CHAPTER 2

Effective Crop, Soil and Pest Management: A Panacea to Food Security

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Abstract

The decreased food production, increases in the prices of food, growing production of bio-fuels are part of the causes for the current rates of food scarcity particularly in less developed countries. Global warming, crop diversity loss and urban sprawl also affect agricultural production. The increasing human population in the less developed countries have put greater pressure on the land leading to destruction of vital forest resources and the overexploitation of cultivable land. The build-up of human-generated greenhouse gases both in the developed and the less developed countries has been the main cause of climate change that threatens food security and healthy environment. Effective soil, crop and pest management techniques have been proved the possible ways to minimise environmental degradation, pollution of surface water and contributing to the mitigation and adaptation of climate change. Appropriate tillage practises and application of organic and inorganic fertilizers coupled with introduction and production of improved crop varieties that are early maturing, high yielding and resistant to plant and diseases have ensured the desirable food security. The control of weed, can be achieved through tillage practises and appropriate application of herbicides while the control of insect pests and diseases through application of insecticides, fungicides, nematicides and other agro-chemicals or the biological control methods, can result in high crop yield.

Keywords: Population growth, food production, climate change, tillage practices, fertilizer application, pest control.

Introduction

Food security is aptly defined as the access of people to sufficient, safe and nutritious food that meets their dietary needs for a healthy life. The emphasis will be on dietary needs and not the preferences which will necessitate, making informed decisions about food choices. Food, which is usually of animal or plant origin, is the main source of energy and of nutrition for animals. The basic food energy sources are carbohydrates, proteins, fats and oil, mineral salts and vitamins. Generally, dietary fats are essential to give the body, energy and support cell growth, keep the body warm and also help the body absorb some nutrients and produce important hormones. Proteins which basic structure is a chain of amino acids, are required for the structure, function, and regulation of the body's tissues and organs. Carbohydrates function to provide energy to the body and also to aid in digestion from consumption of dietary fibre. Vitamins are organic compounds essential for normal growth and nutrition and are required in small quantities in the diet as they cannot be synthesized by the body. Certain medical conditions can result if enough

of any kind is not taken. Vitamins and minerals boost the immune system, support normal growth and development, and help cells and organs carry out their metabolic functions.

Food security and population growth are two inseparable phenomena, as increase in population must be accompanied with higher food production indicating that population growth requires the production of more food. The population in the world is reported to be growing at around 1.07% per year with the current world population estimated at over seven billion (Walker, 2016). The top largest countries by population are listed in Table 1 while the temporal world population outlook between 1955 and 2019 is given in Table 2.

Table 1: The 20 top largest countries by population

S/N	Country	Population
1	China	1,419,868,226
2	India	1,368,168,149
3	U.S.A.	329,003,075
4	Indonesia	269,430,221
5	Brazil	212,333,702
6	Pakistan	204,449,235
7	Nigeria	200,763,776
8	Bangladesh	168,000,117
9	Russia	143,898,218
10	Mexico	132,267,173
11	Japan	126,867,480
12	Ethiopia	110,034,168
13	Philippines	108,044,380
14	Egypt	101,098,993
15	Vietnam	97,392,717
16	D.R. Congo	86,620,945
17	Turkey	82,921,256
18	Iran	82,789,414
19	Germany	82,433,034
20	Thailand	69,301,608

Source: https://www.worldometers.info/world-population/

Table 2: The temporal outlook of world population between 1955 and 2019.

Year	Population
2019	7,714,576,923
2018	7,632,819,325
2017	7,550,262,101
2016	7,466,964,280
2015	7,383,008,820
2010	6,958,169,159

2005	6,542,159,383
2000	6,145,006,989
1995	5,751,474,416
1990	5,330,943,460
1985	4,873,781,796
1980	4,458,411,534
1975	4,079,087,198
1970	3,700,577,650
1965	3,339,592,688
1960	3,033,212,527
1955	2,772,242,535

Source: https://www.worldometers.info/world-population/

Effects of population growth on food security

The increase in human populations puts croplands and water supply upon which food production depends, under strain. This will require expansion of cropland that involves destruction of vital forest resources and the overexploitation of cultivable land. Previous investigation conducted by Hall *et al*. (2017) revealed that projected rapid population growth would be a leading cause of food insecurity and widespread undernourishment across Africa. The effect of population growth on agriculture production varies across regions. Developing regions present higher population growth rates and lower agriculture production growth rates. Most of the future population growth might be occurring in developing countries, with limited ability to feed their growing populations or import food. The situation had been that of poor input and output markets, declining yield levels due to the lack of nutrients, and continued population growth. For instance, the total fertility rate, a measure of the average number of children a woman will have over her lifetime, in East Africa in 2007 was 5.5 compared to the world average of 2.7 (Dorélien, 2008). In many regions, the number of humans exceeds the carrying capacity of the land area in which they live and this had been the cause of many biologically and ecologically destructive phenomena.

Human population growth and activities and climate change

The build-up of human-generated greenhouse gases in the atmosphere that can cause global climate disruption has been identified as threat to the ecology and biodiversity of the earth which can further be a threat to food security. The connections between population and environment (climate factors) would depend on social (cultural factors) and economic aspects. Previous research, had revealed that a society with a small population size and higher economic growth as in developed countries may generate more emission than a society with a large population and small economy such as developing countries. The high emissions of greenhouse gases has been adduced to the concentration of industries and wealth in the developed countries while poor people in developing countries feel the impacts more because of vulnerable geography and lesser ability to cope with damage from severe weather and rising sea levels. The situation has become exacerbated due to unchecked deforestation perpetrated by people in the developing countries.
The scenario of increased human population on climate change can be lucidly explained in the regard of effect of population growth in the United States of America on climate change. More than half of the U.S. population now lives in car-dependent suburbs which indicates that

transportation sector now accounts for one-third of all U.S. carbon emissions while another significant percentage of U.S. carbon emissions comes from the residential sector. The consumption pattern of the people exacerbates the carbon footprint inherent in the basic energy needs of the increasing population.

Climate change will increasingly affect the basic elements of life which include water availability, food production, health and the environment. Food production, which is closely linked to water availability will be adversely affected in regions where water is scarce. However, the main two positive ways to respond to climate change are mitigation and adaptation. Mitigation addresses the ways to reduce climate change itself by lowering the emission of greenhouse gases while the adaptation is to take action to reduce the adverse consequences of climate change (Parikh and Painuly, 1994).

Agriculture is extremely influenced by climate (factors), which in turn is affected by agricultural activities through emitting Green House Gases (GHGs). Increased concentration of CO_2 in the atmosphere could increase rate of photosynthesis and water use efficiency by plants, which may result in improved growth and yield of plants. However, increased level of CO_2, temperature and precipitation could favour insect, pests infestation and plants diseases (Mugambiwa and Tirivangasi, 2017). Agronomic aspects of agriculture that address crop, soil and pest management should be viewed in an intertwined perspective in order to ensure sufficient availability of food of plant sources.

Effective crop, soil and pest management in ensuring food security

The factors that affect crop, growth and yield are climatic, soil and crop. Many of the factors can be controlled by the growers and for high yield, the factors must operate in unison because they are interrelated. The climatic factors, cannot in the real sense be managed, with the exception of rainfall through irrigation. However, many of the soil and crop factors can be modified to obtain high crop yield. The list of selected factors under the climate, soil and crop categories is presented in Table 3.

Table 3: Selected factors affecting crop growth and yield

Climate Factors		**Soil Factors**		**Crop Factors**	
Precipitation	Quantity	Depth (root zone)		Crop species or variety	
	Distribution				
Air temperature		Texture		Planting date	
Relative humidity		Structure		Seed quality	
Light	Quantity	Cation exchange capacity		Seeding rate and row spacing	
	Intensity	Base saturation			
	Duration	Slope and topography			
Altitude		Soil temperature		Evapotranspiration, water quality	
Wind	Velocity	Soil management factors	Tillage	Pests	Insects, diseases
	Distribution		Drainage, Fertilizers		Weeds
CO_2 Concentration		Organic matter		Harvest efficiency	

Source: Tisdale *et al.* (2003)

Soil and crop management strategies that included site specific nutrient management, integrated nutrient management, integrated soil fertility management, integrated soil crop system management, sustainable water management, conservation agriculture, sustainable land management, breeding strategies are approaches that can ensure food security (Shah and Wu, 2019). Before the commencement of the cropping season, the farmer should make the important decision of which type of crop to be cultivated. This would be followed by subsequent operational requirements of water management in relation to crop moisture requirements, tillage and land preparation, liming or acidity control, fertilizer use and crop protection. The first and basic factor to be considered on the selection of crop, is soil suitability.

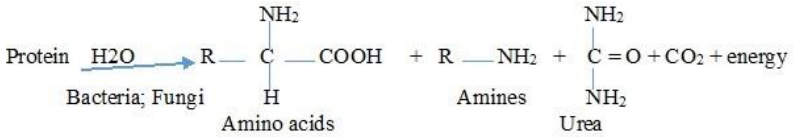
Technological improvements in agriculture are an approach that can ensure food production to comfortably exceed population growth to obtain decline in food prices. The single important factor that has differentiated the developed countries that have sustained long term productivity growth in agriculture from the developing countries that do not have such sustained growth is the attention to agricultural research and development. Countries that have steady stream of new technologies suitable for local farming systems have achieved sustained growth rates in agriculture (Evenson and Fugile, 2010).

The attempt to accomplish the growing food demands of the rising human population requires changes in the production, storage, processing and distribution of agricultural produce. The production and processing aspects can effectively be improved through effective soil, crop and pest management.

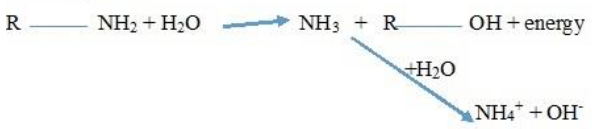
Soil management for food security.

Soil management is the application of operations, practices and treatments to protect the soil and ensure the fertility sustainability. The soil is the ultimate source of mineral nutrient and also to sustain most living organisms that are involved in decomposition and subsequent mineralisation of plant residues to make nutrients in the unavailable organic forms to the inorganic forms for plant's uptake. This is illustrated in nitrogen mineralisation processes of aminization and ammonification schematically represented below:

Aminization



Ammonification



The primary objective of soil management is to provide and maintain good soil structure that is favourable to crop growth. Adoptable good cultural practises such as proper tillage operations,

appropriate organic and inorganic fertilizers, maintaining desirable soil acidity that will ensure nutrient availability are desirable in ensuring soil fertility sustainability. The schematic presentation of soil factors affecting crop growth and yield is shown in Figure 1.

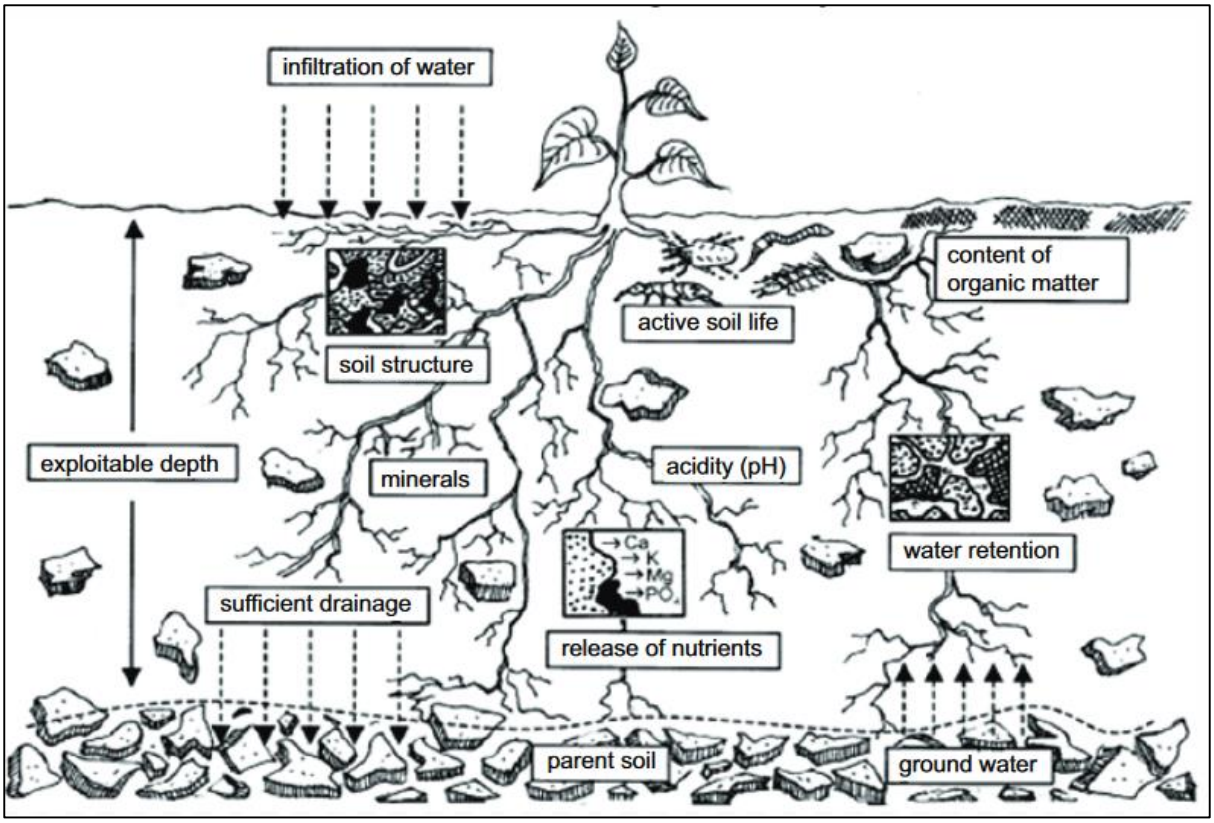


Figure 1. Schematic presentation of soil factors affecting crop growth and yield.
Source: Kostov, 2016

***Adoptable tillage operations*.**

Tillage is the physical, chemical and biological soil manipulation to create the best condition for seed germination, seedling emergence and establishment and it plays a major role in maintaining the productivity of soils. Appropriate tillage operations will minimise accelerated soil erosion and sustainability of soil fertility (Adekayode *et al*., 2008). The two broad types of tillage systems used in seed bed preparation are conventional and conservation tillage. The conventional tillage systems consist of primary and secondary tillage operations that involve ploughing, harrowing, ridging and other subsoil operations. The conservation tillage systems can be classified into reduced, minimum, strip, mulch and zero tillage systems. The production of all crops, irrespective of ecological conditions will require some form of tillage with the main objectives to improve the physical, chemical and biological properties of the soil.

Conventional tillage practices may adversely affect long-term soil productivity due to erosion and loss of organic matter in soils whereas conservation tillage of no-tillage and reduced tillage have significantly higher soil organic matter contents compared with conventionally tilled soils. The advantages of conservation tillage practices over conventional tillage include, allowing crop

residues to act as an insulator and reducing soil temperature fluctuation, building up soil organic matter, conserving soil moisture and reduction in cultivation cost.

Appropriate fertilizer application

A fertilizer is any material of synthetic or natural origin that is applied to soils or to plant tissues (usually leaves) to supply one or more plant nutrients essential to the growth of plants. It can be classified according to its ingredients and can be solid, liquid, inorganic or organic. Generally as a convention, fertilizers are marketed with three numbers that indicate the ratio by weight of nitrogen, phosphorous and potassium. The inorganic or synthetic fertilizers can be classified on the basis of type and form of nutrients and they are prepared as nitrogenous fertilizers, phosphate fertilizers and potash fertilizers. Appropriate fertilizer application will prevent over fertilisation, land and surface water pollution and reduction in greenhouse gases that result in climate change (Adekayode and Akomolafe, 2013).

Organic fertilizers are fertilizers derived from animal matter, animal excreta (manure), human excreta, and vegetable matter (compost and crop residues) and they are naturally occurring. The common organic fertilizers used in crop production are, alfalfa meal, fish emulsion, cotton seed meal, corn gluten meal, seaweed, cow manure, chicken manure (poultry), farm yard manure, compost, mycorrhiza, green manure and vermicompost. Both organic and inorganic fertilizers provide the nutrients that plants will need, to grow healthy and strong.

Irrigation needs

Optimum soil moisture condition is needed for good crop performance. Situation of water stress will require quality water for irrigation. Irrigation is the controlled application of water for agricultural purposes through man-made systems to supply water requirements that are not met by rainfall. The main irrigation types are, the surface, drip and sprinkler.

Favourable soil physical, chemical and biological properties obtained through appropriate tillage operations, appropriate organic and inorganic fertilizer application and optimum soil moisture are needed to provide the essential elements needed by crops in the soil to grow well for high yield. The list of the essential elements and the ionic forms in which they can be absorbed by plants for proper growth is given in Table 4.

Crop and pest management

Crop and pest management practices are the various agricultural practices used to improve the growth and development in order to obtain high yields. The field practices include crop irrigation, mechanical, biological and chemical methods of combating weeds, pests and diseases. The reason the potential maximum yield of most crops far exceeds the current yield levels can be adduced to the omission of any of the necessary field practices.

Table 4: Essential elements and the ionic forms in which they are absorbed in plants.

S/N	*Elements*	*Forms absorbed in plants*
	Macronutrients	
1	Carbon (C)	CO_2
2	Oxygen (O)	O_2
3	Hydrogen (H)	H_2O
4	Nitrogen (N)	NO_3^-, NH_4^+
5	Phosphorus (P)	$H_2PO_4^-$, HPO_4^{2-}
6	Potassium (K)	K^+
7	Calcium (Ca)	Ca^{2+}
8	Magnesium (Mg)	Mg^{2+}
9	Sulphur (S)	SO_4^{2-}
	Micronutrients	
10	Iron (Fe)	Fe^{2+}, Fe^{3+}
11	Manganese (Mn)	Mn^{2+}
12	Zinc (Zn)	Zn^{2+}
13	Copper (Cu)	Cu^+, Cu^{2+}
14	Boron (B)	BO_3^{3-}, H_3BO_3
15	Molybdenum (Mo)	MoO_4^{2-}
16	Chlorine (Cl)	Cl^-

Plant breeding

This is the science of changing the traits of plants in order to produce desired characteristics. Plants that are closely or distantly related but with the most desirable qualities would be crossed to produce offspring that inherit the desired traits. The contribution of plant breeding in crop improvement programme becomes increasingly recognised as the world faces up the major challenges of population growth, overexploitation of cultivable land and climate change resulting from the anthropological activities of man. The manipulation of plant species that involves either controlled pollination, genetic engineering followed by artificial selection result in producing desired genotypes and phenotypes for such specific purposes of early maturing, increase yield and resistance to pest attack (Horn *et al.,* 2017).

Pest and disease control

The control of soil-borne pests and diseases is particularly desirable. The several methods of controlling soil-borne diseases include fumigation and sterilization by gasses or steaming and the use of fungicides and insecticides. However, some fumigants such as dichloropropene, methyl bromide and methyl isothiocyanate destroy a large proportion of the soil micro-organisms responsible for supplying available nitrogen to the plant; this makes the adoption of chemical control a careful choice. The insecticides and fungicides can either be contact or systemic and either organic or synthetic and the emphasis too would be placed on the active ingredient.

Weed abundance in the farm is a nuisance as they compete for space, light, moisture and nutrients and also act as hosts for pathogens, insects and nematodes. The very fact that weeds interfere with harvesting and also that they significantly reduce the quality and yield of crops make their control imperative. Weeds are removed manually, mechanically or with the use of herbicides. In some instances, manual method can be recommended when the crop is too dense to allow machinery or herbicides which may affect the quality of the crops or due to the highly toxic effects of the chemicals which influences not only the crops grown, the broader environment but also the consumers of the crops. The herbicides are categorised into types of pre-emergence or post emergence, selective or non-selective, contact or systemic. The emphasis is rather placed on the active ingredient rather than the trade name under which it is marketed.
The advantages in the use of chemical pesticides not are in regard to the ease with which they can be applied, their relatively low cost, their effectiveness, availability and stability, it is noteworthy to consider the disadvantages in toxicity both to the organisms for which they are intended to control, and other beneficial organisms. Pesticides might be effective for only a period on a particular organism which can mutate and develop resistance thereby requiring other pesticides to control them. The control of pests can also be achieved with biological control methods using natural predators or parasites (macrobials), micro-organisms (microbials) and resources of natural origin and pheromones (biochemicals).

Conclusion

Effective soil, crop and pest management techniques can ensure food security and avert hunger and the attendant social and civic unpleasantness. Soil management that entails appropriate tillage practices will prevent accelerated soil erosion and depletion of soil nutrients and fertility in order to obtain high crop yield. The application of appropriate organic and inorganic fertilizers will prevent over-fertilisation of the soil thereby minimising land degradation, pollution of surface water and the reduction in the emission of greenhouse gases which is the major cause of climate change that forms the main threat to food security and healthy environment.

Plant breeding leads to the introduction and production of improved crop varieties that are early maturing, high yielding, bio-fortified and resistant to pest and diseases. This will result in increased food production to ensure food security and healthy living.

The control of weeds through mechanical means or the appropriate application of herbicides will create the needed favourable environment for crops to grow and produce significantly high yield. The control and possibly the prevention of infestation of insect pest, fungi and other pathogens both in the field and in storage by the application of insecticides, fungicides, nematicides and other appropriate chemicals or the biological control methods will ensure abundant and healthy produce for direct consumption or to feed the agro-allied industries.

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