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Plasticulture and postharvest management in Nigeria

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The world is faced with a lot of challenges in agriculture which are bringing many burdens to solve for example population growth, the effects of climate change, reduction of greenhouse gas emissions, rapid development of the emerging economies and growing insecurity associated with land, water and energy shortages and increase in postharvest wastages. All these situation and challenges heightens the critical role of innovations to make agriculture more effective, competitive and highly sustainable. Innovations come about when society takes ownership of knowledge, ideas, practices and technologies, translating them into a change that is useful and beneficial in productive or organizational life (IICA, 2014). Innovative agro practices need to be adopted towards transformation of Nigerian agriculture.

One of such innovations is the application of plasticulture in agriculture at both pre and postharvest management stages. **Plasticulture is a system in which plastic is used for agriculture activities including growing crops and for postharvest management** especially in horticulture, water-management, food grains storage, transportation and related areas (Sood and Rawal, 2022)**. This is one of the newest developments in the field of agriculture, which is also accepted worldwide for refining agricultural production.** It is the combination of two words, plastics and agriculture (Singh *et al.,* 2018).

Application of plasticulture

Plasticulture applications in both pre and postharvest are seen as one of the most important indirect agriculture input which often results in moisture conservation, water saving, reduction in fertilizer consumption, helps in precise application which is parsimoniously viable, plant protection through the use of nets and use of innovative packaging solutions that help in increasing shelf-life and during collection, storage and transportation of fruits and vegetables.

A complete plasticulture system consists of plastic mulches, drip irrigation, fertigation/chemigation, soil sanitation (fumigation and solarization), windbreaks, stand establishment technology, season-extension technology, integrated pest management, cropping strategies, postharvest handling, and marketing (Sood and Rawal, 2022)

Plastic material like ethylene-vinyl acetate copolymer, glass fiber reinforced polyester, and polypropylene and polyethylene are used prominently in agriculture. Biodegradable plastics like polysaccharide derivatives, poly amino acids, polylactic acids, polyhydroxyalkanoate, polycaprolactone are the most nontoxic polymers among other polymers in existence. Polymers' chemical, physical, thermal and mechanical properties allow or permit its wide versatility and usability in agriculture field such as re-usability, good thermal and water permeability (Singh *et al.,* 2018)**.**

Plastics have definite advantages over conventional materials because it has several properties:

- Higher strength / weight ratio,
- Superior electrical properties,
- Superior thermal insulation properties,

- Excellent Corrosion resistance,
- Superior flexibility,
- Impermeability to water and water,
- Resistance to chemicals,
- Less friction due to smoother surface
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Use of Plasticulture in postharvest management

In Nigeria, with an estimated postharvest loss of 45-50% and 10-15% in perishable and durable crops respectively, and also an estimated population of 210 million, food security remains a mirage that may not come to fulfillment. A substantial part of harvested products are lost before reaching its end-consumer. It is very necessary to save this sizable fraction and improve the system. Lack or inadequate sorting facilities, inappropriate packaging, slow and inefficient transport systems and inadequate storage facilities are some of the key factors behind this loss of goods. Plastics have the potential to play a significant role in preservation of quality and durability of harvested produce (Njume *et al.*, 2020).

In post-harvest management, plasticulture is often used in most of the different value chains and some are listed below:

1. Plastics crates, bins, boxes, leno bags, fish boxes, unit packaging products etc
2. Controlled Atmospheric Packaging (CAP) & Modified Atmospheric Packaging (MAP)
3. Construction of dryers

Major areas of plasticulture technologies application in post-harvest management are drying, short and long term storage, material handling and transportation of agricultural produce. The review highlights some of the plasticulture technologies developed by Nigerian Stored Products Research Institute (NSPRI).

1. Drying of agriculture produce

Drying is an ancient but simple method of preservation of agricultural produce. It is a practical method of conserving food at a very low cost and by means of renewable energy. The plasticulture technology such as NSPRI parabolic solar dryer (Fig. 1) and solar tent dryer (Fig.2) makes good use of modified microclimatic condition for drying of both perishable and durable crops. The cover which is referred to as sun trap is made of polyethylene. High drying rates reduce time of dying and maintain produce good quality than open sun drying depicting some advantages of this plasticulture technology (Varghese *et* al., 2021). Furthermore, Ogunsua et al., (2020) conducted a study which evaluated the two solar dryers developed at NSPRI Parabolic Shaped Solar Dryer (PSSD) and Solar Tent Dryer (STD). There results confirmed that higher temperatures are recorded in the dryers (PSSD= 40.77 ± 1.24°C and STD= 34.62 ± 0.70°C) compared to what was obtained in the ambient (33.59 ± 0.38°C). This resulted in a higher drying rate in PSSD and STD at an average of 0.57 kg/day and 0.52 kg/day respectively compared to the control (0.46 kg/day). Drying in PSSD was completed in 3 days with final moisture content of 7.53%, while it lasted for 4 days in STD and Control with final moisture contents of 8.98% and 9.37% respectively.

Figure 1: NSPRI parabolic shaped dryer

Figure 2: NSPRI solar tent dryer

2. Hermetic storage system

The hermetic storage bags such as the use of Purdue Improved Crop Storage (PICS) bag is used for the storage of durable crops like cowpea, maize, sorghum etc. The bags were designed to reduce grain storage losses on smallholder farms and for their transportation. It consists of three layers: two high-density polyethylene liners fitted inside a woven polypropylene bag (Figure 3). It is a simple and cost-effective way of storing grains and seed without using synthetic chemicals to control or manage insect pests.

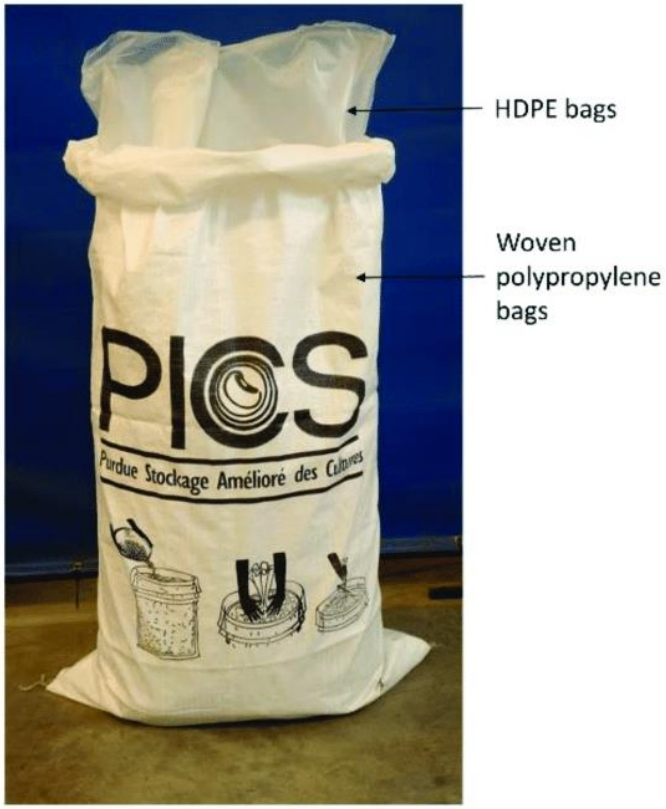

Figure 3: Hermetic storage bags

The PICS bags come in 50kg sizes. Generally, hermetic storage technology is helping farmers and handlers to improve food security and increase income of millions in Africa and beyond and this can be achieved with the help of plasticulture technology (Kabita *et al.*, 2018).

3. Transportation and short term storage system

The significance of plasticulture technology in storage, and transportation of agriculture produce cannot be belittled. Preservation of fresh produce from short term storage to long term storage is one of its usefulness. Packaging keeps produce in a form of microclimate that does not favour the growth of microorganisms and pests thereby maintaining its quality as well as extend its shelf life. It offers several advantages such as ease in handling, flexibility in transport and storage with lower cost of operation. Some of the popular plasticulture technologies are Plastics crates, bins, boxes, leno bags, unit packaging products, colored shade nets, and are detailed below.

NSPRI Plastic crates

Plasticulture technology used for transportation of fresh produce distribution chain is the light-weight plastic crates (Fig.4) because of their ease in handling. They are made of High-Density Polyethylene (HDPE), which is a thermoplastic known for its durability. Plastic crates minimize postharvest losses of fresh fruits and vegetables that can occur when produce is moved, minimizing bruising, crushing, and other damage. Plastic containers are less fragile than cardboard or wood containers, which can also absorb product moisture. The plastic crates come in **large, medium, small, nestable and stackable harvest crates.** Babarinsa et al., (2018) reported a study on a two 25-tonne trucks which were loaded with wholesome tomatoes differently packaged in plastic crate and raffia basket and they found that the use of plastic crate reduced on transit damage up to 88% as compared to raffia basket.

Figure 4: Plastic crates

NSPRI iced fish box

Plasticulture technology significance has also been proven in preservation of fish on short term bases. NSPRI's iced fish box, a technology developed by Nigerian Stored Products Research Institute (NSPRI), is a portable plastic box, semi-air-tight lagged-coolant system of the dimension 49cm × 29cm × 20cm with an effective cooling capacity due to uniform coldness distribution within the box as shown below.

Figure 5: NSPRI ice fish box

It involves the introduction of a measured proportion of ice into a given quantity of fish within an insulated lagged rectangular vacuum to maintain fish freshness within the boxes. The box is made from high density Polyethylene (HDPE) and very durable and cost effective. According to a study conducted by Ajayi et al., (2021), it was observed that the quality of the fishes was kept visibly fresh without offensive smell of decadence for 72 hours. Furthermore, they concluded that the fish box was found to be a simple, but cost effective technology that preserved that fresh caught quality of fish and allow for safe temporary transport and storage.

Conclusion

Plasticulture is a technique that has been in existence with the positive effect for postharvest management of both perishable and durable crops and it has been noted that under plasticulture, food security is ensured. However, the cost of plastic, removal and disposal of plastic materials are some constrains observed globally. Therefore, it is advised to make use of biodegradable plastics for sustaining the productivity and control of environmental pollution.

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