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Irrigation As A Cushion For The Effects Of Global Warming And Its Soil Salinity Implication On Crop Growth In Nigeria

Bello Yusuph Adebayo
Environmental Education and Management Department
Near East University, Turkey

Abstract

The rise in surface temperature across the globe among other climatic issues is a point of concern to the agricultural sectors as changes in climatic conditions increase water demand. This study investigated irrigation as a cushion for the effects of global warming and its soil salinity implication on crop growth in Nigeria. A descriptive survey research design was adopted, and data were electronically collected from a purposively selected 50 respondents with farming, climate, and agricultural background, and analysed using percentage and frequency count on SPSS version 20.

Among other findings, this paper established that irrigation-induced soil salinity leads to a reduction in the productivity of crops. However, an adequately managed irrigation system improves and increases the quality of the edible part of vegetable crops. Irrigation has positive and negative implications on crop growth in Nigeria. Results also showed that irrigation prevents salt accumulation, and reduces soil salinisation among others. Lastly, irrigation reduces the effect of global warming by improving water quality for crops, reducing the temperature impact of climate, and augments crop water requirement shortfall among others.

This study concluded that these implication(s) is determined by the adequacy of irrigation methods adopted. There is a level at which crops or plants can tolerate salinity in the soil, else high, profitable yield, and productivity of the soil will be grossly affected. Thus, it is essential to ensure that while irrigation as an agricultural management practice is employed, its implications on crop growth and yield should be considered.

Keywords: Cushion, Crop Growth, Global Warming, Irrigation, Nigeria, Salinity

1. Background

Across the globe, the effects of climate change are felt by human and non-human entities and activities. These effects such as temperature and rainfall pattern change, sea-level rise and decline, and weathering among others which inadvertently affect agricultural activities, food security, ozone layer depletion, water resources, infrastructure, health, and natural resources depletion are felt in the human environment (Intergovernmental Panel on Climate Change (IPCC, 2014). As a major aspect of climate change, global warming brings about the rise in temperature in the climate system of the earth, and this temperature distortion, change in the nature, formation, or natural order of the climate is strongly connected with the bountifulness or otherwise of agricultural produce, as its harmful or beneficial effects on the yield of crops cannot be over-emphasised (Hossain, et al., 2019).

According to Wheeler and Von Braun (2013), agricultural productivity and crop production are largely connected with the climate which informs rainfall and temperature. This implies that there is a strong link between crop productivity, yield, growth, efficiency, and climate change activities (Arshad et al., 2018). Global warming is a result of changes in climatic conditions. Irrigation can be described as one of the many agricultural adaptation strategies employed by farmers in Africa to mitigate the effect of climatic conditions such as global warming. It is the application of water on farmland through artificial means to address the precipitation shortfall during crop growth periods (Ozdogan et al. 2010).

In recent decades, salinity has been identified as a major factor responsible for poor crop production (SRDI, 2010). Salinity is a major problem for farmers in Africa. Through irrigation of farmlands by farmers, with saline surface water present at the beginning of the low flow period, salinity ingress occurs, and this informs an increase in soil salinity. The efficacy of irrigation patterns or strategies as agricultural management practices employed by farmers informs the soil alkalinity level which may impede the growth and quality of crops over time. The current climatic and environmental realities call for a change in practices in agricultural management (Akinnagbe and Irohibe, 2014).

In literature, studies have examined the impacts of climate change on agriculture with a focus on many agricultural management practices. A survey of irrigation approaches and implications for salinity stress reported that irrespective of the irrigation conditions, the manure application or approach to irrigation causes salinity characterised by high magnesium content (Rezzouk et al., 2020). This implies that irrigation types or methods do not affect the level of salinity stress that can be experienced on farmland. Another survey predicted the effect of salinity on crop growth reduction and possible growth optimisation and reported that adequate means of mitigating the effects of salinity on crop ET and yields are adequate methods of irrigation, proper irrigation scheduling, and cyclic uses of multi-salinity waters(Minhas et al., 2020). By implication, crop growth can be adequately monitored and maintained under salinity environments. This further established that the approach to irrigation informs how well the salinity effect on soil and crops can be controlled.

A similar study established that improved yield and efficiency in crop water use efficiency is achievable through direct root-zone irrigation which could bring about deep-rooting to forestall the water stress in grapevines under seasonal drought, among others (Ma et al., 2020). Identifying the effects of irrigation water salinity on crop yield, Wang et al., (2017) reported, among others, that due to salinity stress, the grain yields were reduced. This also reiterated that irrigation-induced salinity stress has a negative effect as it affects the increased yield of grains.

A simulation of the changes in salinity in a coastal aquifer and quantified changes in net irrigation requirement (NIR) of date palm under climate change, reported among others, that the rapid increase of NIR is significantly influenced by an increase in aquifer salinity (Haj-Amor et al., 2020). This finding also gives credence to the fact that the salinity of the soil is highly correlated with irrigation. An assessment of soil salinity induced by irrigation of protected crops indicated that there is a need to adequately manage salinity to sustain irrigation to forestall salinity and sodicity hazards that can be caused by long-term irrigation(Phogat et al., 2020). Inference from this assessment is that how well salinity is managed determines how effective, profitable, and impactful irrigation can be in agricultural activities on the farm.

From a modelling perspective, at three irrigation intervals, the growth of corn sown under drip irrigation was assessed. Findings established that corn produced statistically highest plant height (183.7 cm), dry matter (16.9 t/ha), grain yield (8.57 t/ha), and water productivity (1.52 kg/m3) under irrigation interval I1 in comparison to that under other irrigation intervals. By implication, the daily irrigation of corn under drip irrigation is a step in the right direction (Chauhdary et al., 2020). Another assessment of the effects of different salinity levels on mineral elements accumulation, production of osmotic solutes, and secondary metabolites of Tetragonia tetragonioides (Pallas) Kuntz in a floating hydroponic system supplied with different seawater proportions (i.e. 15% and 30% seawater, EC=9.8 and 18.0 dSm−1). The study established that the growth of the plant was not hindered by the seawater treatments, thus, leaf succulence and the reduction of both leaf area and specific leaf area with increasing salinity may account for an essential feature of this salt-tolerant species associated with the plants need of limiting transpiration(Atzori et al., 2020). From these reports, it is pertinent to state that salt stress is one of the major impediments to profitably producing crops, as it affects millions of hectares of land across the world.

Studies reported in this section established the relationship between irrigation and soil salinity, not much focus on the African region. Bearing in mind that climatic change effects are not experienced equally across regions and those climatic change-induced agricultural practices and their effects may vary across regions, the need to assess this variation with a focus on Nigeria cannot be over-emphasised. This study investigated irrigation as a cushion for the effects of global warming and its soil salinity implication on crop growth in Nigeria.

The following research questions guided the study:
1) What is the soil salinity implication of irrigation on crop growth in Nigeria?
2) Does irrigation prevent or result in soil salinity/loss of productivity of soil in Nigeria?
3) Does irrigation reduce the effect of global warming on crop growth in Nigeria?

Research Hypothesis
H01: There is no significant relationship between irrigation and the effects of global warming and its soil salinity implication on crop growth in Nigeria.

The remainder of this paper is organised as follows: methodological procedures adopted in the execution of the study and then a presentation of findings and discussion. The conclusions and recommendations finalised the paper.

2. Methods

The descriptive survey design was adopted. A purposive sampling technique was adopted to select 50 respondents with farming, climate, and agricultural background. An online questionnaire was designed using Google Form (see Appendix A), and was shared with the selected respondents via email and social media. The online survey questionnaire collects explicit data on information on the socio-economic characteristics of the sampled farmers and agriculturists (gender, age, education qualification, and occupation). The instrument also collects information on the perceptions of the respondents on the soil salinity implication of irrigation on crop growth in Nigeria; the effects of irrigation on soil salinity/loss of productivity of soil in Nigeria, and how irrigation reduces the effect of global warming on crop growth in Nigeria. Elicited data was downloaded into an Excel file and converted to SPSS-compatible format for statistical analysis. Descriptive frequency count and percentage, as well as Spearman correlation, were used to test the hypotheses.

Data collection was done between the 10th to 20th of June, 2020. Out of the 50 responses supplied by the respondents, 3 uncompleted responses were removed, while the remaining 47 responses were re-coded, saved, and exported into the SPSS version 20 software for analysis.

3. Results And Discussion

In this section, the results are presented in line with the research objectives that guided the study, using data elicited from the online questionnaire.

3.1 Demographic Characteristics of the Respondents

Results presented in Figure 1 revealed that the majority of the respondents were Male (93.6%; Female 6.4%).

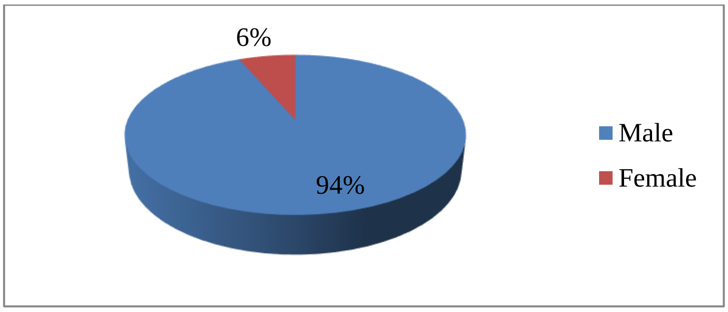

Figure 1: Gender of the respondents

Results presented in Figure 2 showed that 19.1% of the respondents were between the ages of 18-25 years, 51.1% were between the age of 26-34 years, and 29.8% were between the age of 35 years and above.

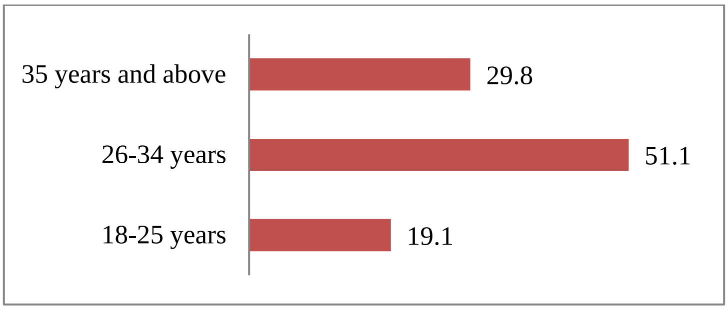

Figure 2: Age of the Respondents

Results presented in Figure 3 revealed that 8.5% of the respondents were Ordinary National Diploma holders, 6.4% were Higher National Diploma holders, 51.1% were Bachelor Degree holders, and 34% were Masters's Degree.

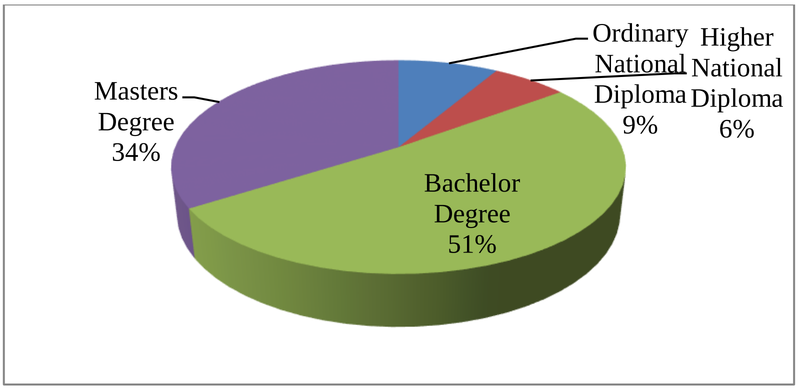

Figure 3: Educational Qualification of the Respondents

Lastly, 27.7% of the respondents were Farmers, 42.6% were Geologists, 8.5% were Agriculturists, and Agricultural Economists respectively, 10.6% were Meteorologists, and 2.1% were Plant Systematists and Economists respectively.

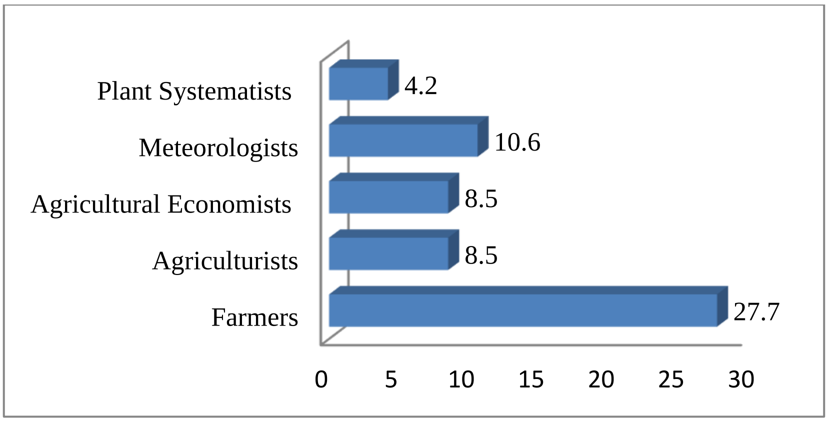

Figure 4: Occupation of the respondents

In summary, the majority of the respondents were male, between the ages of 26-34, Bachelor's degree holders, and Geologists and Farmers respectively.

3.2 Soil salinity implication of Irrigation on crop growth in Nigeria

Results presented in Table 1 showed that irrigation-induced soil salinity leads to a reduction in the productivity of crops, a reduction in marketable yield of crops; a reduction in plants' water retention capacity, inhibition of photosynthesis, development of osmotic stress, and disruption of cell homeostasis, root architecture destruction, wiltingness, yellowness of leaves, and stunted growth in crops; reduced crop yield value and marketability, and constrained crop production; and improved quality of edible part of vegetable crops, increased fruit dry matter content, total soluble solids (TSS), and acid content of some crops, increased carotenoid content and antioxidant activity of some crops. These findings are consistent with Wang et al., (2017) who reported that salinity stress leads to a reduction in grain yields. This, according to Haj-Amor et al. (2020) implies that increased salinity of the soil necessitates irrigation, and this can affect the growth of crops. This finding also aligns with Chauhdary et al. (2020) who reported that corn yield improved significantly under drip irrigation. Also, this finding is supported by Atzori et al. (2020) who revealed that state
salt stress caused by irrigation impedes the profitable production of crops across the globe.

Table 1: Soil salinity implication of irrigation on crop growth in Nigeria

s/n	Soil salinity implication of Irrigation on crop growth i Nigeria	A (%)	SA (%)	D (%)	SD (%
I	Soil salinisation contributes to the loss of productivity c cultivated soils	26 (55.3)	20 (42.6	1 (2.1)	-
Ii	Soil salinity reduces the productivity of many crops	28 (59.6)	18 (38.3	1 (2.1)	-
iii	High salt concentration in soil solution reduces the ability c plants to acquire water and grow	25 (53.2)	20 (42.6	2 (4.3)	-
iv	The salinity of the soil hinders photosynthesis by decreasin CO2 availability as a result of diffusion limitations	31 (66)	13 (27.7	2 (4.3)	1 (2.1)
V	The development of osmotic stress and disruption of cell ion homeostasis by inducing both the inhibition in the uptak of essential elements is caused by salt accumulation in th root zone	26 (55.3)	17 (36.2	4 (8.5)	-
vi	Salt stress destroys crop root architecture	32 (68.1)	12 (25.5	3 (6.4)	-
vii	Salt stress causes wilting, yellowed leaves, and stunte growth in crops	25 (53.2)	18 (38.3	4 (8.4)	-
viii	Salt stress decreases the marketable yield of crops	27 (57.4)	16 (34)	4 (8.5)	-
ix	Salt stress increased the unmarketable yield of crops	33 (70.2)	13 (27.7	1 (2.1)	-
X	Salt stress improves the quality of the edible part of vegetabl crops	26 (55.3)	14 (29.8	6 (12.8)	1 (2.1)
xi	Salinity increased fruit dry matter content, total soluble solids (TSS), and acid content of some crops	32 (68.1)	12 (25.5)	2 (4.3)	1 (2.1)
xii	Salt stress increased the carotenoid content and antioxidant activity of some crops	33 (70.2)	9 (19.1)	3 (6.4)	2 (4.3)
xiii	Soil salinity is a major constraint to crop production	31 (66)	14 (29.8)	2 (4.3)	-

Source: Survey Fieldwork, 2020

3.3 Irrigation as prevention/cause of soil salinisation/loss of productivity in Nigeria

Results presented in Table 2 demonstrated that irrigation prevents the effects of soil salinity on crops, prevents salt accumulation, reduces soil salinisation, and mitigate salt stress effects, while it causes soil salinisation, desertification, and increases the groundwater levels that cause upward movement of salts, and accumulation of salts in the root zone if not appropriately and adequately managed. This finding is supported by Rezzouk et al. (2020) who reported that irrigation, irrespective of its conditions, causes salinity with high magnesium volume. The finding that crop growth is reduced is consistent with the submission of Minhas et al., (2020) that salinity reduces crop growth and hinders crop growth optimisation. However, such can be averted through efficient irrigation methods, scheduling, and multi-salinity waters cyclic uses. This finding of the study also corroborates Ma et al. (2020) that direct root-zone irrigation improves yield and efficiency in crop water. On irrigation as prevention of soil salinity, Phogat et al. (2020) submitted that irrigation protects crops, but must be adequately managed to avoid salinity and sodicity hazards.

Table 2: Irrigation as prevention/cause of soil salinisation/loss of productivity in Nigeria

s/n	Irrigation as prevention of soil salinisation/loss of productivity in Nigeria	A (%)	SA (%)	D (%)	SD (%)
I	Irrigation increases soil salinisation	30 (63.8)	9 (19.1)	5 (10.6)	3 (6.4)
Ii	Irrigation causes desertification	24 (51.1)	14 (29.8)	6 (12.8)	3 (6.4)
iii	Irrigation prevents and mitigates the effects of soil salinity on crops	29 (61.7)	13 (27.7)	5 (10.6)	-
iv	Irrigation prevents the salt accumulation	33 (70.2)	9 (19.1)	5 (10.6)	-
V	Fertilization through irrigation can reduce soil salinisation	32 (68.1)	11 (23.4)	3 (6.4)	1 (2.1)
vi	Irrigation mitigates salt stress effects because it improves the efficiency of fertilizer use	31 (66)	11 (23.4)	5 (10.6)	-
vii	Over-irrigation increases the groundwater levels that cause upward movement of salts	27 (57.4)	16 (34)	4 (8.5)	-
viii	Under-irrigation results in the accumulation of salts in the root zone	35 (74.5)	8 (17)	4 (8.5)	-

Source: Survey Fieldwork, 2020

3.4 Does irrigation reduce the effect of global warming on crop growth in Nigeria?

Results presented in Table 3 revealed that irrigation reduces the effect of global warming by improving water quality for crops, reducing the temperature impact of climate, augmenting crop water requirement shortfall, reducing drought, and increasing soil moisturisation for plants, all of which are the effect of climate change on crop growth. This finding corroborates Ma et al. (2020) that direct root-zone irrigation results in deep-rooting, which forestall the water stress in grapevine under seasonal drought informed by global warming.

Table 3: How irrigation reduces the effect of global warming on crop growth in Nigeria

s/n	How irrigation reduces the Effect of global warming on crop growth in Nigeria	A (%)	SA (%)	D (%)	SD (%)
I	Irrigation improves water quality for crops to water caused by climate change	37 (78.7)	8 (17)	2 (4.3)	-
Ii	Irrigation reduces the temperature impact of climate change on crop	37 (78.7)	9 (19.1)	1 (2.1)	-
iii	Irrigation augments crop water requirement shortfall caused by climate change rainfall pattern alteration	31 (66)	14 (29.8)	2 (4.3)	-
iv	Irrigation reduces the drought effect of climate change on crops	33 (70.2)	11 (23.4)	2 (4.3)	1 (2.1)
V	Irrigation increase soil moisturisation for plants from harsh condition	39 (83)	6 (12.8)	1 (2.1)	1 (2.1)

Source: Survey Fieldwork, 2020

Research Hypothesis

H01: There is no significant relationship between irrigation and the effects of global warming and its soil salinity implication on crop growth in Nigeria.

Table 1: Spearman Correlation Analysis of relationship between irrigation and the effects of global warming and its soil salinity implication on crop growth in Nigeria

	Irrigation	Effects of global warming
Spearman Correlation Coeficient	**1**	.263**
Sig. (2-tailed)		.000
N	**46**	

This hypothesis was tested using Spearman correlation analysis. Table 1 presents the results of the correlation analysis between irrigation and the effects of global warming and its soil salinity implication on crop growth in Nigeria. The correlation has p-value at 0.00 (r=0.263) which is lower than 0.05 significance level, for which reason the null hypothesis is rejected. The results imply that irrigation has moderately positive irrigation and the effects of global warming and its soil salinity implication on crop growth in Nigeria.

4. Conclusion

This article concludes that while irrigation, arguably, serves as a cushion for the effects of global warming, it has positive (improved quality of edible part of vegetable crops, increased fruit dry matter content, total soluble solids (TSS), and acid content of some crops, increased carotenoid content and antioxidant activity of some crops) and mostly negative (showed that irrigation-induced soil salinity leads to a reduction in productivity of crops, reduction in marketable yield of crops; reduction in plants' water retention capacity, inhibition of photosynthesis, development of osmotic stress and disruption of cell homeostasis, root architecture destruction, wiltingness, yellowness of leaves, and stunted growth in crops; reduced crop yield value and marketability, and constraints crop production) implications for the growth of crops in Nigeria. The implication(s) is determined by the adequacy of irrigation methods adopted. There is a level at which crops or plants can tolerate salinity in the soil, else high, profitable yield, and productivity of the soil will be grossly affected. Thus, it is essential to ensure that while irrigation as an agricultural management practice is employed, its implications on crop growth and yield should be considered.

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Appendix A

Google Forms and the link https://docs.google.com/forms/d/e/1FAIpQLSejY4CEVKr-mhmystxysFL9VyJKttW8p8S-ry88a_GFFlrYWA/viewform?usp=pp_url&entry.701124309=Male