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SUSTAINABLE FOOD SECURITY STRATEGIES IN URBAN CITIES: COWPEA (*Vigna unguiculata*) L. Walp. AS A COMPONENT OF URBAN FARMS: A REVIEW

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ABSTRACT

Urban and Peri-urban Agriculture (UPA) is a practice of cultivating, processing and distributing food in or around a village, town or city. It is also an industry that produces, processes and markets food and fuel in response to the daily demand of consumers within a town, city or metropolis, on land and water dispersed throughout the urban and peri-urban area. UPA is thus a remarkable concept of food production especially in urban cities. To make the process more sustainable, the element of food security needs to be incorporated into the system. Food security implies a food production system that makes available acceptable and nutritionally adequate food on continuous basis. This calls for the cultivation of crop plants that possess needed nutrients including proteins, vitamins and minerals in adequate quantities, early maturing and easy to cultivate. Cowpea, *Vigna unguiculata* L. Walp. is a dual purpose crop plant that can be cultivated either as vegetable (immature pods, mature pods and germinated seed), as a fermented product or as grain cowpea where pods are dried to produce grains that can be used in various main meal dishes and snacks. The crop is early maturing, producing pods as early as 33 days, is easily cultivated in urban gardens, on roof tops or balconies and the grain contains about 23 - 25% protein, 8 – 9 % vitamins A, B_1 and C; 1.3% fibre and 50 – 67% carbohydrates. This paper reviews the importance and production processes of cowpea and recommends the incorporation of the crop in urban farming and food security strategies.

Keywords: Urban cities, Grain cowpea, Vegetable cowpea, Urban farms, Insect pests, GM cowpea, Food security

INTRODUCTION

It is now acknowledged that the environmental problems created as a result of human activities has led to the climate change, depletion of the ozone layer and loss of biodiversity on a global scale. All these were brought about by population explosion that leads to land clearing, urbanization, deforestation, desertification, erosion, etc. These impacts led to the concept of sustainability which involves three main components: environment, economic and social equity which were earlier defined as follows:

Environmental health – the long term health and stability of natural systems are crucial to human society
Social equity – the wellbeing and stability of the society are important in creating a sustainable world
Economic development – people's basic needs must first be met before they are expected to attend to the needs of the environment around them

As noted by Aliyu and Wachap (2014) as well as other workers, the concept of Urban and Peri-urban Agriculture (UPA) including Urban Gardening (UG) as a practice of cultivating, processing and distributing food in or around a village, town or city has been in existence for quite some time (Baikey and Nasr, 2000). The United Nations Development Programme (UNDP) has defined Urban Agriculture as "an industry that produces, processes and markets food and fuel, largely in response to the daily demand of consumers within a town, city or metropolis, on land and water dispersed throughout the urban and peri-urban area, applying intensive production methods, using and reusing natural resources and urban wastes to yield a diversity of crops and livestock". At present, over 800 million people are engaged in some form of urban farming and gardening (FAO, 1999). However, the most important consideration is the food security aspect of the production system, that is, whether the food produced is nutritionally adequate, and is continuously available (CFSC, 2013). This implies that for our cities to be sustainable, in addition to the necessary general civilian infrastructures, UPA, including UG should have a framework and/or design initiatives that should ensure that the production processes are not only sustainable but also leads to food security to our

cities, that is, providing acceptable, nutritionally adequate food through local, non-emergency sources at all times (IDRC, 2003).

Cowpea is one of the most important food legumes and a valuable component of the traditional cropping systems in the semiarid tropics (Vavilapalli, *et al*., 2014). It is a warm season, annual herbaceous legume crop, whose growth habit ranges from erect, semi-erect to prostrate and twinning forms. The plants have a strong tap root system and the stem may be green or pigmented while the leaves are alternate, trifoliate with one symmetrical terminal leaflet and two asymmetrical leaflets. The crop is commonly known as asperge in French, yard-long bean in English, wake in Hausa, ewa in Yoruba, akidi in Igbo and kunde in Swahili.

The crop is widely known as the crop of the poor because it provides more than half the plant protein in the diets in many developing countries. In addition, it provides the earliest food available before cereals mature (Abizari, *et al*., 2013). For smallholder farmers, cowpea therefore constitutes the assurance of minimum food security during the hungry season as a source of food, animal feed and also as a source of income (Abizari, *et al.*, 2013). The young leaves and shoot are consumed as spinach and provide one of the most widely used pot herbs in Africa. Similarly, the young and immature pods are consumed raw as fresh vegetable or after simple boiling. It also contributes up to 337 kg N ha^{-1} into the soil due to its nitrogen fixing properties and as a residue which benefits the succeeding crops (Bado, *et al.* 2018; Yahaya, 2019). This is in addition to the fact that it grows well in poor soils with more than 85% sand and with less than 0.2% organic matter and low levels phosphorus (Singh, *et al.*, 2003). Interestingly, all the plants' parts that are used for food including the seeds, pods, stem, leaves, are nutritious, providing protein, vitamins, minerals, fibre, carbohydrate, etc. that are the key elements to any sustainable food security programme.

The Food and Agriculture Organization of the United Nations (2014) estimates the annual world cowpea production to be 4.5 million tonnes from an estimated land area of 12.6 million hectares. West Africa accounts for about 80% of the estimated total land area under cowpea cultivation. Nigeria is the largest producer and consumer of the crop with about 5 million hectares area and 2.4million tonnes production annually (Osipitan, 2017), followed by Brazil. Other countries in Africa, e.g. West Africa, are Senegal, Ghana, Mali and Burkina Faso. Ghana, Niger, and Cameroon are significant producers. The major production areas elsewhere in the world are Asia (India, Myanmar) and the Americas (USA, Brazil, West Indies). Of the developed countries, the USA is the most substantial producer and exporter.

Cowpea can be regarded as the fulcrum of sustainable farming in semiarid lands. This applies to West and Central Africa. In these regions, the area of cowpea production extends in a westerly direction from Cameroon through Senegal, lying mainly between 10 °N and 15 °N, covering the dry savannah (northern Guinea and Sudan savannahs) as well as Sahel zones. There are also a few additional pockets of production at more southerly latitudes, where the dry savannah agro-ecology pen-etrates closer into the West African coast, as in Ghana and Benin (DAIS, 2011).

As noted above, the cowpea plant is a herbaceous legume whose growth habit is either erect, semi-erect, prostrate or twining. It is composed of many accessions, varieties or cultivar groups (cultigroups) but broadly grouped into Grain cowpea and Vegetable cowpea. The grain cowpea which is characterized by short and numerous pods per plant is of the cultigroup *unguiculata* whereas the vegetable cowpea, characterized by long and fewer pods is of the subspecies (ssp) *Sesquipedalis*. Both types mature early (38 days) but some varieties and accessions can be late maturing. The nutritional value of cowpea and its easy cultivation - either on the field, in UGs, in house hold gardens, on roof tops, balconies etc. (hence availability) makes it both an environmentally friendly crop as well as an urban farm and food security crop.

GLOBAL USES OF COWPEA

Human Consumption

Pods and seeds of cowpea can be utilized in a variety of ways and the actual nutritional value may be influenced very markedly by the way in which they are used. Some of the ways in which cowpea can be consumed are as follows:

Mature dry seed

Over the years, cowpea has increasingly become a source of nutritious food across various socio-economic strata and it is readily consumed not only by rural populations but also by the more affluent and rapidly expanding urban populations (Abizari *et al.*, 2013). Most of the cowpea produced especially in sub Saharan Africa is consumed as grain cowpea. In those areas, cowpea seeds are prepared and taken in various forms which could be cooked, made into soup or milled

mixed with pepper, onions, groundnut oil and fried and taken as akara, or it is wrapped in leaves and taken as "moin-moin" (Oyenuga, 1968; Hung *et al*., 1990 cited in Alayade *et al*., 2012).

Considerable variability exists in the seed coat colour of cowpea (Fig. 1). The dried seed is storable and if it can be effectively protected against the common storage pests it is an efficient way of ensuring continuity of food supplies from one harvest to the next. Nutritional values does in fact decline gradually in storage, and tenderness of the seed also declines. The grains are used as part of main meals and in numerous snacks.

Fig. 1. Variability in Cowpea seed coat colour and pods (Courtesy of Carl Davies, CSIRO)

Green mature and immature seed

Cowpea, which can be used fully mature and dry, can also be used when mature but before normal drying out occurs. Immature pod and seed are also used in the freezing or canning industries in Western Europe as these tend to be sweet, tender and with the best flavour (Smart, 1990).

Immature pods

Cowpea pods that remain fleshy for two or three weeks after setting can be picked green and used as vegetable. This is the best way to use vegetable cowpea ssp. *Sesquipedalis*. Nutritionally immature fruits have quite a different value from that of the mature seed. The protein content is lower but they are relatively richer in vitamins and soluble carbohydrates.

The practice of using germinated seed and young seedlings of pulses as a fresh vegetable is widespread in the Orient (Smart, 1990). The storage of dried seed, and their sprouting as required, enables a continuous supply of fresh vegetable to be produced at times when they cannot be produced in the field. The vitamin C content rises from negligible levels in the seed to 12 mg per 100 g after 48 h germination. Riboflavin and niacin contents increase significantly and insoluble carbohydrates are also mobilized.

Fermented products

Fermentation of cowpea leaves coupled with solar drying could be of potential for small scale producers as a method of enhancement of the keeping and nutritive quality. However, like other pulses, cowpeas contain several anti-nutritional factors, which may limit their consumption and affect the digestibility and bioavailability of nutrients.

Extracted cowpea proteins

A protein extraction technology could be usefully employed in the extraction of useful cowpea proteins. This can then be used as food additive.

Animal Feed

Although much valued as food, cowpea is also used as livestock feed. Cowpea forage, both the vines and leaves, either fresh, or conserved as hay or silage, is often used for fodder. The haulms, which are the crop residues of seed production, contain about 45-65% stems and 35-50% leaves and sometimes roots, and are an important by-product in Sub-Saharan Africa (Singh *et al*., 2003; Srinivas *et al.*, 2016). Cowpea pod husks obtained after threshing are also used to feed livestock

Contribution to soil fertility and Environmental restoration

Cowpea is particularly useful for building up fertility in soils that have been run down from over cropping. This is due to its nitrogen fixing properties. When the plant is fully nodulated, cowpea can fix 20 to 337 kg N/ha into the soil Bado, *et al.* 2018; Yahaya, 2019). Cowpea forage helps to eliminate the need for a fallow period between a sorghum crop and the following wheat crop, while providing cover to the soil during summer without demanding too much water.

As a cover crop, cowpea can be incorporated into the soil at any time when sufficient green material is available. The crop is also valuable as a green manure where it is intended to provide readily available, biologically-fixed N for subsequent crops.

Cowpea can also help in carbon sequestration since it can be grown year round in gardens because the crop plants can continue to absorb carbon dioxide (CO_2) from the atmosphere and release breathable oxygen. Thus the crop is highly suitable for adoption in urban farm and gardening strategies since it has no much need for fertilizers which may have negative impacts to human and environmental health but rather contributes to soil structure and fertility.

COWPEA PRODUCTION PROCESSES

Climate and Soil

Cowpea is a warm weather crop and requires less rainfall than most crops. It is also tolerant to drought during vegetative growth. The crop also requires dry weather for harvesting. This makes cowpea ideal for urban farming and gardening. It is grown on a range of soil types, but it is best adapted to well-drained sandy loams. The crop is sensitive to water logging that occur when cultivated on heavy clay soils.

Land Preparation

Zero tillage or minimum tillage using hoe can be applied for cowpea production in urban farms and urban gardens. Zero tillage can be practiced with minimal herbicide spray before sowing. However, soils with poor structure and low water infiltration, could do better when ploughed.

Sowing of Cowpea

Generally, sowing cowpea should be timed in relation to the maturity period of the particular accession or variety in such a way that the crop is harvested in bright dry weather. This is because harvesting under humid cloudy weather favours pod rots. Early maturing types should be planted at the beginning of the rains so that the sensitive stages of the crop avoid the peak activity of insect pests. When planting twice in a year in Nigeria, for instance, the first crop may be planted in late April, and the second crop in late July to mid-August.

Seed rates depends on the plant type, that is whether prostrate, climbing or erect. For erect/semi-erect type, the recommended spacing is 60cm × 20cm with two seeds per hill. Local prostrate varieties should be planted wider spacing of 80 cm × 40 cm. It is better to plant in rows because weeding and pesticide application would be easier. Line planting may be done with the aid of garden lines or sighting poles. A lot of improved, high yielding, cowpea varieties including long podded vegetable cowpea accessions, are available for selection for planting (Table 1).

Fertilizer Application

In most cases, cowpea does not need nitrogen fertilizer. The reduced fertilizer requirement makes cowpea a good crop for urban and garden farms. But the application of a starter dose of nitrogen of as low as 20 kg/ha is recommended. However, the application of a single superphosphate at 40kg/ha increases cowpea yield. Phosphorus application also increases nodulation in cowpea plants.

Table 1: Popular Cowpea Varieties and Accessions

S/N	Grain Cowpea	Vegetable Cowpea (Climbing)	Trailing Varieties (Grain)
	TVx 3236	TVu 14861	IT89KD-245
	ITE-18	TVu 14863	KPR 4-96-73
	IT8ID-1137	TVu 14865	KPR 1-96-32
	IT845-2246-4	TVu 14867	KPR 1-96-54
	IT95K-193-12	TVu 14868	PBL 22
	IT8ID-985	TVu 14869	PBL 112
	IT88D-363	TVu 14871	PBL 73
	IT84D-449	TVu 14872	
	IT87D-885	TVu 14874	
	IT82E-16	TVu 3652	
	IT82D-716	TVu 3653	

Source:

Weed Control

Yield losses caused by weeds alone in cowpea production can range from 25% to 76% depending on the cultivar used and environment (Gupta *et al.*, 2016; Ugbe *et al.*, 2016). Weeds harbour insect pests and also compete with the crop for light, nutrients and space. Therefore, weeding should be done by the second week after germination, although this depends on the types of weeds present and how well the land was prepared. Weed control methods could be cultural, physical (manual) or even biological and chemical. The use of herbicide for weed control in cowpea can significantly reduce the need of labour for manual weeding thereby lowering the cost of production. Herbicides are estimated to replace approximately the need for 10 laborers in weed control operations (Gianessi & Reigner, 2007). Examples of pre emergence herbicides include pendimenthalin, fluchloralin, phenoxaprop-p-ethyl, metolachlor and prometryn mixture, Oxyfluorfen etc. Post emergence herbicides include quizalofop ethyl, imazethapyr, fluazifop-butyl etc. (Akobundu, 1982; IITA, 1989). However, cowpea is more sensitive to herbicide than most of the other grain legumes crops (Akobundu, 1987). For example, bentazon has been effectively used for post emergence control of many annual broadleaf weeds in temperate agriculture (Barrentine & Mc Whorter, 1972; Anderson, 1983) but was phytotoxic to cowpea and failed to control commonly occurring weeds of cowpea. Similarly, alachlor was found to be phytotoxic to cowpea in the forest transition zone in Nigeria (Moody, 1973; Akobundu, 1982) but found safe on the crop at higher rate in the southern guinea savanna zone in Nigeria and India (Sigh *et al*., 1975; Lagoke *et al.*, 1982). This indicates that there is varietal response of cowpea to herbicides. If a pre-emergence herbicide such as Stomp 500E is used, the first weeding may be delayed up to 4 weeks after sowing. The farm should be completely weed free by the end of the 6^{th} week when the crop is establishing ground cover. However, chemicals have adverse effects to both human and environmental health and thus requires a great deal of caution in Urban and peri Urban farms and gardens.

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Staking

Climbing varieties and accessions especially vegetable types (ssp. *Sesquipedalis*) with long pods of up to 1m needs stakes to enable them climb and allow the pods to stay clear of the soil level (Fig. 2). Otherwise the pods could be damaged by soil borne pathogens

Fig. 2. Early Maturing Vegetable Cowpea, TVu 14868 (Aliyu and Wachap, 2014)

Harvesting

Harvesting depends on whether cowpea is planted for grain or vegetable. For grain cowpea, matured dried pods should be harvested promptly because delayed harvesting will encourage weevil infestation in the field and the pods could also shatter and lead to seed loss. The pods should be sun dried immediately, and then threshed. Drying is important to reduce moisture content of grains significantly before storage in order to avoid seed infestation by fungi and other diseases.

When planted for vegetable, fresh pods could be harvested when the need arises for home consumption or marketing fresh pods.

A lot of planning needs to be done before reaching this stage. We must have an idea of the life cycle or maturity time of the particular variety or accession to be planted. Many cowpea varieties are early maturing, taking only about 31 to 33 days to flower and 32 -35 days to produce pods (Aliyu and Wachap, 2014). So we would have a great deal of asking and testing to do before we even prepare the land for planting. However, accessions of vegetable cowpea show a significant variety x location and variety x year interactions (Aliyu and Wachap, 2014; Usman, 2017). This implies that the performance of the varieties could vary across locations and years (Table 1).

Table 2. Analysis of variance for Ten agronomic characters of Vegetable cowpea

Source of Variation	Df	Days to first flowering	Days to first pod	Leaf length (cm)	Number of branches	Pod length (cm)	Fresh pod weight (kg)	Number of pods per plant	Number of seeds per pod	100 seed weight (g)	Grain yield (kg)
Replication	2	12.23	2.47	3.58	0.07	25.31	115312**	9.8	1.82	0.79	0.007
Rep x loc.	1	98.82	93.75	0.14	0.15	0.50	105.3	91.27	0.01	4.11	0.12
Gen.x loc.	9	27.71	29.79**	1.98	0.63	129.7*	18282	8.2	2.35	1.16	0.02**
Genotype	9	205.7	245.7	2.16	3.16	1013.4	38905.7	60.56	1.38	7.9	0.04
Error	21	14.1	7.48	1.04	0.38	62.63	7502	4.24	1.99	1.17	0.003

*Significant at 0.05; ** Significant at P= 0.01. Rep in loc=Replication in location and Gen. x loc.= Genotype x location (Usman, 2017).

Storage

Grain cowpea should be threshed before storage. Storage in pods makes control of cowpea weevil more difficult. Applying pesticides to cowpea seeds will leave the crop with high pesticide residues which is dangerous to health. For small quantities of seed, traditional storage in wood ash is effective. For large quantities, the heat disinfection technique is recommended. Cowpea weevil, larvae and eggs are killed when exposed to temperature of around 57^{o}C for one hour.

` The use of Purdue Improved Crop Storage System (PICS) bag, developed by Purdue University, USA, Scientists under funding by USAID is now more widely recommended (Fig.1).

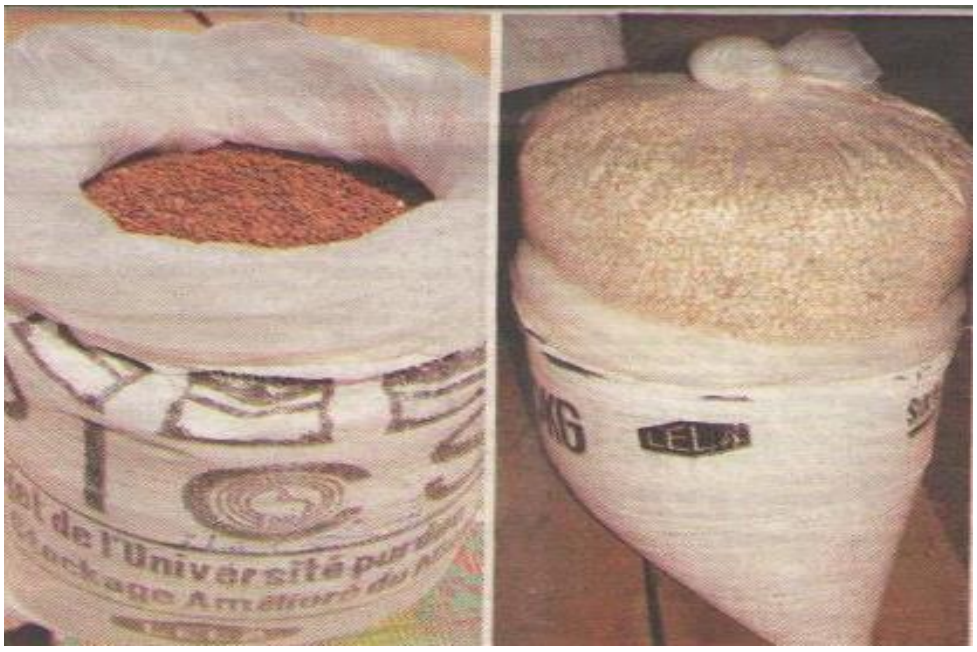


Fig. 3. Murdock bean storage bag multiplied by a Local firm in Kano, Nigeria

CHALLENGES IN THE PRODUCTION OF COWPEA

Insect pests and diseases are among a number of constraints limiting cowpea production in West and many parts of Africa. These constraints include insect pests and diseases (Thio *et al.*, 2016; Abudulai *et al.*, 2017), inadequate knowledge of good cultural practices and high yielding varieties resulting in poor yield. Other constraints include planting at sub-optimal plant density, low soil fertility, drought and weeds (Kanteh *et al.*, 2014; Osipitan *et al.*, 2016; Osipitan, 2017).

Diseases: Some of the diseases affecting the cowpea crop include

Bacterial diseases

Bacterial blight

This is a seed borne disease and its incidence may be reduced by using high quality seed. The disease also survives on diseased crop residues. The symptoms appear as tiny dots on the leaves. The area surrounding the spot dies and develops a yellow coloration. Subsequently, the dead spots merge and large areas of the leaves are affected. The disease may affect the stem, causing it to crack. Affected pods appear water-soaked and from this point, the pathogen enters the seed.

Bacterial pustule

Tiny, dark, water-soaked spots on the under surface of the leaves. Under severe infestation, the spots enlarge becoming dry and sunken in the center, and water-soaked around the margin. The leaves turn yellow and fall down.

Fungal diseases

Anthracnose

This is a stem disease, but may affect all the above ground parts of the plants. It appears as lesions that are brown to tan in colour. The lesions enlarge to girdle the stem, petioles and peduncles. The disease is seed borne and thus, it can be reduced by using clean seed. Fungicides are not normally used on cowpea, but benomyl or mancozeb (0.2% a.i.) can be recommended under severe infection.

Web blight

This is manifested as small, circular reddish-brown sports on leaves which, under humid conditions enlarge into irregular-shaped areas. The leaves become dry. The disease survives in the soil on crop residues.

Stem rots

This affects the base of the stem and cotton-like growth of the pathogen can be seen. Infected plants wilt and die. The stem rots are not seed borne. Good cultural conditions on the field may reduce the disease. Furthermore, a number of leaf spot diseases are common in the wetter growing regions of cowpea. Using seed from approved sources, rotation and cultural practices, will reduce disease prevalence.

Insect Pests Affecting Cowpea

Pre-flowering Pests

Aphids

These are insects that feed on the under surface of young leaves, young stem tissue and pods. In severe conditions, there is premature defoliation and death of young seedlings. The insect also transmits the aphid-borne mosaic virus. After transmission, affected plants show a green vein banding of the leaves. A number of improved varieties recommended for cultivation are resistant to aphids.

Leafhoppers

Feeding by leaf hoppers causes yellow discoloration of leaf veins and margins, followed by cupping of leaves. Therefore, affected plants become stunted in growth. The disease can destroy the crop during the seedling stage.

Foliage beetle

Beetles can totally defoliate cowpea seedlings. The adults appear either as shiny reddish brown, brown or black. Beetles also transmits viral diseases in cowpea.

Thrips

Adults thrips appear as shiny black, small insects in flower bud and flowers. In severe conditions, the plants do not produce flowers. Opened flowers appear distorted and discoloured. Thrips can cause 100% crop loss if the crop is not protected with insecticide. Most of the improved varieties recommended for cultivation by research institutions are resistant to these pests, except flower thrips.

Post-flowering pests

Pod borer

The adult pod borer is a nocturnal moth and its larvae feed on tender parts of the stem, peduncles, flowers and pods, causing serious

damages. The symptoms include webbing of the flowers, pods and leaves.

Pod sucking bugs

As the name implies, the bugs sucks the fluids off the pods of cowpea and as a result, the pods dry prematurely leading to serious yield losses. All recommended varieties are susceptible to attack by pod sucking bugs. At present, control measures are through spraying pesticides such as Karate (at 800 ml/ha) during the podding period. Other pesticides include Perfekthion (dimethoat) or thiodan (endosulphan) and Dursban (an organophosphate). But these have negative effects on human health and also the environment.

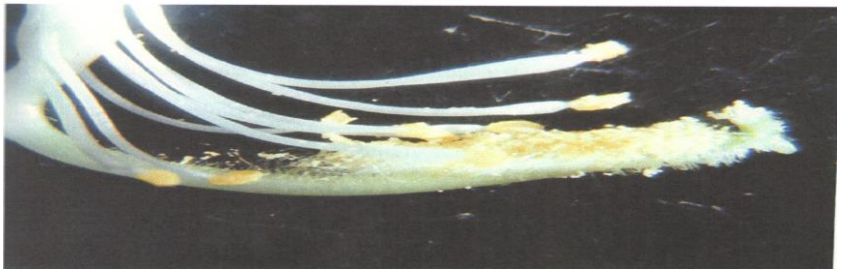
Cowpea weevil (bruchid)

This is also a serious pest of cowpea and can destroy 100% of the grain within six months. All recommended varieties are susceptible but appropriate methods of storage exist to prevent damage by the cowpea weevil.

The combination of flower bud thrips, pod borers, pod suckers and leaf hoppers could seriously limit the realization of the yield potential of a cowpea crop estimated at 1.5-3.0 t ha $^{-1}$. Sources of resistance to some of the insect attacking cowpea have been identified in some wild *Vigna* species (Birch *et al*., 1985; IITA, 1988). Evidence that pubescence (hairiness) on the surfaces of wild *Vigna vexillata* Benth contributes to its resistance to pod sucking bugs (*Clavigralla tomentosicolis* Stal.) was provided by Chiang and Singh (1986). In studies of pod wall trichomes in *V. vexillata*, Jackai and Oghiake (1989) attributed resistance to the adult pod-sucking bug partly to the presence of pubescence on its pods. Chiang and Singh (1988) reported that two varieties of hairy *V. vexillata* proved more highly resistant both under field and screen house conditions to infestation and damage by the pod sucking bug than cowpea. However, transferring genes for pubescence from the wild *V. vexillata* to cultivated cowpea for the control of these insect pests has been complicated by incompatibility barriers.

Monti (1992) reviewed the processes of crossability barriers between species and classified them as pre- and post-fertilization barriers. Pre-fertilization barriers may be at the level of the stigma where pollen germination is inhibited, at the level of the style where pollen tube growth is retarded or inhibited or at the level of the ovaries where fertilization failed to occur. In post fertilization barriers, zygotes may be formed but seeds are not developed because of retarded endosperm development, failure to transfer stored reserves to the embryo or suspensor defects. Barone and Ng (1990) examined the cytological abnormalities in pollen tube growth following crosses between *V. unguilata* and *V. vexillata.* Using a blue light fluorescent microscope, they noted that some pollen grains did not germinate on the stigma, but in other cases pollen grains germinated but were inhibited in the stigmatic tissue by forming undulating or spiralling tubes within the style. They concluded that lack of fertilization or collapse of the fertilized ovules were responsible for the failure of the cross. In similar studies by Barone, *et al.* (1992), pre-zygotic and post-zygotic barriers were identified as the two barriers to crossability between *V. unguiculata and V. Vexillata.* Also using a blue light fluorescent, microscope, they observed that pollen tube abnormalities manifested variously as spiky tube tips, distorting or undulating tubes as well as branching tube tips.

Many procedures were used by Scientists to overcome such incompatibility barriers without success. *Vigna rhomboidea* is also a pubescent wild *Vigna* species that is a potential source of genes for pubescence for incorporation into cultivated cowpea for insect pest resistance (Padulosi, 1993; IITA, 1996. Although the species was thought to be incompatible or partially compatible with cultivated cowpea (Padulosi, 1993; Ng, 1995), Aliyu (2005) used various crossing techniques (Fig. 2) and found the species to be reciprocally crossable with cultivated cowpea. Aliyu (2007) also reported the gene effects and heritability of pubescence on leaf, stem and pod among crosses between cowpea with *V. rhomboidea* as a guide for breeders working on the incorporation of the genes for pubescence from the species to cultivated cowpea.



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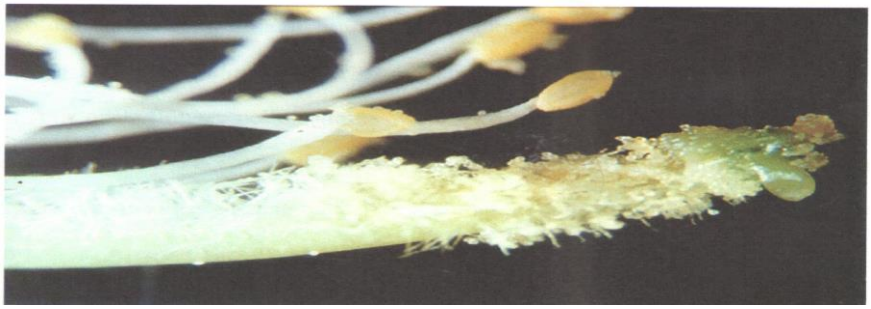

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Fig. 3 Hairy stigmatic surface of *V*. rhomboidea, TVnu 515, showing soft hairs blocking the contact of pollen to the stigmatic surface (a) and a smooth stigmatic surface of cowpea, IT82D-716 showing self pollination (b) (Source: Aliyu, 2005)

BIOTECHNOLOGICAL APPROACHES IN COWPEA IMPROVEMENT

The aim of cowpea breeding is to produce varieties that are high yielding and that are acceptable to farmers and consumers. A lot of high yielding, early maturing and drought tolerant varieties have been developed by Scientists. But as we saw earlier, resistance genes for post flowering insect pests from the wild relatives of cowpea especially *V. vexillata* could not be easily transferred to cowpea.

The use of biotechnological approaches to obtain resistance genes outside the cowpea genome and transferring the genes into cowpea will help improve cowpea yield. This should be possible given the successes achieved with other crops such as maize, tomatoes, sweet potato and cotton.

The first pioneering work on cowpea transformation was done by Garcia, *et. al*. (1986a; 1986b) using agrobacterium mediated transformation of cowpea leaf disc explants. But the transgenic calli failed to produce whole plants. Other workers (Perkins, *et. al.* 1987; Filippone and Penza, 1992) were also not able to regenerate their transgenic calli into whole plants (Obembe, 2009). A lot of other works were undertaken but regeneration of calli to whole plants was not achieved.

Subsequent works using various protocols (but avoiding callus regeneration) were able to achieve some level of success in getting stable Agrobacterium-mediated transformation of cowpea with transmission of transgenes to the progeny. These involved the inoculation of mature cotyledons (Muthukumar, *et al.*, 1996), embryonic axes (Popelka, *et al.*, 2006) and cotyledonary nodes (Chaudhury, *et al.*, 2007; Solleti *et al.*, 2008a). These works provided a progressive increase in transformation efficiency from 0.003 to 0.76 and then to 1.64 % (Adesoye, *et al.*, 2010). Solleti, *et al.*, 2008a) noted that inefficient TDNA delivery to regenerating cells of embryo-derived explants had been responsible for the low transformation efficiency and suggested that to enhance transformation rate early TDNA transfer steps must be optimized.

Today, there are several reports showing experimental evidence for reproducible gene transfer to cowpea including genes for pod borer (Higgins, *et al*., 2012) and cowpea weevil (Solleti, *et al.* 2008a). The first insect resistance trait being tested using biotechnology is against the legume pod borer, *Maruca vitrata* (OECD, 2015). The cowpea pod borer belongs to the Pyralidae, the family to which the European corn borer (ECB) belongs.

A *vip3Ba* gene reconstructed for plant expression was used in transforming cowpea *via Agrobacterium tumefaciens* by Bosibori, *et al.* (2017). Transgenic lines expressing *Vip3Ba* protein were used in insect feeding trials to assess protection against *Maruca* and were found to be completely protected from this pest. The authors proposed that the *vip*-cowpea lines could be combined with existing *cry*-transgenic cowpea to introgress this additional resistance trait and thus avoid or greatly delay the development of resistance in *Maruca*.

The integration of transgenes into cowpea by Agrobacterium infiltration of embryos germinating on selection free medium has also been demonstrated by Adesoye, *et al.* (2010). This technique has the potential of rapidly producing stably transformed cowpea and avoiding all the limitations imposed by de novo regeneration in tissue culture. Other pests such as the cowpea weevil can also be controlled using genetic transformation of cowpea. Numerous genes have the potential to confer resistance to the cowpea weevil if transferred into cowpea and expressed in the seed. The most advanced of these involves transferring an α-amylase inhibitor (αAI) gene from common bean into cowpea. The αAI protein protects the common bean seeds against cowpea weevil and certain other bruchids though not against the common bean weevil. When αAI was linked to a strong seed-specific promoter and transferred into garden pea, the garden pea seeds, which are normally susceptible to cowpea weevil, proved to be highly resistant (Shade, *et al.*, 1994). By transferring the common bean αAI gene into cowpea and expressing it in the seeds, it should be possible to introduce a new source of weevil resistance into cowpea. Genetically modified (GM) cowpea seeds expressing αAI-1, an α-amylase inhibitor from the common bean, have been shown to be immune against several bruchid species (Mishra, *et al.*, 2017).

The African Agricultural Technology Foundation (AATF) based in Kenya, has been implementing a programme to develop genetically engineered Maruca-Resistant cowpeas (OECD, 2015). The project was expected to have led to the release of GM cowpea varieties to the African market in the year, 2017. In a breakthrough, however, Nigeria approved Maruca-Resistant Bt cowpea for open cultivation last year, 2019 (ISAAA, 2019). The work, by IAR in Zaria, Nigeria, in collaboration with the AATF showed that Bt cowpea will reduce the use of pesticide from eight to two sprays per season and increase yield by up to 20%. Meanwhile, the Nigerian Federal Government has approved the regulatory framework for the introduction of genetically modified (GM) cowpea and cotton since the year 2015. Thus cowpea production especially on urban farms would now be more profitable as the process also ensures food security.

SUMMARY AND CONCLUSION

The most important consideration in UPA including UG is the food security aspect of the production systems, that is, whether the food produced is nutritionally adequate, and is continuously available. Cowpea is a warm season, annual herbaceous legume crop, whose growth habit ranges from erect, semi-erect to prostrate and twinning. The crop is nutritionally adequate, containing appreciable amounts of proteins, vitamins, minerals, fiber, etc needed in any food security programme. It can be cultivated for consumption as mature dry seed, green mature and immature seed, immature pods, germinated seed, fermented products, extracted proteins as well as for animal feed. The crop is also useful in building up soil fertility as a cover crop and through its nitrogen fixing properties, contributing up to 140 kg N/ha making it require quite less fertilizers than other crops. These attributes of cowpea coupled with the crop's low growth habit and early maturity makes it a key crop that should be considered for incorporation into the design initiatives of UPA and UGs. The main challenge in the crop's cultivation is attack by insect pests including pod suckers and pod borers but this problem would soon be overcome

with the recent release last year (2019) of Bt cowpea in Nigeria. It is recommended that cowpea, especially the long podded vegetable types be incorporated into urban farming and food security strategies.

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