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Highlights

Cropland Bioaccumulation Risks

Biotic and Abiotic Harmful Factors

The Modified Richardos Equation

Multi-Criteria Selection and Screening

Discovering Thoughts, Inventing Future

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Guava (*Psidium Guajava*)+Summer Groundnut (*Arachis Hypogea*) for Control of Biotic and Abiotic Harmful Factors

By R. A. Singh, I. P. Singh, V. R. Chaudhary, R. K. Singh & Dharmendra Yadav

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Abstract- The field study was laid out during three consecutive years of 2005-06 to 2007-08 at Mainpuri, Farrukhabad and Kannauj districts. The operational area located between catchments area of *Ganga* and *Kali* rivers. The experimental soils were loamy sand, sandy loam and light loam in texture. The analysis of composite soil sample displayed low status of plant nutrients. The four treatments i.e, guava + groundnut cv. Dh-86 + soil application of neem leaves power @ 50 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha, guava + groundnut cv. Dh-86 + soil application of neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha, guava + groundnut cv ICGV 93468 + soil application of neem leaves powder @ 50 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha and guava + groundnut cv. ICGV-93468 + soil application of neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha were tested. The farmers were suggested for plantation of guava at the spacing of 6x6 m^2. The cultivars Dh-86 and ICGV-93468 (Avtar) were selected and planted between 5-10 March of experimental years. The 20 rows of groundnut were planted between two rows guava. The sowing of groundnut was made at spacing of 25 cm in rows.

Keywords: *BND, Dh-86, ICGV-93468, summer groundnut, white grubs.*

GJSFR-D Classification: *DDC Code: 843.91 LCC Code: PQ2637.A274*

GUAVAPSIDIUMGUAJAVA+SUMMERGROUNDNUTARACHISHYPOGEAFORCONTROLOFBIOTICANDABIOTICHARMFULFACTORS

Strictly as per the compliance and regulations of:

Guava (*Psidium Guajava*)+Summer Groundnut (*Arachis Hypogea*) for Control of Biotic and Abiotic Harmful Factors

R. A. Singh [α], I. P. Singh [σ], V. R. Chaudhary [ρ], R. K. Singh [Ѡ] & Dharmendra Yadav [¥]

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Keywords: BND, Dh-86, ICGV-93468, summer groundnut, white grubs.

I. Introduction

In Uttar Pradesh (India), the riverine soils of Semi-Arid-Tropics (SAT) area, having loamy sand, sandy loam and light loam texture is famous for cultivation of groundnut in rainy season. In early 1980s, groundnut was grown in U.P. on an area of 0.3 million ha with production of 0.19 million t. Since then, both area and production have slowly and steadily decreased due to various reason especially white grubs and other soil insect and by 2010-11 the groundnut area reduced to 0.08 million ha and the production to 0.08 million tonnes with an average productivity of 988 kg/ha and the area under rainy season groundnut was gradually occupied largely by guava and other horticultural and field crops. With the introduction and spread of groundnut cultivars Dh-86 and ICGV-93468 (Avtar) for cultivation in summer. The area under summer groundnut grew in leaps and bounds from non in 2001 to 3,17,068 ha in 2011 with productivity of 25.32 q/ha. This rapid growth of area under summer groundnut promoted the need for research on cultivation of groundnut in area occupied by guava. The main objective of the experiment was to explore the feasibility of summer groundnut cultivation in the interspaces of younger plantation or already planted guava for utilizing the vacant spaces along with control of insects especially soil insects, which are damage to the pods of groundnut. The secondary objective was to increase the area under summer groundnut in catchments area of river *Ganga* and its *tributaries*, where, guava orchards have been well established. The experiment was planed on sandy loam, sandy clay loam and light loam soil of Semi-Arid Climatic Zone of Uttar Pradesh for cultivation summer groundnut during March to June by utilizing the area available between the widely spaced rows of guava. Therefore, filler cropping of summer groundnut in guava spaces is the subject matter of this manuscript.

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II. Materials and Methods

The innovative field study was undertaken during three consecutive years of 2005-06 to 2007-08 at Mainpuri, Farrukhabad and Kannuaj districts. The operational area located between the catchments area of rivers *Ganga* and *Kali*. The soils of operational area were loamy sand, sandy loam and light loam in texture. The composite sample of soil was taken and analyzed. The composite soil sample, having pH 7.9, organic carbon 0.27%, total nitrogen 0.03%, available P_2O_5 7.9 kg/ha and available K_2O 192 kg/ha. The pH was determined by Electrometric glass electrode method (Piper, 1950), while organic carbon was determined by

Colorimetric method (Datta, *et al.,* 1962). Total nitrogen was analyzed by Kjeldahl's method as discussed by Piper (1950). The available P_2O_5 and K_2O were determined by Olsen's method (Olsen *et al*., 1954) and Flam photometric method (Singh, 1971), respectively. The treatments i.e., guava + groundnut cv. Dh-86 + soil application of neem leaves powder @ 50 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha, guava + groundnut cv. Dh-86 + soil application of neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha, guava + groundnut cv. ICGV-93468 + soil application of neem leaves powder @ 50 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha and guava + groundnut cv. ICGV-93468 + soil application of neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha were tested. The fields of guava with two to four years old plantation were selected for sowing of groundnut as a summer filler crops. The farmers were advised for the plantation of guava at spacing of 6 x 6 m^2. Two cultivars of groundnut viz., Dh-86 and ICGV-93468 were selected for filler cropping. The groundnut was planted from 5-10 March during the three experimental years. The 20 rows of groundnut were planted between two rows of guava. The sowing of groundnut was done at spacing of 25 cm. The gap of 50 cm was maintained between the adjacent guava and groundnut rows from both sides to facilitate easy intercultural operations. The recommended package of practices was followed for raising of both crops. The groundnut was harvested at 90-95 days after planting in 3 to 8 June of three years. Both crops were irrigated as and when required.

III. Results and Discussion

The pooled data of fruits yield of guava, pods yield of summer groundnut, system productivity and incidence of insects, pest and diseases have been presented in Table-1 and discussed here under appropriate heads.

a) *Fruits yield of guava*

Perusal of data make it clear that guava + groundnut cv. ICGV-93468 + soil application of neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha treatment gave higher fruits yield of guava by 79.00 q/ha (T_4), closely followed by guava + groundnut cv. ICGV-93468 + soil application of neem leaves powder @ 50 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha (77.00 q/ha) in comparison to T_1 (74.00 q/ha) and T_2 (76.00 q/ha). These results confirm the findings of Singh (2009) and Singh (2011).

b) *Pods yield of summer groundnut*

It is clear from the results that not much variation was found under different treatments, though numerically higher pods yield of cultivar ICGV-93468 was weighed under treatment of guava + groundnut cv. ICGV-93468 + soil application of neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha by 31.00 q/ha as compared to other tested treatments. The performance of pods yield of groundnut was T_4 (31.00 q/ha) > T_2 (30.30 q/ha) > T_1 (25.00 q/ha) and > T_3 (24.00 q/ha). These results are in agreement with those reported by Singh (2009) and Singh (2011).

c) *System productivity*

The system productivity was computed from the total production of fruits yield of guava and pods yield of summer groundnut. The highest total productivity was found under guava + groundnut cv. ICGV-93468 + soil application neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit./ha by 110.00 q/ha, closely followed by guava + groundnut cv. Dh-86 + soil application neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit./ha by 106.30 q/ha. The two treatments i.e., T_1 and T_3 displayed the system productivity as 99.00 q/ha and 101.00 q/ha, which was lowest. The higher and lowest yield of guava fruits and pods yield of summer groundnut under tested treatments were responsible for highest and lowest system productivity. Similar results have also been reported by Singh (2009) and Singh (2011).

d) *Biotic Control*

i. *Incidence of insects, pest and diseases*

For the control of white grubs, termites and pod borers, soil application of neem leaves powder was made before the sowing of groundnut. The lower and higher doses of neem leaves @ 50 kg/ha and 100 kg/ha, respectively, fully control the incidence of white grubs and BND disease in groundnut. The 1% incidence of termites was counted under lower dose of 50 kg/ha neem leaves powder, while it was fully control at higher dose of 100 kg/ha neem leaves powder. The pods damage by pod borers was recorded between 1% to 2% under lower and higher doses of neem leaves powder. For the control of white grubs in groundnut, the prophylactic control measure was also adopted by the spraying of neem oil @ 2.5 lit/ha on guava plantation. These plant protection measures displayed the significant achievement in control of insects, pest and diseases in groundnut and guava under agro-forestry system.

ii. *Abiotic control*

It is well known fact that the riverine soils of Uttar Pradesh have more percentage of sand in texture with crumby structure which support to the wind soil erosion. The considerable soil moisture also loss due to high wind velocity during summer season. Being cover crop, groundnut, grown as filler crop, between rows of guava control. The wind erosion of soil and checked the moisture loss. These results are in agreement with those reported by Singh (2011).

IV. Conclusion and Recommendation

In agro-forestry system of guava + groundnut cv. Dh-86 and cv. ICGV-93468 + soil application of neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plantation @ 2.5 lit/ha gave highest fruits yield of guava and pods yield of groundnut during summer season, therefore, farm families of guava and summer groundnut growing tracts may be suggested for adoption of this system and harvest the fruits of newly generated technology.

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Parallel cropping of summer groundnut and guava plantation in catchment area of the river Ganga

Filler cropping of summer groundnut with guava in catchment area of river Kali

Table 1: Fruits yield of guava, pods yield of summer groundnut and percent incidence of insects pest and diseases on summer groundnut under different treatments *(Pooled data of three years)*

S.No.	Treatment	Yield (q/ha)		System productivity (q/ha)	Incidence of insects pest and diseases (%)				Abiotic loss	
		Fruits yield of guava	Pods yield of summer ground-nut		White grubs	Termites	Pod borers	BND	Wind erosion	Moisture loss
1.	Guava + groundnut cv. Dh-86 + soil application of neem leaves powder @ 50 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha (T_1)	74.00	25.00	99.00	NIL	1.00	2.00	NIL	NIL	NIL
2.	Guava + groundnut cv. Dh-86 + soil application of neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha (T_2)	76.00	30.30	106.30	NIL	NIL	1.15	NIL	NIL	NIL
3.	Guava + groundnut cv. ICGV-93468 + soil application of neem leaves powder @ 50 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha (T_3)	77.00	24.00	101.00	NIL	1.00	2.10	NIL	NIL	NIL
4.	Guava + groundnut cv. ICGV-93468 + soil application of neem leaves powder @ 100 kg/ha and spraying of neem oil on guava plants @ 2.5 lit/ha (T_4)	79.00	31.00	110.00	NIL	NIL	1.25	NIL	NIL	NIL

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Cropland Bioaccumulation Risks of Potentially Toxic Elements in Soil of Some Designated Foodstuffs Cultivated in Odu'a Farm Establishment, Aawe, Oyo State, Nigeria

By Taiwo O. Ogunwale, John Adekunle O. Oyekunle, Aderemi O. Ogunfowokan, Simeon O. Oyetola & Oluwaseun Femi Ogunrinola

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Abstract- The purpose of this work was to estimate heavy element bioaccumulation in four staple food crops species, specifically sweet cassava (*Manihot esculenta*), maize (*Zea mays L.*), plantain (*Musa paradisiaca L.*), and white yam (*Dioscorea rotundata L.*), and to assess the human health risks of food crops intake. The analyzed heavy elements included arsenic, cadmium, copper, manganese, lead, and zinc for their bioaccumulation factors to provide benchmark point information regarding ecological health and the suitableness of a farm established in the time ahead. The bioaccumulation factor, heavy elementpollution load index, acceptable daily intake of elements, human health risk index, target hazard quotient toxicology, total diet target hazard quotient, and total target hazard quotienttechniques were employed to estimate the human health risks analysis caused by heavy elements via staple food crops consumption. Quality control techniques comprised blank analysis, spike recovery analysis, and calibration of concentrations. We adopted descriptive and inferential statistics to analyze the data. Overall mean HEPLI values for both seasons were 0.54 and 0.88, 0.28 and 0.92, 0.31 and 0.37, 0.52 and 0.55, 0.28 and 0.55 and 0.24 and 0.31, for As, Cd, Cu, Mn, Pb, and Zn, respectively. Elements in staple food crops were lower than in soils, with ranges of 1.83-3.91, 0.02-0.06, 0.06-0.43, 10.30-26.14, 0.04-0.23 and 2.73-12.04 mg/kg, for As, Cd, Cu, Mn, Pb, and Zn, respectively.

Keywords: toxic heavy elements; human health risk indices; staple food crops; farm establishment; ecosystem health.

GJSFR-D Classification: DDC Code: 333.953416 LCC Code: SD399.7

CROPLANDBIOACCUMULATIONRISKSOFPOTENTIALLYTOXICELEMENTSINSOILOFSOMEDESIGNATEDFOODSTUFFSCULTIVATEDINODUAFARMESTABLISHMENTAAWEOYOSTATENIGERIA

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Taiwo O. Ogunwale [α], John Adekunle O. Oyekunle [σ], Aderemi O. Ogunfowokan [ρ], Simeon O. Oyetola [ω] & Oluwaseun Femi Ogunrinola [¥]

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Keywords: toxic heavy elements; human health risk indices; staple food crops; farm establishment; ecosystem health.

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I. Introduction

Nigeria is an agrarian nation with about 70% of her over 195 million people involved in the farmings sector (Ogunwale et al., 2021), and it adds support for two-thirds (2/3) of Nigerians who are low-income earners (Ogunwale et al., 2021). While the Northern side can indemnity the production of cereals like sorghum, maize, millet, groundnut, melon, cowpea, and cotton, the Middle Belt and the South enjoy the potential to raise root tubers like cassava, yam, cocoyam, and the like crops plantain in addition to maize (Ogunwale et al., 2021). Besides food crops, the country is likewise included in the managing of farm animals, fisheries, forestry, and undomesticated animals.

Nigeria is enriched chiefly with ample biological resources, sundry all-season rivers and auspicious tropical weather. Rainfall is usually sufficient and correctly well-supplied throughout the country (Ogunwale et al., 2021). Of the 98.321 million ha of land found in Nigeria, about 75.30% may be assigned as arable land, of which 10% is under forest reserves and the remaining 14.70% is given to be constituted of permanent pastures, built-up areas, and useless waste (FMARD, 2012). In light of the above-mentioned, agriculture is still a key industry and continuing to be the backbone of the Nigerian economy (Ogunwale et al., 2021).

With the intention of face-lift the farm sector, quite scores of programmes and policies have been carried out by means of the Nigerian Government to boost efficiency in the farming sector consist of:- Farm Settlement Scheme (FSS), Marketing and Commodity Board, National Accelerated Food Product Programme (NAFFP), Agricultural Development Project (ADPs), National Seed Service (NSS), Agricultural Credit and Guarantee Scheme Fund (ACGSF), National Agricultural Cooperative and Rural Development Bank (NACRDB), Operation Feed the Nation (OFN), River Basin Development Authority (RBDA), Green Revolution (GR), Directorate for Food, Road and Rural Infrastructure

(DFRRI), Nigerian Agricultural Insurance Company (NAIC), National Agricultural Land Development Authority (NALDA), the National Economic Empowerment and Development Strategies (NEEDS I and NEEDS II) and the Implementation of Comprehensive African Agricultural Development Programme (CAADP), National Food Security Programme (NFSP), the National Fadama Project (Phase I, II and III), the up-to-date Agricultural Transformation Agenda (ATA), (Salisu, 2016).

With the purpose of encouraging entrepreneurship among our young people, the Odu'a Commercial Farmers' Academy has been established to serve a constructive role through empowering the young people with functional skills and appropriate knowledge needed in agribusiness. Odu'a farm settlements project is designed to let new and emerging farmers establish themselves in viable agribusiness.

The occurrence of heavy and trace elements in the soil ecosystem is gradually becoming a concern of worldwide issue at private in addition to governmental levels, specifically as soil constitutes a major feature of rural and urban ecological communities (Ogunwale et al., 2022), and can be conceived as a very significant "ecological crossroad" in the landform (Ogunwale et al., 2021). Introduction of heavy elements to cropland soils can spring up from various sources. These comprise the repeated utilization of sewage sludge, mineral fertilizers, farm animal manures, agricultural chemicals, and irrigation water, and from atmospheric fall out which, is one of the almost all serious environmental issues, in Nigeria. Some of the dreads about bioaccumulation of heavy elements in cropland soils and staple food crops come from their possible negative impacts on land fertility and in some cases, their ability to build up at the trophic level (Ogunwale et al., 2021).Amongst the substances that give anthropogenically to pollution of the ecosystem, heavy elements are the most subtle. Arsenic, Cd, Cr, Hg, and Pb are toxic elements of growing ecological concern as they enter the feeding level in considerable amounts. Though some trace elements are necessary in plant nutrition, crops cultivated in the adjoining areas of industrial sites demonstrate increased content of heavy elements, serving in many cases as biomonitors of pollution loads (Ogunwale et al., 2021). Staple food crops raised in soils polluted with toxic heavy elements intake that elements and concentrate them in their consumable and non-consumable portions in degrees high enough to cause health problems both to animals and human beings consuming these element-rich food crops as there is no suitable mechanism for their elimination from the body system (Ogunwale et al., 2021). Toxic elements are known to preclinical concerns, including carcinogenesis-induced tumor growth. Hence, the growing consciousness about the health risks related to ecological chemicals has brought a significant shift in, global interest towards avoidance of heavy element bioaccumulation in air, soil, water, and staple foodstuff crops (Ogunwale et al., 2021).

The term 'potentially toxic elements' (PTEs) are also used frequently in research articles to denote elements that are identified to be extremely toxic at elevated contents. Lead, Zn, Cu, Fe, Cd, As, and Ni are among elements that are often referred to as PTEs (Ogunwale et al., 2021). Because of the diversity of vocabularies found in research papers, the term 'heavy elements' are occurred to be the most charming to be used in this work.

There is a growing risk of public contact with heavy elements as a result of the consumption of food crops produced in contaminated soil (Ogunwale et al., 2022). There are several reports in the published articles corroborate this statement (Njagi, 2013; Balk hair and Ashraf, 2016; Ogunwale et al., 2021;Ogunwale et al., 2022). The problem of heavy elements invading the feeding level-entails systematic assessments to create timely decisions to prevent serious health effects as a result of the invisible mode of heavy element toxicity (Ogunwale et al., 2021). Risk analyses have been conducted employing various risk assessment techniques, like the hazard quotient (HQ)(Balkhair and Ashraf, 2016; Zhou et al., 2016; Ogunwale et al., 2021), (the health risk index (HRI) (Ogunwale et al., 2021), the morbidity level (ML) (Srinivasan and Reddy, 2009), the enrichment factor (EF), the degree of contamination (C_{deg}) and the uptake/transfer factor (UF) (Ogunwale et al., 2021), enumeration, mathematics, and geospatial (Hani et al., 2010).

Heavy element exposure takes place considerably by occupational contact. The biotoxin impacts of heavy elements, when consumed beyond the bio-recommended levels, are too numerous to be given little attention to. In most periods, the cultivators who help in sustaining the lives of the citizens through the cultivation of staple crops stand insecure of immediate contact with these toxic elements, via ignorance of these substances. Also, no reported data have been estimated on the Aawe farm establishment. This farm establishment supplies food to adjoining towns and villages in Oyo State and Osun State. It is this relevant to provide baseline information about the levels of toxic elements in this settlement along with equipping the citizenry about the hazards in the use of these substances and the menaces that they pose to the entire ecological community. Farm inputs like fertilizers and agrichemicals are likewise used in the farming of staple food crops, and all these might contain As, Cd, Cu, Mn, Pb, and Zn elements, for staple crops intake on the farm. There is, therefore the need for studies to assay the level of these elements in the staple foodstuffs and soil on this farm establishment. This work estimates the content of some heavy elements: As, Cd, Cu, Mn, Pb, and Zn in some designated commonly consumed

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staple foodstuffs: sweet cassava (*Manihot esculenta L.*), maize (*Zea mays L.*), plantain (*Musa paradisiaca L.*), and white yam (*Dioscorearotundata L.*) cultivated in Aawe communities in the Odu'a farm establishment Oyo State, Southwestern Region of Nigeria. The staple food crops were planted on a farmland soil settlement of Aawe for the period of wet and dry seasons of 2018.

II. Material and Method

a) Area under Study

i. Place and Suitability of Research Site

The research was conducted in Aawe, which is under the Afijio Local Government Area of Oyo State, Nigeria. It situates in the Southwestern Zone of the State, which is approximately encircled by latitudes 7.80 and 4.40 north of the equator. Aawe Farm Centre: Old Rural Community Development Centre (RCDC) Km 12, Aawe-Iwo Road, Aawe, Oyo State. Odu'a farm settlement is specifically designated for this work on account of its influence toAgri-business Industry in Nigeria and happens to be a fast developing farm settlement within the area. The farm settlement scheme conducts training and workshop for all categories of farmers, and young school leavers. Also, the clime of this area has been deemed to be the most appropriate for agricultural productivity in the southwestern Geo–political zone of Nigeria(Ogunwale et al., 2021).The landform is, by and large, undulating with highest being around 213.50 m above the mean water table. There is a good network of rivers and streams and prominent among them are Odooba and Dogiyan rivers. These rivers aid as sources of water for irrigation uses explicitly for staple crop farmers in the dry season. The area falls within two climatic regions in Nigeria (Ogunwale et al., 2021). The Semi Deciduous Forest is available in the northern part whereas the Tropical Rain forest, which is among the wettest region of the country, is available in the southern part. The mean annual rainfallfalls off from 127.77 mm in the south to 111.00 mm in the north. There are two main rainfall characteristics, present between mid-March to early-August and September to early November, with a short dry season present between December-February. Temperatures are moderately high, varying from 23.80-27.90°C. Maximum temperatures occur in February-March, and slightest low-temperature month is August.

Geologically, the research area makes up a portion of the Basement Complex of Southwestern Nigeria and it is naturally covered by hard crystalline igneous and metamorphic rocks (Ogunwale et al., 2021). The soil types of the study zone are primarily connected with Iwo and Egbeda categorizations. They have been figured out as montmorillonite soils which are by far the most extensive and almost all essential soils within the Tropical biomes for both food and tree cash crop cultivation. Such grounds, under natural conditions comprise rich nutrients that are tied-up with the organic layers in their surface soil and, thus sustain healthy crop growth (Ogunwale et al., 2021). Best food crops cultivated are cassava, cocoyam, maize, plantain, pineapple, banana, yam, and vegetables, while chief cash crops include cocoa, rubber, oil palm, cashew, mango, avocado, and citrus.

b) Plant and Soil Sampling

At farm establishment, samples were picked up from diverse plots within the farm since the agronomical practices tolerate great local variation of soil characteristics. Cassava, maize, plantain, yam, and soil samples were taken from the farm that surrounded the farm settlement and one fallow plot in which farming was not taking place, respectively within the research area. Selections from the non-farming plot were collected and assayed to provide reference data as an underlying condition of comparison to the cropland areas. Five pieces of cassava, maize, plantain, and yam with their corresponding soil samples (i.e., varying from 0-20 cm depth from the top of the ridge)were gathered in each plot. The cassava, maize, plantain, and yam samples were harvested from four farms within each parcel, dependent upon the availability of the crops. This was done after the ridges were created and the cassava andyam, and holes were dug while plantain was harvested with a clean machete and maize was plucked with glove hand and samples were taken. Pieces of each crop gathered were wrapped in foil paper and marked with cellulose masking tape to avoid wrong identity. All the pieces were stored in dried polyethylene bags and conveyed to the research laboratory for additional analysis. The pieces were well labeled depending on the location, and also geospatial coordinates were taken in addition.

The cassava, plantain, and yam samples were pared. At the same time, maize grain, each seed was extracted off the cob before drying, and the edible portions were washed with tap water, after that, deionized distilled water, broken into smaller slices with a stainless knife, and naturally dried in a spacious room on a concrete ground for seven 2-7 days. The pieces were then put in a hot air oven with a temperature of 105°C to dry till constant scale was attained. When fully dry, the samples were crushed, and both soil and plants were sieved utilizing a 2 mm plastic sieve before being assessed.

c) Soil Analysis of pH, Electrical Conductivity, Organic Carbon and Organic Matter

Following air-drying for seven days and sieved, 10 g per soil sample was quantified via a Metlar Electronic balance (Model MT 2000) scale and put in glass beakers. To measure the pH 50 mL of distilled water was introduced to the samples which were shaken in durations for one hour. The pH was then measured

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with a HANNA instrument, pHep®, pocket-sized pH meter (Ogunwale et al., 2021).

Electrical conductivity was carried out employing a 10 g dry basis per sample placed in glass beakers with 50 mL of distilled water. The samples were agitated for one hour, and the measurements were done with a HACHUltra meter II 6 Psi serial 6207639. Organic carbon was conducted by means of a potassium dichromate back-titration technique (Ogunwale et al., 2021). The organic matter content was estimated by a factor of 1.72 multiplied by organic carbon modified by Ogunwale et al. (2021).

d) Digestion of Samples (both Staple Food Crops and Soil) for FAAS Analysis

i. *Preparation of Wet Digestion Acid*

$HN0_3$, $HClO_4$, and H_2S0_4 were combined in the proportion of 30:4:1 with a view to composing the wet digestion acid mixture.

ii. *Digestion and Extraction Technique of Heavy Element Analysis for Food Crops and Soil*

For extraction, 1.0 g per dried and crushed sample was determined with the Metlar Electronic balance (Model MT 2000) scale and placed in a glass beaker. A volume of 5 mL aqua regia was introduced (1:3 HNO_3: HCl), and the samples were placed in a hot air oven for 30-60 minutes till finally digested. The stove did not possess a thermometer and the temperature was attuned by turning the on and off the stove, endeavoring to keep the temperature at about 100-120°C. To make sure that the samples did not get burned they were regularly examined. The end of the digestion was noticed by the emission of a dense white fume of perchloric acid ($HCl0_4$) and the decrease of volume to about 5 mL, and then the digestion system was discontinued. The digest was left to cool and conveyed measurably in 50 cm^3 volumetric flasks, then was filled into the grade with laboratory water. The digest per sample was moved into a diverse well-stopper rubber vessel, which was made ready for Flame Atomic Absorption Spectroscopic Analysis.

e) Data Assays

i. *Translocation Factor Estimation*

Heavy elements can potentially translocate from the soil to the consumable portions of the staple food crop and can be done by the bioaccumulation factor (BF) (Balkhair and Ashraf, 2016; Ogunwale et al., 2021). The BF contents for the designated heavy elements were estimated employing the following Equation:

$$BF = \frac{Heavy\ element\ content\ in\ the\ staple\ food\ crops\ consumable\ portions}{Heavy\ element\ content\ in\ the\ soil} \quad \text{.................................eqn(i)}$$

ii. *Heavy Element Pollution Load Index (HEPLI)*

The content of soil pollution perelement was estimated utilizing the heavy element pollution load index (HEPLI) technique dependent upon soil element contents. The resulting reviewed equation was employed to calculate the HEPLI content in soils.

$$HEPLI = \frac{C_{soil}\ (Samples)}{C_{benc\ hmark}\ (Benc\ hmark)} \quad \text{(Ogunwaleet al., 2021)................................ eqn (ii)}$$

C_{soil} (samples) and $C_{benchmark}$ suggest the heavy element contents in extracts of soil and recommended value for the element. The geochemical recommended values in continental crust mean shale of the heavy features under analysis described by Turekian and Wedepohl (1961) were applied as recommended guidelines of the component element.

iii. *Risk Analysis for Daily Allowance of Heavy Elements*

The amount of staple food that can securely be eaten on an everyday basis is estimated from uniting equations for the daily allowance of elements (DAE), human health risk index (HHRI), and target hazard quotient (THQ) (Balkhair and Ashraf, 2016; Ogunwale et al., 2021). The DAE is in line with Balkhair and Ashraf (2016) and Ogunwale et al. (2021)calculated from the daily degree of food consumed ($D_{food\ allowance}$), the content of elements in the food ($C_{element}$), and the mean weight of the body of the consumers ($B_{mean\ weight}$) concerning the equation below. The C_{rate} (0.085) is applied to convert fresh green staple food matter to dry matter (Balkhair and Ashraf, 2016; Ogunwale et al., 2021).

$$DAE = \frac{C_{element}\ \times A_{factor}\ \times D_{food\ allowance}}{B_{mean\ weig\ ht}} \quad \text{............................. ....eqn (iii)}$$

where $C_{element}$, A_{factor}, $D_{food\ allowance}$ and,$B_{mean\ weig\ ht}$ depict the heavy elementvalues in staple food crops (mg/kg), adjustment factor, a daily allowance of foodstuff crops, and mean weight of the body of the consumers, respectively. The adjustment factor (AF) of 0.085 was meant for the transformation of fresh green staple foodstuff matter to dry matter, as revealed by Ogunwale et al. (2021). The mean weight of the body for the adult population was 60 kg, as applied in previous research (Balkhair and Ashraf, 2016; Ogunwale et al., 2021). These contents were also employed for the estimation of HHRI. The daily maximum allowance of 800 g for sweet cassava, plantain, white yam, and maize (Balkhair and Ashraf, 2016) was adopted for this analysis.

iv. *Human Health Risk Index (HHRI)*

The human health risk index is the proportion of DAE and an oral recommended allowance(ORA) employing the subsequent equation:

$$HHRI = \frac{DAE}{ORA}$$ (USEPA-IRIS, 2002; Ogunwale et al., 2021) ……………………….eqn (iv)

Where DAE is the daily allowance of elements and ORA is the oral recommended allowances. The ORA is the highest amount of acomponent, in milligrams per day, that the body can be vulnerable to the outside of yielding a hazardous outcome during a lifespan. Oral recommended allowances were 3.00E-04, 1.00E-03, 4.00E-02, 3.00E-01, 4.00E-03, and 3.00E-01 mg/kg/day for As, Cd, Cu, Mn, Pb, and Zn, respectively (USEPA-IRIS, 2002). An HHRI<1 implies that the vulnerable consumers are said to be in safety (Ogunwale et al., 2021).

When uniting Equation (iii), and (iv) along with HHRI=1, the maximum limit for the amount of food that can securely be eaten on an everyday basis is expressed as:

$$D_{food\ allowance} = \frac{B_{mean\ weight} \times ORA}{A_{factor} \times C_{element}}$$ ………………………….……………….eqn (v)

v. *Target Hazard Quotient (THQ) Technique*

The potential health risks of heavy element allowance through staple foodstuffs were analyzed-depending on the target hazard quotient (THQ) method, which was indicated thoroughly using the United States Environmental Protection Agency (USEPA-IRIS, 2002). The THQ is considering through the subsequent equation:

$$THQ = \frac{EF_r \times ET \times F_I \times EC}{ORA \times BS \times MD} \times 0.001$$ ……….eqn (vi)

Where EF_r is the exposure frequency (350 days/year); ET is the exposure time (55.12 years, corresponding to the mean lifespan of the Nigerian population); F_I is the food ingestion rate (staple foodstuff (sweet cassava, maize, plantain, and white yam) allowance analyzes for adults is 800.0 g/person/day) was adopted for this work (Balkhair and Ashraf, 2016); EC is the element content in the consumable portions of staple foods (mg/kg); ORA is the oral recommended allowance (As, Cd, Cu, Mn, Pb, and Znvalues were 3.00E-04, 1.00E-03, 4.00E-02, 3.00E-01, 3.50E-03, and 3.00E-01 mg/kg/day, respectively) (USEPA-IRIS, 2002); BS is the mean weight of the body size (60 kg for adults) (USEPA-IRIS, 2002); and MD is the mean exposure duration for non-carcinogens (365 days $year-^{1}$ × number of exposure years, supposing 55.12 years in this work). If the THQ value is above 1, the condition is likely to cause significant harmful effects.

The total diet THQ (TDTHQ) of heavy elements for staple foods is stated explicitly using the following equation (Storelli, 2008;Zhou et al., 2016).

$$TDTHQ = \sum_{i=1}^{n}(THQ)i$$ ……………..…eqn (vii)

f) *Quality Control Adopted Utilized*

With the intention of determining the effectiveness of the $HNO_3 - HClO_4$ method of sample digestion, a recovery test was done by spiking 1 g of twenty (20) and ten (10) different soil, cassava, maize, plantain, and yam samples each with 1 cm^3 of standard solutions of the elements As, Cd, Cu, Mn, Pb, and Zn. Recovery test presented % recoveries > 80%. Element contents in functioning standards and digested samples were performed with FAAS (Alpha Star Model 4, Chem-Tech Analytical) at the Centre for Energy Research and Development (CERD) of the Obafemi Awolowo University, Ile-Ife, Nigeria. Instrumental conditions are as stated earlier (Ogunwale et al., 2021). Blanks were also prepared to estimate the input of reagents to element contents.

III. Results

a) *Physicochemical and Heavy Elements Attributes of the Farmland Soils*

The soil attributes (Table2) were assessed in relation to the Ogunwale et al. (2021) guidelines. The investigated variables comprised pH, electrical conductivity (EC), total organic carbon (TOC), and total organic matter (TOM). Supposing the mean value of carbon in soil organic matter (˜58% w/w), an adjustment factor of 1.72 was applied to determine the percentage of organic matter (OM) from the value of organic carbon (Ogunwale et al., 2021).

Table 3 demonstrates the levels of As, Cd, Cu, Mn, Pb, and Zn (mg/kg) in soils present from farmed and non-farmed (control) sites in the research area for both seasons. The mean values of all heavy elements for wet and dry seasons varied from ND-743. 44 mg/kg and ND-806.73 mg/kg, respectively. Arsenic in both seasons varied from 3.27-7.38 mg/kg and Mn ranged from 236.10-806.73 mg/kg in farmed soils while their values were 0.04 and 0.07 mg/kg and 5.12 and 8.95 mg/kg in non-farmed soils, respectively. The levels of most heavy elements in wet and dry seasonswere0.06-0.46, 9.08-23.27, 3.85-13.16, and 16.66-36.12mg/kg for Cd, Cu, Pb, and Zn, respectively while the values for unfarmed soil were ND, 0.06 and 0.18, 0.03 and 0.07 and 1.64 and 1.96, 6.765, 5.635, and 0.875mg/kg for Cd, Cu, Pb and Zn, respectively.

Table 4presents the heavy elementcontents in the assigned food crops (cassava, maize, plantain, and yam) in the area under study. The mean values in cassava for both seasons varied from 0.03-12.24 mg/kg; maize ranged from 0.04-17.38 mg/kg; plantain varied from 0.05-26.14 mg/kg and yam varied from 0.02-15.43 mg/kg, respectively with an overall mean of 2.00 and 3.08 mg/kg; 0.04 and 0.05 mg/kg; 0.14 and 0.24 mg/kg; 14.89 and 17.80 mg/kg; 0.07 and 0.15 mg/kg and 7.35 and 8.60 mg/kg, respectively for As, Cd, Cu, Mn, Pb, and Zn.

The element BF in staple crops is used to express the quantity of bioaccumulation of a compound in a signified biotic complex. Table 5 reveals the BF values of heavy elements in food crops farmed in the research site while Table 6 presents the heavy element pollution load index of features across the sampling points for both seasons. To determine the human health risk per pollutant, it is significant to estimate the level of exposure by finding the routes of contact with target living things. There are numerous likely pathways of contact with humans, but among them, the trophic status is the mostcritical pathway. In our analysis, the mereal lowance path available for As, Cd, Cu, Mn, Pb, and Zn was adopted to staple food allowance.

The DAE values were estimated counted on the mean staple food allowance for adults (Table 7) and related to the recommended daily allowances (USEPA-IRIS, 2002). The results for estimating the mean DAE, HHRI, DFA, THQ,TDTHQ, and TTHQ from the heavy element-polluted staple foodstuff crop are presented in Tables 7-10. The results indicated that the DAE and HHRI values were low in the staple food crops while DFA, THQ, and TDTHQ values were high in the staple foodstuff crops. The mean DAE of the staple food crop for both seasons varied from 2.074E-03 to 4.43E-03, 2.267E-05 to 6.800E-05, 6.800E-05 to 4.873E-04,1.167E-02 to 2.963E-02, 4.533E-05 to 2.607E-04, and 3.094E-03 to 1.365E-02 mg kg^{-1} $person^{-1}$ d^{-1} for As, Cd, Cu, Mn, Pb, and Zn, respectively (Table 7).

Likewise, in staple food crops, the mean HHRI values in wet and dry seasons for As, Cd, Cu, Mn, Pb, and Zn ranged from 6.91E-01 to 1.48E+00, 2.27E-02 to 6.80E-02, 1.70E-03 to 1.22E-02, 3.89E-02 to 9.88E-02, 1.30E-02 to 7.45E-02, and 1.03E-02 to 4.55E-02mg kg^{-1} $person^{-1}$ d^{-1}, respectively (Table 8). Equally, the mean DFA of the staple food crops that can be securely eaten on an everyday basis for both seasons varied from 0.542 to 1.157, 11.765 to 35.294, 65.663 to 470.588, 8.101 to 20.560, 10.742 to 61.765, and 17.588 to 77.569, correspondingly (Table 9). Furthermore, in staple food crops, the mean THQ values in wet and dry seasons for As, Cd, Cu, Mn, Pb, and Zn ranged from 7.799 to 16.664, 0.256 to 0.767, 0.019 to 0.137, 0.439 to 1.114, 0.015 to 0.084, and 0.116 to 0.513, respectively (Table 10) while the mean TDTHQ values of the staple food crops for both seasons varied from 34.093 and 52.420, 1.790 and 2.301, 0.173 and 0.311, 2.539 and 3.035, 0.095 and 0.215 and 1.252 and 1.466, respectively for As, Cd, Cu, Mn, Pb, and Zn (Table 10).

IV. Discussion

a) *Fertility Variables of the Soils*

The pH is one of the variables governing the bioavailability and the movement of heavy elements in the soil in line with (Ogunwale et al., 2021), heavy element mobility decreases with increasing soil pH owing to the evolution of hydroxides, carbonates, or the formation of insoluble organic molecules. In this analysis, it was revealed that the heavy element contents were rise-considerably with a decrement in the pH.

The soil EC also varied considerably with season. On the contrary, (FAO/WHO, 2011) categorized the EC of the grounds as: nonsaline < 2; moderately salty 2–8; very salty 8–16, and potentially salty > 16. From the results of the analysis, the EC is categorized as moderately salty. The EC of the soil samples indicated that all croplands caused no salinity issue (EC $< 200\,\mu S\ cm^{-1}$). The degree of heavy elements mobilized in the soil ecosystem is influenced by pH, attributes of the elements, redox conditions, soil chemistry, organic matter level, and the like soil qualities (Ogunwale et al., 2021). Heavy elements are naturally more mobile at pH < 7 than at pH > 7. The pH of the soils from the farmland site in both seasons varied from 6.37 to 7.40. As a result, these pH values depict that the ecosystem is slightly acidic to neutral, which is suit able for crop land uses because crops are available to uptake and mildly concentrate heavy elements from polluted soils in their consumable portions (Ogunwale et al., 2021).

The levels of organic carbon and organic matter in the soil sample increased considerably with the season. The OC is also elevated with a rising water table (Ogunwale et al., 2021). This finding may be of great ecological interest because it was demonstrated that elevated levels of rain-supplied soil during the study periods elevated the quantities of the OC, which impacts the dissolution and readily available of heavy elements.

b) *Soils Pollution*

In all respects, the mean contents of heavy elements in farmland soils from farmed areas were higher than those obtained in soils from the unfarmed areas (Table 3).The contents of heavy elements revealed spatiotemporal differences, which may be owing to the variation in the rich element sources and the degree of heavy elements in the soil. There was an overall resemblance in the pattern of predominance element levels in grounds from both seasons diminishing in the following order Mn> Zn> Cu> Pb >As> Cd (Table 3). Data from this analysis indicated that values of all heavy elements were primarily low and within specified guidelines of FAO/WHO (2011) and National Environmental Standards and Regulations Enforcement Agency (NESREA, 2018) values for arable land. The variation of heavy elements content in the research area was also owing to inorganic fertilizer and the like agronomic practices. The low content of the rich components of the cropland may have resulted from their continuous removal by staple food crops grown in the chosen areas.

Among the different elements analyzed in soil, the content of Mn was the highest, and variation in its content was many times exceeding those described by Ogunwale et al. (2020). The most elevated deposition of Mn in cropland soil might be a result of its long-term utilization in the production of agricultural implements, paints, pigments, pesticides, insecticides, and alloying of varied farms of the investigated area that might give rise to pollution of the soil and an effect in tillage. Despite what preceded, it was found from the analysis of the data that regardless of the low element contents, there was significant burdening or bioaccumulation of heavy elements in soils from arable land areas as indicated by the evaluated heavy element pollution load index (HEPLI) in Table 6 below.

On the basis of Ogunwale et al. (2021), HEPLI is the degree of pollution per element in farmland soil relative to a recommended content (world benchmark levels of elements in shale/rock). If it is more than one, then there is significant element enrichment in the soil of interest. The overall mean indices of HEPLI for elements assessed in this analysis for both seasons were 0.54 and 0.88, 0.28 and 0.92, 0.31 and 0.37, 0.52 and 0.55, 0.28 and 0.55 and 0.24 and 0.31 for As, Cd, Cu, Mn, Pb, and Zn, respectively, with the rate of amassment being in this order for the wet season As > Mn > Cu > > Cd, Pb > Zn and for dry season Cd > As > > Mn, Pb >Cu > Zn. Cadmium and As contained the highest overall mean HEPLI (0.92 and 0.88) while Zn contained the least overall mean HEPLI (0.24 and 0.31) in the soil from the cropland site. The moderate HEPLI indices of elements in the grounds in this analysis revealed substantial loading and an indication of heavy elements buildup (pollution) in the grounds within the areas from extensive farming activities, which is in corroboration with the findings of most earlier studied (Ogunwale et al., 2021;Zango et al., 2013; Zhuang et al., 2009). In this way, comprehensive agricultural operations in the research area caused the raising of the contents of heavy elements in the soil.

c) Heavy Element Pollution in Staple Foodstuff Crops

The mean contents (in mg/kg dry matter) of heavy elements (As, Cd, Cu, Mn, Pb, and Zn) in the assigned food crops (sweet cassava, maize, plantain, and white yam) in the assessment area were all below values present in their equivalent soils (both farmed and unfarmed soils) as presented in Table 5, showing evidence of heavy element low bioaccumulation in staple food crops. The moderate element contents in the food crops may have been burdened by the noticed rise in heavy element levels as a result of farming operations, as can be inferred from the study of the HEPLI of soils from farmed areas concerning those assessed of unfarmed regions (control) in Table 6.

The HEPLIs of all the elements were below 1, signifying insignificant bioaccumulation of elements in soils in the arable land areas. Except for As, the mean contents of all the heavy features quantified in sweet cassava, maize, plantain, and white yam (Table 4) grown in the farmland areas in both seasons below the prescribed values of FAO/WHO (2011). Investigations revealed that food crops tilled on soils present in arable land sites could be polluted with a heavy element like As and so could introduce consumers of that food to severe health hazards (Ogunwale et al., 2021;Zango et al., 2013; Zhuang et al., 2009).

The findings found from this research in wet and dry seasons indicated that As in cassava, maize, plantain, and yam were above the standard tolerable limit by the Joint FAO/WHO Expert Committee on Food Additives and Food and Nutrition Board (2011) by 25.00 and 16.23%, respectively. Thereby As signify the primary causes of heavy element pollution in the selected foodstuff crops in the communities in the assessment district with Cd, Cu, Mn, Pb, and Zn and demonstrating insignificant pollutants, and this relates to the findings of Zango et al. (2013) and Zhou et al. (2016).

d) Heavy Element Transfer (AF) from Soils to Food Crops

In the general case, by sources of agrichemicals, chemicals leaking the water ecosystem, subsequently, enter into the soil. The soil absorbs the portion of the substances which, suitably, turn into part of the photosynthetic processes. It was thus estimated that the contents of elements in the sweet cassava, maize, plantain, and white yam would exhibit the contents in the soil samples. As expressed by Ogunwale et al. (2021), there is a statistical relationship between element contents in rhizosphere soils and grown crops. Nonetheless, the results of this analysis revealed inconsistency. The association between element contents assessed in soils regarding grown food crops was somewhat varied and insignificant. The contents of elements in soils for both seasons was something like Mn> Zn > Cu > Pb > As > Cd while the sequence in BF in both seasons were As > Cd > Zn > Mn > Pb > Cu and As >Zn> Cd > Mn >Cu> Cd> Pb, respectively. Nonetheless, the analysis of the HEPLI on soils in this assay indicated a statistical difference in the sequence of the HEPLI and total element contents in food crops.

The arrangement of elements for HEPLI in the wet season was As > Mn > Cu > > Cd, Pb > Zn and for dry season Cd > As > > Mn, Pb >Cu > Zn while the sequence of elements bio accumulation factor in wet and dry seasons were As > Cd > Zn > Mn > Pb > Cu and As >Zn> Cd > Mn >Cu> Cd> Pb, respectively. This is corroborated by the findings of Ogunwale et al. (2021) that contents totals of Cd, Pb, Zn, and As in soils varied substantively with the contents present in vegetables grown on the grounds in poultry farm areas. Arsenic and Cd were found to be the most bio accumulated among the foodstuff, with Cu being the minimum. This reveals that the local populations were at high risk of being vulnerable to As and Cd-related health disorders. It was told that Cd which was the second most accumulated heavy element in the food crops, was the minimum taken up in the soils. At the same time, Zn, which was the second most bio accumulated in the ground, was the third most taken up element by the four food crops. Lead (Pb) which was the moderately bioaccumulated element in the grounds, was also least taken up by the four food crops (Tables 3 and 5).

The bioaccumulation factor (BF) for As, Cd, Cu, Mn, Pb, and Zn was below 1 in all of the monitored food crops indicating insignificant bioaccumulation. Those elements that contain a slight transfer factor migrate to the edible part of the plant easier than those with a low transfer factor (Ogunwale et al., 2021), this is the reason that these elements demonstrate their mild bioaccumulation values in sundry food crops to such a minor ratio. The BF values varied for heavy parts in sundry food crops and in farmland plots (Ogunwale et al., 2021). Nominal BF values were present in all of the assayed features with foodstuff crops and could be one of the probable causes for health hazards in humans via their intake. Low BF values for heavy elements were shown in the soil. This result indicated that the absorption of heavy ingredients by means of food crops did not rise directly with rising element contents in the ground. Our research isrelative to the previous conclusions of (Balkhair and Ashraf, 2016; Ogunwale et al., 2021). This occurrence is significant concerning long-lasting utilization of agrichemical; hence so the same degrees would not be part of the feeding level.

e) Daily Allowance of Elements and Human Health Risk Analysis

The human risk analysis determination from the route of the trophic level is of crucial significance in countries like Nigeria, where the agrichemical application continues uncontrolled. There are manifold exposure routes mainly depend on polluted sources of air, water, soil, food, and the consuming community (Ogunwale et al., 2021), but the pathway of contact via the trophic level is one of the primary means of heavy element contact with humans (Ogunwale et al., 2021; Zhou et al., 2016). The Nigerian people are chiefly vegan and count on cereal, fruits, and tuber crops such as (*Manihot esculenta L.*, *Zea mays L.*, *Musa paradisiaca L.,* and *Dioscoreaspp. L.*) as some staple foods. The food crops produced in the current analysis are consumed linearly through the localpopulation or are sold to the marketplace for isolated population intake.

To determine the health risk of occupants of these foodstuff crops in the area under study, the daily allowance rates of element (DAE), the human health risk index (HHRI), target hazard quotient (THQ),total diet target hazard quotient (TDTHQ),and TTHQ were estimated. It was revealed in this analysis (Table 7) that the daily allowance rates of all the heavy elements (As, Cd, Cu, Mn, Pb, and Zn) in the food crops (sweet cassava, maize, plantain, and white yam) are at values which were lower than prescribed by FAO/WHO (2011). Hence, the dwellers in the study region were not likely to be vulnerable to ill health from excess intake of As, Cd, Cu, Mn, Pb, and Zn in sweet cassava, maize, plantain, and white yam at present. The HHRI has been known as a very estimable indicator to assess the human health risk connected with the allowance of heavy element contaminated food crops (USEPA, 2002; Zango et al., 2013; Balkhair and Ashraf, 2016; Ogunwale et al., 2021). If the content of a particular staple food crop is below 1, it is considered to be safe for human health to eat that foodstuff. But if the concentration is above 1, it is considered to be unsafe for human health (USEPA-IRIS, 2002; Ogunwale et al., 2021).

The mean calculated HHRI in this study for sweet cassava, maize, plantain, and white yam was close to 1 in both seasons. Their values ranged from 0.0017-0.839, 0.00397-1.18, 0.00737-1.48, and 0.00227-1.15, respectively. Plant a in being a rhizome food crop, contained higher contents relative to sweet cassava, white yam, and maize, which are stem and root tubers and cereal food crops. Arsenic had the highest HHRI content, with an overall mean of 0.756 and 1.162 in staple food crops, and after that, Mn with an overall mean of 0.0564 and 0.0625 in all the foodstuffs, respectively. The sequence of the dominance of mean HHRI indicator for the element in both seasons are As > Mn > Cd > Zn > Pb > Cu and As > Mn > Cd > Pb > Zn > Cu, respectively. This obviously indicates that the local populations, are most likely to be affected by potential health hazards from the nutritional As.

The oral recommended allowance (ORA) is the daily contact of persons with toxins or pollutants that can make no considerable risk over their lifespan. The ORA values for the toxic elements As, Cd, Cu, Mn, Pb, and Zn are 3E-03, 1.0E-03, 4.0E-02, 3E-01, 3.50E-03, and 3E -01 mg kg^{-1} d^{-1}, respectively (USEPA-IRIS, 2002; Ogunwale et al., 2021). In this work, the heavy elements, apart from As, contained HHRI >1, indicating a possible future human health risk via the intake of food crops. Nevertheless, As was regarded to be non-essential element susceptible to health hazards, even at very low concentrations. Zhuang et al.(2009), Zhou et al.(2016), Ogunwale et al.(2021), and Ogunwale et al. (2022)have also signified anHHRI content for As that above the prescribed values in cereals, tuber, rhizome, and vegetables crops.

Chronic low-level intake of toxic elements harms human health, and the deleterious impact begins to be evident after manifold years of contact with them (USEPA-1RIS, 2002; Ogunwale et al., 2021). The THQ technique was applied to quantify the potential health risks of heavy element bioaccumulation by means of staple foodstuff crop intake in this work. A staple foodstuff intake value for adults in Nigeria is 800.0 g/person/day, respectively (Zango et al., 2013). In the allowance lifestyles of indigenous inhabitants, the plantain intake in both seasons made up 26.80 and 32.20% of the total intake of staple food. After that maize, white yam, and sweet cassava foodstuffs, each of them made up 25.03 and 24.77%, 25.99 and 24.22% and 22.17 and 18.73%, respectively. The mean THQ values of As, Cd, Cu, Mn, Pb, and Zn resulting from staple food allowance for dwellers (adults) of the study area were recorded in Table 10. The mean THQ values of As via intake of sweet cassava, maize, plantain, and white yam for inhabitants were more than for the other five elements types in this study, signifying that the potential health hazards exposure for As were greater for residents. For staple foods, the As mean THQ values of adults ranged from 7.799-9.205 and 9.461-16.664, respectively, and mean Cd THQ values varied from 0.256-6.390 and 0.384-0.767 for adults in both seasons, while mean THQ values for Cu and Zn were below 1, and Mn above 1.0 utilizing the intake of the plantain types only. These findings implied that the potential health risks of heavy elements through intake of staple foods were the highest for all foodstuff types. Furthermore, the total diet THQ of each element (TDTHQ) values of heavy elements in both seasons decreased following the order As >Mn > Cd > Zn > Cu > Pb (Table 10). This signified that for toxic heavy elements, the potential health risks of As and Mn through staple food allowance were more than for Pb.

It has been observed that contact with two or more pollutants may bring about additive and/or cause negative impacts (Zhou et al., 2016; Ogunwale et al., 2021). Thereby, it is difficult to evaluate the potential health hazards of multiple elements by means of each individual THQ value for the heavy stuff. Moreover, the total THQ (TTHQ) of heavy elements is the sum of the unique rich element (As, Cd, Cu, Mn, Pb, and Zn).Target hazard quotient (THQ) values for the four staple foodstuff types, and the values are also presented in Table 10. The TTHQ values for adults via staple food intake in both seasons were 9.986 and 14.937, respectively. This result signified that the inhabitants of the Odu'a farm establishment area might be susceptible to health risks, and the potential health risks for dry season were higher than for the wet season. The relative contributions of As, Cd, Cu, Mn, Pb, and Zn to the TTHQ in damp and dry seasons were 85.36 and 87.74%, 4.48 and 3.85%, 0.43 and 0.52%, 6.36 and 5.08%, 0.24 and 0.36% and 3.13 and 2.45%, respectively; therefore, As was the central element contributing to the potential health risks of staple foodstuff intake for occupants in the study ecozone.

V. Conclusions

The assigned food crop (sweet cassava, maize, plantain, and white yam) are the staple food for the occupants of the research suburb (Odu'a Aawe environs) and the greater part of especially southwestern parts of Nigeria. It is in thisregion that both major and minor agricultural operations are carried out in Nigeria. Albeit, the content of heavy elements in soils from the large-scale farming area where the study was conducted was relatively low and within prescribed values set by FAO/WHO and NESREA standards. The activities of large-scale farmers had led to heavy element burdening or pollution as present from the calculated HEPLIs.

Assessment of element transfers (bioaccumulation factors) revealed that there had been a moderate buildup of heavy elements in the designated food crops, with the contents of As above the maximum limit given by FAO/WHO. Variation in the heavy element contents, in the four food crops is a mark of the differences between the absorption potentials and their translocation to the consumable parts of the plants. The assessments of HHRI and DAE have indicated that plantain is more polluted with heavy elements than white yam, maize, and sweet cassava. The research further reveals that the dwellers were unsafe and at risk of being vulnerable to long-lasting health effects from nutritional As and this is of public health issue. Furthermore, HHRI values >1 were also observed for As intake in food crops. It signified that people who are residing in this settlement and the like areas of equivalent agricultural operations in southwestern Nigeria be enlightening not to consume large quantities of these food crops, in an attempt to reduce or prevent extreme buildup of heavy elements in their bodies. The TTHQ values for wet and dry seasons by foodstuff allowance were 9.986 and 14.628, respectively, signifying that the residents of the Odu'a area may be facing health risks owing to foodstuff intake, and that consumers were subject to the harmful effects of ingestion of heavy elements. Heavy element bioaccumulation by nutritional information of food usually occurs slowly and over a long period (years) and could harm human health. Arsenic was the main contributor to potential health hazards of foods tuff in take for inhabitants in the area under study. It is therefore also recommended that a critical research is necessary to plan and execute proper ways of checking heavy element contents in food crops grown in cropland settlements to avoid their undue accumulation in the feeding level. The potential health hazards of heavy elements utilizing other exposure pathways need to be in the interest of future research. The work has provided information on the extent of heavy element pollution in the cropland establishment as a way of assessing the environmental health of the area under study as a result of heavy element pollution. The work also added to the baseline data on risk of potentially toxic elements studies in our environment.

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Statement of Competing Interests

The authors declare that they have no competing interests.

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Table 1: Geographical Positions of the Sampling Locations

Sampling Point	Latitude(N)	Longitude(E)
Yam	07°49.519'	003° 27.520'
Cassava	07°49.486'	003° 27.459
Maize	07°49.629'	003° 27.578
Plantain	07°49.475'	003° 27.409
Control	07°49.856'	003° 27.722

Source: Field Survey, (2018)

Table 2: Mean Physico-chemical Variables of Soils Sample for Wet and Dry Seasons

Sampling Point	pH	EC (µS/cm)	%TOC	%TOM
		Wet Season		
Cassava	6.57±0.06	44.23±3.76	0.86±0.02	1.48±0.05
Maize	6.70±0.07	39.73±3.72	0.95±0.04	1.63±0.07
Plantain	6.50±0.05	51.56±3.95	0.98±0.05	1.69±0.09
Yam	6.97±0.08	75.19±4.08	0.83±0.02	1.43±0.06
Control	6.68±0.07	44.91±3.82	1.02±0.06	1.75±0.11
Min.	6.50	39.73	0.83	1.43
Max.	6.97	75.19	1.02	1.75
Overall mean	6.68	51.12	0.93	1.60
SD	0.08	3.80	0.05	0.08
CV	1.20	7.43	5.38	5.00
		Dry Season		
Cassava	6.93±0.12	81.53±5.06	0.63±0.06	1.08±0.08
Maize	6.77±0.08	87.28±6.30	0.70±0.08	1.20±0.09
Plantain	6.57±0.05	86.96±5.20	0.65±0.06	1.12±0.05

Yam	7.40±0.18	159.94±10.40	0.72±0.05	1.24±0.06
Control	6.70±0.08	92.45±7.50	0.80±0.08	1.38±0.09
Min.	6.57	81.53	0.63	1.08
Max.	7.40	159.94	0.80	1.38
Overall mean	6.87	101.63	0.70	1.20
SD	0.10	9.36	0.03	0.09
CV	1.46	9.21	4.29	7.50

Source: Field Data, (2018)

Table 3: Mean Total Elements Content of Soils Sample for Wet and Dry Seasons (mg/kg)

Sampling Point	As	Cd	Cu	Mn	Pb	Zn	Total metal load
Wet Season							
Cassava	3.27±0.28	0.09±0.02	10.14±2.08	236.10±20.26	3.85±0.71	16.66±3.42	270.11
Maize	3.76±0.30	0.06±0.01	16.01±3.06	302.64±23.08	6.03±0.83	18.81±3.50	347.31
Plantain	3.96±0.29	0.07±0.01	20.26±3.24	743.44±40.16	8.06±0.92	25.64±3.70	801.43
Yam	3.93±0.25	0.12±0.03	9.08±1.02	468.91±31.20	4.26±0.74	30.01±4.08	516.31
Control	0.04	ND	0.06±0.01	5.12±0.90	0.03±0.00	1.64±0.96	6.89
Min.	0.04	ND	0.06	5.12	0.03	1.64	6.89
Max.	3.27	0.12	20.26	743.44	8.06	30.01	801.43
Overall mean	2.99	0.09	11.11	351.24	4.45	18.55	388.43
SD	0.25	0.01	1.85	24.62	0.75	3.70	
CV	8.36	11.11	16.65	7.01	16.85	19.95	
Dry Season							
Cassava	4.91±0.80	0.25±0.02	13.30±2.26	251.10±45.26	8.89±0.99	21.39±3.48	299.84
Maize	6.77±0.88	0.16±0.01	17.26±2.60	313.89±50.20	11.63±1.02	25.86±3.70	375.57
Plantain	7.38±0.93	0.23±0.02	23.27±3.55	806.73±80.60	13.16±1.23	34.15±3.91	884.92
Yam	5.46±0.85	0.46±0.03	11.50±2.20	498.75±58.25	10.67±1.20	36.12±3.90	562.96
Control	0.07±0.01	ND	0.18±0.03	8.95±2.19	0.07±0.02	1.96±0.63	11.23
Min.	0.07	ND	0.18	8.95	0.07	1.96	11.23
Max.	7.38	0.46	23.27	806.73	13.16	36.12	884.92
Overall mean	4.92	0.28	13.10	375.88	8.88	23.9	426.96
SD	0.58	0.03	2.58	60.63	0.97	3.76	
CV	11.79	10.71	19.69	16.13	10.92	15.73	
FAO/WHO Guideline (2011)	30	3	140	2000	300	300	

Source: Field Survey, (2018)

Table 4: Mean Heavy Elements Staple Crops Sample of Odu'a Farm Establishment for Wet and Dry Seasons (mg/kg)

Foodstuff	As	Cd	Cu	Mn	Pb	Zn	Total metal load
Wet Season							
Cassava	1.83±0.06	0.03±0.00	0.06±0.01	10.30±2.21	0.08±0.01	2.73±0.10	15.03
Maize	1.98±0.07	0.04±0.01	0.14±0.01	15.26±2.36	0.05±0.00	8.95±1.08	26.42
Plantain	2.03±0.09	0.05±0.01	0.26±0.02	21.70±2.50	0.09±0.01	7.17±1.03	31.30
Yam	2.16±0.10	0.02±0.00	0.08±0.01	12.32±2.28	0.04±0.00	10.54±1.23	25.16

Min.	1.83	0.02	0.06	10.30	0.04	2.73	15.03
Max.	2.16	0.05	0.26	21.70	0.09	10.54	31.30
Overall mean	2.00	0.04	0.14	14.89	0.07	7.35	24.49
SD	0.09	0.01	0.01	1.26	0.01	0.61	
CV	4.50	2.50	7.14	8.46	14.29	8.30	
				Dry Season			
Cassava	2.22±0.12	0.06±0.01	0.18±0.03	12.24±2.06	0.16±0.02	3.34±0.18	18.20
Maize	3.12±0.18	0.04±0.00	0.23±0.06	17.38±2.68	0.11±0.01	10.24±1.20	31.12
Plantain	3.91±0.20	0.05±0.01	0.43±0.08	26.14±2.80	0.23±0.03	8.79±1.08	39.55
Yam	3.05±0.14	0.03±0.00	0.13±0.02	15.43±2.17	0.09±0.01	12.04±1.40	30.77
Min.	2.22	0.03	0.13	12.24	0.09	3.34	18.20
Max.	3.91	0.06	0.43	26.14	0.23	12.04	39.55
Overall mean	3.08	0.05	0.24	17.80	0.15	8.60	29.92
SD	0.17	0.01	0.02	1.60	0.01	0.80	
CV	5.52	20	8.33	8.99	6.67	9.30	
FAO/WHO Guideline (2011)	0.50	0.20	40	45	0.30	60	

Source: Field Data, (2018)

Table 5: Mean Bioaccumulation Factor (BF) of Heavy Elements Staple Crops of Odu'a Farm Establishment for Wet and Dry Seasons (mg/kg)

Common Name	Scientific Name	As	Cd	Cu	Mn	Pb	Zn
				Wet Season			
Sweet Cassava	*Manihot esculenta*	0.56±0.02	0.33±0.01	0.006±0.001	0.044±0.002	0.021±0.001	0.164±0.002
Maize	*Zea mays L.*	0.53±0.01	0.67±0.03	0.009±0.002	0.050±0.001	0.008±0.001	0.476±0.005
Plantain	*Musa paradisiaca*	0.51±0.01	0.71±0.05	0.013±0.003	0.029±0.001	0.011±0.002	0.280±0.003
White Yam	*Dioscorea rotundataL.*	0.55±0.02	0.17±0.01	0.010±0.002	0.026±0.001	0.009±0.001	0.350±0.004
Min.		0.51	0.17	0.006	0.026	0.008	0.476
Max.		0.56	0.71	0.013	0.05	0.021	0.164
	Overall mean	0.54	0.47	0.009	0.037	0.012	0.318
SD		0.01	0.01	0.001	0.001	0.002	0.005
CV		3.56	2.13	11.11	2.70	16.67	1.570
				Dry Season			
Sweet Cassava	*Manihot esculenta*	0.452±0.02	0.240±0.01	0.014±0.001	0.049±0.003	0.018±0.003	0.156±0.002
Maize	*Zea mays*	0.461±0.03	0.250±0.02	0.013±0.001	0.055±0.005	0.009±0.002	0.396±0.004
Plantain	*Musa paradisiaca*	0.530±0.02	0.217±0.01	0.018±0.002	0.032±0.002	0.017±0.003	0.257±0.003
White Yam	*Dioscorea rotundata L.*	0.559±0.03	0.065±0.02	0.011±0.001	0.031±0.001	0.008±0.001	0.333±0.002
Min.		0.452	0.065	0.011	0.031	0.008	0.156
Max.		0.559	0.250	0.018	0.055	0.018	0.396
	Overall mean	0.500	0.193	0.014	0.042	0.013	0.286
SD		0.010	0.020	0.001	0.002	0.003	0.007
CV		2.00	10.36	7.14	4.76	23.08	2.45

Source: Field Data, (2018)

Table 6: Mean Heavy Element Pollution Load Index across the Sampling Points

Site	As	Cd	Cu	Mn	Pb	Zn
			Wet Season			
Cassava	0.47	0.30	0.23	0.28	0.19	0.18
Maize	0.54	0.20	0.36	0.36	0.30	0.20
Plantain	0.57	0.23	0.45	0.87	0.40	0.27
Yam	0.56	0.40	0.20	0.55	0.21	0.32
Min.	0.47	0.20	0.20	0.28	0.19	0.18
Max.	0.57	0.40	0.43	0.87	0.40	0.32
Overall mean	0.54	0.28	0.31	0.52	0.28	0.24
			Dry Season			
Cassava	0.70	0.83	0.30	0.30	0.44	0.23
Maize	0.97	0.53	0.38	0.37	0.58	0.27
Plantain	1.05	0.77	0.52	0.95	0.66	0.36
Yam	0.78	1.53	0.26	0.59	0.53	0.38
Min.	0.70	0.53	0.26	0.30	0.44	0.23
Max.	1.05	1.53	0.52	0.95	0.66	0.38
Overall mean	0.88	0.92	0.37	0.55	0.55	0.31

Source: Field Data, (2018)

Table 7: Mean Daily Element Allowances Estimate (DEA) for Wet and Dry Seasons

Foodstuff	As	Cd	Cu	Mn	Pb	Zn
			Wet Season			
Cassava	2.07E-03	3.40E-05	6.80E-05	1.17E-02	9.07E-05	3.09E-03
Maize	2.24E-03	4.53E-05	1.59E-04	1.74E-02	5.67E-05	1.01E-02
Plantain	2.30E-03	5.67E-05	2.95E-04	2.46E-02	1.02E-04	8.13E-03
Yam	2.45E-03	2.27E-05	9.07E-05	1.40E-02	4.53E-05	1.20E-02
Min.	2.07E-03	2.27E-05	6.80E-05	1.17E-02	4.53E-05	3.09E-03
Max.	2.45E-03	5.67E-05	2.95E-04	2.46E-02	1.02E-04	1.20E-02
Overall mean	2.27E-03	3.97E-05	1.53E-04	1.69E-02	7.37E-05	8.33E-03
			Dry Season			
Cassava	2.52E-03	6.80E-05	2.04E-04	1.39E-02	1.81E-04	3.79E-03
Maize	3.54E-03	4.53E-05	2.61E-04	1.40E-02	1.25E-04	1.16E-02
Plantain	4.43E-03	5.67E-05	4.87E-04	2.96E-02	2.61E-04	9.96E-03
Yam	3.46E-03	3.40E-05	1.47E-04	1.75E-02	1.02E-04	1.37E-02
Min.	2.52E-03	3.40E-05	1.47E-04	1.39E-02	1.02E-04	3.79E-03
Max.	4.43E-03	6.80E-05	4.87E-04	2.96E-02	2.61E-04	1.37E-02
Overall mean	3.49E-03	5.10E-05	2.75E-04	1.88E-02	1.67E-04	9.76E-03

Source: Field Data, (2018)

Table 8: Mean Human Health Risk Index for Specific Heavy Elements Owing to the Intake of varied Staple Crops Raised in the Vicinity of Odu'a Farm Establishment for Wet and Dry Seasons

Foodstuff	As	Cd	Cu	Mn	Pb	Zn
Wet Season						
Cassava	6.91E-01	3.40E-02	1.70E-03	3.89E-02	2.59E-02	1.03E-02
Maize	7.48E-01	4.53E-02	3.97E-03	5.80E-02	1.62E-02	3.38E-02
Plantain	7.67E-01	5.67E-02	7.37E-03	8.20E-02	2.91E-02	2.71E-02
Yam	8.16E-01	2.27E-02	2.27E-03	4.65E-02	1.30E-02	3.98E-02
Min.	6.91E-01	2.27E-02	1.70E-03	3.89E-02	1.30E-02	1.03E-02
Max.	8.16E-01	5.67E-02	7.37E-03	8.20E-02	2.91E-02	3.98E-02
Overall mean	7.56E-01	3.97E-02	3.83E-03	5.60E-02	2.11E-02	2.78E-02
Dry Season						
Cassava	8.39E-01	6.80E-02	5.10E-03	4.62E-02	5.18E-02	1.26E-02
Maize	1.18E+00	4.53E-02	6.52E-03	4.62E-02	3.56E-02	3.87E-02
Plantain	1.48E+00	5.67E-02	1.22E-02	9.88E-02	7.45E-02	3.32E-02
Yam	1.15E+00	3.40E-02	3.68E-03	5.83E-02	2.91E-02	4.55E-02
Min.	8.39E-01	3.40E-02	3.68E-03	4.62E-02	2.91E-02	1.26E-02
Max.	1.48E+00	6.80E-02	1.22E-02	9.88E-02	7.45E-02	4.55E-02
Overall mean	1.16E+00	5.10E-02	6.88E-03	6.25E-02	4.73E-02	3.25E-02

Source: Field Data, (2018)

Table 9: Mean Maximum Limit for the Amount of Food Crop that can in Safety be consumed on an Everyday Basis in Area under Study (Wet and Dry Seasons)

Foodstuff	As	Cd	Cu	Mn	Pb	Zn
Wet Season						
Cassava	1.16E+00	2.35E+01	4.71E+02	2.06E+01	3.09E+01	7.76E+01
Maize	1.07E+00	1.77E+01	2.02E+02	1.39E+01	4.94E+01	2.37E+01
Plantain	1.04E+00	1.41E+01	1.09E+02	9.76E+00	2.75E+01	2.95E+01
Yam	9.80E-01	3.53E+01	3.53E+02	1.72E+01	6.18E+01	2.01E+01
Min.	9.80E-01	1.41E+01	1.09E+02	9.76E+00	2.75E+01	2.01E+01
Max.	1.16E+00	3.53E+01	4.71E+02	2.06E+01	6.18E+01	7.76E+01
Overall mean	1.06E+00	2.27E+01	2.84E+02	1.54E+01	4.24E+01	3.77E+01
Dry Season						
Cassava	9.54E-01	1.18E+01	1.57E+02	1.73E+01	1.54E+01	6.34E+01
Maize	6.79E-01	1.76E+01	1.23E+02	1.28E+01	2.25E+01	2.07E+01
Plantain	5.42E-01	1.41E+01	6.57E+01	8.10E+00	1.07E+01	2.41E+01
Yam	6.94E-01	2.35E+01	2.17E+02	1.37E+01	2.75E+01	1.76E+01
Min.	5.42E-01	1.18E+01	1.23E+02	8.10E+00	1.07E+01	1.76E+01
Max.	9.54E-01	2.35E+01	6.57E+01	1.73E+01	2.75E+01	6.34E+01
Overall mean	7.17E-01	1.68E+01	1.41E+02	1.30E+01	1.90E+01	3.15E+01

Source: Field Data, (2018)

Table 10: Mean Element Target Hazard Quotient (THQ) Values Springing up from Intake of Four Staple Food Types (Adults) for Wet and Dry Seasons

Foodstuff	As	Cd	Cu	Mn	Pb	Zn	TTHQ
Wet Season							
Cassava	7.80E+00	3.84E-01	1.90E-02	4.39E-01	2.90E-02	1.16E-01	8.79E+00
Maize	8.44E+00	5.11E-01	4.50E-02	6.50E-01	1.80E-02	3.81E-01	1.00E+01
Plantain	8.65E+00	6.39E-01	8.30E-02	9.25E-01	3.30E-02	3.06E-01	1.06E+01
Yam	9.21E+00	2.56E-01	2.60E-02	5.25E-01	1.50E-02	4.49E-01	1.05E+01
TDHQ	3.41E+01	1.79E+00	1.73E-01	2.54E+00	9.50E-02	1.25E+00	9.99E+00
Dry Season							
Cassava	9.46E+00	7.67E-01	5.80E-02	5.22E-01	5.80E-02	1.42E-01	1.10E+01
Maize	1.33E+01	5.11E-01	7.40E-02	7.41E-01	4.00E-02	4.36E-01	1.51E+01
Plantain	1.67E+01	6.39E-01	1.37E-01	1.11E+00	8.40E-02	3.75E-01	1.90E+01
Yam	1.30E+01	3.84E-01	4.20E-02	6.58E-01	3.30E-02	5.13E-01	1.46E+01
TDTHQ	5.24E+01	2.30E+00	3.11E-01	3.04E+00	2.15E-01	1.47E+00	1.49E+01

Source: Field Data, (2018)

The total diet THQ of each element (total diet i.e., the sum of sweet cassava, maize, plantain, and white yam)

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Multi-Criteria Selection and Screening for Karnal Bunt Resistance of Wheat (*Triticumaestivum* L. Em. Thell.) in Eastern Uttar Pradesh

By Sanoj Kumar, Shri Niwas Singh, Rajesh Kumar, Baij Nath Singh, Ram Lala Patel & Shashi Kant

Abstract- Twenty wheat germplasm were evaluated on 14 parameters in an experiment at Center for Research and Development (CRD), Gaunar, Usaraha, Gorakhpur, U. P. in a randomized block design with three replications. The objective of the experiment was to select top five good performing genotypes on the basis of all the parameters and extent of Karnal bunt (KB) infestation. Normalized cumulative ranks were used to assess the relative performance of twenty genotypes. KOH seed soaking technique was used to assess the extent of Karnal bunt infestation. Based on normalized accumulating ranks the performance order of twenty wheat genotypes isHD3117, HPYT480, HPAW152, HD3271, HPAN196, HPYT443, HPAN165, HD3226, HPYT409, HPAN153, HPYT474, CSW18, HPYT424, HPYT489, HPYT441, HPYT490, HPYT426, HPYT418, HPAN163 and HPYT446. Four genotypes were completely resistant. Sixteen genotypes were susceptible to Karnal bunt and infestation ranged from 1.33% (HPYT-418) to 30% (HPYT-446). High performer genotypes like HD3117, HPYT480, HPAW152, HD3271, HPAN196 and Karnal bunt resistant genotypes like HPYT409, HPAN153, HPYT489 and HPYT 490 should be recommended for cultivation in this area.

Keywords: *ideotype, karnal bunt, normalized cumulative ranks, selection.*

GJSFR-D Classification: *DDC Code: 813.4 LCC Code: PS2472*

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Strictly as per the compliance and regulations of:

Multi-Criteria Selection and Screening for Karnal Bunt Resistance of Wheat (*Triticumaestivum* L. Em. Thell.) in Eastern Uttar Pradesh

Sanoj Kumar [α], Shri Niwas Singh [σ], Rajesh Kumar [ρ], Baij Nath Singh [ω], Ram Lala Patel [¥] & Shashi Kant [§]

Abstract- Twenty wheat germplasm were evaluated on 14 parameters in an experiment at Center for Research and Development (CRD), Gaunar, Usaraha, Gorakhpur, U. P. in a randomized block design with three replications. The objective of the experiment was to select top five good performing genotypes on the basis of all the parameters and extent of Karnal bunt (KB) infestation. Normalized cumulative ranks were used to assess the relative performance of twenty genotypes. KOH seed soaking technique was used to assess the extent of Karnal bunt infestation. Based on normalized accumulating ranks the performance order of twenty wheat genotypes isHD3117, HPYT480, HPAW152, HD3271, HPAN196, HPYT443, HPAN165, HD3226, HPYT409, HPAN153, HPYT474, CSW18, HPYT424, HPYT489, HPYT441, HPYT490, HPYT426, HPYT418, HPAN163 and HPYT446. Four genotypes were completely resistant. Sixteen genotypes were susceptible to Karnal bunt and infestation ranged from 1.33% (HPYT-418) to 30% (HPYT-446). High performer genotypes like HD3117, HPYT480, HPAW152, HD3271, HPAN196 and Karnal bunt resistant genotypes like HPYT409, HPAN153, HPYT489 and HPYT 490 should be recommended for cultivation in this area.

Keywords: ideotype, karnal bunt, normalized cumulative ranks, selection.

I. Introduction

Wheat is a staple food crop of majority of the people in the world. However, its production depends on availability of suitable varieties and control of diseases and pests. Plant breeders provide suitable varieties to farmers to boost food production and minimize loss incurred by pests and diseases. With the objective of providing suitable varieties to farmers we evaluated 20-wheat genotypes on 14 parameters including a test for Karnal bunt infestation. This paper presents the findings of this experiment.

II. Materials and Methods

Afield experiment was conducted in Rabi season 2019-20 at Center for Research and Development (CRD) located at Gaunar-Usaraha, Gorakhpur, Uttar Pradesh. The experimental site is located at 26°42' 45.5" N latitude, 83°36'36.6" E longitude and 86 m above mean sea level. The climate is semi-arid with hot summer and cold winter. Nearly 80% of the rainfall is received during monsoon along with a few winter showers. Twenty wheat germplasm, included in this experiment, were taken from the germplasm stock available at CRD and BRD PG College, Deoria. These genotypes were raised in a randomized block design in a timely sown condition with standard package of practices for wheat cultivation. Thus, 20 genotypes were evaluated on 14 parameters in three replications. The parameters evaluated are 1. Biological yield (abbreviated as Bio Yield), 2. 1000 seed weight, 3. Yield per hectare, 4. Days to 50% flowering, 5. Flag leaf area, 6. Karnal bunt infestation, 7. Effective tillers, 8.Spikes/m^2, 9.Spikelets/ear, 10.Ear length, 11. Peduncle length, 12.Plant height, 13.10 Ear weight and 14.Yield/Plot.

Data were collected on five randomly selected plants of all 20 genotypes and were compiled to calculate average of three replications. These were further used to calculate replication mean. These values were subjected to normalized cumulative rank (NCR) analysis as discussed by Singh and co-workers (Sanoj Kumar 2021; Singh 2017; Singh et al. 2018; Yadav et al. 2020). The idea of this analysis is based on the concept of crop ideotype as given by Donald 1968. That is why, in this analysis, we are looking for ideal plant types (=crop ideotypes) that would rank relatively high in majority of the parameters and would come first in cumulative rank or normalized cumulative rank.

III. Results and Discussion

Table 1 shows the average values of the three replications.

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Table 1: Average values of three replications

S.N.	Variety↓ Sort order→	Bio Yield	1000 seed wt	Yield/ha	Days-to-50%F	Flag Leaf Area	Karnal Bunt	Effective Tillers	Spikes/m2	Spikelets/Ear	Ear Length	Peduncle Length	Plant Ht	10 Ear Wt	Yield/Plot
		0	0	0	1	1	1	0	0	0	0	0	0	0	0
1	HD3271	28.13	40.67	26.63	84.67	49.87	3.33	5.87	570.33	20.07	9.83	47	97.97	30.67	2.13
2	HPAN153	28.93	41.67	21.04	84.67	51.93	0	6.47	420.33	18.53	9.7	50.03	99.93	26	1.68
3	HPAN163	17.47	38.67	29.83	88.67	39.37	6.33	6.07	531	17.07	9.53	45.63	99.34	23.33	2.39
4	HPAN165	23.07	45.33	25.17	86	51.26	9.67	5.73	385	19.13	10.63	53.67	111.23	28.67	2.01
5	HPAN196	19.87	43.67	26.46	86	46.7	5	5.33	517.67	20.27	10.03	47	107.83	28.67	2.12
6	HPYT409	15.87	40	27.63	84.67	48.57	0	4.2	518.33	19.87	10.01	50.3	100	28	2.21
7	HPYT418	16.8	41.67	25.46	82	52.05	1.33	4.73	402.67	18.47	10.87	51.3	98.67	24.67	2.04
8	HPYT424	23.73	41.33	30.75	87.33	49.05	11.33	5.93	497.33	18.33	9.47	50.17	99.9	25.33	2.46
9	HPYT426	23.6	44.67	27.33	87.33	57.5	11.33	6	422	17.53	9.13	45.83	100.37	30.67	2.19
10	HPYT441	18.93	38.67	23.04	86.67	42.9	3.33	5.27	520	17.87	10.17	49.7	102.2	26.67	1.84
11	HPYT443	22.67	45.33	26.75	85.33	46.27	9	6.53	427.33	18.73	10.17	52.7	101.73	22	2.14
12	HPYT446	22.13	46.33	19.33	86	35.95	30	5.6	448.33	20.13	9.48	43.03	101.23	14	1.55
13	HPYT474	19.2	43.67	30.13	86	35.84	3.33	5.2	513.67	18.53	8.67	44.13	101.73	23.33	2.41
14	HPYT480	20.13	41.67	32.08	80	55.26	11	4.33	460.33	20.87	10.87	51.07	106.87	26	2.57
15	HPYT489	18.67	37.67	16	82.67	51.51	0	5.33	507	20.53	9.67	51.73	106.8	22.67	1.28
16	HPYT490	19.73	34.33	25.54	90	50.06	0	4.8	579.67	20.27	10.53	46.6	100.3	24.67	2.04
17	HPAW152	21.33	42	26.83	84.67	50.49	5.67	4.73	552	18	10.43	53.79	108.97	29.33	2.15
18	HD3117	29.47	40.67	30.67	83.33	46.74	3	6.2	525.67	20.53	11.2	51.72	110.7	30	2.45
19	CSW18	24.27	40	17.42	89.33	59.84	3.33	5.2	446.33	22.13	11.8	48.63	112.4	32.67	1.39
20	HD3226	23.73	41.67	20.17	88.67	64.49	3.33	5.2	591.33	20.13	10.99	49.33	105.3	28.67	1.61

Table 2 shows ranks, cumulative ranks (CR) and NCR values of genotypes.

Table 2: Ranks, CR and NCR values of genotypes

S.N.	Variety↓ Sort order→	Bio Yield	1000 seed wt	Yield/ha	Days-to-50%F	Flag Leaf Area	Karnal Bunt	Effective Tillers	Spikes/m2	Spikelets/Ear	Ear Length	Peduncle Length	Plant Ht	10 Ear Wt	Yield/Plot	CR	NCR
		0	0	0	1	1	1	0	0	0	0	0	0	0	0		
1	HD3271	3	13	10	5	10	7	7	3	9	13	14	20	2	10	126	2
2	HPAN153	2	8	16	5	15	1	2	18	13	14	10	16	11	16	147	2.33
3	HPAN163	18	17	5	17	3	14	4	5	20	16	18	18	16	5	176	2.79
4	HPAN165	8	2	14	10	13	16	8	20	11	6	2	2	6	14	132	2.1
5	HPAN196	13	5	11	10	6	12	10	9	5	11	14	5	6	11	128	2.03
6	HPYT409	20	15	6	5	8	1	20	8	10	12	8	15	9	6	143	2.27
7	HPYT418	19	8	13	2	16	5	17	19	15	4	6	19	14	12	169	2.68
8	HPYT424	5	12	2	15	9	18	6	12	16	18	9	17	13	2	154	2.44
9	HPYT426	7	4	7	15	18	18	5	17	19	19	17	13	2	7	168	2.67
10	HPYT441	16	17	15	14	4	7	12	7	18	9	11	9	10	15	164	2.6
11	HPYT443	9	2	9	9	5	15	1	16	12	9	3	10	19	9	128	2.03
12	HPYT446	10	1	18	10	2	20	9	14	7	17	20	12	20	18	178	2.83
13	HPYT474	15	5	4	10	1	7	13	10	13	20	19	10	16	4	147	2.33
14	HPYT480	12	8	1	1	17	17	19	13	2	4	7	6	11	1	119	1.89
15	HPYT489	17	19	20	3	14	1	10	11	3	15	4	7	18	20	162	2.57
16	HPYT490	14	20	12	20	11	1	16	2	5	7	16	14	14	12	164	2.6
17	HPAW152	11	7	8	5	12	13	17	4	17	8	1	4	5	8	120	1.9
18	HD3117	1	13	3	4	7	6	3	6	3	2	5	3	4	3	63	1
19	CSW18	4	15	19	19	19	7	13	15	1	1	13	1	1	19	147	2.33
20	HD3226	5	8	17	17	20	7	13	1	7	3	12	8	6	17	141	2.24

On sorting the table 2, on the basis of CR or NCR in increasing order, we get table 3.

Table 3: Ranks, CR and NCR similar to table 2, but the data are sorted in increasing order based on CR or NCR

S.N.	Variety↓ Sort order→	Bio Yield	1000 seed wt	Yield/ha	Days-to-50%F	Flag Leaf Area	Karnal Bunt	Effective Tillers	Spikes/m2	Spikelets/Ear	Ear Length	Peduncle Length	Plant Ht	10 Ear Wt	Yield/Plot	CR	NCR
		0	0	0	1	1	1	0	0	0	0	0	0	0	0		
18	HD3117	1	13	3	4	7	6	3	6	3	2	5	3	4	3	63	1
14	HPYT480	12	8	1	1	17	17	19	13	2	4	7	6	11	1	119	1.89
17	HPAW152	11	7	8	5	12	13	17	4	17	8	1	4	5	8	120	1.9
1	HD3271	3	13	10	5	10	7	7	3	9	13	14	20	2	10	126	2
5	HPAN196	13	5	11	10	6	12	10	9	5	11	14	5	6	11	128	2.03
11	HPYT443	9	2	9	9	5	15	1	16	12	9	3	10	19	9	128	2.03
4	HPAN165	8	2	14	10	13	16	8	20	11	6	2	2	6	14	132	2.1
20	HD3226	5	8	17	17	20	7	13	1	7	3	12	8	6	17	141	2.24
6	HPYT409	20	15	6	5	8	1	20	8	10	12	8	15	9	6	143	2.27
2	HPAN153	2	8	16	5	15	1	2	18	13	14	10	16	11	16	147	2.33
13	HPYT474	15	5	4	10	1	7	13	10	13	20	19	10	16	4	147	2.33
19	CSW18	4	15	19	19	19	7	13	15	1	1	13	1	1	19	147	2.33
8	HPYT424	5	12	2	15	9	18	6	12	16	18	9	17	13	2	154	2.44
15	HPYT489	17	19	20	3	14	1	10	11	3	15	4	7	18	20	162	2.57
10	HPYT441	16	17	15	14	4	7	12	7	18	9	11	9	10	15	164	2.6
16	HPYT490	14	20	12	20	11	1	16	2	5	7	16	14	14	12	164	2.6
9	HPYT426	7	4	7	15	18	18	5	17	19	19	17	13	2	7	168	2.67
7	HPYT418	19	8	13	2	16	5	17	19	15	4	6	19	14	12	169	2.68
3	HPAN163	18	17	5	17	3	14	4	5	20	16	18	18	16	5	176	2.79
12	HPYT446	10	1	18	10	2	20	9	14	7	17	20	12	20	18	178	2.83

Top few accessions of table 3 could be recommended for cultivation as they might be close to ideal plant type we are looking for. From table 3, it is clear that top five genotypes *viz*., HD3117, HPYT480, HPAW152, HD3271 and HPAN196 could be recommended to farmers for cultivation in this region. Top few varieties are highly likely to replace the current standard check variety gradually. It is also clear from tables 1, 2 and 3 that only four of these varieties are completely resistant to Karnal bunt. Resistant genotypes like HPYT409, HPAN153, HPYT489 and HPYT490should be recommended for cultivation in this area. The extent of Karnal bunt infestation in susceptible varieties is ranging from 1.33% to 30%. In worst case scenario, the less infested varieties with high relative performance could be recommended for cultivation. Karnal bunt has shown its presence in this region and it should be controlled in its initial stages.

This analysis is shown step by step for the comprehension of students, but to be precise, table 1 and table 2 could be merged into a single table and again the data could be sorted in increasing order based on CR or NCR. Thus, the whole paper could be summarized in a single table as given in table 4. This is being named as precise varietal recommender system.

Table 4: Precise varietal recommender system

S.N.	Variety↓ Sort order→	Bio Yield	1000 seed wt	Yield/ha	Days-to-50%F	Flag Leaf Area	Karnal Bunt	Effective Tillers	Spikes/m2	Spikelets /Ear	Ear Length	Peduncle Length	Plant Ht	10 Ear Wt	Yield/Plot	CR	NCR
		0	0	0	1	1	1	0	0	0	0	0	0	0	0		
18	HD3117	29.47 (1)	40.67 (13)	30.67 (3)	83.33 (4)	46.74 (7)	3 (6)	6.2 (3)	525.67 (6)	20.53 (3)	11.2 (2)	51.72 (5)	110.7 (3)	30 (4)	2.45 (3)	63	1
14	HPYT480	20.13 (12)	41.67 (8)	32.08 (1)	80 (1)	55.26 (17)	11 (17)	4.33 (19)	460.33 (13)	20.87 (2)	10.87 (4)	51.07 (7)	106.87 (6)	26 (11)	2.57 (1)	119	1.89
17	HPAW152	21.33 (11)	42 (7)	26.83 (8)	84.67 (5)	50.49 (12)	5.67 (13)	4.73 (17)	552 (4)	18 (17)	10.43 (8)	53.79 (1)	108.97 (4)	29.33 (5)	2.15 (8)	120	1.9
1	HD3271	28.13 (3)	40.67 (13)	26.63 (10)	84.67 (5)	49.87 (10)	3.33 (7)	5.87 (7)	570.33 (3)	20.07 (9)	9.83 (13)	47 (14)	97.97 (20)	30.67 (2)	2.13 (10)	126	2
5	HPAN196	19.87 (13)	43.67 (5)	26.46 (11)	86 (10)	46.7 (6)	5 (12)	5.33 (10)	517.67 (9)	20.27 (5)	10.03 (11)	47 (14)	107.83 (5)	28.67 (6)	2.12 (11)	128	2.03
11	HPYT443	22.67 (9)	45.33 (2)	26.75 (9)	85.33 (9)	46.27 (5)	9 (15)	6.53 (1)	427.33 (16)	18.73 (12)	10.17 (9)	52.7 (3)	101.73 (10)	22 (19)	2.14 (9)	128	2.03
4	HPAN165	23.07 (8)	45.33 (2)	25.17 (14)	86 (10)	51.26 (13)	9.67 (16)	5.73 (8)	385 (20)	19.13 (11)	10.63 (6)	53.67 (2)	111.23 (2)	28.67 (6)	2.01 (14)	132	2.1
20	HD3226	23.73 (5)	41.67 (8)	20.17 (17)	88.67 (17)	64.49 (20)	3.33 (7)	5.2 (13)	591.33 (1)	20.13 (7)	10.99 (3)	49.33 (12)	105.3 (8)	28.67 (6)	1.61 (17)	141	2.24
6	HPYT409	15.87 (20)	40 (15)	27.63 (6)	84.67 (5)	48.57 (8)	0 (1)	4.2 (20)	518.33 (8)	19.87 (10)	10.01 (12)	50.3 (8)	100 (15)	28 (9)	2.21 (6)	143	2.27
2	HPAN153	28.93 (2)	41.67 (8)	21.04 (16)	84.67 (5)	51.93 (15)	0 (1)	6.47 (2)	420.33 (18)	18.53 (13)	9.7 (14)	50.03 (10)	99.93 (16)	26 (11)	1.68 (16)	147	2.33
13	HPYT474	19.2 (15)	43.67 (5)	30.13 (4)	86 (10)	35.84 (1)	3.33 (7)	5.2 (13)	513.67 (10)	18.53 (13)	8.67 (20)	44.13 (19)	101.73 (10)	23.33 (16)	2.41 (4)	147	2.33
19	CSW18	24.27 (4)	40 (15)	17.42 (19)	89.33 (19)	59.84 (19)	3.33 (7)	5.2 (13)	446.33 (15)	22.13 (1)	11.8 (1)	48.63 (13)	112.4 (1)	32.67 (1)	1.39 (19)	147	2.33
8	HPYT424	23.73 (5)	41.33 (12)	30.75 (2)	87.33 (15)	49.05 (9)	11.33 (18)	5.93 (6)	497.33 (12)	18.33 (16)	9.47 (18)	50.17 (9)	99.9 (17)	25.33 (13)	2.46 (2)	154	2.44
15	HPYT489	18.67 (17)	37.67 (19)	16 (20)	82.67 (3)	51.51 (14)	0 (1)	5.33 (10)	507 (11)	20.53 (3)	9.67 (15)	51.73 (4)	106.8 (7)	22.67 (18)	1.28 (20)	162	2.57
10	HPYT441	18.93 (16)	38.67 (17)	23.04 (15)	86.67 (14)	42.9 (4)	3.33 (7)	5.27 (12)	520 (7)	17.87 (18)	10.17 (9)	49.7 (11)	102.2 (9)	26.67 (10)	1.84 (15)	164	2.6
16	HPYT490	19.73 (14)	34.33 (20)	25.54 (12)	90 (20)	50.06 (11)	0 (1)	4.8 (16)	579.67 (2)	20.27 (5)	10.53 (7)	46.6 (16)	100.3 (14)	24.67 (14)	2.04 (12)	164	2.6
9	HPYT426	23.6 (7)	44.67 (4)	27.33 (7)	87.33 (15)	57.5 (18)	11.33 (18)	6 (5)	422 (17)	17.53 (19)	9.13 (19)	45.83 (17)	100.37 (13)	30.67 (2)	2.19 (7)	168	2.67
7	HPYT418	16.8 (19)	41.67 (8)	25.46 (13)	82 (2)	52.05 (16)	1.33 (5)	4.73 (17)	402.67 (19)	18.47 (15)	10.87 (4)	51.3 (6)	98.67 (19)	24.67 (14)	2.04 (12)	169	2.68
3	HPAN163	17.47 (18)	38.67 (17)	29.83 (5)	88.67 (17)	39.37 (3)	6.33 (14)	6.07 (4)	531 (5)	17.07 (20)	9.53 (16)	45.63 (18)	99.34 (18)	23.33 (16)	2.39 (5)	176	2.79
12	HPYT446	22.13 (10)	46.33 (1)	19.33 (18)	86 (10)	35.95 (2)	30 (20)	5.6 (9)	448.33 (14)	20.13 (7)	9.48 (17)	43.03 (20)	101.23 (12)	14 (20)	1.55 (18)	178	2.83

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The Modified Richard's Equation for Assessing the Impact of Drought and Salinity in Arid and Semi-Arid Zones. Part Two: A Soil Hydraulic Capacitance

By El-Shazly Mohamed Hegazy
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Abstract- A soil hydraulic capacitance is a new physical property related to the interactions between the agro eco-system components soil, water, plant and atmosphere. It gives new quantitative details about the processes control the plant water uptake, ascending of sap and soil response toward the root water uptake under a certain soil moisture regime and climatic changes. The soil hydraulic capacitance, a tank like a plant water reservoir, is being controlled by signals, valves like switches. Three types of signaling devices, Geo, Bio, and weather controlled were discussed. The soil hydraulic capacitance property was first discovered by the author when modeling the wheat root water uptake under saline and drought conditions. Under the latter extreme conditions, treating plants with silica products was the managerial practice used for enhanced plant growth and water uptake. A split-split plot experimental design with four replicates was used to conduct the research in Oraby Village, Maryout area, Alexandria, Egypt in the last year of the most water-scarce decade.

Keywords: *soil hydraulic capacitance, drought and salinity stresses, strain, compensated water uptake.*

GJSFR-D Classification: *FOR Code: 070308*

THEMODIFIEDRICHARDSEQUATIONFORASSESSINGTHEIMPACTOFDROUGHTANDSALINITYINARIDANDSEMIARIDZONESPARTTWOASOILHYDRAULICCAPACITANCE

Strictly as per the compliance and regulations of:

The Modified Richard's Equation for Assessing the Impact of Drought and Salinity in Arid and Semi-Arid Zones. Part Two: A Soil Hydraulic Capacitance

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Abstract- A soil hydraulic capacitance is a new physical property related to the interactions between the agro eco-system components soil, water, plant and atmosphere. It gives new quantitative details about the processes control the plant water uptake, ascending of sap and soil response toward the root water uptake under a certain soil moisture regime and climatic changes. The soil hydraulic capacitance, a tank like a plant water reservoir, is being controlled by signals, valves like switches. Three types of signaling devices, Geo, Bio, and weather controlled were discussed. The soil hydraulic capacitance property was first discovered by the author when modeling the wheat root water uptake under saline and drought conditions. Under the latter extreme conditions, treating plants with silica products was the managerial practice used for enhanced plant growth and water uptake. A split-split plot experimental design with four replicates was used to conduct the research in Oraby Village, Maryout area, Alexandria, Egypt in the last year of the most water-scarce decade. The aim of the experiment was to put the sink/ source term of Richard's equation, S, into investigation under a macroscopic electrical modeling, AMUN_SHC. Natural drought and salinity stressors are the abiotic extremes. Silicon foliar applications are the managerial practices used for combating the latter extremes. The Plant stress index, soil stress index and strain of straw sap were calculated. The S-shaped relative extreme response function was used to describe the SSI$=f$(h, z, t). the effect of silicon as a beneficial element on the soil hydraulic capacitance and therefore the winter wheat water uptake was estimated and discussed. The soil hydraulic capacitance equations were derived and discussed. The brilliant result from the research is that the soil hydraulic capacitance, a recently discovered soil hydro-physical property, controls the root water uptake under drought and saline conditions in accordance with stress, strain and weathered controlled relationships.

Keywords: soil hydraulic capacitance, drought and salinity stresses, strain, compensated water uptake.

Abbreviations: SHC, β: Soil Hydraulic Capacitance, SSI: Soil Stress Index, PSI: Plant Stress Index.

AMUN_SHC: The Code of Calculating SHC. CRWU: Compensated Root Water Uptake.

MENA & WANA: They are acronyms of Middle East North Africa Region and Western Asia Northern Africa Region, respectively. They are antonyms. They include approximately 24 countries. They are as follow: Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, Palestine, Yemen, Ethiopia, Sudan and Western Sahara. This region has the largest reservoirs of kerogenic hydrocarbons. It Occupies 60% of the world's oil reserves and 45% of the world's natural gas reserves. Many crises, clashes, revolutions or sometimes wars are predominated therein. The oil war between Iraq and Kuwait, the border clashes between Sudan and Ethiopia and the incoming water war between Egypt and Ethiopia for instance not for a survey.

All the equations used in the materials and methods section are owned to the author

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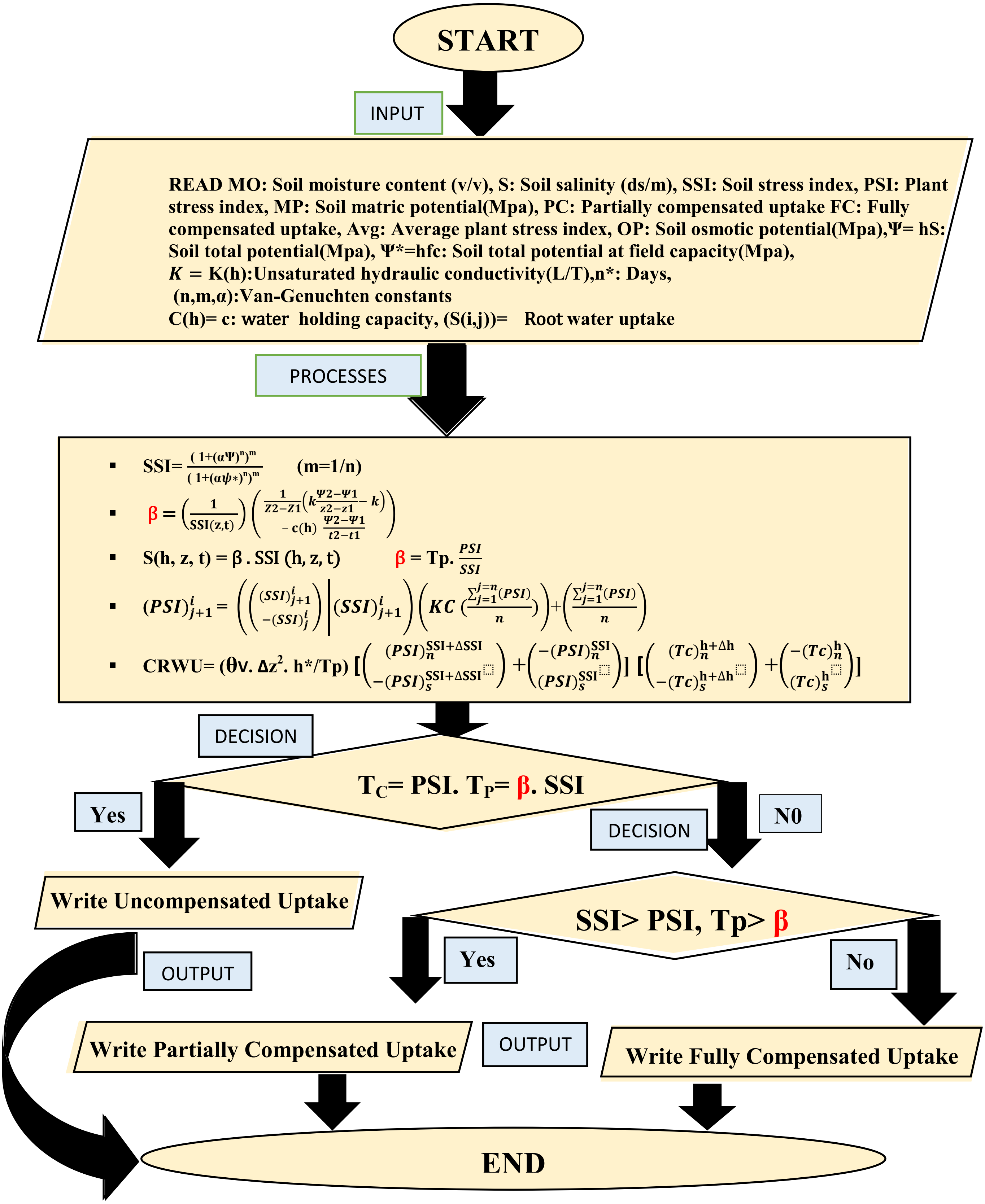

Figure 1: Graphical abstract of AMUN_SHC pseudo-code.

I. Introduction

The world will be conquered by exacerbated cycles of drought due to global climatic changes. Shortages in rain-fed agriculture and crops' yield will be caused, unless a restricted environmental policy is followed (FAO, 2020a). As global climatic changes have been blown, rises in the temperature and decreases in precipitation patterns would have attacked earth taking it from the fascinated greenish optimum conditions toward the terrible relative extremes yellow ones. Lots of environmental catastrophes will have threated the existence of mankind on planet earth due. Worldwide, the U.S. concurrent information system indicated a deteriorating climate situation. 47.81% of the U.S. and 57.06% of the lower 48 states were in a drought in the last week of February 2022. In addition, 200.6 million acres of crops in the U.S. were experiencing drought conditions, 93.1 million people in the U.S. and 91.8 million in the lower 48 states were affected by drought. 32 U.S. states were experiencing moderately worse drought at the latter week (NIDIS, 2022).

Sea level rises, temperature rises, storm surges, floods, and droughts are the main effects of global climatic changes. Moreover, climatic changes hold a series of interrelated side-effects to agriculture such as the deteriorated soil fertility, soil salinization, land degradation, shrunk crops' yields, rise of the freshwater's demand and decrease of the available water's supply (Fig. 2a) (IPCC, 2013). The agricultural drought is determined by dividing the precipitation by evapotranspiration in order to characterize states of moisture's regime. The conceptual definitions of drought focus on the physical processes involved in drought, such as the scarcity of precipitation (meteorological drought), regime in soil moisture (agricultural drought), lack of overland flow (hydrological drought) and shortage of municipal water (socioeconomic drought) (Hereher et al., 2022). Soil faces short periods of wetting cycles and long periods of drying ones now and again. The reason is the increase in soil evaporation due to the rising in air temperature and therefore increasing in plant transpiration (Schoups et al., 2010). Accordingly, the net capillary movement of soil water will have a much moving upward pull during the growing season which accelerates soil salinization. Hence, hydrological systems, especially soils, have been considered as sensitive elements to climatic changes (Hopmans et al., 2008).

All countries receive drought waves but their frequency, severity and duration may vary from one to another and from region to region. The non-sustainable uses of natural resources, weather variability and climatic changes are the main factors responsible for the drought (Miyan, 2015). Most of the region WANA falls within the hyper-arid, arid and semi-arid zones (Fig.2). As the region is subject to frequent droughts, agriculture is a major and sensitive sector of the economy and consumes most of the water resources. The rain-fed crops are strongly affected by fluctuated precipitations to a degree of an extent that the era between 2000- 2010 is nominated as the decade of water scarcity (ASCAD, 2011). The total number of the people affected by the drought attack in WANA countries between 1970- 2009, is about 38.09 million (Abu Swaireh, 2009). Egypt (Hegazy, 2020), Mauritania, Sudan (Hamid and Eltayeb 2011), Syri a (ASCAD, 2011), and Comoros Islands are examples, not a survey. In the most dried year, a localized famine attacked parts from south Sudan (Hamid and Eltayeb, 2011). In the cropping season of 2009/2010, most of the world's croplands faced severe drought waves which

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negatively affected the crops' productivity especially where no renewable water resources exist.

Drought, salinity and desertification are the negative consequences of global climatic changes. They are interrelated and common in MENA region as it is located in arid and semi-arid zones where the precipitation are regimes (Fig. 2). The land degradation by salinization and desertification are spreaded where no renewable water resources exist such as in Libya (Abaghandura et al., 2017). Saudi Arabia (Elhag, 2016) and Kuwait (Alsulaili et al., 2022). The Agricultural exploitation of Aridisols under global climatic changes requires special managerial practices to reach the sustainable use. Mapping and monitoring drought and land degradation are vital to keep track and anticipate further degradation and essential for properly and timely interventions to adjust the managerial practices or undertake suitable reclamation and rehabilitation measures especially under climatic changes conditions which increase the shrinkage of mud (Nwer et al., 2013). In the 1970s there were about 1 billion hectares of salt-affected soil worldwide. This survey is still under consideration till 2020 despite the current global climatic changes and their series consequences on agro-ecosystems and food security. For sustainable management and economic exploitation of saline soils, a new survey about their features and distribution should be adopted (FAO, 2020b).

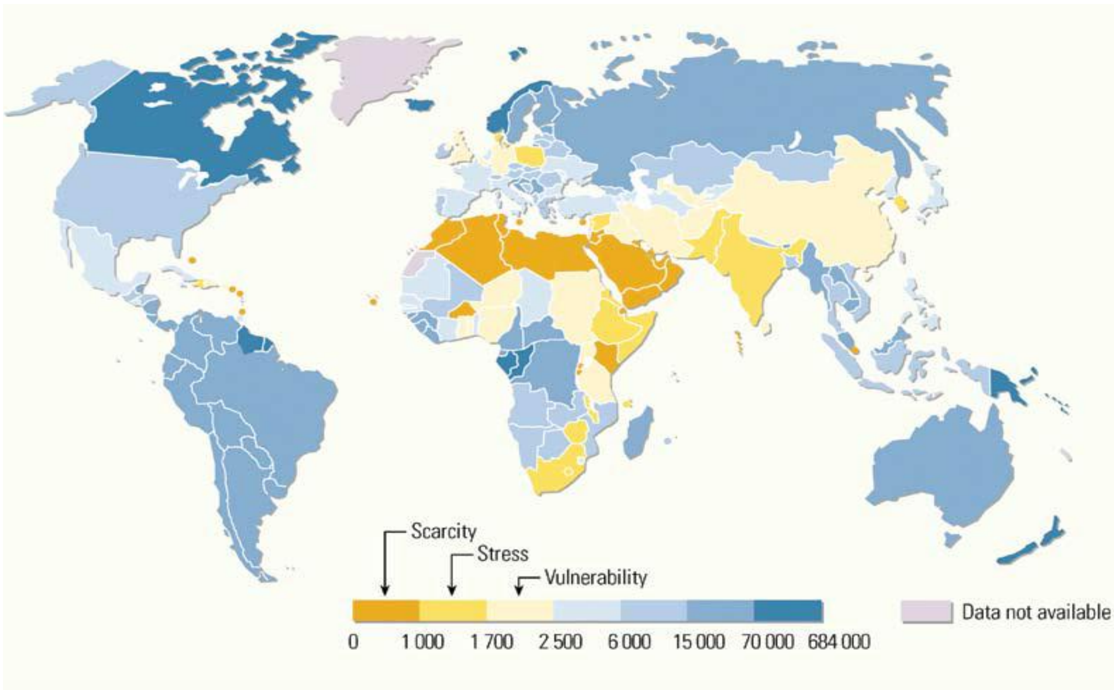
Water is being added in a measure or in some cases a deficit during the sustainable water saving techniques. There is not enough water to rinse the salinans formed either by the irrigation with saline water or by the capillarity rise of water table. It's the water scarcity, which obligates the pedologists to use the deficit irrigation or the low water quality resources for irrigation. The reuse of treated municipal and agricultural waste water, mixing fresh water with saline water, mulching, antitranspirants, silicate fertilizers, shifting to the cultivation of crops that require less quantities of irrigated water and using the concept of virtual water for importing the high water demand crops instead of cultivating them are examples. Saudi Arabia leads the concept of agricultural investments in various countries where the agricultural inputs are available and have a low pricing such as Sudan, Ethiopia, Egypt and Pakistan.

The climatic changes, cause the temperature rises, enhance the subsurface capillarity rises and surface evaporation. Accordingly, salts accumulate in the topsoil. Other factors in that manner are the seawater intrusion, poor drainage system and pedogenic processes related to the parent material (Hereher et al., 2022). The Joaquin valley, California, USA is an example in that context. Approximately 47,000 hectares have been retired due to regional drainage problems and pedogenic factors. On the other wards, the parent materials of marine and lacustrine depositions, being rich in natural salts and shalls, are the primary sources of salinization beside the poor drainage and water scarcity. Another example is the marine and lacustrine depositions in Egypt such as the lacustrine depositions of the lake Maryout and Abees. The water scarcity in these regions brings the agro-ecosystem toward the relative extremes more than that of the non-saline or even saline aeolian depositions widely spreaded in the African Sahara desert, northern China, southern central Asia, central Europe, Argentina, Alaska and central United States.

It was being believed that water is a priceless resource and it was being forbidden to pay for using it. As a consequence, low water use efficiencies in all fields of municipalities and agro-lands were estimated. The Pricing water is needed not as a punishment to use but as a kind of financial support for the giant projects which deliver the trans-boundary fresh water from where it is a useless renewable resource to where it is a useful one. These projects are unaffordable to be implemented by the developing countries. Although the water pricing is an effective way to achieve the best water use efficiency, sharing the costs of trans-boundary water systems is easier to be implemented in arid and semi-arid zones. By taking Egypt as an example, a pipeline connects the river Nile with the river Congo saves 887MCm being lost with the Congo river's up-stream toward the Atlantic ocean. The 4MCm from the Egyptian cuta being lost in the Mediterranean sea, need to be dammed opposite to the surface land flow of Nile's freshwater toward the sea and slurry walled against of the subsurface intrusion of Mediterranean sea. The 11MCm being lost by the evaporation from the lake of Nasser need to be saved by finding another lake in the northern Egypt. The water delivery through pipelines is not a recent idea but a simulation to the Libyan great manmade river implemented by Muammar Gaddafi. As the price of that pipeline is unaffordable, it needs a financial solidarity from all MENA countries which will put its water under exploitation. Arab water and the Peace water are examples (Hegazy, 2022b).

The water holds dissolved salts in a form of soil solution at a high state of energy or high osmotic potential. As the processes of sinking soil moisture take place, the regime of soil wetness causes a negative matric which limits the easy uptake of water and nutrients with plant roots (FAO, 2020b and Ma et al., 2020). The total high energy state of soil water negatively affects the plant growth, plantation properties and yield of many plants but in less degree of extent in halophytes (FAO, 2020b and Hereher et al., 2022)..The sink term of modified Richard's equation consists of two components. The first is the soil stress index, SSI, and the second is the soil hydraulic capacitance, β. The two latter terms are being multiplied to produce the root water uptake. β reveals the interaction between the continuum components of soil, water, plant and atmosphere. All degrees of continuum's response and interaction to abiotic stressors fall under the first law of thermodynamics. Soil hydraulic capacitance can be measured with time and depth, β (z,t), using two types of probes. The first probe for detecting moisture with time and depth, ϴ (z,t), by the resistivity (Ganiyu et al., 2020). The second for detecting electrical conductivity with time and depth, EC (z,t). The collected datasheet of signals with time and depth are inserted in AMUN_SHC. Improving soil hydraulic capacitance under drought and saline conditions requires a successful in farm and out farm managerial practices for soil, water, plant and continuum's canopy.

(A) **2007**



(B) **1995 - 2025**

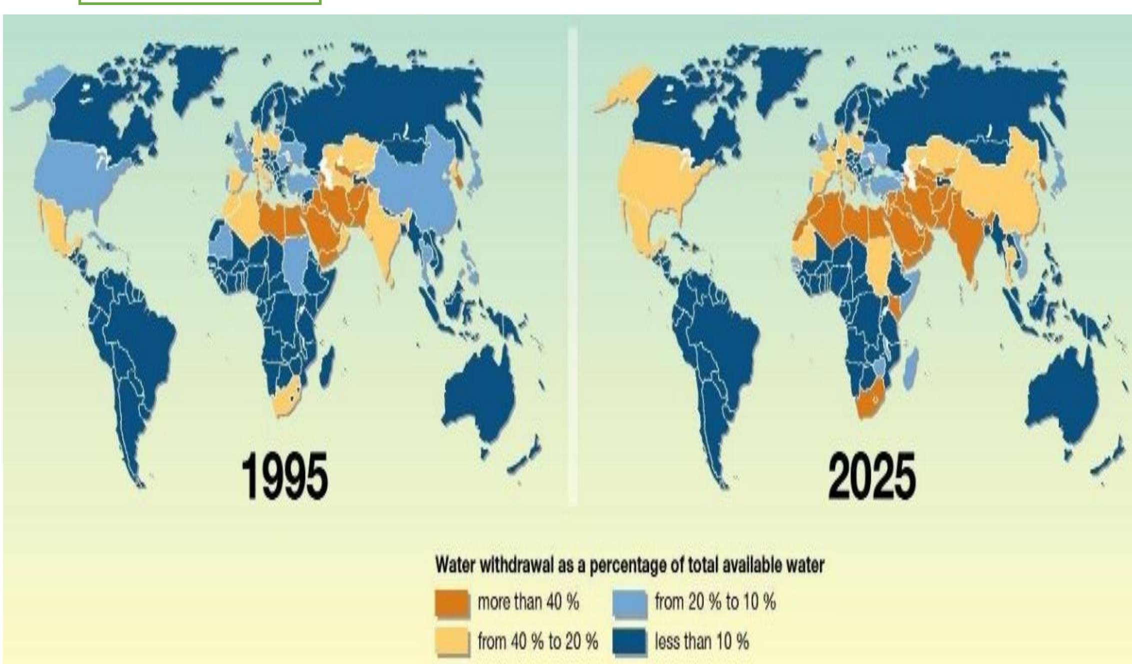


Figure 2: (A): The fresh water availability cubic meters per person per year. (Source: EL-Ashry et al., 2010). (B): The worldwide water stress change from the year 1995 to 2025. (Source: ecomena.org).

The combined abiotic stresses of drought and salinity make the main components of the agro-ecosystem, plant and soil, start their response functions on (0/1) to save the life on planet earth. The soil water becomes less or even unavailable for plant machinery systems in spite their cumulative actions whether they are either additive or multiplicative. The wheat's hydraulic signal could roll leaves in order to reduce the leaf area index and net radiation (Nar et al., 2009) and could inhibit the root growth in the dry topsoil as a response to applied stress. Silicon, the second most abundant element in the earth's crust, can act as plants' first aid for healing the stressed parts to overcome the abiotic extremes (Epstein, 2009). As a response to a highly energetic soil solution, plants increase the uptake of silicon to alleviate the damaging effects of abiotic stresses. The negative interaction between silicon and sodium and the positive interaction between silicon and basic nutrients may stimulate plants to alleviate the side effects of abiotic stresses. Its deposits in roots enhance the elasticity, in tricombs enhance their function in cooling leaves and in leaves increase the water use efficiency under optimal conditions (Elsokkary, 2018) and enhance the transpiration under sub-optimal conditions. Silicon enhances the process osmoregulation which makes the suction head inside the plants' roots to be in a higher negative potential in order to overcome the total potential of soil solution (Hegazy, 2020). Despite of the natural abiotic stresses produced by global climatic changes, the siliceous nutrition of plants is not only scientifically intriguing but also important in a world where more food will have to be wrung from a finite area of land, especially for the deficit irrigation and partial root-zone drying scenarios which will put crops under artificial stress. (Epstein, 2009 and Elkhatib et al., 2017). The aims of this research are to use the stress form of modified Richard's equation to achieve a set of equations, AMUN_SHC. The latter is used to calculate, analyze and discuss the soil hydraulic capacitance and therefore determines the water uptake under stress conditions. Moreover, this research studies the forces control β, the stress strain relationship, and therefore the ascending of sap under the relative extreme combined stresse conditions.

II. Materials and Methods

All the equations used in the materials and methods section are owned to the author

In the present investigation, a field experiment was carried out in Egypt as a major country in the African Sahara desert. An open field experiment was conducted at Oraby village, Maryout area, Alexandria between latitudes 30^o: 31^o degree north and between altitudes 30:32 east during the latest most drying year, 2009/2010 (Natural drought and salinity treatments (Fig. 3). Wheat grains, Sakha 94, were sown on November 27th in all field experimental plots and harvested in the first week of May. Fertilization was managed according to the recommendations of the ministry of agriculture this year.

Natural drought and salinity were managed by silica fertilization. The response of wheat to silicon doses was investigated by its addition as potassium silicates and sodium silicates in three concentrations 0.0, 30.6, and 40.8 ppm. All of them were foliar sprayed at the ages of 40, 60, and 75 days from seed emergence at the early morning. The 6 treatment combinations were distributed in three salinity levels for saturated soil paste, ECe= 6.4, 9.7 and 10.3 mS/cm, in a split-split plot design with four replicates.

In order to calculate soil stress index, soil hydro-physical properties were estimated by HYDRUS- 1D (Vr. 4.17) at depth z dimension (Simunek et al., 2013).ET_C was calculated from meteorological data according to FAO (2002). The irrigation interval is each 20: 25 day.

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Soil moisture values were estimated gravimetrically in two dimensions x and y then converted to soil matric potential. The parallel soil electrical conductivity values were estimated in saturated soil paste and in 1:2.5 suspension, ECe and EC, respectively (Jackson, 1973) using EC meter, at 25°C then converted to soil osmotic potential. The soil total potential was calculated using the additive function taking into account the SI unites and prefixes which figurate the states of soil water each day in the wetting and drying cycles.

The soil stress index was calculated from equation (1). The plant stress index was calculated from equation (2). The soil hydraulic capacitance was calculated from equation (3). The strain of straw sap was calculated from the change of straw sap water potential between two days divided by the straw sap of the first one. The FORTRAN programing language was used to model the relation between the soil hydraulic capacitance and plant response functions which start to do on, (0/1), compensation according to. SSIMOD (Hegazy, 2022a). The model assumes that the soil-moisture profile is as a series of capacitors (each of which represents water storage in a given layer), which are linked via the variable (potential-dependent) resistance of unsaturated Darcian flow. When current flows from the atmosphere downward (analogous to infiltration), it charges up the capacitors, causing soil wetting up. That storage is subsequently discharged by continued downward drainage beyond the bottom of the root zone or by upward flow in response to atmospheric evaporation of moisture from the soil surface. Each layer in the root zone is also discharged by roots present within it, and the extracted water thus flows toward and through the stem to the canopy and then to the atmosphere in the process of transpiration, now and then, each wetting-drying cycle (Hillel, 2002). The latter evapotranspiration is weather controlled by the water's upward forces in plant and soil, the surface tension and capillarity (Fig. 4). As the salinity treatments are natural, the salinity levels 10.3 and 9.7 mS/cm are combined because both of them are approximately clayey texture and convergent to a similar salinity level.

a) The AMUN_SHC

$$\mathbf{SSI} = \frac{\mathbf{1} \qquad {}^{\mathbf{n\ m}}}{\mathbf{1} \qquad \boldsymbol{\psi}*^{\ \mathbf{n\ m}}} \qquad \mathbf{(m=1/n)} \qquad (1)$$

<u>Where</u>

SSI: soil stress index. , n, m: hydraulic parameter could be predicted by HYDRUS 1D.-4.17 (Simunek et al., 2013). Ψ, Ψ*: total soil potential at a given temporal or spatial condition and at optimum condition for wheat growth in the field under investigation, respectively. Ψ* could be predicted by HYDRUS 1D.-4.17 (Simunek et al., 2013)

$$(PSI)^{i}_{j+1} = \left(\begin{pmatrix} (SSI)^{i}_{j+1} \\ -(SSI)^{i}_{j} \end{pmatrix} \middle| (SSI)^{i}_{j+1} \right) \left(KC \left(\frac{\sum_{j=1}^{j=n}(PSI)}{n} \right) \right) + \left(\frac{\sum_{j=1}^{j=n}(PSI)}{n} \right)$$

<u>Where</u>

SSI: soil stress index. Kc: crop coefficient. PSI: ratio between actual and potential transpiration. i: soil depth (cm). j: time (days).

$$\beta = \left(\frac{1}{SSI(z,t)}\right)\left(\frac{1}{Z2-Z1}\left(k\frac{\Psi 2-\Psi 1}{z2-z1}-k\right) - c(h)\,\frac{\Psi 2-\Psi 1}{t2-t1}\right) \quad (3)$$

- Equation (3) is the stress form of Richard's equation (Hegazy, 2022b)

<u>Where</u>

t, z: time and depth respectively (t, l), SSI: dimensionless soil stress index, c(h): soil water holding capacity (l^{-1}), K: unsaturated hydraulic conductivity (l/t). β: soil hydraulic capacitance. Ψ: soil potential.

$$S(z,t)= \mathbf{SSI\ .\ \beta = PSI.\ S_{max}}$$

$$\mathbf{Tc_{(z,t)}= SSI\ .\ \beta = PSI.\ Tp} \quad \mathbf{(4)}$$

<u>Where</u>

S, Smax: actual and potential water uptake, respectively, Tp: actual and potential transpiration, respectively. The factors affecting the soil hydraulic capacitance are TP, PSI and SSI. The term β allows us to study, analyze and compare different groups of soil types, plant species, varieties and atmospheric conditions. This comparison may be either inter, intra or in combination between them. Such a comparison allows us to select from the latter groups the types of components which cause the maximum crop yield with minimum agricultural precise inputs in order to choose the good from the best.

There are three special cases from the soil hydraulic capacitance: as follows:

- **$Tc_{(z,t)=}$ β = Tp , SSI=PSI=1**

This means that soil moisture reservoir of the continuum hydraulic capacitance is able to meet the required potential transpiration and there is no stress and the uptake is uncompensated.

- **SSI> PSI, Tp> β**

  This means that the soil moisture reservoir of the continuum hydraulic capacitance is unable to meet all the needs of the plant hydraulic machinery system. Plant roots respond to this moisture deficit by compensatory root growth for compensating water uptake from another layer which has a higher soil moisture reservoir of the continuum hydraulic capacitance (Hegazy, 2022). This type of compensation is called partially compensated water uptake.

- **SSI< PSI, Tp< β**

  β this means that the soil moisture reservoir of the continuum's hydraulic capacitance is unable to meet all the needs of the plant hydraulic machinery system and there is another soil reservoir that can recover the moisture deficit actually by compensated root growth for compensated water uptake. This type of compensation is called fully compensated water uptake.

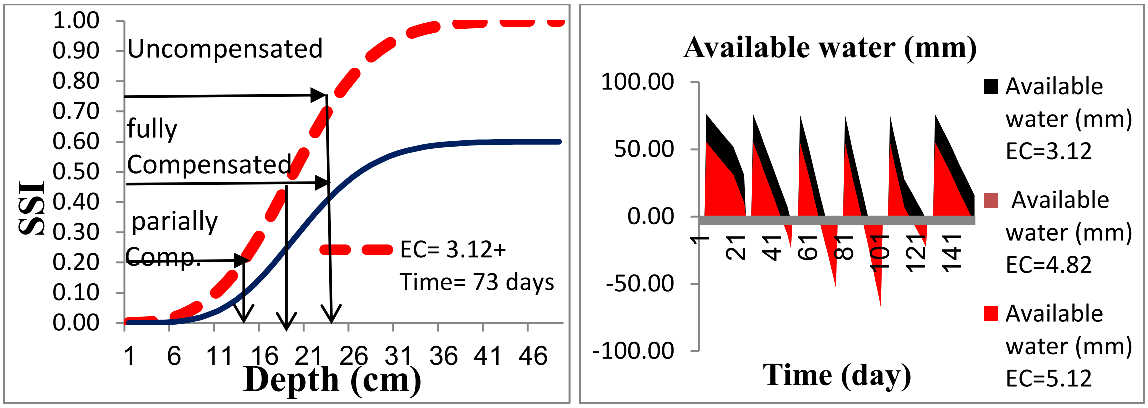

Figure 3: The S shaped SSI with depth (Left). Available water as a response to the combine stress (right).

$$\mu = (dPSI|dSSI) = 1/\omega \quad (5)$$

Where:

μ: first order derivative of PSI= *f*(SSI). dSSI: change in soil stress index. dPSI: change in plant stress index.1/ ωc: the compensation factor.

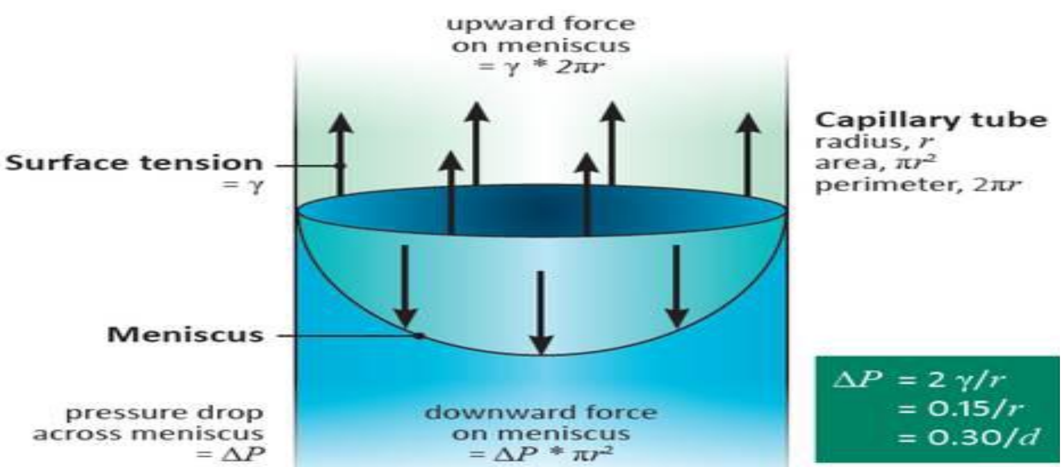

Figure 4: A fully-developed meniscus in a cylindrical tube showing the equality between the upward pull of surface tension and the downward pull of the suction in the water from which the relation ΔP=2γ/r can be derived (Bazaraa, 2015).

b) Modeling the root response to harch extreme moisture regime

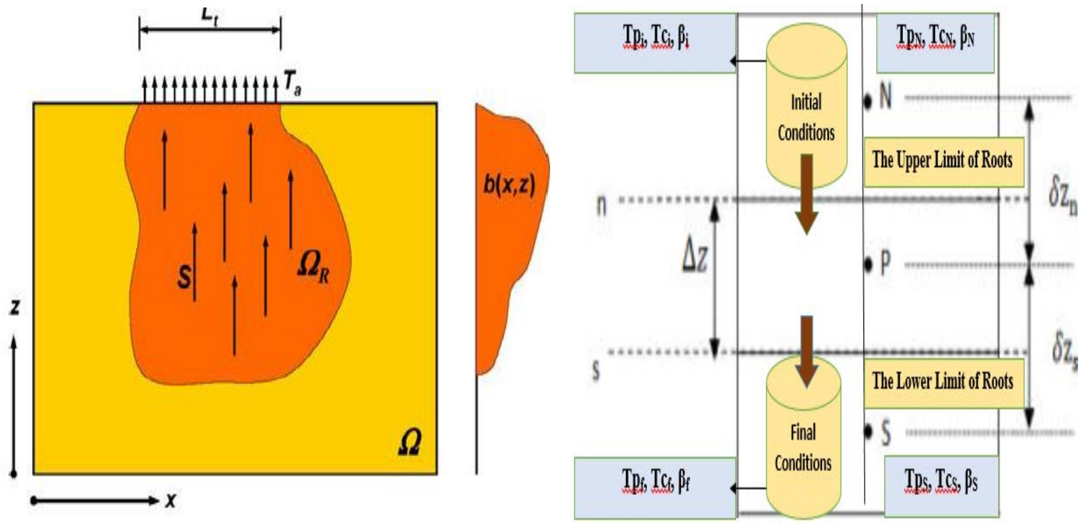

Figure 5: Schematic of the potential water uptake distribution function, b(x, z, t), in the soil root zone (Left).A control volume from root zone (Rght).

$$S_{(z,t)} = SSI\ .\ \beta = PSI.\ S_{max}$$

$$\mu = dPSI/dSSI$$

i. *Root navigation bath* $= \iint_{s,(SSI)}^{n,(SSI+\Delta SSI)} \mu\ dSSI\ dz = \iint_{s,(SSI)}^{n,(SSI+\Delta SSI)} (dPSI/$

$$dSSI)\ dSSIdz = \int_s^n (PSI^{SSI+\Delta SSI} - PSI^{SSI})dz$$

$$= [\left(\begin{matrix}(PSI)_n^{SSI+\Delta SSI} \\ -(PSI)_s^{SSI+\Delta SSI}\end{matrix}\right) + \left(\begin{matrix}-(PSI)_n^{SSI} \\ (PSI)_s^{SSI}\end{matrix}\right)]\ (\Delta z). \qquad (6)$$

ii. *Domain root for Compensation* $\Omega RC = \iint_{s,(h)}^{n,(h+\Delta h)} \mu\ dh$

$$dz = \iint_{s,(h)}^{n,(h+\Delta h)} \left(\frac{dPSI}{dSSI}\right) dhdz$$

$$= (h^*/Tp) \iint_{s,(h)}^{n,(h+\Delta h)} dTc\ dz = (h^*/Tp) \int_s^n (Tc^{h+\Delta h} - Tc^{h})dz$$

$$= (h^*/Tp)\ [\left(\begin{matrix}(Tc)_n^{h+\Delta h} \\ -(Tc)_s^{h+\Delta h}\end{matrix}\right) + \left(\begin{matrix}-(Tc)_n^{h} \\ (Tc)_s^{h}\end{matrix}\right)]\ (\Delta z) \qquad (7)$$

iii. *Compensated root water uptake* =

$$(\theta v.\ \Delta z^2.\ h^*/Tp)\ [\left(\begin{matrix}(PSI)_n^{SSI+\Delta SSI} \\ -(PSI)_s^{SSI+\Delta SSI}\end{matrix}\right) + \left(\begin{matrix}-(PSI)_n^{SSI} \\ (PSI)_s^{SSI}\end{matrix}\right)]\ [\left(\begin{matrix}(Tc)_n^{h+\Delta h} \\ -(Tc)_s^{h+\Delta h}\end{matrix}\right) + \left(\begin{matrix}-(Tc)_n^{h} \\ (Tc)_s^{h}\end{matrix}\right)] \qquad (8)$$

III. Results and Discussions

a) The response to silica under saline and drought conditions

The plant response under environmental abiotic stressed conditions could be discussed from the side of dynamics in plant roots and shoots used to minimize stress, reduce consumed energy, and maintain water and nutrient uptake. (Arsova et al., 2020 and Munns et al., 2020b). Firstly, plant enhances the uptake of nutrient element responsible for combating abiotic stress, silicon. Secondly, the beneficial functional element, silicon, interact positively with macro and micronutrient and stimulate the biophysical functions inside plant's tissues (Epstein, 2009). Thirdly, Plant responds to applied stress by accumulating osmolytes (Tuna et al., 2008), Silicon also appears to be a part of the osmoregulation within cells subjected to drought stress which enables the plant to uptake and transpirate more water for combating the stressed conditions. (Figs. 6 and 7) (Amin et al., 2014). Fourthly, the wheat's hydraulic signal reduces water loss via transpiration by decreasing leaf area index and increasing leaves rolling (Nar et al., 2009). Fifthly, the adaptive root growth (Clausnitzer and Hopmans 1994), the compensated root water uptake (Simunek and Hopeman, 2009) and root hydraulic redistribution to cope with the heterogeneity in soil moisture regime (Thomas et al., 2020).

The soil system under drought cycles shrinks its energy to the half of its value at the wetting cycles to save plant's life and prevent the plasmolysis (Homaee et al., 2002, Wang et al., 2020, and Hegazy, 2022a). The shrinkage of soil energy exceeds with the existence of salinity beside drought (Hegazy, 2020). Drought concentrates the soil solution, increases its conductivity which is already high due salinity, decreases the thickness of electric double layer, increases the diffused ions swarm (Sposito, 2008) which satisfies the remaining charges of the soil particles electrostatically, and therefore reduces the surface potential of highly energetic clayey particles. Accordingly, drought reduces the free energy of the background soil solution. In fact, it reduces the free energy responsible for the capillarity phenomenon (Fig. 4). Therefore, the in-vitro geo-regulated abiotic stress signal causes two in-vivo strains, the strain of osmoregulation achieved by osmaticum on one hand and the strain of cell turgidity on the other hand supporting plant growth (Nassar and Horton, 1997). At equilibrium, the latter strains are balancing each other to make the biological system holds minimum free energy and maximum entropy.

Silicon increases the water potential of the root's sap (Gong and Chen, 2012 and Amin et al., 2014) and leaf area index (Hegazy, 2022b) which enables plants to uptake and transpirate more water for combating the stressed conditions. Therefore silica enhances the latter in vivo strains (Figs. 6 and 7). The turgor strain causes cell wall expansion, rigidity, and optical growth which enable Plant roots to penetrate the soil system categorizing the energy states of soil water seeking the easiest available water to compensate with minimum plant consumed energy.

In tillering crops such as wheat, a drying non-friable soil was found to limit root growth at the top 30 cm using the hydraulic signal for increasing cell wall elastic modulus and maintaining turgidity strain while promoting root extension and growth into depth. As dry soil was re-watering, it would become moist and friable, and the plant would be converting the fast root growth to the topsoil instead of the deep. As a result of the latter turgidity strain, plant roots elongated started to absorb water from less stressful parts of root zones (Albasha, 2015). Si depositions in the roots can increase cell wall elasticity during root cell elongation (Laing et al., 2007). Therefore, silicon makes the roots penetrate the soil system in a smoothy way which enables roots to click the easiest bath, the moist wide friable planar voids, in searching and categorizing moisture to water and nourish (Peter, 2016). This is the reason that silicon saves plant energy under stress conditions. The latter biophysical functions are controlled by the weathered induced stress-strain relationship, the soil hydraulic capacitance (Eq. 5).

As drought and salinity increased, the water inside plant became less strained (Fig. 6), uncompensated water uptake decreased. Silica fertilization has an ameliorative effect on both main agro-ecosystem components, plant and soil (Epstien, 2009 and Choobbasti et al., 2015), under such conditions. As a result of this effective management practice, silicon concentrate the straw sap, creates a more negative water potential inside it, and makes the osmotic pressure is balanced by, the adhesive strain (Almeras and Gril, 2007).

water inside the plant more strained which creates an effective suction force that introduces downward to the roots and supports wheat water uptake (Fig. 7) (Kirkham, 2004). Then the signal transmits back to back toward the leaves as a diluted hydraulic signal by the act of high tensile strength of water. It's the hydrogen bonding of water molecules which acts as a rope tying water molecules each to other, causing the high tensile strength, and therefore the ascending of sap from root to shoot by vascular tissues (Tyree and Zimmermanm, 2002). On the other wards, they are strains generated by water tension delivered water from soil through plants to the atmosphere to satisfy the driving force of evaporative demands, the cohesive strain. Moreover, they transmitted to the cell wall in which they contained causing turgidity, a mechanical pressure in the living cells, where the

At the optimum conditions, SHC should equal the Tp in order to direct the osmolytes for building the crop biomass. Unless SHC may either overcome or downcome the Tp according to root adaptability to the adverse effects of abiotic stresses. Estimating the plant response toward the moisture regimes is illustrated in figures (8 and 9). As moisture becomes less available, the soil hydraulic capacitance and therefore compensation decreases. Whereas slightly saline soils have SHC much more than saline ones and so as in the case of irrigation water. Accordingly, seawater intrusion diminishes the SHC with the exception for the case of special soil, water, and plant managerial practices such as leaching and drainage for soil, magnetism for water, and silicon foliar application and gene transfer for the plant which use to raise SHC in some degree of extend. In halophytes, PSI is always greater than SSI. Accordingly, SHC exceeds the Tp and the opposite is true in sensitive plants. As silicon concentrates straw sap, it makes the root sap more strained. Therefore silicon allowed plants to withstand abiotic stress by shaking down the limits of actual stress plant roots may bear from the log phase until disappear. SHC in control treatment is higher than Tp on silicon treatments. The latter means that SSI is greater than PSSI. Moreover, a little pulse of environmental abiotic stress will cause a greater negative response on crop yield without silica fertilization. Potassium silicate is better than sodium silicate in the latter manner because the soil under investigation is rich in clay mineral fixes potassium between its layers, Attapolgite (Fig. 8).

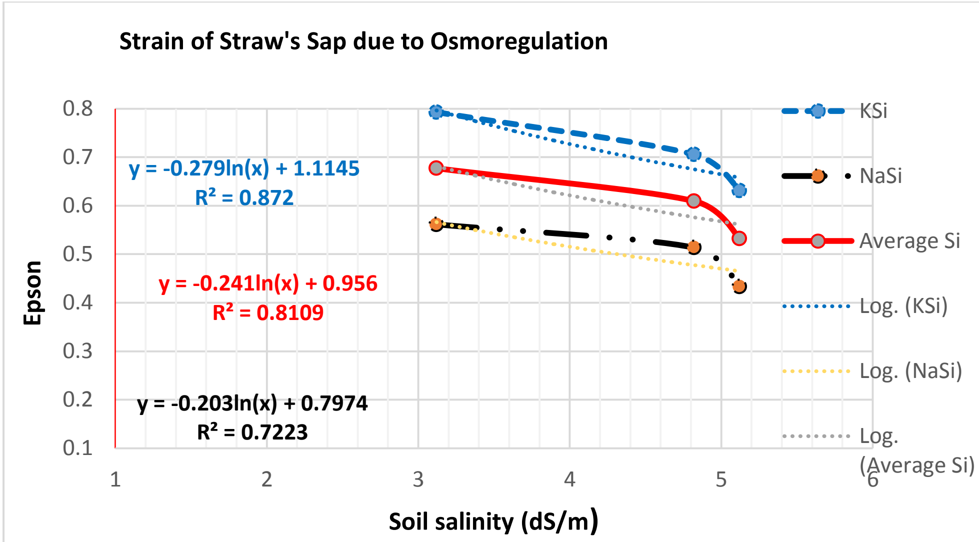

Figure 6: Variation in the strain of wheat's straw sap due to osmoregulation with respect to soil drought and salinity under silica fertilization.

Each type of water uptake takes place over a range of soil water potential and accordingly SSI (Fig. 4). As, h, SSI, PSI, Tc, Tp and ΔZ are known, the root navigation bath, ΩRC and the compensated uptake are easily estimated.

The AMUN_SHC assumes the variably saturated zone contains layered soil moisture capacitors connected each to other with the potential guidance of Darian flow. As precipitation infiltrates the soil system, each capacitor charges up according to its pedotransfer function of sand, silt and clay. Root navigates soil layers, categorizing their energy states,

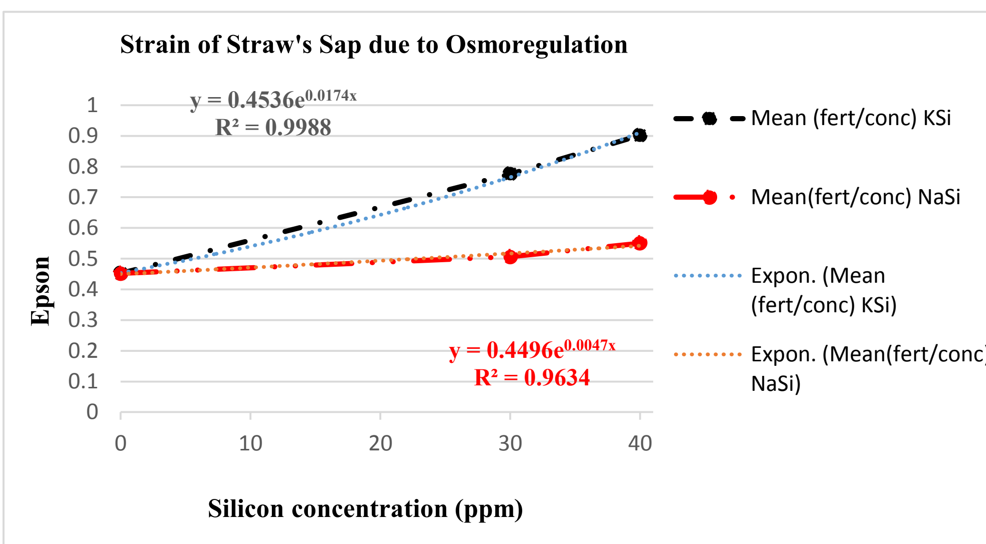

Figure 7: Variation in the strain of wheat's straw sap due to osmoregulation with respect to Si foliar application under combined stress conditions

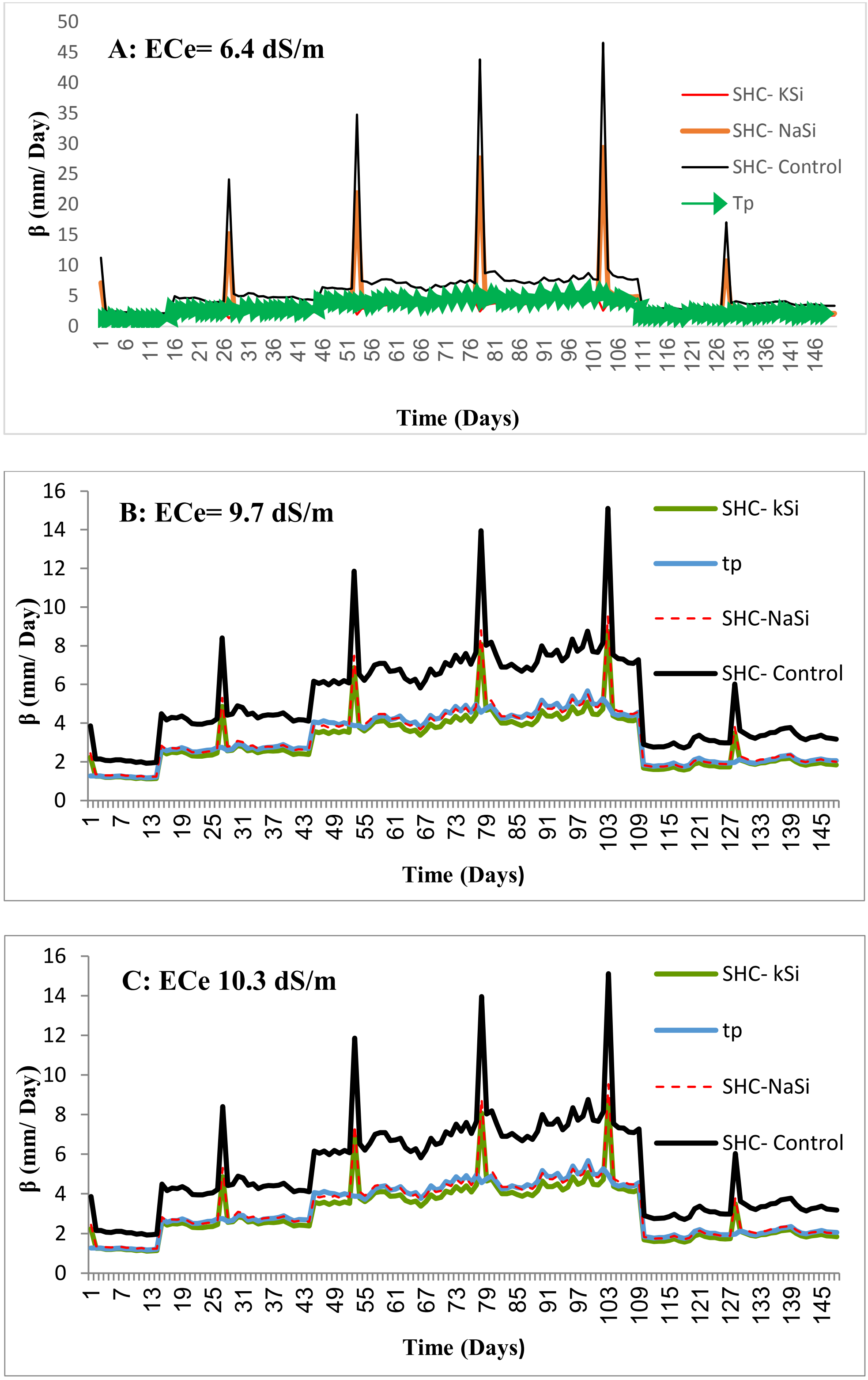

Figure 8: Soil hydraulic capacitance for A: Control soil ECe= 6.4 dS/m, B: Saline soil ECe= 9.7 dS/m and C: Saline soil ECe= 10.3 dS/m, respectively.

preferring the conditions that make their overall SHC in a state of equilibrium by the potential transpiration with a minimal consumed mechanical energy in order to achieve the potential yield. As SHC reveals the overall interaction between the ecosystem components (Eqs. 6, 7 and 8), the managerial practices affect the plant, soil and atmosphere and their interaction each to other may affect it. Treating the plant and soil with silica affects SHC (Figs. 8). The anti-transpirants cause roots hydraulic redistribution, magnetic water causes stress signals reduction, genetic transfer from halophytes to salt sensitive plants creates a new plant variety able to concentrate its root sap and increase its strain, organo-nanoparticles conditioners maintain the soil bed, harvest the atmospheric humidity and reduce the water losses via evaporation, leaching and deep percolation (Hegazy, 2002), treating the atmosphere with chemtrial gas causes a reduction in global warming and climatic changes and…etc. may all affect the SHC in many degrees of extend start in vivo by increasing the strain signal of root sap and extend in vitro by lowering the environmental abiotic stress signals but their quantitative responses should have put under the macroscopic point of view in another research.

In the agro-lands of MENA countries with marine and lacustrine origins, the overexploitation of groundwater under the conditions of water scarcity and global climatic changes causes the intrusion of seawater. As the saline water intrudes the variably saturated zone under a harsh extreme condition, the potentially guided Darian flow charges the capacitors from the bottom upwardly. Charging the capacitors in the electrical model defined by Hillel (2002) is different than that of the AMUN_SHC electrical model as the former did not consider that water quality affects its uptake. For instance, the water salinity decreases the availability of irrigation water. AMUN_SHC model takes the concept of total energy states into consideration. Assessing the impact of specific ion toxicity has a certain value of salt index under abiotic stress conditions may be achieved by making SSI speciation. The latter speciation may be done in order to know the combined stress of drought, salinity and specific ion toxicity such as in the case of using potassium chloride instead of potassium sulfate fertilizers. SSI speciation, SSIS, is still under investigation. Moreover, SSIS needs to be validated when assessing the impact of saline contaminated groundwater with iron and manganese on plant growth under deficit irrigation scenario.

IV. Conclusion

Estimating the root water uptake when using the stress form of modified Richard's equation, SSI*B, involves the term soil hydraulic capacitance. SHC represents the response of the soil moisture reservoir toward a certain plant water demand under a certain atmospheric condition. Soil profile consists of layered capacitors. Each of which is recharged during the infiltration by precipitation, irrigation or both forming the constant shaped soil moisture profile. The easy available water is being stressed by discharging the soil capacitors during the root water uptake creating the variably saturated zone. In between the sink: source terms of Richard's equation, the discharge: recharge terms of soil capacitors or the root uptake: hydrological release terms, root navigates soil capacitors categorizing their energy states to select what has the easiest available water and bath to pass in order to water by exerting a minimum consumed energy. SHC depends on soil genesis, plant species, varieties, ages and adaptability, atmospheric conditions and the high tensile strength of liquid phase. Under deficit irrigation and or the harsh extreme conditions of aridsols, SHC determines the types of water uptake in accordance with weathering induced stress- strain signaling devices. The

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latter devices are being regulated for the sake of preventing the hydrological release and complete the life cycle. Silicon enhances the overall signaling devices to be in a favorable states under the abiotic stress conditions. The result from that research clarifies the types of environmental managerial practices should have been adopted when dealing with the natural abiotic stress of drought and salinity due to global climatic changes or artificial one due to irrigation deficit scenario because of the three incoming reasons:

- Since the geo-signal is being induced by more compacted electric double layer, hysteric behavior and the Albert Ainkhtien's relativity of clayey lattice.
- As the bio signal is being induced by osmoregulation strain and turgidity strain.
- As the weather controlled signaling device is being induced by canopy evaporative demand.

Analyzing soil system under saline and drought conditions using AMUN_SHC showed the merciful behavior of soil toward plant under abiotic stress conditions. This is because the plots were treated with silicon, the second abundant element in the earth's crust

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Program AMUN_SHC

```
! Symbols:  MO: Soil moisture content (v/v), S: Soil
salinity (ds/m), SSI: Soil stress index, PSI: Plant stress
index, MP: Soil matric potential, OP: Soil osmotic
potential, hS: Soil total potential, hfc: Soil total
potential at field capacity PC: Partially Compensated
uptake
FC: Fully Compensated uptake, kc: crop coefficient: water
holding capacity Avg: average plant stress index
Beta1: SHC calculated from root water uptake, Beta2: SHC
calculated from Richard's equation.

IMPLICIT NONE
REAL Mo(1,50),S(1,50),SSI(1,50),PSI(1,50), dssi, AVG, KC,
hfc,Tp,beta,Beta1, Beta2, hs, ht, dh,Mp,Op,x,y,Zs,Zp, c
INTEGER  i, j
X=0
y=0
Zs=0
zp=0
I=1
dssi=0
avg=0
kc=0
Tp=0
ht=0
dh=0
beta1=0
beta2=0
WRITE (*,*) 'inter  hfc, dssi, avg, kc, c'
READ (*,*)  hfc,dssi, avg, kc, c
OPEN (UNIT=7,FILE="input3.txt")
OPEN (UNIT=77,FILE="output.txt")
DO J=1,50
READ (7,*) (MO(i,j))
READ (7,*) (S(i,j))
MO(I,J)= x
Mp=(x)*0.0174
S(I,J)=y
op=(y)*0.036
hs=Op+Mp
dh=hs- ht
ht=hs
SSI(I,J)= hs/hfc
SSI(I,J)=Zs
dssi= SSI(I+1,J)-SSI(I+1,J)
PSI(I,J)=(Avg * kc*dSSI/zs)+(Avg)
PSI(I,J)= zp
```

```
Beta1= (zp*Tp)/ Zs
Beta2= (1/Zs)*(((kc*dh)-kc)-(c*dh))
beta= (beta1+beta2)/2
IF (beta.LT.tp)THEN
WRITE(77,*)"partially compensated water uptake"
ELSEIF (beta.GT.tp)THEN
WRITE(77,*)"Fully compensated water uptake"
ELSE
WRITE(77,*)" uncompensated water up"
END IF
END DO
WRITE(*,*)((SSI(i,j),PSI(I,J),i=1,1),j=1,50)
WRITE(77,10((SSI(i,j), PSI(I,J),i=1,1),j=1,50))
10 format(/1x,E6.3,1x/)
End AMUN_SHC
```

Global Journals Guidelines Handbook 2023

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Memberships

FELLOWS/ASSOCIATES OF SCIENCE FRONTIER RESEARCH COUNCIL

FSFRC/ASFRC MEMBERSHIPS

Introduction

FSFRC/ASFRC is the most prestigious membership of Global Journals accredited by Open Association of Research Society, U.S.A (OARS). The credentials of Fellow and Associate designations signify that the researcher has gained the knowledge of the fundamental and high-level concepts, and is a subject matter expert, proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice. The credentials are designated only to the researchers, scientists, and professionals that have been selected by a rigorous process by our Editorial Board and Management Board.

Associates of FSFRC/ASFRC are scientists and researchers from around the world are working on projects/researches that have huge potentials. Members support Global Journals' mission to advance technology for humanity and the profession.

FSFRC

FELLOW OF SCIENCE FRONTIER RESEARCH COUNCIL

FELLOW OF SCIENCE FRONTIER RESEARCH COUNCIL is the most prestigious membership of Global Journals. It is an award and membership granted to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Fellows are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Fellow Members.

Benefit

To the institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

Exclusive Network

Get access to a closed network

A FSFRC member gets access to a closed network of Tier 1 researchers and scientists with direct communication channel through our website. Fellows can reach out to other members or researchers directly. They should also be open to reaching out by other.

Career Credibility Exclusive Reputation

Certificate

Receive a print ed copy of a certificate

Fellows receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

Career Credibility Exclusive Reputation

Designation

Get honored title of membership

Fellows can use the honored title of membership. The “FSFRC” is an honored title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FSFRC or William Walldroff, M.S., FSFRC.

Career Credibility Exclusive Reputation

Recognition on the Platform

Better visibility and citation

All the Fellow members of FSFRC get a badge of "Leading Member of Global Journals" on the Research Community that distinguishes them from others. Additionally, the profile is also partially maintained by our team for better visibility and citation. All fellows get a dedicated page on the website with their biography.

Career Credibility Reputation

Future Work

Get discounts on the future publications

Fellows receive discounts on future publications with Global Journals up to 60%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

Career | Financial

GJ Internal Account

Unlimited forward of Emails

Fellows get secure and fast GJ work emails with unlimited forward of emails that they may use them as their primary email. For example, john [AT] globaljournals [DOT] org.

Career | Credibility | Reputation

Premium Tools

Access to all the premium tools

To take future researches to the zenith, fellows and associates receive access to all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

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Organize seminar/conference

Fellows are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent. Additionally, they get free research conferences (and others) alerts.

Career | Credibility | Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

All fellows receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

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Earn 60% of sales proceeds

Fellows can publish articles (limited) without any fees. Also, they can earn up to 60% of sales proceeds from the sale of reference/review books/literature/ publishing of research paper. The FSFRC member can decide its price and we can help in making the right decision.

Exclusive | Financial

Reviewers

Get a remuneration of 15% of author fees

Fellow members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

Access to Editorial Board

Become a member of the Editorial Board

Fellows may join as a member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. Additionally, Fellows get a chance to nominate other members for Editorial Board.

Career | Credibility | Exclusive | Reputation

And Much More

Get access to scientific museums and observatories across the globe

All members get access to 5 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 10 GB free secure cloud access for storing research files.

ASFRC

ASSOCIATE OF SCIENCE FRONTIER RESEARCH COUNCIL

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Career | Credibility | Exclusive | Reputation

CERTIFICATE

RECEIVE A PRINT ED COPY OF A CERTIFICATE

Associates receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

Career | Credibility | Exclusive | Reputation

DESIGNATION

GET HONORED TITLE OF MEMBERSHIP

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Career | Credibility | Exclusive | Reputation

RECOGNITION ON THE PLATFORM

BETTER VISIBILITY AND CITATION

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Career | Credibility | Reputation

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john [AT] globaljournals [DOT] org.

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Earn 30-40% of sales proceeds

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Exclusive Financial

Reviewers

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Associate members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

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Get access to scientific museums and observatories across the globe

All members get access to 2 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 5 GB free secure cloud access for storing research files.

Associate	Fellow	Research Group	Basic
$4800 **lifetime designation**	$6800 **lifetime designation**	$12500.00 **organizational**	APC **per article**
Certificate, LoR and Momento 2 discounted publishing/year **Gradation** of Research 10 research contacts/day 1 **GB** Cloud Storage **GJ** Community Access	**Certificate,** LoR and Momento **Unlimited** discounted publishing/year **Gradation** of Research **Unlimited** research contacts/day 5 **GB** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**Certificates,** LoRs and Momentos **Unlimited** free publishing/year **Gradation** of Research **Unlimited** research contacts/day **Unlimited** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**GJ** Community Access

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- o You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- o Give details of all of your remarks as much as possible, focusing on mechanisms.
- o Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- o One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- o Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation)
by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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