A REVIEW OF THE SHORTCOMINGS OF MAIZE PRODUCTION IN WEST AFRICA AND THE CHEMICAL SOLUTIONS

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Frederick Teghtegh, SAMOH[1*]; Godwin Ogbaji, EGAH[2]; John Owoicho, ONUH[3]; Olamide Mohammed ISSA[4]

[*1]Department of Chemistry, Faculty of Physical Science, University of Ilorin, Ilorin, Kwara State, Nigeria
[2]Chemical Sciences Department, Faculty of Pure and Applied Sciences, Federal university Wukari, Taraba State,
[3]Centre for Food Technology and Research, Benue State University, Makurdi, Benue State, Nigeria
[4]Department of Food Science and Biotechnology, Teesside University, Middlesbrough
Corresponding email: samoh.ft@unilorin.edu.ng

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Abstract

Maize seeds have various uses in our communities. They have very important roles in ensuring food security and a healthy dieting. However, research suggests that the optimal production practices of maize in West Africa are still not fully overcome. Their potential yields and rapid propagation could be of benefit if explored more comprehensively. This review presents the literature relating to the current production practices of maize in West Africa. It organizes the findings into the following contributions; the yield and propagation challenges of maize production, the health and nutritional benefits, the opportunities that comes with the production of this crop and the chemistry solutions to these challenges. A major obstacle is that farmers are not valuing local traditional methods of improving these crop production. The results show the need for farmers to be enlightened on the use of cheaper agricultural waste materials as a resource to improving the production of this indigenous food crop.

Key words: Agricultural Wastes, Food Security, Maize production, Phytochemicals, Bio-Fertilizer, Bio-Pesticides

Introduction

Maize (*Zea mays L.*) is a principal staple crop, produced and consumed by almost all farming households in West Africa. It is mostly produced by smallholder resource poor farmers during rainy conditions. The crop is well adapted and grows in most of the ecological zones of West Africa including the northern savannahs. It provides a major source of calories (Obour *et al.*, 2022). Today, maize utilisation goes beyond human consumption. It is also used for livestock feed production especially by poultry farmers. This had led to increase in the demand for maize in the market (Traore *et al.*, 2018). Hence stimulating the need for increase in its production

Maize Description and Cultivation

For optimum growing conditions, maize grows better in light (sandy), medium (loamy), and heavy (clay) soils and where the soils are well-drained. The soils can be slightly acidic or neutral and it cannot grow in the shade. Also, it needs a cultivated bed of soil to thrive. A maize plant requires nitrogen, phosphorus and potassium nutrients to thrive and is generally attained through chemical fertilizers or manure. They are added usually before plowing, at planting time or as the plants grow. Sweet corn generally begins developing two to three days after it is planted (Falade and Labaeka, 2020)

Zea mays plant has a single stalk structure supported by adventitious roots or prop roots. The roots act as a mechanism of support for the plant. The maize cob originates from the stalk and leaves and can be seen above the soil. The roots below the soil surface are used to absorb water and minerals from the soil. About twenty long, broad leaves grow off the stalk, but only fifteen usually survive until maturity. The leaves of the plant are used in photosynthesis to produce sugars. The flowering parts of the plant are the tassel at the very top, the stalk (male reproductive structure) and the ear (female reproductive structure). The ear is protected by a husk and is about nine inches long with about eighteen rows of kernels. Since *Zea mays* is a monocious plant, these flowers aid in reproduction. The ear is covered by kernels and protected by a husk. This is shown in Figures 1.

Fig 1; Maize Plant and Seed

For the cultivation of *Zea mays*, it has a growing season of four to six months. This generally begins in April or early May. The soil is prepared for planting by using a plow. The plow breaks the soil up to a depth of six to ten inches and spaces each row of corn twelve to sixteen inches apart. This protects the soil from erosion. The optimum soil temperature for planting *Zea mays* is fifty-five degrees Fahrenheit. Seeds are planted fifteen to thirty inches apart and about two inches deep. Harvesting usually takes place when the moisture content of the mature kernels reaches 28 percent. This is usually between August and late October. A corn combine picks the ears off the stalks, removes the husks, and shells the corn. The shelled grain is dried by heated air and stored in bins until further use (Bioweb, 2022)

Nutritional Profile of Maize

Maize is an edible and nutritive part of the plant. The composition of maize seed is presented in Table 1. It also contains vitamin C, vitamin E, vitamin K, vitamin B1 (thiamine), vitamin B2 (niacin), vitamin B3 (riboflavin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine), folic acid, selenium, N-p-coumaryl tryptamine, and N-ferrulyl tryptamine. Potassium is a major nutrient present which has a good significance because an average human diet is deficient in it (Kumar & Jhariya, 2013). Roasted maize kernels are also used as coffee substitute (Breadley, 1992).

Table 1. Composition Per 100 g of Edible Portion of Maize

Composition	Amount per 100 g
Carbohydrate	71.88 g
Protein	8.84 g
Fat	4.57 g
Fiber	2.15 g
Ash	2.33 g
Moisture	10.23 g
Phosphorus	348 mg
Sodium	15.9 mg
Sulfur	114 mg
Riboflavin	0.10 mg
Amino acids	1.78 mg
Minerals	1.5 g
Calcium	10 mg
Iron	2.3 mg
Potassium	286 mg
Thiamine	0.42 mg
Vitamin C	0.12 mg
Magnesium	139 mg
Copper	0.14 mg

(Source: Shah *et al*., 2015; Gopalan *et al.*, 2007))

Phytochemical Value of Maize (Zea mays)

Phytochemicals are bioactive chemical compounds naturally present in plants that provide human health benefits and have the potential for reducing the risk of major chronic diseases (Liu, 2004). Maize is an essential source of various major phytochemicals such as carotenoids, phenolic compounds, and phytosterols (Lopez-Martinez *et al*., 2009). The concentration of carotenoids, phenolic compounds, and phytosterols are as presented in Table 2.

Table 2. Concentration of Major Phytochemical Compounds of Maize

Compounds	Concentration (mg/100gm)
(1) Caroteniods	
(a) Carotene	2.20
(b) Xanthophylls	2.07
(i) Lutein	1.50
(ii) Zeaxanthin	0.57
(2) Phenolic compounds	
(a) Ferulic acid (FA)	174
(b) Anthocyanins	141.7
(3) Phytosterols	14.83
(a) Sitosterol	9.91
(b) Stigmasterol	1.52
(c) Campesterol	3.40

(Source; Rouf *et al*., 2016)

Health Benefits of Maize

Maize is an essential source of various phytochemicals that play an important role in our health (Kopsell *et al.*, 2009). There is inverse correlation between the consumption of phytochemicals and the development of chronic diseases. This is due to their potent antioxidant activities towards reducing the risk of many health diseases (Rouf *et al*., 2016) as shown in Table 3.

Table 3. Summary of Health Benefits of Maize

Phytochemical	Maize Part	Functions	Reference
B-complex vitamins	Maize seed	Good for the skin, hair, heart, brain, and proper digestion. It also prevents the symptoms of rheumatism	Rouf *et al.*, 2016
vitamins A, C, and K together with beta-carotene and selenium	Maize seed	Improves the functioning of thyroid gland and immune system	Rouf *et al*, 2016
Potassium	Maize seed	A major nutrient with diuretic properties	Rouf *et al*, 2016
Flavonoid antioxidants Decoction or crude extracts	Maize Silk silk, roots, and leaves	To treat kidney stones, urinary tract infections, jaundice, and fluid retention. Has a potential to improve blood pressure, support liver functioning, and produce bile. It acts as a good emollient for wounds, swelling, and ulcers Used for bladder problems, nausea, and vomiting, while decoction of cob is used for stomach complaints	Kumar & Jhariya, 2013
Essential fatty acids, especially linoleic acid Vitamin E	Maize oil Maize oil	Plays an important role in the diet by maintaining blood pressure, regulating blood cholesterol level, and preventing cardiovascular maladies Vitamin E in maize oil which is known as a key chain breaking antioxidant prevents the promulgation of oxidative stresses in biological membranes and prevents the development of atherosclerosis through intervention of maize oil in the diet	Sen *et al*., 2006 icciarelli *et al.*, 2001
Zein (alcohol-soluble prolamine)	Maize endosperm	It is GRAS (generally recognized as safe), nontoxic, and biodegradable protein. It acts as a nanoscale biomaterial that has unique solubility and film-forming properties. It has novel applications in pharmaceutical and nutraceutical areas to coat nanoparticles, develop promising nanocomposite antimicrobial agents, produce novel food packaging, encapsulate nutrients, and provide target delivery with controlled release.	Lai & Guo, 2011;
Resistant starch	Maize endosperm	It escapes digestion and its consumption helps in altering microbial populations, lowering cholesterol and enhancing its fecal excretion, increasing the fermentation and short-chain fatty acid production in large intestine, reducing symptoms of diarrhea, which altogether reduce the risk of cecal cancer, atherosclerosis, and obesity- related complications	Murphy *et al.*, 2008
Carotenoid pigments	Maize seed	These pigments are also beneficial in preventing cancer	Michaud *et al.*, 2000

The Opportunities in Maize Production

- Small-holder commercialization and market development leading to revenue generation
- Post-harvest management from the use of preservatives to improved storage facilities
- Intensification and improvement of crop production setbacks (Drought resistant varieties, pest/weevils infestation, poor soil nutrients)
- Processing and value addition (Conversion into other products of importance: golden morn, the cornflakes, the packaged roasted corn, the pap and custard,)

Maize Production Output in West Africa

West African countries are known for large production of maize. Quantities produced differ from one country to another and Nigeria is known as one of the largest producer of *Zea mays* in West African. Some countries and their quantities produced are as shown in Table 4.

Table 4: Maize Production output in West African Region for the year 2020 (FAOSTAT, 2020)

Serial No	Area	Value (tones)
1	Nigeria	12,000,000
2	Mali	3,516,865
3	Ghana	3,071,000
4	Cameroon	2,091,263
5	Burkina Faso	1,920,000
6	Benin	1,611,615
7	Cote d'Ivoire	1,175,715
8	Guinea	907,941
9	Togo	885,000
10	Senegal	761,883
11	Chad	407,371
12	Niger	46,597
13	Gambia	35,000
14	Sierra Leone	26,549
15	Mauritania	15,000
16	Guinea-Bissau	7,000

The Yield and Propagation Challenges of Maize in West Africa

West Africa is at the center of massive maize shortages due to unavoidable agricultural farming challenges. These challenges have a huge impact on agricultural productivity (Masih *et al*., 2014). Food insecurity caused by crop failures is growing rapidly in many West African countries, leading to famine, and environmental and financial crises, which can undermine the region's commitment to achieving the UN Sustainable Development Goals (SDGs) by 2030, especially SDG 1: End poverty in all its forms everywhere and SDG 2: End hunger, achieve food security, improved nutrition and promote sustainable agriculture (United Nations, 2022). Table 5, hence, summarizes the key challenges of maize production in West Africa to be majorly the high cost of agro inputs, poor income of farmers and the biotic factors. These Challenges are reviewed on Table 5;

Table 5: A Review of Challenges of Maize Production in West Africa

Country	Activity	Constraints of Maize Production	Reference
Burkina Faso	Indentifying farmers' preferences and constraints to maize production in two Agro-ecological zones in Burkina Faso	The most important constraints mentioned by farmers across sites were unreliable rainfall followed by *Striga*, weeds and termites. In addition, high cost or lack of seeds and fertilizer.	Dao *et al.*, 2015
Cameroon	Evaluating the Constraints and Opportunities of Maize Production in the West Region of Cameroon for Sustainable Development	The major maize production constraint was poor access to credit facilities. Farmers do not have enough labor supply from their household for the purpose of maize production 16.7% had the problem of inadequate training, 12.5% had problem of high cost of inputs, 11.66% had problem of pest and diseases, 12.5% had poor marketing system, 10% had faced the problem of poor storage facilities.	Abu *et al.*, 2011
Ghana	The 2020 Maize Production Failure in Ghana: A Case Study of Ejura-Sekyedumase Municipality	The recurrence of drought during the 2020 minor growing season resulted in the withering and failure of the maize plant. The prevalence of diseases and pests like fall armyworm attacks on maize plants, contributed substantially to the maize production failures. Other factors were poor soils, a general lack of inputs and under-resourced mechanization	Obour *et al.*, 2022 Boon and Anuga, 2020
Mali	Factors Influencing Maize Production in Sikasso Region of Mali	The low educational level of respondents could have negative effect on their receptivity of innovations and its an important factor in accessing subsidized inputs, agricultural information and in understanding the need for involvement in agricultural intervention programme such as input subsidy programme ,High cost of inputs. Inputs are not sufficient to meet maize producers need. Inputs not readily available. Remoteness of maize producers location. Inadequate credit. Input is of poor quality. Inputs not easily accessible. Poor information.	Traore *et al.*, 2018
Nigeria	A Review of production constraints confronting Maize crop in Northern Nigeria and the way forward	**Biotic conditions** ***Pests*** like monkeys, rodents, arthropod insects, mollusks, Stem borers (*Busseola fusca* and *Sesemia calamistis*); shoot flies (*Atherigona* spp); grasshoppers (*Zonocerus variegatus*) and army worms (*Spodoptera exempta* and *Helicoverpa armigera*) ***Diseases*** play an important role in the reduction of the potential yield of cereal crops. Agents causing diseases included; bacteria, fungi, viruses, nematodes **Abiotic Factor** The various abiotic factors including climatic, edaphic, nutrient deficiency, agronomic, logistic and social contributors	Falade and Labaeka, (2020)
Benin	Determinants of maize farmers' performance in Benin, West Africa	The results of the estimation suggested that the quantity of labor, fertilizer, capital, and seeding rate had significant and positive effects on the productivity of maize. The use of fertilizer significantly increased land productivity. Furthermore, WFP (2014) showed that depletion of land fertility and land degradation are the main problems faced by farmers in Benin, making access to fertilizer indispensable for maize production in the country. Farm size significantly and negatively affected farmers' productivity.	(Amegnaglo, 2018) WFP, 2014
Senegal, Mauritius, Niger, Mali, Ghana, Burkina Faso,	Sensitivity of Maize Yield in Smallholder Systems to Climate Scenarios in Semi Arid Regions of West Africa: Accounting for Variability in Farm Management Practices	Across climate models, variations in fertilizer application, planting dates and soil types explained the variation in the impact among farms.	MacCarthy *et al.*, 2019
Togo	Yield Performance and Economic return of Maize as affected by Nutrient Management Strategies on Ferralsols in Coastal Western Africa	That the most significant biophysical constraint to increased production of crops in SSA is the poor mineral and organic content of the soils. Low affordability capacity of the required large amount of fertilizer and liming	Detchinli and Sogbedji, 2015

The Chemist Solutions to Maize Production Challenges

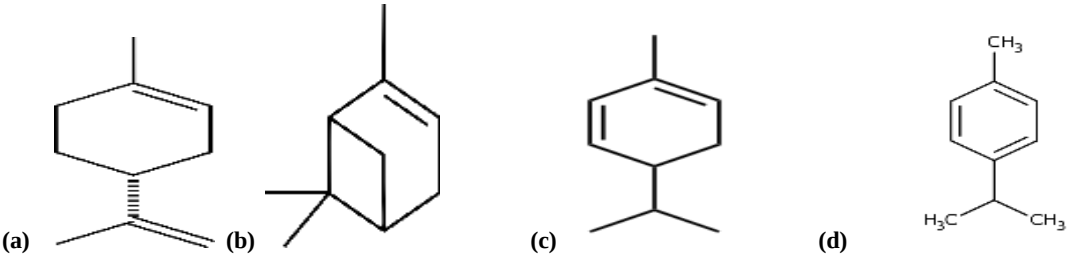
Agriculture is the primary economic activity within sub-Saharan Africa (Berg *et al.*, 2018). Agrochemicals are one of the key inputs for crop protection and better yield during pre-harvest stage. Judicious use of crop protection chemicals supports sustainable farm management and delivers socio-economic benefits to meet the challenges of feeding an ever-growing population. Agrochemicals include pesticides, insecticides, herbicides, fungicides, preservatives along with fertilizers and soil conditioners (Princy, 2020). They are composed of synthetic chemicals, examples include Perfect Killer for pests, insects and weeds control and NPK/Urea for soil enrichment. Their active ingredient is majorly of inorganic origin and requires precision for their manufacture, a method quite expensive, tedious, and unavailable to the household farmers and products with overwhelming environmental damages (Mohammed, 2022). Some plants ingredients reveal promising potentials as agrochemicals as they are derived from deserted agricultural waste materials such as Orange peels, leguminous plants, and left over stalks from harvested maize as shown in Figures 2 - 4. These are commonly available to household farmers which themselves can cheaply and easily convert into agrochemical products of great importance (Vidhya, 2017).

Fig 2. Orange peel

Fig 3. Legume plant

Fig 4. Maize stalks

Hence there is need to explore the development of safer and cheaper agrochemicals from agricultural wastes, to reduce pre and post-harvest losses of crops, while ensuring food security. It has been reported that most agricultural waste materials have demonstrated promising preservative, fungicidal, pesticidal, insecticidal (Arvinder and Nomita 2011) and bio-fertilizer properties (Judia, 2018). Notable among them are the essential oil and floral water of Citrus peels (Anna *et al.*, 2017), the Nitrogen fixing bacteria and orthophosphate from legume and corn wastes (Yulia *et al.*, 2015). The properties of these agricultural waste materials are attributed to the presence of secondary metabolites such as pinene, limonene, phellandrene, **P**-Cymene, geraniol and terpinene which are present in orange peels (Anna *et al.*, 2017), non-secondary metabolites like phosphorus and nitrogen are present in legume and corn plant wastes (Yulia *et al.*, 2015). Some orange peel Secondary Metabolites are as given in Figures 5.



(a) (b) (c) (d)

Fig. 5: Some orange peel Secondary Metabolites; (a) limonene (b) pinene (c) phellandrene (d) P-Cymene

However, to further correct the inappropriate bio-fertilizer formulation (High Nitrogen, Low Phosphorus and Low Potassium) ratios (Barin *et al.*, 2022), more sources of this elements are required. Ashes (Figures 6) are good sources of Potassium and phosphorus gotten from burnt grasses and woods (Danuta and Mariola, 2022), Local restaurants, village kitchens and will be cheaply available for collection and inclusion during the formulations.

Fig.6; Ashes from Grasses and woods

Unlike the conventional chemicals, the conversion of these waste materials into cheaper, useful and safer agrochemicals does not require any high precision or big technologies, hence, can be produced by both household farmers and industries

Conclusion

Maize is a healthy food due to the presence of nutrients and phytochemicals. The production process of Maize is also characterized by high cost of agro inputs, poor control of biotic factors and cultivated by a majority of low income farmers without access to agrochemical credit systems. Most Agricultural waste materials are cheap and available sources of these nutrients required for soil fertility and maize plant protection. They are easily formulated into useful Bio-Fertilizers and Bio-Pesticides, some simple methods practicable by low income farmers. Hence, farmers needs to be enlightened or trained to produce agrochemicals from wastes, as these in part, addresses the challenges with accessing agrochemical inputs in rural areas and obtaining the required production yield of maize.

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