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ARTICLE

Saline Irrigation Water Retards Growth of Amaranthus in Coastal Kenya

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ABSTRACT

Salinity is a major biotic factor that negatively affects growth and yield of crops. Over 90% of the coastal region of Kenya is arid and semi-arid, most farmers in the region use borehole irrigation water which is saline. Amaranthus spp. is one of the main vegetables grown in coastal region. There is limited information regarding the effect of salinity on amaranthus production. The study sought to determine the effect of saline irrigation water on amaranthus growth in coastal Kenya. Two experiments were set up, one at Mivumoni Secondary School farm in Kwale County and another at Pwani University farm in Kilifi County from beginning of September 2019 to the end of January, 2020. The experiments were laid out in a randomized complete block design and replicated three times. The six treatments tested were: fresh water alone, 75% saline water alone, 100% saline water alone, fresh water + DAP, 75% saline water + DAP, 100% saline water + DAP. Crop growth data collected were: emergence rate, plant height, leaf number, leaf area, chlorophyll content, stem thickness, root density, root weight, root volume and total plant biomass. Data obtained were subjected to analysis of variance using SAS statistical package (SAS, Version 10) and treatment effects were tested for significance using F-test. Significant means at F-test was ranked using Tukey's test at 5% level of significance. Amaranthus seeds sown in fresh water had higher emergence rate compared to seeds sown in saline water. Salinity regardless of concentration used and application of DAP, resulted in decrease in height, leaf number, leaf area, stem thickness, chlorophyll content, root length, root weight, root volume and total biomass. The study demonstrates that saline irrigation water in coastal Kenya has a negative effect on Amaranthus growth.

1. Introduction

Salinity is a major biotic factor that negatively affects growth and yield of crops [1]. With over 90% of the coastal region of Kenya being arid and semi-arid, most farmers in the region are forced to use borehole irrigation water which is mainly saline [2]. Saline water refers to any water that contains more than 1,000 parts per million (mg kg^{-1}) dissolved solids or one that has a specific conductance more than 1,400 µ℧/cm at 25 °C [3]. Salinity has a significant effect on crop and soil. Salinity results in deterioration in

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the physical structure of the soil like water permeability and reduction in soil aeration, and reduction in the osmotic potential of the soil solution. Salinity consequently result in the reduction of plant water availability and minerals uptake, increase in the concentration of certain mineral ions that have an inhibitory effect on plant metabolism and physiology which negatively affect growth and yields [4,5].

Kilifi County experiences unreliable rainfall with frequent drought [6]. Areas like Bamba, Ganze and western part of the county experience about 5-6 months of continuous dry weather. Therefore, groundwater contributes nearly 50% of the water used in the area through boreholes [7]. Kwale County on the other hand which lies on the southern part of the Kenyan coastal line is also dry and experiences unreliable rainfall. Subsistence agricultural activities within the area are rainfed while commercial agriculture mainly relies on underground saline water to complement the few rivers around.

According to Kumar and Rao [8], irrigation water quality depends on the type and quantity of dissolved salts. 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 limits plant water uptake [9]. Elements like sodium (Na), chlorine (Cl), and boron (Bo) have specific toxic effects on plant. According to Akbarimoghaddam *et al*. [10] as well as Reynolds *et al*. [11], 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. Saline growth medium has adverse effects on plant growth; osmotic stress, salt stress, nutrition imbalance or combination of the factors [12]. Accumulation of salts in the soil is known to cause metabolic and physiological disturbance in crop affecting, yield, growth and crop quality [13-16]. Salt accumulation around the root zone prevents plant roots from withdrawing water from the surrounding soil decreasing available water for plant, causing stress to plant [17]. Soil salinity causes flocculation which promotes soil aeration and growth of roots; however, its increase to high level is lethal to plant growth [18]. Sodium salts accumulation in soil has an opposite effect to salinity in soil. High concentration of sodium salts causes dispersion which leads to reduced infiltration, surface crusting and reduced hydraulic conductivity [19]. In clay soil high sodium concentration causes aggregation and swelling [20]. High Na concentration causes osmotic stress leading to cell death [17].

Amaranthus spp. is an important crop for human diet and income generation in the coastal region [21]. However, its yield and quality have been declining. This has been attributed to poor soil condition and irrigation water quality, especially salinity, in addition to other factors like unfavourable weather conditions leading to poor growth and poor yields [22]. Despite the importance of salts in crops nutrient uptake, physiological and metabolic activities and the resulting yields and quality, limited research has been carried out on the effects of saline borehole water especially within the Kenyan Coast. Objective of the study was to determine the effect of saline irrigation water on amaranthus (*Amaranthus dubius* Mart. ex Thell.) growth in Coastal Kenya.

2. Materials and methods

2.1 Site of the Study

Two experiments were set up, one in Mivumoni Secondary School farm in Kwale County and another in Pwani University farm in Kilifi County, from beginning of September 2019 to the end of January, 2020. Kilifi County lies between latitude 3.63° S and longitude 39.85° E in the Coastal lowland (CL) 3-CL6. The landscape covers an area of 12,609.7 square kilometers and lies within 30 to 310 meters above sea level. It experiences average daily temperature of 21°C - 32°C and average annual rainfall of 600-1100 mm. It is dominated by sandy-loam soil which is well drained, shallow to moderately deep, dark brown to yellowish brown whose pH ranges between 4.22 - 7.80 [23]. Kwale County on the other hand lies between latitudes 4.33° S and longitudes 39.52° E in the Coastal lowlands agro-ecological zones CL3-CL5. It covers an area of 8270.2 square kilometers, altitude of between 0 - 462 meters above sea level and receives poorly distributed, unreliable annual rainfall ranging from 400 mm to 1200 mm per year and mean annual minimum and maximum temperatures are 24 °C and 27.5 °C respectively. The predominant soil in the area is sandy-clay whose pH ranges between 5.35 and 7.80 [23].

2.2 Candidate Crop

Amaranthus (*Amaranthus dubius* Mart. ex Thell.) were procured from Amiran, Mombasa, Kenya. The vegetable was chosen because it is widely grown and consumed in the coastal region.

2.3 Experimental Design, Treatment Application and Crop Husbandry

The experiments were laid out in a randomized complete block design and replicated three times. The six treatments tested were: fresh water alone, 75% saline water alone, 100% saline water alone, fresh water + DAP, 75% saline water +

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DAP, 100% saline water + DAP. Kwale county composite soils were used for Mivumoni greenhouse experiment while Kilifi county composite soil samples were used for the Pwani University greenhouse experiment trials. Four kilograms composite soil samples were measured and put in five-liter plastic pots. DAP fertilizer (250 kg/ha) was measured, incorporated in each pot that was meant for DAP treatment and mixed thoroughly. Saline water (200 ml) at 4 dS m^{-1} electrical conductivity (EC) was used for 100% saline water, fresh water of EC 0 dS m^{-1} and a mixture of the 150 ml saline water and 50 ml of the fresh water for the 75% saline water treatments were added every 2 days to compensate for evaporative losses. Twenty amaranthus seeds were then sown in each pot. Thinning was done to allow only ten seedlings per pot. Water treatments (200 ml) were applied throughout the experimental period (60 days) in the form of manual irrigation.

2.4 Data Collection

Three plants per pot were randomly selected from the pots in the inner rows and tagged for data collection. Crop growth data collected were:

2.4.1 Emergence Rate

Number of seedling emergence per treatment per day was counted from 1st day of sowing and recorded up to 10th day, recorded and percent emergence computed.

2.4.2 Plant Height

Plant height was established by measuring the height of the tagged plants from each pot using a meter rule. The measurements were carried out on weekly basis from one till tenth week after crop emergence. The measurements were taken from the ground level to the tip of the shoot and recorded in centimeters (cm).

2.4.3 Number of Leaves

Number of leaves was determined by counting the total number of leaves on the tagged plants per pot on weekly bases two weeks after crop emergence up to tenth week after emergence.

2.4.4 Leaf Area

Fully expanded leaves (third, fourth, and fifth from the shoot) of the tagged plants per pot were used to determine leaf area. The length and width of the leaf were measured using a ruler. Length and width were multiplied by a constant as in the formula: Leaf Area = Length × width × 0.75 (constant) for the triangular leaves such as amaranthus. Leaf area was measured one week after emergence and thereafter on weekly basis up to tenth week and results recorded in squared centimeters (cm^2).

2.4.5 Stem Thickness

Tagged plants per pot were used to measure stem thickness using a standard vernier caliper. The jaws of vernier caliper were placed on the stem just above the ground level and readings recorded in centimeters (cm). This was done on a weekly basis until tenth week from 1st week of crop emergence.

2.4.6 Root Growth Characteristics

Root length: on the tenth week after emergence, the tagged plants per pot were uprooted, washed. Root length measured using a ruler and recorded in centimeters (cm). Root weight (dry): on the tenth week after emergence, the tagged plants per pot were uprooted, washed, dried and weighed on an electronic weighing balance and Weight recorded in kilograms (kg). Root volume: on the tenth week after emergence, the tagged plants per pot were uprooted, roots chopped off, washed and used to determine root volume by displacement method. Known volume of water was filled into the beaker to the brim. Clean roots were immersed then displaced water was collected. Volume of displaced water was measured and recorded in cubic centimeters (cm^3).

2.4.7 Chlorophyll Content

Chlorophyll content was measured using chlorophyll meter (CCM-200, Opti-sciences, Inc. Tyngsboro, MA, USA) with a precision of ± 1.0 chlorophyll concentration index units (CCI). This was done every until the tenth week after emergence. The readings were taken from the tagged plants per pot on the third, fourth, and fifth leaves from the shoot that had fully expanded.

2.4.8 Total Biomass

On the tenth week after emergence, the tagged plants per pot were uprooted, then oven dried at 75 °C until a constant weight and used to determine biomass yield. Yield was determined by weighing on an electronic weighing balance and weight recorded in kilograms (kg).

2.5 Data Analysis

Data obtained were subjected to analysis of variance using SAS statistical package (SAS, Version 10) and treatment effects were tested for significance using F-test. Significant means at F-test was ranked using Tukey's test. All analysis was at 5% level of significance.

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3. Results

3.1 Seedling Emergence Rate

Significantly ($p \leq 0.05$) higher emergence rate of seedlings was observed in fresh water compared to those from saline water in Pwani University (95%) and Mivumoni (97%) respectively (Figure 1). This was followed by fresh water which had significantly higher rate of emergence compared to saline water plus DAP, 75% saline water plus DAP and 75% saline water were not significantly different. Saline water plus DAP had the lowest rate of emergence in both sites.

3.2 Plant Height

Amaranthus grown in fresh water plus DAP was significantly ($p \leq 0.05$) taller compared to the rest of the treatments, in both Pwani University and Mivumoni by 56% and 54% respectively (Table 1). This was followed by fresh water, 75% saline water plus DAP and saline water plus DAP. Plants grown in saline water plus DAP were the shortest.

3.3 Leaf Number

Plants grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher number of leaves, followed by fresh water compared to the rest of the treatment in both Pwani university and Mivumoni. Amaranthus grown in saline water, saline plus DAP and 75% saline which had comparable number of leaves. Plants grown in saline water had the lowest number of leaves (Table 1).

3.4 Leaf Surface Area

Amaranthus planted in fresh water plus DAP had sig-

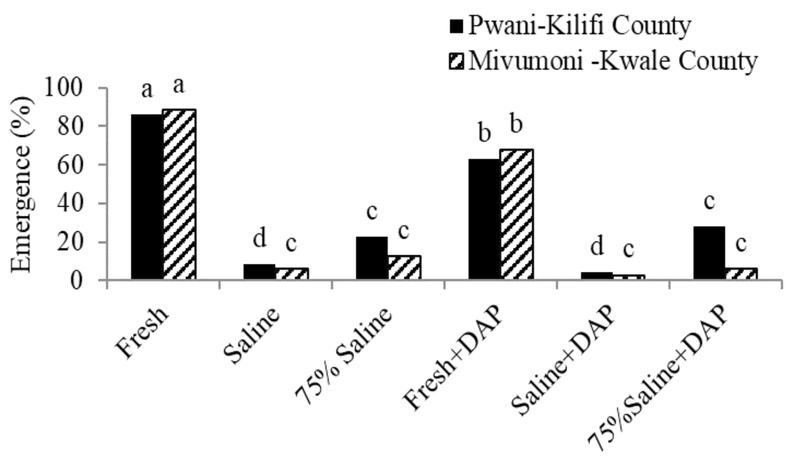

Figure 1. Effect of saline borehole water on emergence of amaranthus in Pwani University (Kilifi county) and Mivumoni (Kwale county). Means followed by the same letters within a study site are not significantly different according to Tukey's Test ($p \leq 0.05$).

Table 1. Effect of saline borehole water on growth of amaranthus in Pwani University (Kilifi county) and Mivumoni (Kwale county)

	Plant height (cm)		Leaves (no./plant)		Leaf surface area (cm^2)		Stem thickness (cm)	
Treatment	PU	MI	PU	MI	PU	MI	PU	MI
Fresh	27.8^a	27.4^a	12.6^b	10.2^a	12.7^{ab}	13.4^{ab}	1.2^b	1.3^a
Saline	13.9^c	14.1^b	4.8^c	4.0^c	4.8^d	8.7^{bc}	0.8^d	1.0^{bc}
75% Saline	18.5^b	18.6^b	7.5^c	5.3^{cb}	8.1^{cd}	12.0^{abc}	1.0^c	1.3^{ab}
Fresh + DAP	31.7^a	28.0^a	19.3^a	17.0^a	15.7^a	17.0^a	1.4^a	1.4^a
Saline + DAP	13.9^c	12.9^b	4.6^c	4.0^c	5.9^d	7.2^c	1.0^c	1.0^c
75% Saline + DAP	16.4^{bc}	16.3^b	7.4^c	7.0^{cb}	11.9^{bc}	13.2^{ab}	1.1^{bc}	1.2^{abc}
LSD (0.05)	4.0	7.5	3.3	5.3	3.8	5.6	0.2	0.2
CV (%)	6.9	13.4	12.4	23.6	13.5	16.8	5.1	6.3

Means followed by the same letter(s) within a column are not significantly different according to Tukey's Test ($p \leq 0.05$). PU = Pwani University, MI = Mivumoni.

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nificantly ($p \leq 0.05$) larger surface area compared to the rest of the treatment in both Pwani University and Mivumoni by 69% to 58% respectively (Table 1). This was followed by fresh water alone. Amaranthus plants in saline, saline plus DAP, 75% saline plus DAP and 75% saline had comparable leaf surface area. Plants grown in saline water plus DAP had the lowest leaf surface area.

3.5 Stem Thickness

Amaranthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher stem thickness compared to the rest of the treatments in both Pwani University and Mivumoni by 42% and 25% respectively (Table 1). This was followed by fresh water. Plants planted in saline water, saline plus DAP, 75% saline plus DAP had comparable stem thickness. Plants planted in saline water had the least stem thickness.

3.6 Root Growth Characteristics

Amaranthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) larger root volume compared to the rest of the treatments, in both Pwani University and Mivumoni by 84% and 82% respectively followed by fresh water alone (Table 2). Plants grown in saline, saline plus DAP, 75% saline plus DAP and 75% saline had comparable root volume. Plants grown in saline water had the lowest root volume.

Amaranthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher root weight compared to the rest of the treatments in both Pwani University and Mivumoni by 91% and 86% respectively (Table 2). This was followed by those grown in fresh water alone. Plants grown in saline, saline plus DAP, 75% saline plus DAP and 75% saline had comparable root weight. Plants grown in saline water had the lowest root weight.

Amarnthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) longer roots compared to the rest of the treatment in both Pwani University and Mivumoni by 73% and 55% respectively (Table 2). This was followed by fresh water alone. Plants grown in saline, saline plus DAP, 75% saline plus DAP and 75% saline had comparable root length.

3.7 Chlorophyll Content

Chlorophyll content of amaranthus plants grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher chlorophyll content compared to the rest of the treatment both in Pwani University and Mivumoni by 31% and 28%. There was no significant difference in chlorophyll content in fresh water, 75% saline and 75% saline plus DAP. Plants grown in saline water had the lowest chlorophyll content (Figure 2).

3.8 Total Biomass

Amaranthus grown in fresh water plus DAP had significantly ($p \leq 0.05$) higher biomass compared to the rest of the treatments in both Pwani University and Mivumoni by 88% and 74% respectively. This was followed by fresh water alone. Biomass of plants grown in 75% saline and 75% saline plus DAP had comparable biomass. Plants grown in saline water and saline water plus DAP had the lowest biomass in both sites (Figure 3).

Table 2. Effect of saline borehole water on root growth of amaranthus in Pwani University (Kilifi county)

	Root volume (cm^3)		Root weight (g)		Root length (cm)	
Treatment	PU	MI	PU	MI	PU	MI
Fresh	9.0^{b}	10.0^{b}	1.5^{b}	1.4^{ab}	14.4^{b}	15.6^{b}
Saline	2.2^{d}	2.5^{e}	0.2^{f}	0.3^{b}	5.4^{c}	8.9^{e}
75 % Saline	5.8^{c}	6.0^{cd}	0.8^{d}	0.7^{b}	7.7^{c}	9.0^{de}
Fresh + DAP	13.8^{a}	14.0^{a}	2.2^{a}	2.2^{a}	19.8^{a}	19.9^{a}
Saline + DAP	5.5^{c}	5.2^{d}	0.5^{e}	0.4^{b}	7.9^{c}	10.6^{d}
75 % Saline + DAP	8.2^{b}	7.5^{c}	1.1^{c}	1.6^{ab}	13.1^{b}	13.1^{c}
LSD value	2.2	2.2	0.8	1.4	2.9	1.7
CV (%)	10.3	10.4	6.0	44.6	8.9	4.6

Means followed by the same letter(s) within a column are not significantly different according to Tukey's Test ($p \leq 0.05$). PU = Pwani University, MI = Mivumoni.

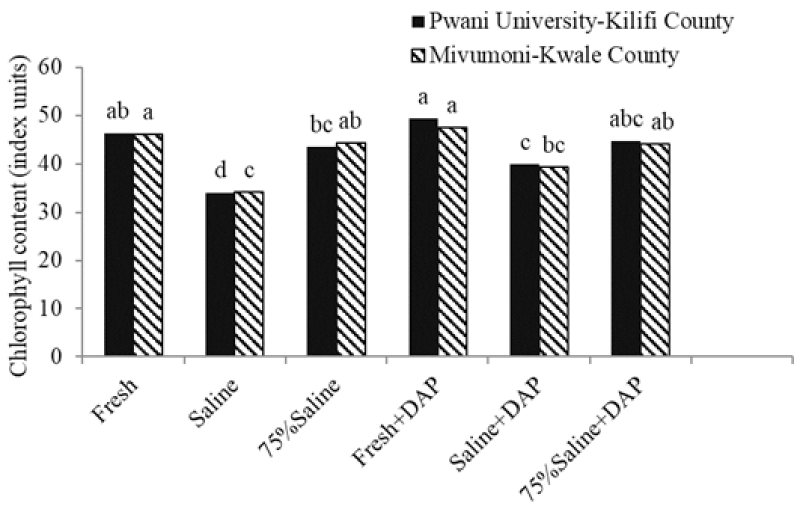

Figure 2. Effect of saline borehole water on chlorophyll content of amaranth leaves during production in Pwani University (Kilifi County) and Mivumoni (Kwale County). Means followed by the same letter(s) within a study site are not significantly different according to Tukey's Test ($p \leq 0.05$).

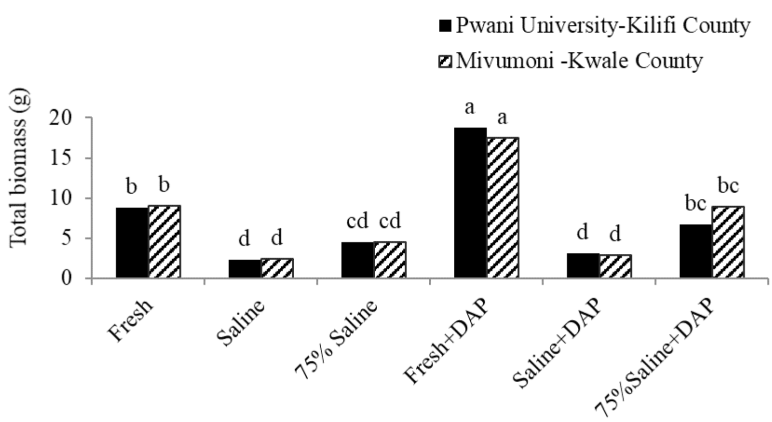

Figure 3. Effect of saline borehole water on total biomass of amaranth during production in Pwani University (Kilifi county) and Mavumoni (Kwale county). Means followed by the same letter(s) within a study site are not significantly different according to Tukey's Test ($p \leq 0.05$).

4. Discussion

Amaranthus seedlings grown from fresh water had higher emergence rate compared to those grown in saline water. Salinity may affect germination by reducing water imbibition in seeds since activities are related to germination. Additionally, salinity may have promoted absorption of toxic ions altering hormonal or enzymatic activities [24]. Cuartero and Fernandez-Munoz [25] found that seeds required more days to germinate (50%) in medium at EC 1.4 mS/cm and 100% delayed germination in medium at EC 3.4 mS/cm. Neamatollahi *et al.* [26] reported that increasing NaCl concentration in priming treatments causes higher osmotic pressure hence reducing germination percentage on fennel seeds. Asch and Wopereis [27] found that salinity levels below 4 mS cm^{-1} delayed germination by 1 - 2 days, while higher salinity delayed germination by more than a week. Osborne *et al.* [28] also observed that exposure of amaranthus to high salinity inhibits germination and reduce rate of germination. Similar findings were reported with *Eriochiton sclerolaenoides, Maireana georgei, M. pentatropis, M. pyramidata, M. trichoptera* and *M. triplera* species in semi-arid climate Australia [29].

Increasing salt concentrations resulted to decrease in height, shoot and root lengths, root volume, leaf number, leaf surface area, chlorophyll content and stem thickness. Salinity affects a number of aspects of plant growth and development like; germination, reproductive and vegetative growth. Salinity may cause reduction in water availability by decreasing osmotic potential of total soil water potential. Matric potential and osmotic potential of soil are both elements of total soil water potential and add up

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the effects on availability of water which causes decline in both yield and evapotranspiration [30,31]. Abbas *et al*. [32] found that salinity and Fe deficiency reduced chlorophyll concentration, shoot and root growth, photosynthetic, stomatal conductance and transpiration rates. Retarded growth may have been caused by osmotic inhibition of oxidative stress, water absorption and specific ions that affect crucial physiological processes in plants. Oxidative stress prevents photosynthetic performance in high saline conditions. Saline soil conditions affect stomatal aperture and reactive oxygen species that hinder activities of the enzymes and membranes related to photosynthesis [5]. Saline soils reduce the uptake of plant phosphorus significantly since phosphate ions precipitates with Ca ions [9]. Salinity has an effect on the absorption of some specific ions across the cell membranes which cause nutritional disturbances to crops [33]. This includes uptake of NO_3^- which is lowered by Cl^- and K^+ uptake which is reduced by Na^+. When sodium accumulates in the cell wall excessively, it leads to rapid osmotic stress causing death of the cells [34].

Soil physical properties can be affected by accumulation of some salts such as sodium in the soil solution as observed in the study and the exchange phase can cause clay dispersion, especially for smectitic clays, which affect soil physical and chemical characteristics by reducing its structural stability and promoting surface crust formation; increasing bulk density and mechanical resistance resulting in poor soil tilth and soil aeration. Reduction of hydraulic conductivity and infiltration rate causes significant water management problems by increasing runoff and erosion potential due to surface sealing and poor infiltration leading to poor water and nutrient uptake hence poor crop growth [35,36].

5. Conclusions and Recommendations

Results observed indicate that salinity had effects on growth characteristics of amaranthus. Amaranthus grown in fresh water plus DAP had significantly (p≤0.05) higher growth characteristic than the rest of the treatments. Plants grown in saline water had the lowest growth characteristics in both sites. There was significantly higher (p≤0.05) emergence rate in seeds sown in fresh water compared to those from saline water in Pwani University (95%) and Mivumoni (97%) respectively. Fresh water plus DAP improved amaranthus growth compared to saline water plus DAP in both Pwani University and Mivumoni by 56% and 54% respectively. This was followed by fresh water, 75% saline water plus DAP, 75% saline water, saline water and saline water plus DAP.

Based on the research findings there is need for further studies on:

i. Effect of saline soils on physiology of vegetable crops in coastal region.
ii. Effects of saline irrigation water on various crops in the coastal region.
iii. Effects of saline irrigation water on availability and uptake of mineral elements.

Other policy recommendations include:

Farmers should adopt appropriate measures to manage salinity in irrigation. These measures could include diluting the saline water with fresh water, application of manure to supplement soil nutrients and improve soil structure, water retention capacity, soil microbial activities and buffer soil and appropriate method of irrigation water application.

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ARTICLE

Major Causes of Calf Morbidity and Mortality in Smallholder Dairy Farms in Shashemene Town, Ethiopia

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ABSTRACT

A cross-sectional study was conducted to determine the major causes of calf morbidity and mortality in smallholder dairy farms and associated potential risk factors in Shashemene. A total of 187 calves from 46 farms were included in the present study. The overall crude morbidity and crude mortality rates were 27.8% and 6.4%, respectively. The most frequent disease syndrome was diarrhea with incidence rate of 28(15%) followed by pneumonia 8(4.3%), Gastrointestinal tract (GIT) disorder 8(4.3%) and septicemia 5(2.7%). In addition skin lesion, navel ill and unidentified cases were encountered. The main causes of death were diarrhea 6(3.2%), Septicemia 2(1.1%), GIT disorder 2(1.1%), pneumonia 1(0.5%) and others 1(0.5%). The most important risk factors associated with morbidity and mortality were housing hygiene, floor condition and calf size in farm. Out of 187 calves examined for GIT parasites; 63(33.3%) were positive for nematode eggs. Prevalence of helminthes parasite increased with increasing age, showing higher prevalence (P<0.05) in calves above 2 months than in calves below 2 months of age. Besides, majority of the calves, 48(25.7%) were found positive for coccidian oocyst. In general; diarrhea, pneumonia and septicemia were the major causes of calf morbidity and mortality. Interms of risk factors housing hygiene, floor condition, calf size in the farms, age and breed were identified major role players. Therefore, identifying major causes and improving management practices and breed should be given to emphasis by advisory of smallholder dairy farms.

1. Introduction

In Sub-Saharan African countries, livestock plays a crucial role both in national economies and the livelihood of rural communities [1]. It provides drought power, milk, and meat, input for crop production and soil fertility and raw material for industry. The livestock sector contributes 13-16% of total agricultural GDP in Ethiopia [2].

Despite the huge number of cattle and their economic importance, the productivity is low due to the constraints of disease, nutrition, poor management, lack of marketing facilities and opportunity, inadequate animal health services, uncoordinated development programs between various levels of government institutions and/ or non-government organizations and poor performance of indigenous breeds. These constraints result in poor reproductive performance of dairy cattle [3]. Consequently, national milk production remains among the lowest in the world even by African standard [4]. However, there is a slow and gradual

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overall growth in milk production in Africa due to cross breeding programs that are being introduced in many tropical countries to increase milk production [5].

Diseases have numerous negative impacts on productivity and fertility of herds i.e. losses due to mortality and morbidity, loss of weight, depressed growth, poor fertility performance, decrease physical power and the likes [6]. This results from complex interaction of the management practice, environment, infectious agent and the calf itself. Major causes of calf diseases and death were diarrhoea, pneumonia, joint problems, umbilical diseases, trauma, congenital abnormalities, nutritional deficiencies, dystocia and other infections [7-9]. Calf losses were significantly reduced by introducing new techniques of management including on time colostrum feeding, housing, feeding and nutrition [10].

Several factors affect the health and vigor of the calves immediately after birth [11].The poor immune system and lack of previous exposure to infection and poor management make new born calves susceptible to infectious diseases [12]. Proper nutrition is fundamental for calf growth and for the general profitability of calf rearing enterprise. In young stock, a good nutritional strategy optimizes rumen development and growth while minimizing stress and disease. Livestock housing conditions greatly affect health and productivity [13]. Cleanliness of the barn influences calf health, as calves housed in unclean barns are at higher risk of diseases than calves housed in clean barns [9].

The mode of passive transfer in neonates varies with the type of placentation and in the case of neonatal calves; it is based on an immediate postpartum ingestion of antibody rich colostrum [14]. The age of the calf is the most important factor affecting morbidity and mortality, approximately 75% of the mortality in dairy animals less than one year of age occurs in the first month of their life [15].

Failure of passive transfer in heifer calves is linked with decreased rate and efficiency of growth and decreased first and second lactation milk production [16]. In developing parts of the world including Ethiopia there is a growing trend in the development of dairy farming which is becoming an important source of income particularly for small holder farmers. However, this cannot be realized without the application of effective calf health and management practices as the future of any dairy farming production depends on the successful program of raising replacement animals (calves). With the above background, the objectives of the present study were:

- To assess the major causes of morbidity and mortality in calves
- To identify risk factors associated with calf morbidity and mortality in smallholder dairy farms in Shashemene

2. Materials and Methods

2.1 Study Area

The study was conducted in Shashemene town, West Arsi Zone, Oromia Regional State, which is located distance of 250 km south east of the capital Addis Ababa at latitude of 7° 11'33'' north and a longitude of 38° 35'33'' east. The area lies within the Rift Valley, with an altitude ranging from 1700 to 2600 metres above sea level (masl). Its annual rainfall ranges 700 to 950 mm while annual temperature range is 12-27°C. The livestock population in zone includes cattle (3,629,900), sheep (694,213), goats (322,332), horse (227,784), donkeys (165,367), mules (8,953) and camels (57). It is also known by production of teff, barley, wheat, maize, sorghum, potato, sweet potato, cabbage, spinach and onion. Annual crops are predominant and rain fed agriculture is mainly practiced using draught power.

2.2 Study Design

Both cross-sectional and longitudinal prospective observational studies were undertaken in six months. The sampling units (calves) were identified individually and monitored throughout the study period.

2.3 Data Collection

Data was collected through questionnaire survey, clinical and laboratory examinations for parasite from study populations. It was collected from 46 purposely selected dairy farms based on the farm size and willingness of the farm owners to participate in the study. Accordingly, a total of 187 calves' from 46 farms were considered.

2.3.1 Cross-sectional Study Based on Questionnaire

The owners and / or attendants of the included dairy farms were interviewed using structured and open ended questionnaires. The contents of the questionnaire were demographic information, farm size, feeding habits and management of the livestock farms, calf age, housing of the animals, disease occurrence, calf death, and sex of calves.

2.3.2 Longitudinal Study

Monitoring of dairy farms for calf morbidity and mortality was carried out for 6 months. For the purpose of this study, calves of age less than six months were considered. Morbidity as any sickness that has recognizable clinical manifestation, and mortality as death of calves after birth to 6 months of age were used during the study period. For the monitoring, all calves in the selected farms at the

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beginning of the follow up period and individual records were prepared. The calves were withdrawn from the follow up when they completed their 6 months of age.

Subsequently, a regular visit was made every three weeks to observe and record calf morbidity, mortality and possible causes. The main activities accomplished during the regular visits were clinical examination of calves for any health problem; observation on different calf management aspects like cleanness of the calf house and feeding practices; and collecting information from calf attendants about occurrence of calf health problem incidents between the visits and recording of the history of the calf health problem that would enable the investigator suppose the possible cause and thus assist diagnosis.

Calf morbidities encountered during the monitoring period were categorized following disease conditions/syndromes based on their clinical signs:

Diarrhoea: Any conditions characterized by passing of lose or watery feces with increased frequency, which could or could not be accompanied by other systemic signs like dehydration, decreased appetite or fever.

Pneumonia: When frequent coughing observed with or without respiratory discharges and fever.

Septicemic condition: Any condition characterized by depression, anorexia and fever without any distinct involvement of specific body system.

Navel ill (omphalitis): Swelling of umbilical cord which is painful when palpated and with or without abscess formation

Joint ill (arthritis): Enlargement of joints usually with abscess formation in any one or all limbs, which could or could not be preceded by other disease condition.

2.3.3 Fecal Sample Collection

A fresh fecal sample was collected from the rectum of each calf using sterile disposable gloves. The sample was placed in a labeled clean glass bottle container and was transported to the parasitology laboratory on the same day and was kept at 4°C in a refrigerator until processing within 48 hours of arrival. At the time of sampling, the name of the farm owner, date of sampling, age, sex, breed, tag number (if present) was recorded for each calf on a recording format and examined the infection rate of Coccidia and internal parasites by using flotation technique at the Parasitology Laboratory, School of Veterinary Medicine, Hawassa University.

2.4 Data Analysis

The collected were fed into Microsoft excel spread sheet program, coded, edited and saved until analysis. Data analysis was undertaken using statistical program for social science version 20.0 (SPSS) software. During data analysis, descriptive analysis and chi-square test were employed. A p-value ≤ 0.05 was considered significant in the analysis.

3. Results

3.1 Morbidity and Mortality

The study revealed that diarrhea was the most frequently observed clinical disorder (28 cases out of 187 calves) followed by GIT disturbance, pneumonia and septicemia (Table 1).

3.2 Risk Factors Associated with Incidence of Calf Morbidity and Mortality

Out of 46 farms visited, 24 (72.3%) morbidity and 13 (100%) mortality were recorded in farms with poor hygienic condition (P=0.000). Considering floor type, mor-

Table 1. Summary of diseases/syndromes that caused morbidity and mortality in dairy calves

Health Problems/syndrome	Morbidity case	Morbidity (%)	Mortality case	Crude Mortality (%)
Septicemia	5	2.7	2	1.1
Diarrhea	28	15	6	3.2
GIT Disturbance*	8	4.3	2	1.1
Pneumonia	8	4.3	1	0.5
Other*t	3	1.6	1	0.5
Total	52	27.8	12	6.4

GIT Disturbance*include bloat, indigestion and any pain symptoms from GIT

Other* include navel ill, skin lesion, unidentified bidity and mortality record was 6(18.2%) and 1(7.7%), respectively in the concrete farms (Table 2).

Generally, housing hygiene, floor condition and calf size in the farm seem to be the major factors for diseases incidences in the present study. Hence, calves house in soil floor were more often at risk than calves housed in the concrete floor. Similarly, calf size in farm and housing hygiene has been significantly associated ($P <0.05$) with dairy calf morbidity and mortality.

3.3 Prevalence of Gastrointestinal Nematodes and Coccidian Oocyst

In addition to other health problems, parasitic infection was the most prevalent in investigated smallholder dairy farms. Out of 187 examined calves, 4(6.3%) and 9 (18.8%) calves aged less than 1month were positive for nematode parasites and positive for coccidian oocyst, respectively (Table 3).

Considering breed as potential risk factor, 22 (34.9%) local, 34(54%) exotic and 7(11.1%) cross breeds were positive for nematode parasites. Breed of calves with significant effect on the occurrence of gastrointestinal nematodes and coccidian oocyst (Table 4).

Based on sex, 18(37.5%) male and 30(62.5%) female calves were found infected with coccidian oocyst (Table 5).

4. Discussion

The study showed that 6.4 (n=12) mortality and 27.8% (n=52) morbidity cases were recorded. In this study, the mortality rate found for 6 months has considerably agreed with the mortality rates reported for similar period by different studies in Ethiopia [17]. However, it was lower than the 12% mean calf mortality rate in smallholder dairy production in Sub-Saharan Africa [18] and from western world which were reported in the ranges of 9 to 13 % for Europe and similar to 6.3% for USA [15].

On the other hand, the present finding was much lower than previous report (25%) by [19] in Ethiopia. On the other hand, low prevalence of 3.4% mortality was reported by [20] from Abernossa Ranch, whereas, [9] reported relatively

Table 2. Potential risk factors associated with calf morbidity and mortality at farm level

	Morbidity				Mortality			
Factors coded	No of farm	Affected no (%)	χ^2-value	P-value	No of farm	Affected no (%)	χ^2-value	P-value
Education status 0=non-educated 1=primary 2=sec and above	11 30 5	6(18.2) 22(66.7) 5(15.1)	3.61	0.164	11 30 5	3(23.1) 7(53.8) 3(23.1)	2.849	0.241
House hygiene 0=poor 1=clean	24 22	24(72.7) 9(27.3)	19.769	0.000	24 22	13(100) 0(0)	16.611	0.000
Floor condition: 0=soil 1=concrete	31 15	27(81.8) 6(18.2)	11.060	0.001	31 15	12(92.3) 1(7.7)	5.119	0.024
Calf size in farm 0=less than 5 1= greater than 5	22 24	12(36.4) 21(63.6)	6.148	0.013	22 24	2(15.4) 11(84.6)	7.643	0.006
Sex: 0=female 1=male	22 24	14(42.4) 19(57.6)	1.366	0.243	22 24	3(23.1) 10(76.9)	4.448	0.035

Table 3. Prevalence of GIT nematodes and coccidian oocyst within different age groups

Helminthes eggs					Coccidia Oocyst			
Calf age	No of examine	Positive (%)	χ^2-value	P-value	No of examine	Positive	χ^2-value	P-value
< 1month 1-2 month 3-4 month > 4 month	73 41 39 34	4(6.3%) 21(33.3%) 20(31.7%) 18(28.6%)	42.688	0.000	73 41 39 34	9(18.8%) 6(12.5%) 20(41.7%) 13(27.1%)	25.649	0.000

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Table 4. Prevalence of GIT nematodes and coccidian oocyst within breed

Helminthes eggs					Coccidia Oocyst			
Breed	No of examined	Positive (%)	x^2-value	P-value	No of examined	Positive	x^2-value	P-value
local exotic cross	49 101 37	22(34.9) 34(54%) 7(11.1%)	6.369	0.041	49 101 37	19(39.6%) 22(45.8%) 7(14.6%)	6.095	0.047

Table 5. Prevalence of gastrointestinal nematodes and coccidian oocyst within sex

Helminthes eggs					Coccidia Oocyst			
Calf sex	No of examines	Positive (%)	x^2-value	P-value	No of examines	Positive (%)	x^2-value	P-value
Male female	81 106	25(39.7%) 38(60.3%)	0.511	0.475	81 106	18(37.5%) 30(62.5%)	6.889	0.346

higher overall crude mortality of 18% compared to the present findings.

Concerning the morbidity and mortality of calves, most previous reports from Ethiopia were based on studies in research stations and state farms with large herd sizes and usually holding high exotic blood level animals, apparently these were associated with increased risk of calf disease occurrence [9]. In the present study, the number of calves per farm was small and the farmers can easily monitor calves and take measures to avoid calf health problems improve management and different methods used in diagnosis. Some authors reported calf morbidity based on producer diagnosis and treatments while others depended on veterinarian diagnosis [9]. This could be one of reasons to find relatively lower mortality rate than those mentioned above farms.

In the present investigation, calf diarrhea was found to be the predominant calf health problem with incidence rate of 15% followed by pneumonia and GIT disturbance (4.3%). Diarrhea was also the leading cause of mortality in the study herds. This finding is in agreement with the findings of [9] who reported calf diarrhea and pneumonia the predominant calf health problems in dairy calves at Ada'a district of Oromia region. However, the present finding was higher for diarrhea and pneumonia as compared to [13] who recorded a prevalence of 10% and 0.7% for diarrhea and pneumonia respectively. On the other hand, there were studies which found pneumonia as the leading cause of calf mortality [21].These differences could be emanated from the difference in management and other factors such as; housing hygiene, ventilation, environment, age, season, herd size and other related factors. Furthermore, analysis of the potential risk factors was done for calf diarrhea and age of the calf, condition of birth and cleanness of the calf house were the factors. This was due to inadequate passive transfer of colostral immunity. Such calves either would lack vigor to suckle on time or will fail to absorb even if they managed to suckle. Calves from prolonged labor develop respiratory acidosis, which interferes with absorption of colostral immunoglobulin [22].

Epidemiological investigation of nematodes in livestock using suitable and cost effective diagnostic methods was found to be important. In this study 33.3% were positive for nematode eggs and 25.7% were found positive for coccidian oocyst. This result was lower than (58.00%) prevalence [23] and 54% [24] in Haramaya University. This difference is may be due to less contact with other animals, different management system or due to increase in awareness of the farmer to treat their animals with antihelmentic drugs. But the prevalence of gastrointestinal parasites in the current study is higher than 11% [25]. This difference may occur due different area and management.

Helminthes parasite prevalence was observed to increase with increasing age and showing a significantly higher prevalence ($P <0.05$) in calves above 2 months than in calves below 2 months. This was agreement with [26] reported that GIT parasite burden and diversity increased with age and at weaning and ends of first year of life, calves acquired the parasite spectrum similar to that of adult cattle. This could be due to the fact that as age increases, calves were given fresh grass as supplemental feed. Additionally, there was mixing of calves of different age groups. Also there was close contact with adult animals. This could be possible means of acquiring parasitic infections. In majority of smallholder dairy farms, calves were commonly open grazed or tethered on natural pastures [13]. The impact of parasitic burden should be taken into account in the veterinary health care to dairy calves.

In the present study the risk factors were tested for their association with crude mortality and crude morbidity in smallholder farms. Among risk factors assessed; housing hygiene was found to be significantly associated with the incidence of disease problems having at (P=0.000). This significant association with disease problems found in present study was in agreement with other reports [27,21] who documented the existence of significant association between higher risk of morbidity and dirtiness of calf barn. Similarly, a significant association of age at first colostrum feeding with calf morbidity was reported different researchers, [9] and higher risk of morbidity in late fed-(after 6 hours) was related to failure of passive transfer of colostral immunity during this period [28]. Similarly, floor condition was significantly associated at (P=0.024) this present study was agreement with [13].

Other risk factor for health problems was higher in male calves (17.1%) than female calves (14.1%). This finding agrees with [13] finding who reported higher health problems in male calves than females particularly during the first months of their age. This could be due to less attention and management care given to the male calves as their role in the farms was considered not profitable in this study. So, it is important to know that the feeding and the general management, of male calves needs to be improved for animal welfare reasons as well as for more profitable utilization of beef from these calves for consumption. However there is also another reason that should be taken in to account that is male calves have less absorption ability of serum immunoglobulin's than female calves and they could become more immune deficient than female calves.

5. Conclusions and Recommendations

The calf morbidity and mortality rates found in this study were higher than economically tolerable and that can be achieved through good management. Given the fact that the study farms raise their own replacement stock and have small herd size, higher rates calf morbidity and mortality will be great hindrance to improve productivity of dairy production through selection. Calf diarrhea and pneumonia were the predominant calf health problems of the farms involved in this study. Among the potential risk factors evaluated for their association with the occurrence of calf health problems; risk factors associated with diseases occurrences and death indicating, calf housing hygiene, floor conditions, farm size and sex as potential risk factors.

Based on the above conclusion the following recommendations are forwarded:

- Greater attention should be given to risk factors associated with disease occurrences and death indicating such as; hygienic conditions and optimum time of colostrum feeding to minimize calf health problems and hence their mortality.
- More researches should be conducted to identify the causative agent of the major health problems identified in this research as this is crucial in formulating effective preventive and control strategies like use of vaccination or other methods.
- Extension services need to focus on awareness creation among dairy farm owners about good calf management's practices and their roles in productivity of dairy farming investments.

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