformity in water quality throughout the year	Salt in the area	53.3	53.3
	Low water table	26.7	26.7
	Drought	13.3	13.3
	I don't know	6.7	6.7
Whether bore water has been tested for quality	Yes	0.0	0.0
	No	100.0	100.0

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Table 4: Farmers response regarding soil and water management (n = 60)

Variable	Categories	Response (%) Kilifi County	Response (%) Kwale County
The most profitable crop grown	Amaranthus	73.3	80.0
	Okra	6.7	0.0
	Cotton	6.7	0.0
	Maize	13.3	20.0
Type of irrigation methods used by the respondent	Drip	13.3	20.0
	Watering can	73.3	66.7
	Surface	13.3	13.3
Reason for the choice of irrigation method	Relatively cheap	38.5	30.8
	Simple	61.5	53.8
	Land is fairly flat	0.0	15.4
Awareness of effects of salty borehole water on crop	Yes	35.7	28.6
	I don't know	64.3	71.4
Trend on crop yield observed	Gradual decline in crop yield	86.7	100.0
	Stunted growth	13.3	0.0
Whether they have tested their soil	Yes	0.0	0.0
	No	100.0	100.0
Reason for not testing soil	Lack of information	92.9	86.7
	Expensive	7.1	6.7
	Lack of funds	0.0	6.7
Crop management on saline irrigation water	None	0.0	6.7
	Mix rainwater	40.0	20.0
	Use manure	60.0	73.3
Awareness of effect of salty water on soil	Yes	15.4	21.4
	No	84.6	78.6
Knowledge of the importance of manure in farm management	Yes	84.6	64.3
	No	15.4	35.7
Main fertilizer used by the farmer	DAP/CAN	86.7	100.0
	DAP/Urea fertilizer	13.3	0.0

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