A review of the uses and methods of processing banana and plantain (*Musa spp.*) into storable food products.

A.O. ABIODUN-SOLANKE and K.O. FALADE
Department of Food Technology,
University of Ibadan, Ibadan. Nigeria

ABSTRACT

Plantain belongs to the genus Musa of the family musaceae. Nearly all edible plantain cultivar are derived from two wild species, M. acuminate and M. balbisiana (Robinson, 1996). These wild species are classified on the basis of the proportion of the genetic constitution contributed by each parental source (Robinson, 1996). Plantain (Musa spp.) is an important dietary source of carbohydrate in the humid tropical zones of Africa, Asia and South America. (Robinson, 1996). Plantain is rich in vitamins A, C and B group as well as minerals such as calcium and iron (Marriott & Lancaster, 1983). Musa spp. are useful as food to be consumed by human either as flour to be used in confectionaries or as jams and jellies; in chips etc. It's peel can be used as animal feed. All parts of the banana plant have medicinal applications: the flower in bronchitis and dysentery and on ulcers, cooked flowers are given to diabetics etc. It's leaves are also useful for lining cooking pots and for wrapping. Improved processes have also made it possible to utilize banana fibre for ropes, table mats and handbag (Chandler, 1995). Despite these many uses of Musa spp.and the huge tonnages harvested each year, there are certain problems such as inaccessibility to production areas, far distances between production areas and customers, inadequate infrastructures for harvesting, carelessness on the part of harvesters and handlers among others which are all factors that lead to high rate of post harvest losses, hence the need for processing of these important crops. Different processing methods of Musa spp. into new food products which include production of flour, preparation of jams and jellies and the quality attributes of the products obtained from processed Musa spp.. were reviewed. It can therefore be concluded that subjecting Musa spp. to processing methods will help enhance and improve the value of the fruit and make it available all year round for better utilization.

Keywords: Drying, flour, banana, powder, jams, jellies.

INTRODUCTION

Banana is the common name used for the herbaceous plants of the genus *Musa* which is cultivated in more than 100 countries throughout the tropics and subtropics, with an annual world production of about 98million tonnes, of which around a third is produced in each of the African, Asia-Pacific, and Latin American and Caribbean regions (Frison & Sharrock, 1999).

Banana plants are monocotyledonous perennial and important crop in the tropical and Sub tropical world regions (Valmayor *et al.,* 2000), including

dessert banana, plantain and cooking bananas. Traded plantain *(Musa paradisiaca AAB)* and other cooking bananas *(Musa ABB)* are almost entirely derived from the AA-BB hybridization of *M. acuminate (AA)* and *M. bulbisiana (BB)* (Robinson, 1996). Plantain and cooking bananas are very similar to unripe dessert bananas *(M. cavendish AAA)* in exterior appearance, although often larger; the main differences in the former being that their flesh is starchy rather than sweet, they are used unripe and require cooking (Valmayor *et al.,* 2006). Dessert bananas are consumed usually as ripe fruits; whereas ripe and unripe plantain fruits are usually consumed boiled or fried (Adeniji *et al.*, 2006).

Plantain belongs to the genus *Musa* of the family *musaceae.* Nearly all edible plantain cultivar are derived from two wild species, *M. acuminate* and *M. balbisiana* (Robinson, 1996). These wild species are classified on the basis of the proportion of the genetic constitution contributed by each parental source (Robinson, 1996). Plantain is a staple crop and an important dietary source of carbohydrate in Nigeria and in the humid tropical zones of Africa, Asia and South America (Robinson, 1996). Plantain is rich in vitamins A, C and B group as well as minerals such as calcium and iron (Marriott and Lancaster, 1983; Robinson, 1996). Plantain provides between 9% and 35% of the total calories in the diets of more than 14 million people in Sub sahara Africa (Robinson, 1996). The contributions of this staple starch crop to the food chains of this region cannot be overemphasized (Robinson, 1996).

Plantains are typical climacteric fruits in that they exhibit a well defined pre-climateric phase after harvesting during which the fruit remains unripe, the basal respiration rate is low and ethylene production is almost undetectable. The respiratory climacteric commences spontaneously and there is a rapid and well-defined rise in respiratory rate which is closely synchronized with evolution of ethylene, with chlorophyll breakdown in the peel and with starch to sugar conversion and tissue softening in the pulp (Marriot and Lancaster, 1983; Ogazi, 1996). The fruit usually harvested at it's mature but unripe stage, ripens within two to seven days, thus making plantain a highly perishable crop, particularly in the overripe stage (Robinson, 1996). An unripened banana and the plantain have high starch and low sugar levels plus copious amounts of bitter-tasting latex. Starch is converted to sugar as the fruit ripens, so that bananas can eventually contain about 25% of total sugars. As the banana ripens, the latex is also decomposed. Plantain has the stinging, bitter latex, so the peel is removed with a knife and the pulp is soaked in salt water for 5–10 min prior to cooking. Bananas are harvested unripe and green, because they can ripen and spoil very rapidly (Daniells *et al.*, 2001)

FAO (2004) data sources put the world production of plantains at about 60 million tons (FAO, 2004). In West Africa, plantain production increased at an average annual rate of between 2.3% to 2.6% (FAO, 2004). The level of

production of plantains in Africa is comparable with other fruits like grapes (57 million tons); citrus (50 million tons) but much greater than most other important fruits like apples (21 million tons) and mangoes (13 million tons) (FAO, 2004). The higher production figures for plantains has been attributed to the cheaper methods of growing that require few labor inputs, little soil preparation and little weeding are needed once the plant has established vegetative cover. (FAO, 2004).

MATURITY INDICES OF MUSA spp

Plantain require about three months from the beginning of flowering until harvest. Multiple fruits are produced on a large bunch, weighing between 50-200kg (Ogazi, 1996). Within the bunch are clusters of double rows of fruit called "hands" and individual fruit called "fingers". (Ogazi, 1996).

Maturity standards for plantains are less precise than they are for bananas. Several different external and internal fruit characteristics can be used to determine plantain maturity. These include fruit diameter, age of the bunch, angularity of the fruit, length of the fruit, and peel color (Johnson *et al.,* 1998). The stage of maturity for harvest depends on the intended market destination (Johnson *et al.,* 1998). Locally marketed plantains can be harvested at a more advanced maturity stage compared to export market fruit. Export market destined fruit should be harvested the day before or the same day of shipment (Ogazi, 1996). Plantain maturity is related to the diameter of the fingers. This is determined by measuring the diameter of the fruit at its mid point with a pair of calipers (Ogazi, 1996).

Another method for estimating plantain maturity is to record the age of the bunch. The time from when the fruit bunch first becomes visible (Shooting) is recorded. Bunches can be tagged with different colored ribbons at the time of shooting, and subsequently harvested after the appropriate time for the particular cultivar, based on the season of the year and experience (Johnson *et al.,* 1998). The colour of the ribbons is changed weekly to coincide with the time of shooting and subsequently the age of the bunch (Johnson *et al.,* 1998).

A third method used to determine harvest maturity is to observe the shape (fullness) and angularity of the fruit. Immature fruit is angular in cross-sectional shape and has distinct ridges (Ogazi, 1996). As the fruit matures, it becomes less angular and more rounded or full. The degree of roundness differs between cultivars and location of the hand on the bunch. Typically, the fullness of the fruit on the middle hand is measured. The appropriate shape to harvest the fruit depends on the market destination. Fruit intended for the domestic market should be harvested when the fruit shape is nearly round (Johnson *et al.,* 1998).

A fourth way of estimating plantain bunch maturity is to measure the length of the edible pulp portion of the fruit from the fingers in the middle hand. The length should be a minimum of 15cm for the domestic market and 18cm for the export market (Johnson *et al.,* 1998). Finally, peel colour is another frequently used method of assessing fruit maturity. The peel remains green throughout growth and development of the fruit until it reaches physiological maturity. It then changes to a yellow colour during ripening. (Ogazi, 1996).

However, plantain fruit should be harvested when the peel is green in colour to withstand the rigors of handling and distribution (Johnson *et al.,*1998). Internal fruit composition changes dramatically during plantain fruit ripening. At physiological maturity, the fruit is fully developed in size, green in peel colour, and at its highest level of starch (Ogazi, 1996). The starch will progressively be converted to sugar as ripening progresses.

The stage of harvest maturity of plantains will depend on the target market. Plantains for local market are harvested at a more advanced stage of maturity than those for exportation (Ogazi, 1996). However, if the fruit is too mature at harvest, particularly following irrigation or rainfall, fruit splitting can occur during handling. Also, mature fruit may ripen prematurely during transport or storage (Ogazi, 1996).

PROCESSING QUALITY

The bulk of the banana, cooking banana and plantain are eaten either as raw, in the ripe state, or as a cooked vegetable, and only a very small proportion are processed in order to obtain a storable product. Generally, preserved products do not contribute significantly to the diet of the millions of people who eat banana, cooking banana and plantain, however in some countries or areas, the processed or preserved products are important in periods when food is scarce. Processing is recognized as a way of preserving the fruit. Yet the proportion of fruits processed and the suitability of the various *Musa* groups to processing is relatively unknown. New *Musa* hybrids should therefore be screened for their processing quality or suitability for processing (Thompson, 1995).

The ripe banana is utilized in a multitude of ways in the human diet, from simply being peeled and eaten out of hand to being sliced and served in fruit cups and salads, sandwiches, custards and gelatins, being mashed and incorporated into ice cream, bread, muffins and cream pies (Adeniji *et al.,* 2006). Ripe plantains are often sliced lengthwise, baked or boiled, and served (perhaps with a garnish of brown sugar or chopped peanuts) as an accompaniment for ham or other meats. Ripe plantain may be thinly sliced and cooked with lemon juice and sugar to make jam or sauce, stirring frequently during 20 or 30 minutes until the mixture jells. Whole, peeled plantain can be spiced by adding them to a mixture of vinegar, sugar, cloves

and cinnamon which has boiled long enough to become thick and then letting them cook for 2 minutes (Chandler, 1995).

Banana puree is important as infant food and can be successfully canned by the addition of ascorbic acid to prevent discoloration. The puree is produces on a commercial scale in factories close to banana fields and packed in plastic-lined 10 cans and 55-gallon metal drums for use in baby foods, cake, pie, ice cream, cheesecake, doughnuts, milk shakes and many other products (Ogazi, 1996).

In Polynesia, there is a traditional method of preserving large quantities of bananas for years as emergency food in case of famine (Ogazi, 1996). A pit is dug in the ground and lined with banana and Heliconza leaves. The peeled bananas are wrapped in Heliconza leaves, arranged in layer after layer, then banana leaves are placed on top and soil and rocks heaped over all. The pits remain unopened until the fermented food, called "masi", is needed.

In Costa Rica, ripe bananas from as entire bunch are peeled and boiled slowly for hours to make thick syrup which is called "honey" (Ogazi, 1996).

Through experimental work with a view to freezing peeled, blanched, sliced green plantain, it has been found that, with a pulp-to-peel ratio of less than 1:3 the fruits turn gray on exposure to air after processing and this discoloration is believed to be caused by the high iron content (4.28p/m) of the surface layer of the flesh. Its reaction to the tannin normally present in green bananas and plantains. At pulp to peel ratio of 1.0, the tannin level in green bananas is 241.4mg; at 1.3, 151.0mg, and at 1.5, 112.6mg, per 100g (Ogazi, 1996). Therefore, it is recommended that for freezing, green bananas should be harvested at a stage of maturity evidenced by 1.5 pulp-to-peel ratio. Such fruits have a slightly yellowish flesh, higher carotene content, and are free of off-flavors. The slices are cooked by the consumer without thawing (Ogazi, 1996).

Completely green plantains are 50% flesh and 50% peel (Ogazi, 1996). Plantain for freezing should have a pulp content of at least 60% for maximum quality in the ultimate food product, but a range of 55 to 65% is considered commercially acceptable (Ogazi, 1996).

In Ghana, plantains are consumed at 5 different stages of ripeness (Chandler, 1995). Fully ripe plantains are often deep fried or cooked in various dishes. A Ghanian pancake called "fatale" is made of nearly full ripe plantains and fermented whole meal dough of maize, seasoned with onions, ginger, pepper and salt, and fried in palm oil. "Kaklo" is the same mix but thicker and rolled into balls which are deep-fried. Because home preparation is laborious, a commercial dehydrated mix has been developed. In Ghana, green plantains are boiled and eaten in stew or mashed, together with boiled cassava, into a

 popular plastic product called "fufu" which is eaten with soup. Because of the great surplus of plantains in summer, technologists have developed methods for drying and storing of strips and cubes of plantain for house use in making "fufu" out of season. The cubes can also be ground into plantain flour. Use of infra red, microwave, and extrusion systems have resulted in high-quality finished products. Processing has the added advantage of keeping the peels at factories where they may be converted into useful by-products instead of being added to the bulk of household garbage (Chandler, 1995).

Banana or plantain flour, or powder, is made domestically by sun drying slices of unripe fruits and pulverizing (Anon, 1999). Commercially, it is produced by spray-drying, or drum-drying, the mashed fruits (Anon, 1999). The flour can be mixed 50-50 with wheat flour for making cupcakes. Two popular Puerto Rican foods are "pasteless" and "alcapurais" both are pastry stuffed with meat, the first is wrapped in plantain leaves and boiled the latter is fried. The pastry is made of plantain flour or a mixture of plantain with cassava or cocoyam.

Commercial production and marketing of fried green plantain and banana chips has been increasing in various parts of the world over the past 25 years and these products are commonly found in retail groceries alongside potato chips and other snack foods.

In Africa, ripe bananas and plantains are also processed into beer and wine. The Tropical Products Institute in London has established a simple procedure for preparing acceptable vinegar from fermented banana rejects (Anon, 1999)

Flour and Powder

Flour can be made from green unripe banana, cooking banana or plantain. Fruits are hand-peeled and sliced or chopped into pieces about 5-10 mm thick. The slices will be dried in the sun by spreading out the slices on mats, on bamboo framework, on cement floors, or on a roof or sheets of corrugated iron or simply on a sweptbare ground. Various designs of solar dryers can also be used, or they may be dried in ovens, over fires, in a cabinet dryer or tunnel dryer (Thompson, 1995). The fruits are either sun-dried which is the former, oven-dried, the latter or foam-mat dried which will be described now. Sun and oven-drying methods have been used for drying of plantain and banana (Bowrey *et al.,* 1980; Johnson et al., 1998; Demirel & Turhan, 2003) with some success, the introduction of foam-mat drying brought much more (Falade and Olugbuyi, 2009). *Musa spp. e*specially cooking banana is cheaper relatively when compared with wheat and other cereals for the production of flours therefore processing of cooking banana should be encouraged.

In foam-mat drying plantain puree was prepared by blending steam blanched plantain and distilled water for 2 mins in a Waring blender to produce a 30 ± 0.4% total solids (TS) paste. A 20% (w ∕ w) glyceryl monostearate (GMS) suspension is prepared by dissolving a known weight of GMS in hot water at 100°C. The 20% suspension is added to obtain a 0.02% GMS in the plantain paste. The mixture of plantain paste (30% TS) and GMS suspension are then transferred into a Kenwood Chef mixer and whipped at maximum speed for 4 mins until homogenous foam is obtained. The whipped foam could be extruded using a manual Euroline icing syringe (Model 5 Nozzles stainless steel 19 cm, Euroline, Essex, UK) with an outlet orifice of 4 mm diameter on a stainless steel wire mesh and dried in a cross-flow Gallenkamp Oven at 60°C for 45–90 mins. The dried plantain is scraped off and packaged in low density polyethylene (100 μm) to prevent moisture absorption (Falade and Olugbuyi, 2009). After drying, the chopped pieces have a moisture content of about 5-10%. The dried pieces were ground and usually sieved to produce the flour. The flour is packaged in moisture proof bags. The dried slices are stored and only converted to flour when needed since the flour tends to lose its flavour rapidly or may absorb moisture (hygroscopic) and become mouldy.

Powder could be prepared from fully ripe banana, cooking banana or plantain. Fruits are washed, hand-peeled and chopped fairly coarsely. The material is converted into a paste by passing through a mill to reduce the particle to a colloidal size (below about 10 μm). A 1-2% Sodium metabisulphite solution is added at this stage to improve the colour of the final product or to prevent discolouration. The material is then dried. Drying can be achieved, either in a spray dryer (at 30 to 32°C and less than 30% Relative Humidity under vacuum) or a drum dryer (product temperature should not exceed 94°C). After drum drying it might be necessary to further dry the product in a cabinet dryer. The final moisture content of the powder should be about 2% and should be stored in moisture proof bags (Thompson, 1995).

Banana, plantain and cooking banana (*Musa spp)* may be processed into many products at different stages of physiological maturity; unripe, ripe, overripe or in a number of ways such as frying, grilling, boiling and drying. According to Demirel & Turhan (2003), drying adds value to banana in addition to preservation. Moisture removal from plantain seems to be an appropriate and economical means of preserving *Musa spp*, resulting in shelf stable and convenience products. Currently, unripe plantain flour is being processed into a thick paste product known as 'amala' in the western part of Nigeria, which is medically recommended for diabetic patient (Adeniji *et al.,* 2006). Ripe banana powder is used in bakery and confectionery industries, in infant diets and the treatment of intestinal disorders (Adeniji *et al.,* 2006).

Improved cultivars of plantain and banana may provide high quality whole flour from the entire fruit for livestock feed, which may eventually provide protein in human diet from consumption of meat and other products of livestock (Thompson, 1995.). Such flour may be employed in traditional dishes for human consumption based on their nutritional profiles. Although, there is need to investigate the application of whole *Musa* flour in baking and confectioneries from the point of view of their pasting properties but that notwithstanding it has recorded success when used in addition to the conventional wheat flour. The use of entire fingers of plantain and banana could be a rapid approach in flour production with improved levels of nutrients, especially minerals, which are concentrated in the peel (Izonfuo and Omuaru, 1988).

Canned slices

Several methods for canning banana slices in syrup have been described (Thompson, 1995). Best quality slices are obtainable from fruit at an early stage of ripeness. The slices are processed in syrup of 25° Brix with pH of about 4.2 and in some processes calcium chloride (0.2%) or calcium lactate (0.5%) are added as firming agent (Marriot and Lancaster, 1983). Canning plantain slices in syrup are considered to be unsatisfactory (Sanchez-Nieva and Hernandez, 1967). However, ripe slices may be cooked in 40° Brix syrup until the concentration of the syrup reach 54-60° Brix and cinnamon and lemon juice is added to improve the colour. The product may be packed in boilable plastic pouches and quick frozen at -23°C. It is served by boiling the pouches in water for 15 mins.

Chips (Crisps)

Various methods of preparing banana or plantain chips have been described in the literature. Typically, unripe banana or plantain may be thinly sliced vertically or transversely (1.2-0.8 mm thick) (Berg *et al.,* 1971) The slices are immersed in a sodium or potassium metabisulphate solution (to improve the colour of the final product or to prevent discolouration) and fried in hydrogenated oil at 180-200°C. The fried slices are dusted with salt and antioxidant (e.g. butylatedhydroxytoluene to delay rancidity); (Marriot and Lancaster, 1983). Alternatively slices may be dried before frying and the antioxidant and salt are added with the oil. Fried chips should have moisture content of about 1.5 to 2.0%. The temperature at which the chips are fried and the frying time affects their oil content, appearance, texture and flavour (Thompson, 1995). The chips must be packed in moisture proof bags to prevent them absorbing moisture and losing their crispness.

Jam and Jelly

The various methods of preparing jam and jelly have been described in several literatures. In one method for the preparation of jelly, fully ripe or over-ripe fruits are used. Fruits are hand-peeled and cut into 2 cm pieces or slices. The slices are boiled for 1 hr in 60° Brix sugar syrup at the rate of 1 lb of banana to 1 pint of syrup (454 g to 0.5681). This is then strained and the clear solution is boiled until it sets. The pH should be adjusted to 3.5. Pectin may be added to improve the set (Thompson, 1995). A commercial formula for producing banana jam is as follows (Thompson, 1995): 200 lbs of sugar, 10 gallons of water and 12 ounces of cream of tartar.

These are heated to 110°C and then 2.5 gallons of lemon juice (lime juice or citric acid can be used to replace the lemon juice to reduce the pH of the jam to 3.5) are added.   The mixture is heated to 107°C until the correct consistency is obtained.

MEDICAL USES

All parts of the banana plant have medicinal applications: the flowers in bronchitis and dysentery and on ulcers; cooked flowers are given to diabetics; the astringent plant sap in cases of hysteria, epilepsy, leprosy, fevers, hemorrhages, acute dysentery and diarrhea, and it is applied on hemorrhoids, insect and other stings and bites, young leaves are placed as poultices on burns and other skin afflictions, the astringent ashes of the unripe peel and of the leaves are taken in dysentery and diarrhea and used for treating malignant ulcers, the roots are administered in digestive disorders, dysentery and other ailments; banana seed mucilage is given in cases of catarrh and diarrhea in India (Anon, 1999).

Antifungal and antibiotic principles are found in the peel and pulp of fully ripe bananas. The antibiotic acts against Mycobacteria. A fungicide in the peel and pulp of green fruits is active against a fungus disease of tomato plants. Norepinephrine, dopamine and serotonin are also present in the ripe peel and pulp. The first two elevate blood pressure; serotonin inhibits gastric secretion and stimulates the smooth muscle of the intestines (Anon, 1999).

OTHER USES

Banana and plantain leaves are widely used as plates and for lining cooking pits and for wrapping food for cooking or storage. A section of leaf often serves as an eye-shade (Anon, 1999). In Latin America, it is a common practice during rains to hold plantain leaf by the petiole, upside-down, over one's back as an "umbrella" or "raincoat" (Anon, 1999). The leaves of the 'Fehi" banana are used for thatching, packing and cigarette wrappers. The pseudomonas has been fastened together as rafts. Seat ads for benches are

made of strips of dried banana pseudostems in Ecuador. In West Africa, fiber from the pseudostem is values for fishing lines. In the Philippines, it is woven into a thin, transparent fabric called "agna" which is the principal material in some regions for women's blouses and men's shirts. It is also used for making handkerchiefs. In Ceylon, it is fashioned into soles for inexpensive shoes and used for floor coverings (Thompson, 1995).

Plantain fibre is said to be superior to that from bananas. In the mid-19th Century, there was quite an active banana fiber industry in Jamaica. Improved processes have made it possible to utilize banana fiber for many purposes such as rope, table mats and handbags. A good quality paper is made by combining banana fiber with that of the betel nut husk (Chandler, 1995).

Dried banana peel, because of its 30 to 40% tannin content is used to blacken leather. The ash from the dried peel of bananas and plantains is rich in potash and used for making soap. That of the burned peel of unripe fruits of certain varieties is used for dyeing (Ogazi, 1996).

ANIMAL FEED

Rejected ripe bananas, supplemented with protein, vitamins and minerals, and are commonly fed to swine. Green bananas are also used for fattening hogs but, because of the dryness and astringency and bitter taste due to the tannin content, these animals do not care for them unless they are cooked, which makes the feeling costs too high for most growers. Therefore, dehydrated green banana meal has been developed and, though not equal to grain, can constitute up to 75% of the normal hog diet, 40% of the diet of gestating sows. It is not recommended for lactating sows, nor is ripe bananas even with a 40% protein supplement (Anon, 1999).

Beef cattle are very fond of green bananas whether they are whole, chopped or sliced. Because of the fruit's deficiency in protein, urea is used at the rate of 8.8 lbs (4 kg) per ton, with a little molasses mixed in to mask the flavor. But transportation is expensive unless the cattle ranch is located near the banana fields. A minor disadvantage is that the bananas are somewhat laxative and the cattle need to be washed down daily. With dairy cattle, it is recommended that bananas constitute no more than 20% of the feed (Chandler, 1995).

In the Philippines, it has been found that meal made from dehydrated reject bananas can form 14% of total broiler rations without adverse effects. Meal made from green and ripe plantain peels has been experimentally fed to chicks in Nigeria. Flour from unpeeled plantains, developed for human consumption, was fed to chicks in a mixture of 2/3 flour and 1/3 commercial chick feed and the birds were maintained until they reached the size of

fryers. They were found thinner and lighter than those on 100% chick feed and the gizzard lining peeled in shreds. It was assumed that these effects were the result of protein deficiency in the plantains, but they were more likely the result of the tannin content of the flour which interferes with the utilization of protein (Anon, 1999).

Leaves, pseudostems, fruit stalks and peels after chopping, fermentation and drying, yield a meal somewhat more nutritious than alfalfa press cake. This waste material has been considered for use as organic fertilizer in Somalia. In Malaya, pigs fed the pseudostems are less prone to liver and kidney parasites than those on other diets.

Banana peel contains beta sitosterol, stigmasterol, campesterol, cyclocucalenol, cycloartanol and 24-methylene cycloartanol (Anon, 1999). The major constituents of banana peel are 24-methylene cuycloartanol palmitate and an unidentified triterpene ketone (Anon, 1999)

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Implications of structural policies on the wheat market – comparative static and dynamic analysis for the EU and US

JADWIGA ZIOLKOWSKA
Humboldt University of Berlin
Chair for Agricultural Policy
Germany

ABSTRACT

Structural policy instruments can directly influence agricultural production, productivity, and other market variables. Using a Cobb-Douglas market model, we quantitatively assess national and global implications of structural policies on the wheat market, determined by technical progress and other structural policy measures in 2005-2020. With a comparative-static and comparative-dynamic analysis for the European Union (EU-27) and the United States of America (US) (as leading wheat exporting countries), we show that structural policies (e.g. technical progress) on the wheat market in the analyzed countries brings about an increase of the producer surplus; however, it has negative impact on national budgets in the EU-27 and the US, regardless of the implemented price policies. Moreover, structural policies implemented over time contribute to an increase of welfare, producer surplus, and budget expenditures in the analyzed countries. A global effect of national structural policies in the EU-27 and the US is a continuously decreasing world market price of wheat. Structural policies in the analyzed countries bring about global positive effects for the economies of other countries in the world, e.g., growing welfare and consumer surplus, while negative effects for producers in the rest of the world.

Keywords: Structural policy, technical progress, dynamic market effects, wheat market

INTRODUCTION AND RESEARCH QUESTION

Wheat is the most important cereal crop in the world. In 2007, the world wheat production amounted to 607 million tons (FAO, 2008), and the biggest wheat exporters were United States, Russia, the European Union (EU-27), Canada, and Argentina (OECD, 2007). In the European Union (EU), internal prices of wheat and other cereals are, on the average, higher than world market prices. In order to support national producers, the export of the European cereal crops is subsidized. A different price policy is implemented in the United States of America (US), where the wheat production is not directly subsidized, but free trade on the wheat market is allowed (see: Ziolkowska et al., 2009). Price policies determine directly wheat market prices and the wheat production.

However, wheat supply can be influenced also by other instruments, such as structural policies.

The term 'structural policy' used in this paper refers to national policies on the wheat market in the European Union and the United States. Structural policy refers to a bundle of measures and activities (undertaken by the national governments and followed by farmers) which influence economic structures or else economic conditions on markets. With a structural policy, changes in an economy, caused by technical progress, globalization, or structural change, should be weakened, in order to reach overall economic equilibrium.

In the analyzed case of the wheat market, we define structural policies as measures and activities that directly influence suppliers (wheat producers), thus leading to shifts of the supply curve and finally to changes of market variables, such as welfare, producer surplus, and consumer surplus.

Several studies have been undertaken in recent years on the subject of wheat production from the background of food price policies to improve food production efficiency. Amid (2007) analyzed self-sufficiency of wheat production in Iran and addresses political difficulties in introducing reforms which could reduce the need for import. Da Silva and Grennes (1999) investigated the change of market policy from protectionist to free trade policy on the wheat market in Brazil and emphasized implications for the national food economy. Studies referring to effects of price policies on the wheat market have been conducted also in 1990s and before this time, especially in developing countries. Azzam (1991) for example, presented a three-sector model for analyzing effects of subsidy policies on the Moroccan soft wheat market. The price intervention policy has also been addressed by Muchnik and Allue (1991) who analyzed price bounds and objectives of the price policies on the wheat market in Chile. Morris (1989) provided an operational method for measuring comparative advantage for the wheat market policy in Zimbabwe.

Most of the recent studies on wheat and wheat market analyze the question of price policies and their implications for national economies. However, the questions of the influence of different productivities in the leading wheat exporting countries and structural policy implications, both on the world market of wheat and on third countries , have not yet been analyzed explicitly. This paper contributes to current discussions on structural policies on the wheat market in the EU-27 and the US and implications for the rest of the world.

In the paper, two cases of structural policies are visualized by the shift of the supply curve to the right: a) structural policy determined by technical progress, and b) structural policy determined by other political instruments. We analyze the global wheat production and do not investigate different internal and external factors influencing the wheat production.

In order to investigate the impacts of changing structural policies, we quantitatively estimate dimensions of market changes by analyzing market variables. The paper has an explorative character, as little research has been done on the question of changing productivity and structural policies on the wheat market. Using a simple market model, we make an attempt to quantitatively assess potential developments and trends on the wheat market by different scenarios of structural policies in the European Union and the US. Particularly, we focus our analysis on changes of producer surplus, budget expenditures, and welfare as a result of increasing technical progress and of implementing structural policy instruments over time.

THEORETICAL FRAMEWORK

Structural policies are usually financed by national budgets; however, also structural policies without financial contributions from the state budgets are common, as a result of changing legal rules and production conditions.

For the analyzed case of the EU-27 and the US, we define structural policy as a policy addressing economic conditions of political economies. Apart from inter-provincial and international trade, training, regulations (such as rules governing the financial sector), and tax policies, structural policies include also support for technical research and development (compare: Department of Finance Canada, 2008). We explicitly undertake one of the structural policy issues – technical progress and define it as changes and technical innovations that can result from new applications of knowledge, improved or new methods, work processes and proceedings, and finally new products (BZfPB, 2004). Technical progress brings about changes in the relations of applied production factors, changes in the production, and subsequently, an increase of productivity. As a result of technical progress, the input-output relation can be improved, while a certain production amount (output) is produced by means of a possibly low input of production factors or else a possibly high production is achieved by means of a certain input of production factors. Technical progress makes possible to reduce production costs and to increase the productivity. This development brings

about the shift of the supply curve (S) to the right (S'), which influences again other variables on the wheat market (figure 1).

The change of a structural policy in a closed economy (and the shift of the supply curve to the right) brings about a change of the market equilibrium: the equilibrium quantity is growing (change from q to q') while the equilibrium price is decreasing (change from p to p'). As a result, in the equilibrium, the consumers can purchase higher amount of a product for a lower price (consumer surplus is growing), while producers have to produce for a lower price (producer surplus is decreasing). However, at the same time, producers are benefiting just from the structural policy and the shift of the supply curve. These distribution effects will directly influence welfare changes that are defined in the case of a closed economy as a change of consumer surplus and a change of producer surplus. As an effects of structural policy, welfare is growing (shaded area between S and S' curves in figure 1).

Figure. 1. Distributional effects of structural policies in a closed economy.
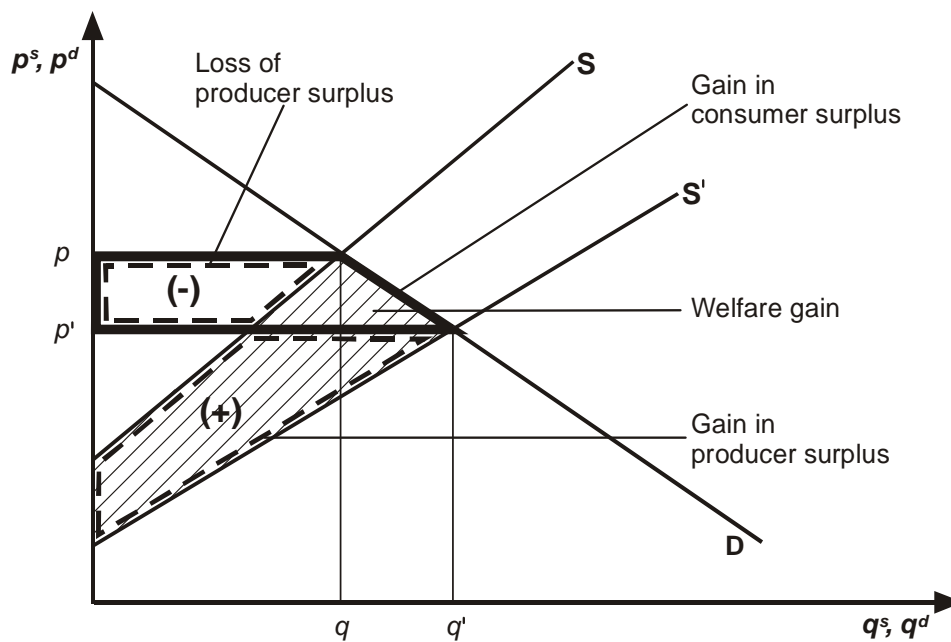
METHODOLOGY AND DATA

We analyze the implications of technical progress and of other policy instruments on the wheat market in the EU and the US by means of the Cobb-Douglas market model, following the theoretical concept of Kirschke and Jechlitschka (2002). In the model, the supply and demand functions include the following variables: world market price, national demand and supply prices, demand and supply quantities, and demand and supply price elasticities for the respective countries (Ziolkowska et al., 2009). We adopt the world market price for wheat as reported at the US Gulf Ports in 2006 and 2007 (142.8 €/t), and we abstract simultaneously from additional transport costs. We estimate the national supply and demand prices of wheat using Nominal Protection Coefficient (NPC) Indicators developed by the Organization for Economic Co-operation and Development (OECD); both Producers NPC (for estimation of supply prices) and Consumers NPC (for estimation of demand prices). The producer NPC measures the ratio between the average price received by producers (at farm gate), including payments based on output, and the border price (at the farm gate). The consumer NPC measures the ratio between the domestic price paid by consumer (at the farm gate) and the border price (at the farm gate) (OECD, n.d.). Thus, these indicators reflect a ratio between national and border prices and allow estimating producer and consumer prices. This estimation is necessary, as demand prices are not available in any official database. According to these estimations, two different price policies were identified for the analyzed countries on the wheat market: free trade in the US and export subsidy of 7% in the EU-27.

We use the statistical database from the OECD to identify the demand and supply quantities, as well as the Food and Agricultural Policy Institute (FAPRI) and United States Department of Agriculture (USDA) databases for estimation of demand and supply price elasticities (FAPRI, 2007; USDA, 2007). The demand and supply price elasticities were derived from external databases due to missing quantitative and qualitative data that was necessary for statistical estimations. Using the above data, we define the supply (production) and demand (consumption) functions (formula 1 and 2) in the situation without any

structural policy changes (basis scenario).

(1) $q^s(p) = c * p^{s\,(\varepsilon^s)}$

(2) $q^d(p) = d * p^{d\,(\varepsilon^d)}$

with:

p^s – supply price p^d – demand price
q^s – supply quantity q^d – demand quantity
c – supply constant   d – demand constant
ε^s – supply elasticity ε^d – demand elasticity.

In order to analyse changes of the production function resulting from an increasing productivity (technical progress or other structural policy instruments over time), we integrate a shift parameter 'f' into the supply function (formula 3).

(3) $q^s(p) = c \times (1+f) \times p^{s\,(\varepsilon^s)}$; $\varepsilon^s > 0$

with:

f – shift parameter.

Following, we calibrate the model on the basis of the supply and demand constants.

The demand function does not change its form, as technical progress or other structural instruments do not influence the demand for wheat. As technical progress also influences production costs, we integrate the shift parameter in the cost function (1+f) (formula 4). Additionally, the change of the supply curve implies changes of price elasticities (ε^s + 1) which results from the calculation way of the cost function ($p^s \times q^s$ refers to the change of economy equilibrium, while the second part of the formula and its calculation are related to the change of the slope of the supply curve).

(4) $C = p^s \times q^s - c \times p^{s\,(\varepsilon^s+1)^{\frac{(\varepsilon^s+1)}{}}} \times (1+f)$

with:

C – production costs.

The shift parameter 'f' (reflecting an average annual increase of wheat yields) was estimated with discrete estimation as a slope parameter ($\ln y_t = \ln y_0 + wt$), basing on the wheat yields in the time 1995-2004. Hence, following parameters were included in the analysis:

$f_{(EU-27)} = 0.61\%$

$f_{(USA)} = 1.35\%$

The shift parameter $f = 0.0061$ indicates that, in the analyzed time period, the wheat yield in each following year was growing by 0.61% on average as compared to each previous year. The supply and demand functions were estimated using the formulas 3 and 2, respectively. The calibration of the model was conducted on the basis of the supply and demand constants. For this purpose, the supply and demand constants ('c' and 'd') were set initially to 1. In this way, the supply and demand calibration parameters have been estimated, assuming a case that the constants are equal. Further, calibration parameters have been used to estimate the exact constants of the demand and supply curves in the situation of export subsidy in the EU and free trade in the US. The constants have been estimated as follows: $c = q^s$/supply calibration parameter and $d = q^d$/demand calibration parameter. The Cobb-Douglas market model in the basis scenario for the EU and the US is presented in figure 2.

Figure. 2. Cobb-Douglas market model for the EU-27 and the US in basis scenario.

Cobb-Douglas market model - EU-27					
p^s	p^d	p^w		Supply	Demand
152.80	152.80	142.80		133.35	125.63
			Calibration parameter	4.52	0.22
	Constants:		Price elasticities		Shift parameter
	c	d	of supply	of demand	f
	29.3	568.0	0.3	-0.3	**0.0061**

Cobb-Douglas market model - US					
p^s	p^d	p^w		Supply	Demand
142.80	142.80	142.80		58.06	31.19
			Calibration parameter	5.68	0.07
	Constants:		Price elasticities		Shift parameter
	c	d	of supply	of demand	f
	10.1	454.6	0.35	-0.54	**0.0135**

Source: Author's calculation

Technical progress can influence the production quantity and production costs, thus, the supply is influenced not only by the supply price, supply price elasticity, or supply amount. In the paper, we quantitatively assess the impact of technical progress on the wheat markets in the EU-27 and the US, and focus our research on welfare, producer surplus, and budget expenditures. We calculate the named market variables as follows:

Welfare = benefits – costs + foreign exchange,

Producer surplus = revenue – costs,

Budget expenditures = supply*$(p^w - p^s)$ – demand*$(p^w - p^d)$.

The basis (reference) situation on the wheat market is presented with the shift parameter f = 0 (without technical progress and without any other structural instruments influencing the wheat supply). In order to estimate the impact of structural policies as a result of technical progress, we analyze a second situation with the shift parameter f = 0.61% for the European Union and 1.35% for the US. Further, we estimate welfare, producer surplus, and budget expenditures for both scenarios.

In the basis scenario, current price policies in the EU-27 and in the US are displayed: export subsidy in the EU and free trade in the US, respectively.

For the analyzed research question, we first abstract from the time-referenced perspective and investigate a comparative-static market system in which productivity changes at a given point of time determine changes of other market variables at the same point of time. In this model, a "small country" presumption applies, which means that the price policies of the analyzed countries have no impact on the world market price. Thus, the assumed world market prices are constant.

In a next step, we extend the analysis on implications of time-referenced changes on the wheat market by other structural policy instruments with a comparative-dynamic system by including the time parameter (n) and calculating the shift parameter fn for the respective years 2005-2020 (formula 5):

$$(5) \qquad f^{n} = 1 + f^{(n-1)}$$

with:

n – time parameter for the respective years (2005-2020), n = 0, …, 15

f^n - shift parameter for the respective years n

f - shift parameter estimated for the analysis in the basis scenario (f $_{(EU-27)}$ = 0.61%, f $_{(USA)}$ = 1.35%).

Following, we investigate budget expenditures, producer surplus, and welfare in the analyzed years for the calculated shift parameters over time.

RESULTS AND DISCUSSION

Implications of technical progress on the wheat market in the EU-27

By increasing productivity resulting from technical progress, the supply curve moves to the right. This structural policy in the EU-27 would induce an increase of welfare by 86.9 million €, which simultaneously superposes welfare losses resulting from the protectionist price policy. Hence, compared to the free trade situation without technical progress, welfare is still positive, apart from negative welfare effects of the protectionist price policy. Technical progress also brings about an increase of producer surplus, which is caused by growing supply quantity under the condition of unchanged national wheat prices. The results show that when implementing protectionist price policy in the EU-27, growing productivity would contribute to an increase of producer surplus by 95 million € as compared to the basis situation without any structural policy instruments. On the contrary, growing productivity negatively influences budget expenditures. When implementing structural policies in the EU-27 the expenditures induced by the protectionist price policy would increase by 8.1 million €.

Similar implications of technical progress were found for the free trade situation on the wheat market in the US. The shift of the supply curve to the right, resulting from technical progress, brings about an increase of producer surplus and welfare. Thereby, the increase of both variables is similar (81.1 million €), which indicated an increase of producer surplus by 1.33% and of welfare by 1.05%, as compared to the situation without structural policies. The budget expenditures under free trade amount to zero.

The analysis proves that regardless of the price policy instrument implemented on the wheat market (protectionist policy in the EU-27, free trade in the US) the tendencies in implications of structural policies on the market variables in the analyzed countries are similar. Indeed, structural policy in the free trade situation has no negative effects for the national budget, which is to expect when implementing protectionist price policy.

Implications of structural policy on the wheat market in the EU-27 over time

Shifts of the supply curve can be evoked by growing productivity (effected by technical progress, private and public expenditures) or by other structural policy instruments that, however, do not require financial support from the national budgets. The effects of structural policies can be comparably measured in the course of time for several years. In order to estimate these effects quantitatively, we adjust and rebuild the comparative-static model to the comparative-dynamic one, and estimate changes of market variables over the time period of 15 years (2006-2020) in the EU-27. With this comparative-dynamic model, we estimate market variables for each year and compare them over the analyzed time period. In order to differentiate between technical progress and other structural policy measures (e.g., in situations without budget expenditures for productivity increase), we investigate two situations of structural policies:

1) Structural policy effected only by technical progress (the shift parameter f = 0.61%), and

2) Structural policy effected by other political measures that can influence the shift of the supply curve apart from technical progress (the shift parameter f = 0.91%).

The shift parameter for the second analyzed situation was assumed as 50% of the structural policy effected by technical progress. This assumption is necessary as no empirical data and estimations on effects of structural policy measures over time are available. Thereby, the analyzed market system has an exemplary character and aims at showing potential changes and implications of different policy scenarios.

For the analyzed situation, we assume constant national and world prices on the wheat market. The analysis has a prognosis character; and statements about the future development on the wheat market are made basing on results of time series analysis. Therefore, we investigate differences between the analyzed two situations as net effects of structural policies. The net effects are defined as changes of budget expenditures, producer surplus, and welfare (in the second analysed situation) compared to the first situation reflecting structural policy determined only by technical progress.

The analysis shows that in the analyzed time period, welfare, producer surplus, and budget expenditures in the EU-27 grow continuously.

Figure 3 shows that in the scenario of structural policy determined by technical progress, the welfare would increase by 1,361.4 million € in 2020, which is 6.4% more than in 2005. Thus, the welfare change is relatively small over the analyzed time period. Other structural policy measures would contribute to a welfare increase of 2,074.5 million €, which is 9.8% as compared to the welfare level in 2005. Thus, apart from the triggers of the structural policy (technical progress or other structural policy instruments), the welfare changes are not very significant in the analyzed time period.

Figure. 3. Changes of welfare as result of technical progress and other structural policy instruments by protectionist price policy in the EU-27 in 2005-2020.
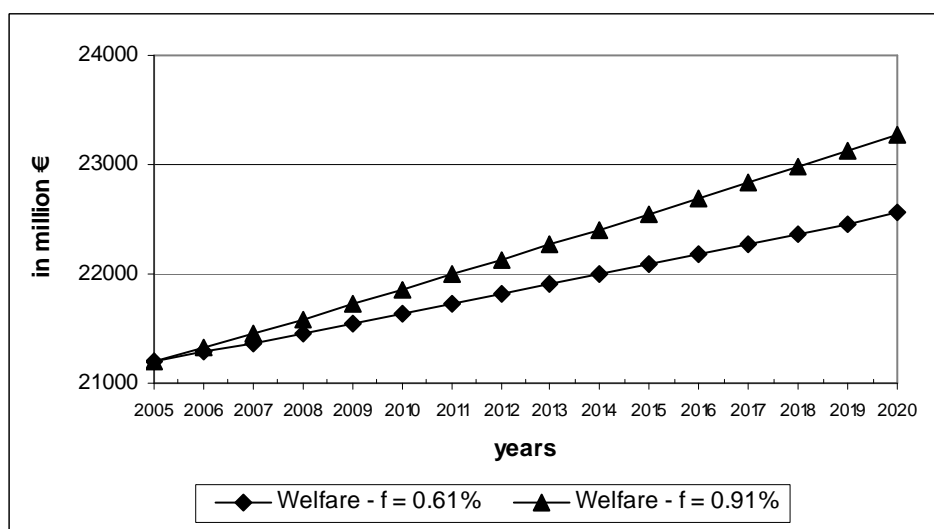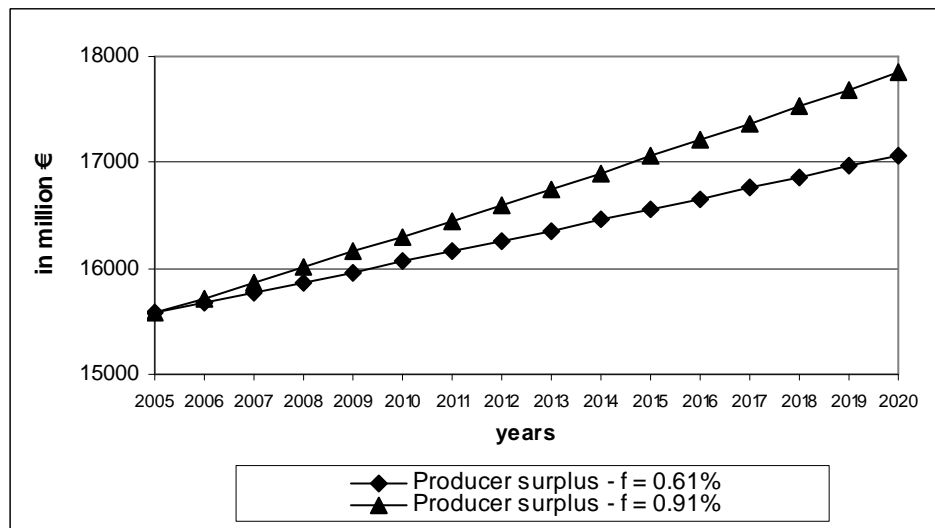

Source: Authors' calculation

More significant changes were found for producer surplus and budget expenditures. According to the analysis, technical progress would bring about an increase of producer surplus by 1,488 million € (9.6%) in 2020, while other structural policy instruments by 2,267.4 million € (14.6%), as compared to the basis scenario in 2005 (figure 4).
Simultaneously, technical progress would positively influence budget expenditures which are in 2020 almost three times as high as in 2005 (an increase of 126.6 million €). Other structural policy instruments would bring about almost four times higher budget expenditures than in 2005 (an increase of 192.9 million €).

The analysis shows also that the increase of the analyzed variables in the scenario with structural policy measures is considerably higher. The difference between the values of the variable in the first situation (technical progress) and in the second situation (other structural policy instruments) indicates net effects of structural policies on the wheat market in the EU-27. As absolute changes of welfare, producer surplus and budget expenditures have a growing tendency, the net effects of structural policies are also positive and growing.

Figure. 4. Changes of producer surplus as result of technical progress and other structural policy instruments by protectionist price policy in the EU-27 in 2005-2020.

Source: Authors' calculation

World market effects of growing productivity in the EU-27 and US
Structural policies in the leading wheat exporting countries influence also third countries (rest of the world). In a next step, we expand the analysis and investigate, how far structural policies on the EU wheat market (in the situation of protectionist price policy) and on the US wheat market (in the free trade situation) would influence the world market price of wheat and market variables in third countries in 2005-2020. This investigation can be seen as a prognosis analysis. We assume constant national prices for wheat and estimate structural policy as an effect of technical progress, thus assuming the shift parameters f = 0.61% (for the EU-27) and 1.35% (for the US). For the analysis of

word effects, we extend the model by including third countries and calibrate it for the new situation. The internal price of wheat in third countries is assumed to be equal to the world market price. The calibration of the model occurred for the supply and demand quantities resulting as a difference between the wheat supply and demand in the world and in the EU and US. Thereby, we assume that the market is cleared (supply = demand) and we abstract simultaneously from stocking possibilities. Thus, in the basis scenario, the market balance is equal to zero. In this situation, production surplus can be stated in the EU-27 and the US, while in third countries the supply exceeds the demand by 33 mega tons. The model is presented in figure 5.

For the analyzed market and the basis scenario, we assume the free trade situation on the world market of wheat. Due to the broad definition of 'rest of the world' comprising several world countries, no information on price elasticities is available. As in third countries free trade situation is presented; we assume the demand and supply price elasticities on the same level as in the US with free trade policy.

Effects of growing productivity on the world market price of wheat
In order to estimate effects of structural policies in the EU-27 and the US over time we integrate the shift parameters once in the EU model and in the US model, consecutively. We investigate changes of the world market price of wheat by different structural policies in the European Union and the United States in 2005-2020.

The analysis shows that structural policy in the analyzed countries would bring about a stepwise decrease of the world market price of wheat in the following years. Thus, through technical progress, the world market price of wheat would decrease to 140.8 €/t in the EU-27 and to 140.7 €/t in the US, as compared to the world price of wheat of 144.3 €/t in the basis situation without any structural policies in 2005 (figure 6). This development can be explained with the fact that through technical progress wheat production costs are decreasing, which directly influences world market prices of wheat.

Figure. 5. Basis scenario for analysis of world market effects on the wheat
          market.

EU						
p^s	p^d	p^w		Supply	Demand	Surplus
152.80	152.80	142.80		132.50	125.60	6.90
			Calibration parameter	4.52	0.22	
	Constants:		Price elasticities:			
	c	d	of supply	of demand		
	29.3	567.8	0.3	-0.3		

US						
p^s	p^d	p^w		Supply	Demand	Surplus
142.80	142.80	142.80		57.30	31.20	26.10
			Calibration parameter	5.68	0.07	
	Constants:		Price elasticities:			
	c	d	of supply	of demand		
	10.1	454.7	0.35	-0.54		

Third countries						
p^s	p^d	p^w		Supply	Demand	Surplus
142.80	142.80	142.80		430.60	463.60	-33.00
			Calibration parameter	5.68	0.07	
	Constants:		Price elasticities:			Balance
	c	d	of supply	of demand		0.0
	75.8	6756.1	0.35	-0.54		

Source: Author's calculation

Figure. 6. World market price of wheat by growing productivity in the EU-27 and US in 2005-2020.
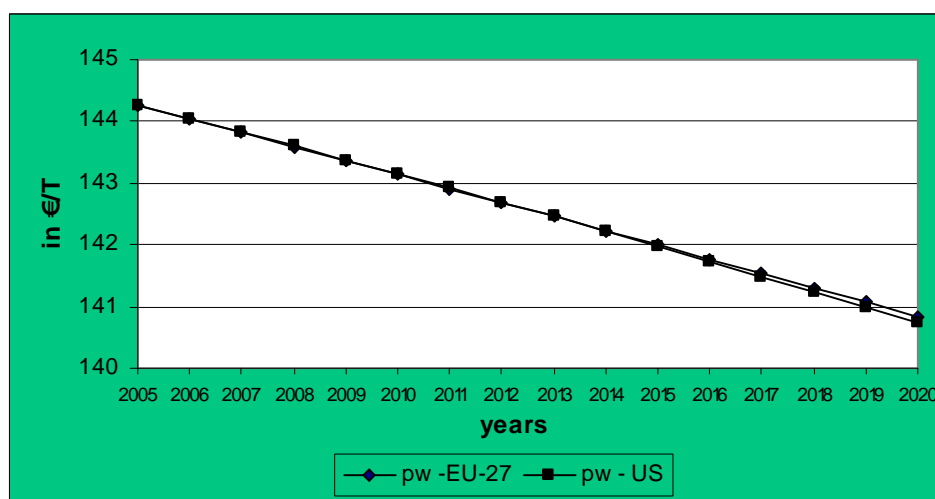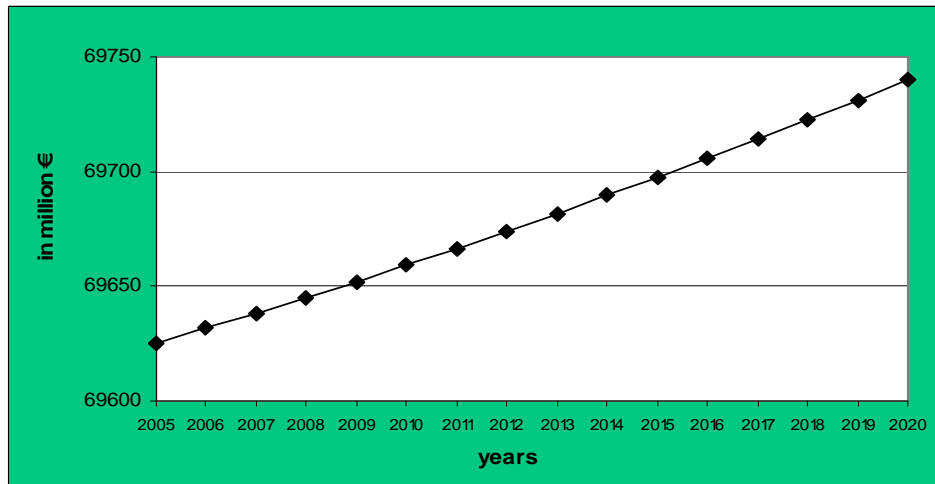

Source: Author's calculation

Figure 6 shows that a similar tendency was found for the world market prices of wheat, determined by technical progress in the US. Therefore, the estimated prices are almost on the same line regardless of different price policies implemented in the analyzed countries. The analysis shows that technical progress indeed determines the world market price of wheat; however, the impact of structural policies on the wheat market is quite similar for big wheat exporting countries.

Effects of growing productivity on third countries

Structural policies in the EU-27 and in the US can also influence third countries. In order to quantitatively assess changes of economic variables in the rest of the world, we focus our analysis on welfare, producer surplus and consumer surplus, provided the objective to maximize welfare under the given conditions. The analysis shows that growing productivity in the EU-27 and in the US over the time period 2005-2020 results in growing welfare and consumer surplus in third countries (see figure 7 and 8 for the EU-27).

Figure. 7. Influence of growing productivity in the EU-27 in 2005-2020 on
welfare in third countries.

Source: Author's calculation

Figure. 8. Influence of growing productivity in the EU-27 in 2005-2020 on
consumer surplus in third countries.
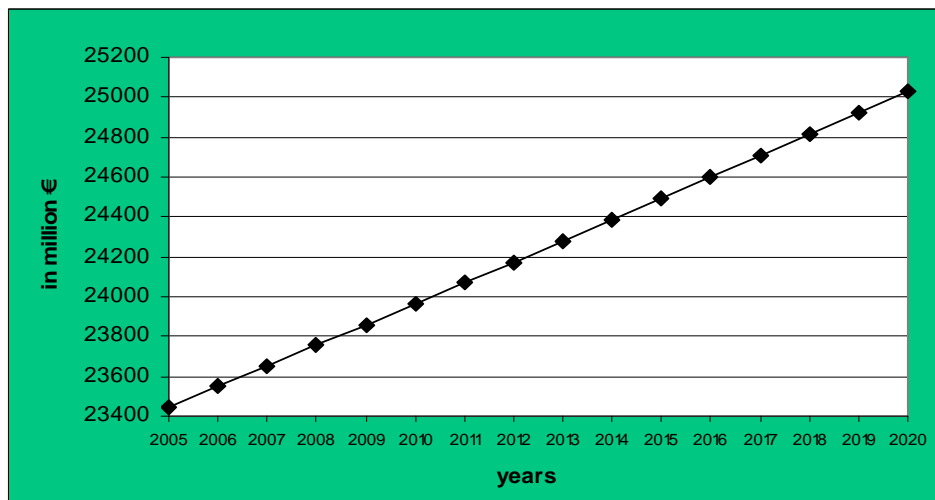
Source: Author's calculation
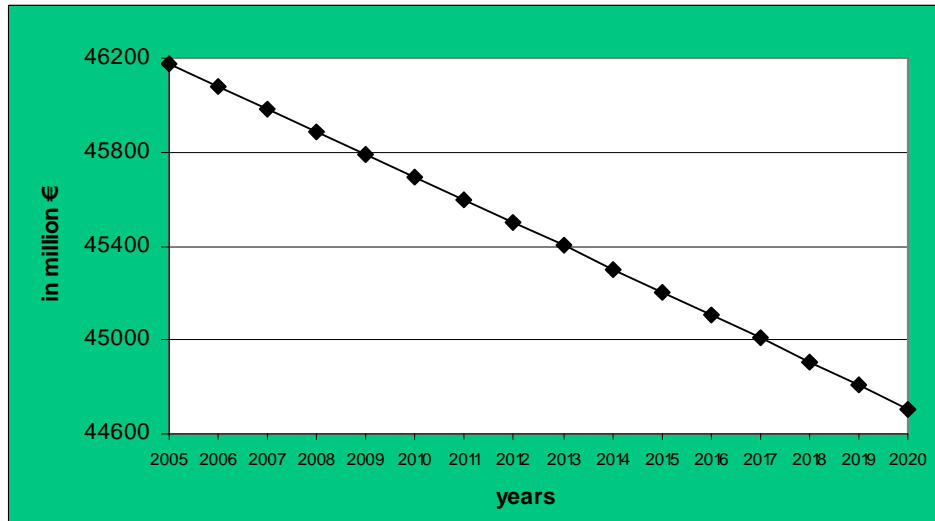
Simultaneously, negative effects for producers in third countries are
expected (see Figure 9 for the EU-27).

Figure. 9. Influence of growing productivity in the EU-27 in 2005-2020 on producer surplus in third countries.

Source: Author's calculation

An increase of welfare and consumer surplus in third countries can be explained with the fact that third countries in the model are wheat importers (demand > supply). The growing productivity in the EU-27 results in decreasing world market price for wheat, which again brings about a welfare increase. The decreasing world market price is also beneficial for consumers and disadvantageous for producers in third countries.

A similar tendency was found for structural policies in the US. The expected influence on third countries is the same as in the case of structural policies in the EU, and also effects of these changes are comparable. Thus, the analysis proves again that regardless different structural policies (and thus different productivities) in the analyzed countries, implications for third countries are similar.

CONCLUSIONS

Structural policy instruments can directly influence agricultural production and productivity. Using a Cobb-Douglas market model, we conduct an explorative analysis on potential national and global implications of structural policies on the wheat market in the EU-27 and US. The investigation proves that when implementing protectionist price policy in

the EU-27, technical progress can contribute to an increase of producer surplus by 95 million € and of welfare by 86.9 million €; as compared to the basis situation without any structural policy instruments. However, it has a negative impact on budget expenditures which can increase by 8.1 million €. Similar implications of structural policies were found for the wheat market in the US and the free trade situation. Thus, apart from price policies implemented on the wheat market, the implications of structural policies on the market variables in the analyzed countries are similar. However, structural policy in the free trade situation has no negative effects for the national budget, which is the case in the situation of protectionist price policy in the EU-27. Hence, provided limited budget funds, growing productivity on the wheat market is more beneficial in case of free trade policy.

Dynamic effects of structural policies can be effected by different instruments (technical progress or other structural policy instruments), and measured in the course of time. In the paper, implications and effects of different structural policy instruments were investigated. In the analyzed time period 2006-2015, in the scenario of structural policy determined by technical progress in the EU-27, the welfare can increase up to 1,361.4 million € in 2020, which is 6.4% more than in 2005. Other structural policy measures can contribute to a welfare increase by 2,074.5 million €, which is 9.8% more than in 2005. In both cases, the welfare changes do not exceed the level of 10%. More significant changes were found for producer surplus and budget expenditures. As a result of technical progress, producer surplus can increase by 9.6% till 2020, while other structural policy instruments can lead to an increase of producer surplus by 14.6%, as compared to the basis scenario in 2005. Technical progress can positively influence budget expenditures, which are almost three times as high as in the basis scenario in 2005, while other structural policy instruments can bring about four times higher budget expenditures than in 2005.

In this paper, also the impact of structural policies in the leading wheat exporting countries on third countries (rest of the world) was analyzed. As a result of structural policies, a continuous decrease of the world market price of wheat to 140.8 €/t in the EU-27 and 140.7 €/t in the US was estimated, as compared to the world price for wheat of 144.3 €/t in the basis situation in 2005, without any structural policies. Thus, leading wheat exporting countries can influence the situation on the world market; however, changes of structural policies in these countries are not significant and can lead to a decrease of the

world price of wheat by approximately 4 €/t. Growing productivity in the EU-27 can contribute to an increase of consumer surplus by 6.8%, welfare by 0.2%, and to a decrease of producer surplus by 3.2% in 2020, as compared to 2005 without any structural policies implemented.

Additionally, the analysis proves that apart from different productivities in the leading wheat exporting countries, implications for the world market of wheat and for third countries are similar.

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Maize Response to a Synthetic Organic Nitrogen Fertilizer, Poultry Manure and Time of Application in the Guinea Savannah of Nigeria

[1]J. A. OLOFINTOYE, [2]M. O. SUNNIE-ODODO and [1]V. MAKINDE
*[1]Department of Agronomy, University of
Ilorin, P.M.B.1515, Ilorin, Nigeria.
[2]National Museum, Ilorin.
e-mail: olofintoyejoseph@yahoo.com*

ABSTRACT

Two field experiments were conducted at the Teaching and Research Farm of the University of Ilorin, located in the Guinea savannah agro-ecological zone of Nigeria, to study the effects of a synthetic organic nitrogen fertilizer (Urea) and poultry manure (Pm-a natural organic nitrogen source) and their time of application on growth and yield of maize (Zea mays L.). The response of maize to the two sources of nitrogen varied significantly with time of application. Urea applied at 4 and 6 weeks after planting (wap) gave the best crop performance while poultry manure applied between planting and 4 wap recorded better crop performance than the other times of application. Maize growth and grain yield were consistently better in poultry manure and urea-treated plants than in the no-fertilizer control treatment at p<0.05. Poultry manure compared favorably with urea in promoting crop growth and yield when applied between planting and 4 wap. This suggested that Pm could be used to raise crops of maize on marginal soils that would not normally support maize production without nitrogen fertilizers.

Keywords: Natural, Synthetic-Organic-Nitrogen-Fertilizer, Maize.

INTRODUCTION

Maize (*Zea mays* L.) is used extensively as the main source of calories in animal feeds and it constitutes the staple item of the diets for more human beings over a longer period of time than any other cereal (Okoruwa, 1995). The increasing global demand for grains, to feed the growing human population and the ever-expanding livestock industries have made the need to increase maize production necessary.

The Guinea savannah agro-ecological zone of Nigeria (the food basket of the nation) has the greatest potential for maize production (Kassam and Kowal, 1973). Ironically, however, the average maize yield in farmers' fields, where the bulk of the maize is produced in this zone is estimated at about 1.5 t ha^{-1}. This yield level is much lower than the potential yields of improved maize varieties (estimated at about 3 to 4 t ha^{-1}) developed for high grain yield in the country. The factors which have been responsible for the low maize yield in Nigeria include: low levels of soil organic matter (Jones, 1973) and native nitrogen and phosphorus (Bache and Rogers, 1970). The low soil fertility has long been recognized as one of the major biophysical constraints affecting food production in sub-Saharan Africa. Soil fertility depletion in small holder farms in the region has been identified as the fundamental cause of declining per capita food production (Sanchez *et al.,* 1990). The depletion has been attributed mainly to intensive and continuous cropping with little or no fertilizer application and thus culminating into imbalance between nutrients supply and extraction from the soil (Sanchez *et al.,* 1990).

The declining productivity of many tropical soils has been one of the major constraints limiting the realization of the genetic potentials of available improved crop varieties (Dudal and Deckers, 1993).The need to take appropriate steps to check the declining soil productivity by improving the physico-chemical properties of the soil including its fertility in order to increase maize yield is urgent, because the rate of deterioration is increasing and it is bound to have serious implications on future food security in the region. Adequate inputs of nutrients as fertilizers as well as soil amendments to improve physico-chemical properties are required to overcome the constraints. Maize for example, has high demand for nitrogen, thus nitrogen becomes the first limiting nutrient as land use intensifies. This explains why it is almost impossible to grow maize successfully on some soils in the Guinea savannah of Nigeria without nitrogen fertilizers. For example, FAO (1988) reported that the role of nitrogen in maize production in the Guinea savannah of Nigeria is not easily substituted. The scarcity and the increasing cost of inorganic fertilizers in Nigeria presently have limited their use for maize production (Willrich *et al.,*1974). There is therefore the need to look inwards for alternative sources of nutrients for maize production. An increasing dependence on natural organic wastes, such as farmyard manures, compost, crop residues and poultry manure as sources of nutrients for crop production is inevitable in the nearest future, in the light of the present predicaments in sourcing for inorganic fertilizers.

Poultry manure is abundantly available in many parts of Nigeria, wasting and sometimes constituting a nuisance where it is generated as a bye-product of poultry farms. It has been established that poultry manure (Pm), contains sizeable levels of nitrogen and that 60-80% of its nitrogen is in organic form, while the remaining 20-40% is in inorganic fractions, and that approximately 50% of the organic nitrogen is mineralizeable within 90 days under laboratory conditions (Sims,1986; 1987; Tanimu *et al.,* 2007). It is therefore necessary to provide more information on the management of Pm as source of nitrogen for maize production. This work was therefore designed to evaluate the response of an improved maize variety to poultry manure and urea (a synthetic organic nitrogen fertilizer).

MATERIALS AND METHODS

Two field experiments were conducted during the 2004 and 2005 cropping seasons at the Teaching and Research Farm of the Faculty of Agriculture, University of Ilorin (8°,20'N and 4° 35'E), in the Guinea savannah agro-ecological zone of Nigeria. The experiments were designed to evaluate the response of maize to two organic sources of nitrogen and their time of application on a sandy-loam soil. Initial soil samples were taken from the experimental site and analyzed for physico-chemical properties. The results of the soil analysis was as presented: sand, 81.5%; silt, 10.5%; clay, 8.0%; pH (H_2O), 5.79; organic matter,20 g kg^{-1}; available P, 5.5 ppm; Calcium, 1.5 cmol kg^{-1}; Potassium,

0.2 cmol kg^{-1}; Magnesium, 1.1 cmol kg^{-1}; Sodium, 1.2 cmol kg^{-1}; total nitrogen, 4.22 g kg^{-1}.

The site was cropped to maize during the previous season. The land was ploughed once, harrowed twice and maize was planted on the flat. Two organic nitrogen fertilizers (urea and Pm), a no-fertilizer control and five times of application [2 weeks before planting (wbp), at planting (atp) 2, 4 and 6 weeks after planting (wap)], were tested on an improved maize variety (SWAN-1-SR), maturing in about 100days. The treatments were arranged as a 3×5 factorial in randomized complete block design (RCBD), in 2004. Each of the 15 treatment combinations was replicated three times. In 2005 the two organic nitrogen sources and the no-fertilizer control and four times of application (atp, 2, 4, and 6wap) were evaluated using 3×4 factorial arrangement in RCBD, with three replications. The synthetic organic nitrogen fertilizer used was urea $(CONH_2)_2$ containing 46% N and the rate of nitrogen from this source was 100 kg N ha^{-1}. In estimating the quantity of Pm needed to supply 100 kg N ha^{-1}, 1.29 % N was used as the percentage of N in Pm instead of the 4.3 % total N obtained in a laboratory analysis as the percentage of total N in the Pm. The 1.29% N represented the mineralizable N in the Pm, based on literature that 60 – 80 % of nitrogen in poultry manure is in organic fraction and that approximately 50 % of the organic fraction was mineralized within 90 days under laboratory conditions (Sims, 1986; 1987 Tanimu *et al.,* 2007). The poultry manure was therefore applied at the rate of 5.8 t ha^{-1}. Wet and well disintegrated Pm was used. Phosphorus and potassium were applied at the rates of 50 kg P_2O_5 and 30 kg K_2O ha^{-1}, respectively, to all plots using single supper phosphate and muriate of potash, respectively. The spacing was 90 cm between and 60 cm within rows and three plants were maintained per stand. Data on grain yield and yield components were collected in 2004 while growth parameters were included in 2005. All plots were weeded two times during the growing season. All the data collected were subjected to statistical analysis and the significant means were separated by using the new Duncan's multiple range test (DMRT).

RESULT

Table 1 shows the mean square of ANOVA of treatments on yield components and grain yield of maize in 2004. Time of application of the nitrogen sources had no significant effects on cob length and diameter but it significantly influenced the weight of 1000 seeds and grain yield. Heavier grains were recorded for the 6 wap treatment than in all other times of application (Table 2). The superiority of the 6 wap treatment over other times of application as recorded in the weight of 1000 grains, was however, not reflected in the grain yield, which was not statistically different for all times of application except for the 2 wbp treatment,

which produced the lowest grain yield. The influence of nitrogen sources on yield and yield components was highly significant. Cob length and weight of 1000 seeds in urea and Pm treated plants were comparable and they were significantly better than that obtained in the no- fertilizer treatment. Urea however, produced higher grain yield than the poultry manure (pm) and the no-fertilizer control while Pm was also superior to the no-fertilizer control. Cob diameter was not affected by nitrogen sources (Table 2).

Interaction between nitrogen sources and time of application was significant for grain yield in 2004 (Table 1) and for plant height, stem girth and grain yield in 2005 (Table 3). The main effects of nitrogen sources and time of application on plant height, stem girth, grain yield and yield components in 2005 are presented in Table 4.Time of application had no significant effects on weight of 1000 grains while nitrogen sources had marked influence. Urea and Pm were comparable and consistently better than the no-fertilizer treatment in their effects on weight of 1000 seeds.

The interactive effects between nitrogen sources and time of application on grain yield in 2004, 2005, stem girth and plant height in 2005 are presented in figures 1,2,3 and 4, respectively .The figures, (interactive bar charts) showed that time of application was a determining factor in the responses of maize to the nitrogen sources. In other words, how well the crop responded to the nitrogen sources in terms of growth and yield was dependent on the time during the life duration of the crop that the fertilizer was applied. In figures 1 and 2, the highest grain yields were recorded for urea applied at 4 wap (3.8 t ha^{-1}, in 2004 and 2.80 t ha^{-1}, in 2005), followed by urea applied at 6 wap (3.60 t ha^{-1} in 2004 and 2.20 t ha^{-1} in 2005). The two treatments were comparable and they produced yields which were statistically higher than yields obtained from the same source of N applied at 2 wbp, atp and 2 wap. Urea at all its time of application was superior to the no- fertilizer control. Application of urea at 2 wbp in 2004 produced the lowest yield (2.1 t ha^{-1}) for urea (fig. 1) while in 2005 the lowest grain yield (1.08 t ha^{-1}) was recorded in urea applied at planting. Urea was only superior to Pm at all times of application when applied at 4 and 6 wap; at other times of application urea and Pm were comparable. Poultry manure produced significantly higher grain yield than the no- fertilizer control at all times of application except 2 wbp in 2004 and at planting in 2005. The highest grain yield for Pm was recorded at application made 4 wap (2.5 t ha^{-1}) and 6 wap (2.45 t ha^{-1}). Poultry manure applied 2 wbp produced the least and significantly lower yield (1.84 t ha^{-1}) than yield in other times of application. On the contrary, Pm applied 2 wap produced the highest grain yield (1.81 t ha^{-1}) in 2005, which was significantly better than yields recorded for Pm at other times of

application. Yield from Pm applied at 2 wap compared favorable with yield from urea applied 2 wap (1.90 t ha^{-1}) and it was better than the yield from urea applied at planting (1.63 t ha^{-1}). Application of Pm at planting was not better than the no-fertilizer control in 2005, but in 2004 it was significantly better.

The interactive effects of the nitrogen sources and time of application on stem girth and plant height are presented in figures 3 and 4. The no-fertilizer treatment recorded significantly lower plant height and stem girth than urea and Pm at all the times of application. Urea-treated plants were significantly taller and thicker in diameter than Pm-treated plants, at all the times of application. The highest height (177.9 cm) and and thickest stem girth (2.70 cm) were obtained in applications made at 2 wap. Responses of maize to the nitrogen sources in terms plant growth, varied significantly with time of application, as shown in the figures 3 and 4.

DISCUSSION

The results show that, when applied at the right time, urea and Pm had significant positive impacts on maize performance as compared with the no-fertilizer control treatment. Applied between planting and 4 wap, Pm compared favorably with urea in its influence on the growth and yield of maize. This result was corroborated by other reports that higher soyabean grain yield was obtained with poultry manure applied at 10-20 t ha^{-1} as compared with mineral fertilizers in the Guinea savannah of Nigeria (Alofe *et al.,* 1995). Other works have also demonstrated the efficiency and effectiveness of farmyard manure and other organic nutrient sources in maintaining soil fertility, increasing maize and other crops' yields and sustaining soil productivity (Asfaw *et al.,* 1997; Grant, 1981; Heluf Gebrekidan *et al.,* 1999). These results therefore suggested that Pm could be used to successfully raise crops of maize in the absence of mineral fertilizers, on exhausted soils that would not have been able to support maize cultivation without mineral nitrogen fertilizers in the Guinea savannah of Nigeria. The reality of such marginal soils in the Guinea savannah of Nigeria would explain why it is almost impossible to grow maize without mineral fertilizers on some soils in the region. The statement credited to FAO (1988), that the role of nitrogen in maize production in the Guinea savannah of Nigeria is not easily substituted, confirms the reality of the presence of such marginal soils in the region.

The results also indicated that the response of maize to the nitrogen sources varied significantly with time of application. In other words, timely application of the organic nitrogen sources was an important factor determining how well the maize responded to them. For urea, applications made at 4 and 6 wap gave the best results while Pm applied between planting and 4 wap recorded the best crop performance.

The apparent poor response of maize to the fertilizers applied 2 wbp could be due to the absence of crop roots to receive the nutrients from the fertilizers when applied. Most of the nitrogen in the fertilizers, particularly urea, could have been lost before crop establishment, owing to the mobility of nitrogen in the soil. This inference sounds convincing, considering the porous nature of the soil used in these trials.

The application of urea at 4-6 wap resulted in good grain yield, because the applications coincided with the period of flower initiation in the maize cultivar used, which matures in 90 - 100 days; its flower initiation was expected at 4-7 wap. The application of Pm at planting to 4 wap also ensured that nitrogen was made available to maize during the period of flower initiation to taselling, through mineralization and slow release. It has been established that the period between flower initiation and anthesis is the time cereals most need nitrogen for grain formation and development (Tanaka *et al.,* 1966). Works on rice at the International Rice Research Institute (IRRI) also revealed that 75% of the carbohydrates in cereal grains come from photosynthesis after flowering (Tanaka *et al.,* 1966).

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Constraint to Women's Participation in Agricultural Production in Rural Areas of Kaduna State, Nigeria

R .O. YUSUF, Y.A. ARIGBEDE and O. KOLADE
Department of Geography,
Ahmadu Bello University, Zaria,
Nigeria

ABSTRACT

Despite the increasing advocate for women empowerment through equitable policy framework , many women in rural areas still face serious obstacles that frustrate their attempt to secure qualitative livelihood from farming activities. The major aim of this paper is to examine the constraints faced by rural women farmers towards actualizing their aim for household food security and improved income from farming enterprises. To achieve the aim and objectives, questionnaire survey of 280 women systematically drawn from four rural districts of Sabon-Gari and Giwa Local Government Areas (LGAs) of Kaduna state was employed .Descriptive statistics such as frequency table, and percentages were employed to analyse the data collected while Student's t-test was used to validate the hypothesis. From the results, about 70% of sampled women farmers practice farming on a subsistence basis. Also, 96% claim that their productive potential is not maximized while 83.64% encounter several socio-economic constraints among which were financial and socially-embedded constraints with 33.18% and 87.27% responses respectively. The result of the Student's t test reveals that the critical t value of 2.179 with 12 degrees of freedom is significant at 0.05 level .Consequently, the hypothesis that similar financial and socio-cultural constraints face women farmer's agricultural activities is rejected. The results revealed that constraints faced by women farmers tend to reduce with increasing urbanization though further study is needed in this direction. Conclusion was based on the recommendations that there should be formulation and implementation of women-biased landholding and titling policies through modification of the present land tenure system, creating a financial credit pool for women using the Welfare Departments of local government councils, and organizing women farmers into functional women cooperatives for easy access to loans and farm input.

Key words: Constraints, women farmers, rural area, Giwa LGA, Sabon-Gari LGA.

INTRODUCTION

Several policy related efforts such as Back to land scheme, Green Revolution, Operation feed the nation, Agricultural Development Programmes geared at intensifying the drive to a food-secured Nigeria has not achieved the targeted aim because of several lapses. A major area of concern is the inadequate integration of women into the agricultural sector. Women encounter different agricultural-related bottlenecks which have continued to drawback their striving for food self-sufficiency and improved income at the household and community levels. As Mamman (1995) rightly observed, there is a monumental loss in any developing country's economic productivity that is negligent of the role of women in agricultural production.

In the 1970s most of the researches carried out on the agricultural activities of women particularly in northern Nigeria showed that women involvement were low. For example, Salihu and Ohwona (1995) found out that in Giwa and Makarfi Local Government Areas (LGAs) of Kaduna state, women's agricultural productivity was grossly inadequate. Even during colonialism several factors combined to restrict women's productive participation in farming (Trenchard, 1987). Lately, however and due to economic realities, the role of women as food producers has increased substantially to between 60% - 80% even though few data exist on the agricultural and economic activities of rural women (Odugbesan, 2008). The idea that men are the real or supposed to be the breadwinners of their households is deeply entrenched in the society (Mamman, 1995; Ubogu and Ata, 2010) .Hinged on this premise; male farmers were the target beneficiaries of agricultural extension programmes and services.

Yet as more men migrate to urban areas from rural areas, more women are left as household heads carrying on with the agricultural activities that provide basic needs for their families. It is documented that over 80% of all rural women in sub-saharan Africa including Nigeria are economically active in one agricultural activity or the other (Onyenechere, 2008). Studies from different parts of the world have demonstrated the unrivalled role of rural women in agricultural production. They produce 70% of food crops for domestic consumption and sales, and make up over 70% of the agricultural labour force (Emeghara and Njoku, 2008; Ayoola, 2001).

Women no doubt constitute the largest rural population especially where male-focused rural out-migration is well established. Also they work long hard hours as wives, mothers and bread winners (Djaji, 1998). Ipingbemi, and Aloba (2005), discovered that women perform close to 90% of works associated with processing of food crops; 80% of hoeing and weeding; 80% of efforts relating to food storage and transportation from farm to village, as well as 60% of the harvesting and marketing work. Also, as documented by Lyam and Jeiyol (2008) the agricultural activities of women do not lead to serious environmental degradation when compared to men Unfortunately, agricultural development programmes are in most cases designed and planned for men especially in rural societies where socio-religious patriarchy is well entrenched. Worse still, men displace women when new innovations are introduced (Olayiwole, 1984).

In eastern Nigeria, farming is the important economic activity of the rural women (Akande, 1984). Studies in former Anambra and lmo states, revealed that over 90% of the rural women were engaged in farming and post-harvest operation, as they perform such tasks as land clearing and preparation, planting, weeding and harvesting work on their own small plots as well as on their husband plots. The women grow food crops such as rice, maize, cassava,

vegetable etc while men on the other hand grow tree crops and tuber crops especially yams. Although depending on the socio-cultural flexibility of different Nigerian ethnic groups, a large number of women were involved in decision making concerning farm operations (Mamman, 1995) and animal husbandry (Makun, *et. al. 2005,*). Indeed, Lyam and Jeiyol (2008)'s study in Benue state,Nigeria, reveals that there is no glaring difference in the agricultural operations of both male and female farmers .

It is clear from the foregoing that the position of the rural women in developing countries has not changed significantly since the 1970s. Rather, their socio-economic conditions have continued to deteriorate. This situation is even more worrisome considering the fairly higher level of economic prosperity achieved by these countries during the same period and the vigorous campaign for gender equality in access to economic opportunities and women empowerment. In fact this partly is one of the issues emphasized after the 1995 Beijin Conference 35% affirmative action on women representation. According to an IFAD (1992) survey, the number of women in poverty in developing countries increased by 50% in the last two decade while that of the overall population grew by only 40%.Also in Nigeria, available data indicates that incidence of poverty among women is higher (FOS, 1997& 1998). Also, the poverty profile in Nigeria (FOS, 1999) cited in Yusuf (2008) shows that with a poverty incidence of 67.7%, Kaduna state ranked among the tenth poorest states in Nigeria.

Implication of this is that rural poverty is increasing at a faster rate amongst women whereas regrettably though, the number of women assuming house-hold headship is increasing. The rural female-headed households are poorer than the others; they have less access to both tangible and non tangible resources of production (Emeghara and Njoku, 2008). Thus, if these women continue to face constraints it will increase not only the poverty level of the households but will also contribute to child and maternal mortality with the attendant consequences on the nation's development. Constraints as used here are limitations, problems, tightly controlled restrictions and other processes that stifle or hinder progress. The aim of this paper is therefore to analyze these constraints in rural settlements from a section of northern Nigeria where poverty incidence is high and socio-cultural rigidities are also well entrenched. This is what the paper addresses with a two-pronged objectives: (1) to find out the area of agricultural production in which women participation are relevant , and (2) to examine some of the major challenges hindering women from effectively benefiting from progress in agricultural development and contributing their quota to boosting their income and food security.

The Study Area

Giwa LGA lies approximately within latitudes 11°- 11° 30` N and longitude 7°15`- 7° 30` E while Sabon-Gari LGA lies approximately between latitudes 11°- 11° 30` and 7° 30` and 8° E. The vegetation type is Savannah wood land (Statistical year book of Kaduna state 2001) with a relatively low precipitation. The average annual rainfall is about 127mm. The soil in the study area fade from the less fertile laterite soil into ferruginous types derived from the basement complex rocks. This enables the predominance of farming as the main occupation of the people living in the area grown crop include maize, vegetable, guinea com, millet etc.

The study area falls within the northern Kaduna region. Giwa was carved out of Igabi LGA of Kaduna state. It has 11 rural districts serving as administrative headquarters for the villages. The area is bounded in the west by Birnin-Gwari LGA, 1gabi LGA in the south; Sabon-gari and Zaria LGAs are to the east while Katsina state is to north. Sabon Gari LGA on the other hand was created out of Zaria LGA. It has six districts out of which two are rural while the remaining four are urban The LGA is surrounded by Zaria LGA, Kudan LGA and Giwa LGA to the south, north-west and east respectively.

According to 2006 National Population Census, Giwa LGA has a population of 286,427 while that of Sabon-Gari is 137,867. Majority of the people in this area are involved in farming activities. Other primary production activities in this area include livestock rearing, carving etc. The secondary activities include bakery and other local food processing activities. The tertiary activities in this area are basically transportation and marketing of agricultural products .However, quite a handful population work in the local government secretariats, educational institutions and other government-owned parastatals.

The study LGAs are dominated by the Hausas. Fulanis are also common. Other ethnic groups include the Yorubas, Igbos, Igala, Nupes, Ebiras etc. Two major religions in the area are Islam and Christianity. Generally, socio-cultural patriarchy is well established in these rural settlements. Despite that, there is the need to examine if spatial variation exists in the constraints faced by the women given the similarity of the agro-ecological and socio-cultural conditions.

Theoretical framework of constraints to women in agriculture and development

Since the end of colonialism in many African countries, increasing research attentions have examined the roles of and limitations to women in agriculture. In fact, prior to this time, it was said that African women have suffered under 'two colonialisms'; that of Europe and that of men (Stock, 2004). Although a variety of theoretical postulations have been used to understand these feminist issues (Peet, 1998), two preferred in this study are those of Boserup (1970) and Miller (1990).

Boserup's book, 'Women's Role in Economic Development' (1970) was a ground breaking work that generated a great deal of research that have globally restructure the views on women in development and stimulate feminist ideas as a whole. Although Ester Boerup did not challenge the then underlying prevailing global economic system that led to the erosion of traditional right of women to land, the kernel of her discourse which remains valid to the present study can be highlighted as follows::-
- Developmental polices rarely credit or invest in women despite their enormous contributions to agriculture.
Women's right to use and own properties are rarely formally recognized or supported by formal laws and developmental agencies.
In trade and commerce women's role are often overlooked, and access to credit denied when they do not lack property titles
In Third World countries, regions with high female contributions to farming tend not to have egalitarian gender relations.

Regions with high female participation in farming in developing countries of Sub-saharan Africa, parts of Latin America and South east Asia with indigenous low-farming system are associated with these characteristics. Boserup's theory was indeed put into practical research application in
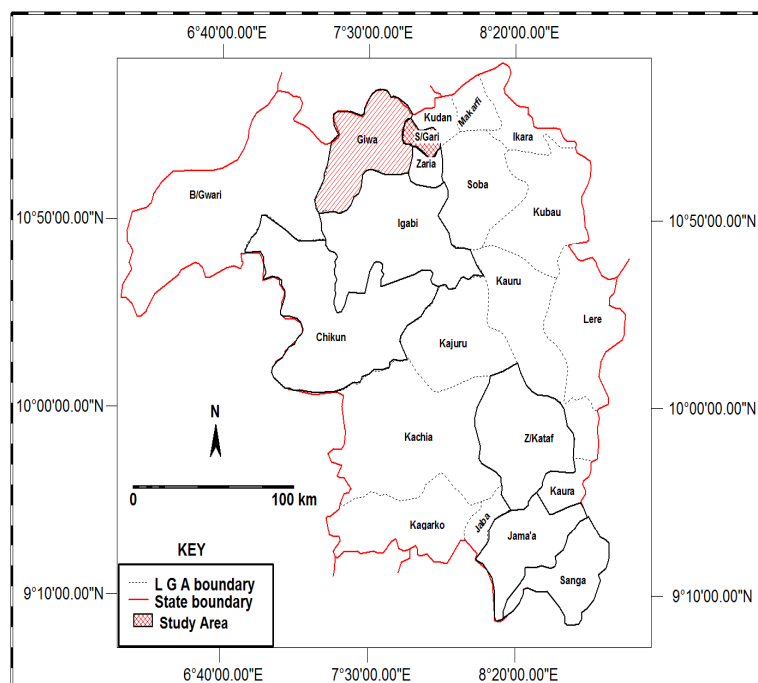

FIG. 1 KADUNA STATE SHOWING THE STUDY AREAS
Source : Adapted and Modified from Bureau for Land and Survey, Kaduna State

Guatemala where four different communities were examined in order to understand the impact of various changes of the economic participation and social condition of women. All these studies confirmed Boserup's assertion.

Indeed, feminist studies globally focus on explaining the denigration suffered by women indifferent socio-cultural setting. For example, Bronstein, 1982 cited in Peet (1998) synthesized from the International Labour Organization's publication   that women comprises 50% of the world's population, do two-thirds of the world's work hours, receive 10% of the world's income and own less than 1% of the world property. Analyses like these are the building blocks for terms like 'feminization of poverty'.

Miller (1990) in her analysis started with the study of unequal sex ratio. Sex ratio is the number of males per hundred females. In Miller's theory as summarised by Bossen (2005), the participation of women in economic activities outside the home was a major explanation for the different values placed on girls and women in the Northern and Southern region of India.

In the northern region of India, sex ratio was very high because of the practice of female infanticide. due to this practice, daughters generally suffered higher malnutrition and mortality in childhood than boys, leading to a disproportionate number of males in the population. In the southern part of India however, fatal discrimination against daughters is not common and such birth and child sex ratio are closer to the expected ratio of around 106% boys per 100girls.

Miller (1990) considered the general difference in agriculture as a possible foundation of some difference in sex ratio. In northern India, where wheat was grown and plough agriculture was practice, there was little need for female farm labour, women made few contributions to food production, they were confined to purdah and were seen to have little value beyond reproduction. See also Mamman (1995).In the southern part of India conversely, where intensive irrigated rice farming required much more hand labour, women made publicly recognized contribution to farming, their families did not practice purdah and daughters were married to equals with little dowry and did not marry very far away from their natal families. The foregoing reflects differences in women's role based on societal accepted norms.

Boserup's theory helps to understand that women own lesser properties and have lesser income but they play vital role in agriculture. In both of these approaches, gender inequality and the work of social conditions of women are measured. These are problems of gender inequality that stalk women empowerment and development in many regions of the world (Bossen, 2005), particularly in developing countries (Stock, 2004).Intervention in the plight of women has led to proliferation of governmental, non-governmental and multilateral organizations such as Kabissa (Niger Delta Women for Justice),

Women in Agriculture in Nigeria, Women in Development Network, The African Women's Development and Communication Network, and, United Nations Development Fund for Women among others. Against this backdrop, this paper examines the constraints to rural women's participation in agriculture using systematically collected data from Kaduna state.

MATERIALS AND METHOD

In order to achieve the aim and objectives of this research a reconnaissance survey was conducted and this afforded the opportunity of knowing the villages in the districts prior to sampling. It also informed the sampling frame and technique appropriate for the study. As such data were generated from primary sources such as field observation, questionnaire administration and interview schedules. Supportive evidences were also systematically extracted from textbooks, journals, periodicals and abstracts of statistics.

In order to select settlements, the two rural districts in Sabon-Gari LGA and another two districts from Giwa LGA, having considered the spatial extent, were purposively selected so as to eliminate bias from the sample size. Using this approach, Bomo and Basawa districts (Sabon-Gari LGA) and Yakawada and Gangara (Giwa LGA) were selected. To select respondents therefore, in the absence of a predetermined definite population sample, 280 copies of questionnaires were administered on the basis of 70 per district through a systematic sampling technique at interval of 4. In each household, the wife of the house hold head was the respondent.

Where the head of the house hold is woman, then she was selected and there after adjusted to every 4th house .Information obtained was analyzed through descriptive statistic such as table, percentages, pie chart and histograms. Student's t test was used to test hypothesis. It was hypothesized that there is no difference in the constraints faced by women farmers in the two LGAs. Student's t test was preferred because of the need to find the differences in the two sample means of the LGAs.

PRESENTATION AND DISCUSSION OF RESULT

The information obtained is discussed under socio-economic characteristics of the respondents, constraining factors to enhanced agricultural productivity of rural women and particularly the variation in the sampled settlements. At the end, remedial measures were recommended. These are discussed below.

Socio-economic characteristics of Respondents

From the survey 48.6% of the respondents were between 26 and 30 yrs, 19.6% were between 15-20yrs, 24.1% were between 30 and 35 yrs, and only 7.7% were above 35yrs.This mean a lot of respondents were married with family responsibilities hence are expected to contribute very well to ensuring food and income self-sufficiency in their households. About 78% have children to take care of. This implies that the number of women that engage in farming activities in the study area is very high, in order to supplement household food supply, and provide for other material consumption for themselves and their children. Majority of the respondents were Muslims, (84.6%) while 12.1% of the respondents were Christians, only about 3.3% still held traditional religious beliefs.

Moreover, 25.5% of the respondents attended primary school while about 14.7% had secondary education. This is because the increasing awareness on the value of western education makes a good number of them to continue their basic education even after they got married. Only 4.8% had acquired tertiary education. And this percentage perhaps represents a minute percentage whose parents or husbands are educated. A lot of the women (55%) were still attending Quranic schools because of the emphasis on religion in the study area. There is however an intra rural pattern disparity to these broad categories. Majority of the women in Sabon-Gari LGAs appear to be more "modern" and elitist in their socio-demographic attributes. For instance those with secondary and tertiary education are more in Sabon-Gari than Giwa LGA.

Involvement of rural women in Agriculture

Respondents were asked the level of their involvement in agricultural activities. It was clearly seen from the response that all the respondents were in one way or the other involved in agricultural activities. Table 1 presents the analysis.

Table 1: Type of Agricultural Activities involved in by women.

Agricultural activity	No. of respondents	Percentage (%)
Planting & Hoeing	51	18.2
Livestock keeping	24	8.6
Mixed farming	165	58.9
Harvesting	40	14.3
Total	280	100

Source: Field Survey, 2008-2009

Of the 280 respondents, about 18.2% were involved in crop production processes such as planting and hoeing, 8.6 % were involved only in livestock keeping. These include small ruminant animals like goat and sheep kept for food and cash purposes. About 58.9 % were involved in mixed farming, which is made up of crop production and animal husbandry. This constitutes the most

important category of all rural agro-related enterprises. Precisely, 40 (14.4 %) of the respondents usually partake in harvesting of farm produce. From this analysis, a substantial number of sampled women in the study area were involved in farming (Mamman, 1995) and animal rearing (Makun, *et. al. 2005*) for both domestic and financial reasons. This further emphasizes the role of women as direct providers of food to the rural communities.

Sources of farm land among the respondents

Figure 2 shows that 3.6% of the women who engaged in farming in the study area purchased the land they use, 22.3% borrowed the land and 74.1% farm on the land that is in the family pool through inheritance. This category of women inherited the land either from parental or marital source. This is illustrated in the pie chart below.
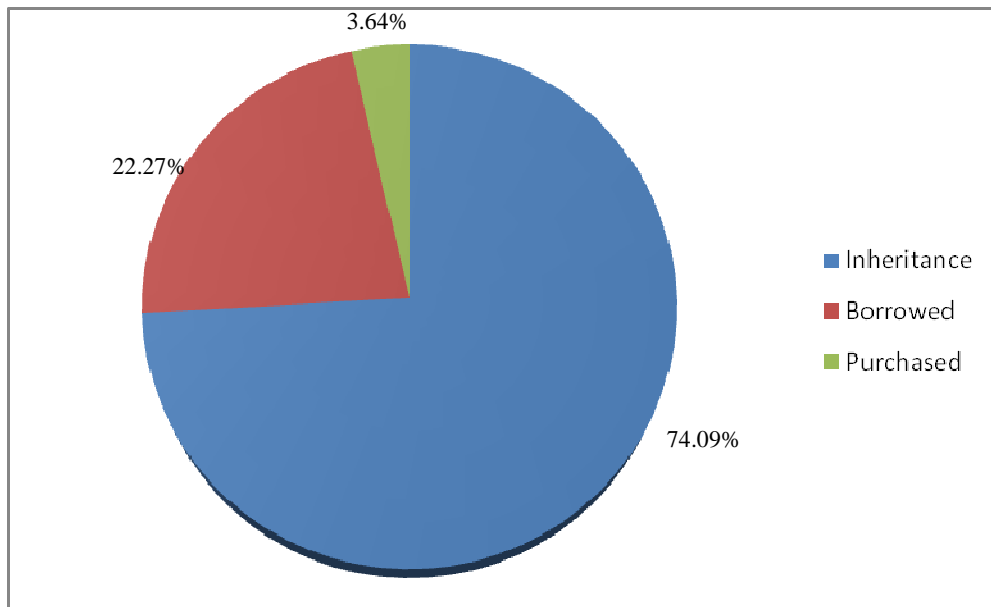
Figure 2: Sources of farmland of respondents.
Source: Field Survey, 2008-2009

From the analysis, purchasing land by rural women for agricultural activities is uncommon. In fact, the few that purchased their land were non-Hausa settlers engaging in salaried employment in Sabon-Gari LGA. Majority of the indigenous Hausa women utilize small parcels of land allotted to their parents or spouses for farming. This, coupled with the socio-cultural bias against women means their capacity to efficiently use the land adopting sustainable land management strategies for maximum production is likely to be seriously undermined. Such tenure is insecure, and it is one the reasons why fragmented land-holdings in family pool are not negotiable as collateral for loan from

agricultural-financing institutions. This is because inherited land is usually a small portion owned by large population of children that usually characterize an average rural family.

Size of Farm land cultivated by Women

The women were further asked on the size of the farm plot they cultivated. This was necessary because the size of land is a major factor that determines agricultural output. The result is presented in table 2.

Table 2: Size of Farm land cultivated by Women

Size (in acres)	No. of respondents	Percentage (%)
1-2	184	65.7
3-5	56	20
7-8	34	12.2
9 and above	6	2.1
Total	280	100

Source: Field Survey, 2008-2009

Table 2 shows the size of farmland cultivated by women farmers in which 65.7% of the women farmers cultivated farm size between 1-2 acres while only 20% farm between 3-5 acres. Very few owned what can be considered as significantly large holding. The inability to own large farmlands due to the land ownership situation is a great constraint to efficient and viable agricultural production among women. This is because small farmlands lead to low productivity and output. Low output in turn results in low income and the cycle continues.

Ownership of land is a socio-cultural phenomenon, and due to low income (and other factors) women can not purchase sizeable land large enough for their production. This is reflected in the fact that inheritance is the major source of ownership for the rural women.

Apart from knowing the farm size, the respondents were asked whether the land is adequate for their purpose to which 87% responded negatively. Only 4 widows in Giwa LGA claimed that the farmland is adequate for their purposes. When the scale of production was considered close to 86% of the respondents claimed that they farm for subsistence while about 14% of the respondents engaged in what can be termed 'pseudo-commercial farming', cultivating vegetables and spices. This was a direct consequence of the constraints faced by women because commercial agriculture requires a lot of input which all the sampled women asserted were difficult to come by.

Limitations to Women's Farming Activities

As a precondition to establish whether the sampled women face certain limitations to farming activities, it is necessary to get their perception of their productivity. Based on this, they were asked on whether they were producing at

their maximum potential or not. From the analysis, it is clearly revealed that about 87.5% of the women claimed they were producing below their maximum potential, while only 4.09% of the respondents believed their productivity is at the maximum. This unsatisfactory level of output according to the respondents exacerbates food insecurity and poverty among women in the study area. Consequently the women were asked on the type of problems confronting them. Table 3 presents the result.

Table 3: Challenges faced by rural Women

Type of constraints faced	No. of respondents	Percentage (%)
Financial constraints	102	36.4
Land constraints	94	33.6
Inaccessibility to extension service	18	6.5
Inaccessibility to government subsidized farm input	14	5
Religio-cultural rigidities	28	10
Inaccessibility to modern production technology	13	4.6
Others	11	3.9
Total	280	100

Source: Field Survey, 2008-2009

From Table 3, it was observed that the serious constraint faced by 36.4% of the respondents is finance. Looking at the socioeconomic status of the women, majority of them were housewives without a substantial income-earning opportunities. This straitens opportunities to save or be credit worthy to obtain loan facilities from either local or official money lending sources. Inaccessibility to substantial land adequate enough for reasonable cultivation was another problem with about 33.6% of respondents subscribing to this. Other challenges were religious constraint, inaccessibility to government subsidized input, inaccessibility to extension services and inaccessibility to modern production technology. In order to test the hypothesis put forward, Student's t test was employed. Table 4 presents the analysis.

The Student's t test revealed that the critical t value of 2.179 with 12 degrees of freedom is significant at 0.05. Since the tabulated value is greater than the calculated value, the hypothesis that similar financial and socio-

cultural constraints to women agricultural activities is rejected. For instance, in Giwa LGA, more women face financial bottlenecks Sabon-Gari LGA

Table 4. Analysis of Student's t - test

CONSTRAINTS	GIWA LGA		SABON-GARI LGA	
	X	X^2	Y	Y^2
Financial constraint	44	1936	58	3364
Fragmented Land size	50	2500	44	1936
Poor extension service	7	49	11	121
Inadequate farming input	5	25	9	81
Religious rigidity	11	121	17	289
Inadequate modern technology	5	25	8	64
Others	7	49	4	16
	$\sum x = 151$	$\sum x^2 = 5871$	$\sum y = 129$	$\sum y^2 = 4705$

$\sum x = 151$ $\sum y = 129$

$\overline{X} = 21.6$ $\overline{Y} = 18.4$

$\sigma_x = \sqrt{\dfrac{\sum x^2}{n} - \overline{x}^2}$ $\sigma_y = \dfrac{\sum y^2}{n} \sqrt{y^2 \quad \overline{}}$

$\sigma_x = \sqrt{\dfrac{581}{7} - 466.6}$ $\sigma_y = \dfrac{4705}{7} - \sqrt{338.6}$

$\sigma_x = \sqrt{372.1}$ $\sigma_y = 333.5 \sqrt{}$

$\sigma_x = 19.3$ $\sigma_y = 18.3$

$$t = \cfrac{\overline{X} - \overline{Y}}{\sqrt{\dfrac{\sigma x^2}{n} + \dfrac{\sigma y^2}{n}}}$$

$$\cfrac{3.2}{\sqrt{\dfrac{372.5}{7} + \dfrac{334.9}{7}}}$$

$$t = 0.3$$

Degree of freedom = $(n_x - 1) + (n_{y-1})$ =   (7-1) + (7 - 1) = 12
The degree of freedom of 12 at 0.05 significant level is 2.179.Therefore, since the tabulated value (2.179) is greater than the calculated value (0.3), there is a significant difference between the constraints faced by rural women farmers in Giwa and Sabo-Gari LGAs.

This perhaps reflects the disparity in the degree of 'urbanity' between the two areas. Sabon Gari LGA is more cosmopolitan and heterogeneous in ethnic composition than Giwa LGA, hence the likelihood of availability of several financial opportunities that can be invested in agricultural activities. Further analysis of spatial variation indicates that the constraints are relaxed as rural communities come into contact with modernization. For instance in Bomo (Sabon-Gari LGA) 22% of the respondents non Hausa Christian women were among those who cultivate more than 1 acres of farmland compared to Muslim women who predominate in Yakawada, (Giwa LGA). It is instructive that 23 of them are civil servants with some access to formal and informal loans to expand their agricultural activities.

 Despite this spatial disparity, all the respondents believed that the constraints and hindrances they were facing were gender-selective. To them, those hindrances were because they were women and if they were men, the story would perhaps, be different. A major deduction from this is that many women are getting conscious of their peculiar disadvantaged conditions in the society. Although, there is a need to empathize with women because they face more stringent socioeconomic circumstances, their constraints are not substantially different from that of the male small-holder and sharecropping farmers in rural setting. This therefore, warrants a challenge to policy makers to continuously develop innovative ways of improving the socio-economic empowerment of women and rural dwellers in general because multiple deprivations are broad and multidimensional while opportunities for mitigation are narrow.

 Conclusion and Recommendations
This study has shown convincingly that there are serious structural and financial constraints to rural women's effective participation in agriculture in Giwa and Sabon-Gari LGAs. This should nonetheless becloud an observed

spatial variation due to disparity in level of urbanization and intensity of indicators of modernization. As such, it can be concluded that constraints faced by rural women are relaxed with increasing heterogeneity of the rural settlements, though further studies are needed to validate this assertion. However, urgent remedial actions are needed to improve the situation. As a result, the following recommendations are proffered.

There should be improved access to loan, either by establishing women-centred cooperative societies that would aid easy access to loan by these low-income and resource-poor women. . Evidences abound that women are more often afflicted by poverty and rural women are usually the worse off due to a number of interacting socio-economic factors. Women farmers should be given attention by the Microfinance institutions (MFIs) and Nigerian Agricultural Credit and Rural Development Bank (NACRDB) currently used by government. This is because women by their nature can be more parsimonious and debt-conscious than men hence are more likely not to default in payment of loans. More over Women and Children welfare departments in the local government councils can partner with MFIs and NACRDB to specifically develop loan scheme that will benefit rural women farmers.

The current land tenure system should be re-evaluated and negotiated through workable policies on land restructuring and reform such that fertile land will be available for agricultural purpose of women to boost their production. It is pleasing that the federal government has made Land Reforms one of its Seven-Point Agenda to achieving vision 20-20-20. However conscientious effort should be made to see that its implementation favours rural women who have been hitherto disadvantaged by the existing socio-culturally defined tenure system

Also, there should be improved access to inputs such as fertilizer, improved seeds, pesticide etc. at subsidized rates. In this direction, organizing women to form functional cooperative societies will be helpful. Through these cooperatives, subsidized input would get to the rural women farmers, by-passing the middle-men that inflate prices. Better access of women to agricultural extension services should be emphasized. By this, information on best practices will get to them so as to enhance greater yield. Public enlightenment programmes should be organized for women farmers using their various cooperative societies. Through these they would improve on their skill in agricultural practices and encourage rural development.

On a general note, there is a need to further examine the constraints to agriculture facing both rural women and men. It is not enough to single out a gender for empowerment since both men and women engage in agriculture. Above all, human capital development is a major key to unlocking poverty and increasing productivity. Education of the girl-child and

rural women should be intensified. Without being educated women (especially rural women) will continue to grope in the abyss of poverty and under maximization of their agricultural potentials.

The findings of the study have potential research benefits. There is a need for further investigation of the factor that account for disparity in constraints experienced by rural women in different socio-cultural settings so that remedial measures for specific target groups can be evolved.

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The Use of Parkia Husk and Melon Wastes as Soil Amendments

O.B. FAWOLE, T.J. AJAYI, M.O. ADULOJU and J.O. OLANIYAN
Department of Agronomy, University of Ilorin,
Ilorin, Nigeria.

ABSTRACT

A pot experiment was conducted to assess the effects of amending soil with agricultural wastes (Parkia biglobosa (Locust bean) husk (PAH), melon (Citrulus vulgaris) waste (MEW) and their mixture (PAH + MEW)) on some soil physical and chemical properties. The agricultural wastes were applied at two levels (7.5% and 10% w/w agricultural waste/soil) in a randomized complete block design. Changes in soil properties (bulk density, water holding capacity, organic carbon and available phosphorus contents) were observed over a period of 12 weeks. The available phosphorus (P) content of the soil was significantly increased (P<0.05) by all treatments. The P contents of the soils at 12 weeks after amendment at 10% level were: 8.6 mg Kg^{-1} soil for MEW, 7.7 mg Kg^{-1} soil for PAH, 7.0 mg Kg^{-1} soil for PAH + MEW while that of the control (no amendment) was 2.5 mg Kg^{-1} soil. All the treatments significantly improved the soil physical properties. A significant reduction (P<0.05) in soil bulk density was observed. MEW significantly improved soil properties than PAH or the mixture of PAH and MEW. Both MEW and PAH were found to have potentials for use in improving soil fertility and soil physical properties.

Key words: Agricultural waste, *Parkia* husk, melon waste, soil properties

INTRODUCTION

The yields of crops have increased over the last fifty years, and especially so in the last decade. This has taken a heavy toll on the soil, since it has had to supply the nutrients required for the increase in crop yields. Most soil nutrients have been found to correlate positively with the organic matter content of Nigerian soils (Agboola and Corey, (1976). This remarkable increase in soil productivity has caused reduction in organic matter level in the soil, leaving the soil more prone to degradation and erosion (Ano, 1990).

Chemical fertilizers are essential in most cropping systems. However, in long term field experiments where only mineral fertilizers have been used, problems which include increase in soil erosion, soil compaction and environmental pollution have been encountered (Lal, 1986). The use of ammonium sulphate as a nitrogenous fertilizer was reported to increase acidity in some soils and also destroy biotic life (Lal, 1986). The overall effects of these chemical inputs in crop production include soil degradation, poor plant nutrition and consequently, poor human nutrition, with resultant public health implications. Organic fertilizers or manures have been shown to improve physical properties of soils (Chai *et al.*, 1988), soil fertility and consequently crop yield (Lal and Mathur, 1989). Apart from production of more vigorous and high

yielding crops, improvement in overall soil quality from the use of organic soil amendments could reduce the potential for nutrient contamination of ground and surface water. Also, research studies have shown that incorporation of crop res   idues after harvest improved crop yields either directly by enhancing nutrient availability (Rebefka *et al*, 1993, Sidhu and Sur, 1993) or indirectly because of positive changes in soil properties (Power *et al*,1998; Sow *et al*, 1998).

Phosphorus is an element of great importance in crop production, especially in the savanna ecological zone. It is most abundant in seeds and fruits. It is usually in short supplies in savanna soils and the little available quantity is often sorbed and rendered unavailable to plants (Lombin, 1983). Most of the phosphorus in savanna soils is positively correlated with soil organic matter. In the southern Guinea savanna zone of Nigeria where this study was carried out, *Parkia biglobosa* (Locust bean) is a common economic tree crop while *Citrulus vulgaris* (melon) is a very important annual crop. The wastes from both crops are usually discarded haphazardly on refuse dump sites or left to rot on farmer's farms in the study area.

Over the last decade, a lot of research into the use of plant residue as organic fertilizer have been carried out. Nottidge *et al*. (2005), Adetunji and Okeleye (2001), and Yusuf and Fawole (2006) worked on the use of *Panicum maximum* and *Imperata cylindrical (*common grass weeds in this study area*)* for improving soil available P. They all reported that soil physical properties were improved and P contents of soils were increased when plant residues were used as organic amendments. There are still many agricultural wastes that can be used for soil amendments and as organic fertilizer. This work studied the changes in soil properties and phosphorus content when *Parkia* husk and melon waste were used for soil amendment.

MATERIALS AND METHODS

Pot experiment
Soil samples were taken randomly at a depth of 0-15cm from the Teaching and Research Farm of the Faculty of Agriculture, University of Ilorin, in the Southern Guinea Savannah zone of Nigeria. The soil samples were air-dried and three kilograms of each sample was weighed into small plastic pots with basal perforation. The pots were arranged in a screen-house in a Randomized Complete Block Design (RCBD). One kilogram of each of the soil samples were air-dried and sieved with a 2-mm sieve for chemical analyses in the laboratory.

The two agricultural wastes: husk of *Parkia biglobosa* and waste of melon (*Citrullus vulgaris*) were collected from local farmers' farms, sun dried and ground, then used as soil amendments. The Parkia husk and melon wastes used for the study were weighed at two levels (7.5% and 10% w/w waste/soil). Also, the mixture of the two wastes was prepared at two different levels (7.5% w/w waste/soil and 10% w/w waste/soil). The various levels of Parkia husk and melon waste were incorporated into the soil. Each of the treatments was set up in triplicates. An average of 50ml of water was added per day to aid microbial decomposition. Soil samples were taken at the 2nd, 4th, 7th and 12th weeks after treatment for physico-chemical analysis.

Soil analysis

Organic matter, available P, particle size analysis (before and after the use of organic amendment), pH (1:1 soil:water ratio), exchangeable cations (extracted with normal and neutral ammonium acetate solution) and organic matter (OM) were determined by the methods described by Udo and Ogunwale, (1988). Nitrogen was determined by the regular micro-Kjeldahl method. Core (142.5cm^3) samples for determination of bulk density and water holding capacity were taken before and after 12 weeks of introduction of the amendments.

RESULTS AND DISCUSSION

Soil Properties

The properties of the soil used for the experiment are shown in Table 1. The soil is sandy, slightly acidic and low in organic matter, nitrogen and available P.

Table 1: Physiochemical properties of the soil before amendment.

Properties	Value
Sand (%)	88.8
Silt (%)	7.2
Clay (%)	4.0
pH (water)	6.0
O.M (%)	0.7
N (%)	0.4
P (cmol/Kg soil)	2.5
K ,,	0.39
Ca ,,	2.5
Na ,,	0.14
Mg ,,	0.4
Bulk density	1.6

Effect of soil amendment on the available Phosporus level of the soil
Table 2 shows the effect of the different treatments on the available P content of the soil over a period of 12 weeks. The available P content of soil amended with 10% Parkia husk increased from 5.6mg/kg to 7.7mg/kg by the 12th week, while it increased from 6.0mg/kg-8.6mg/kg for soils that received 10% melon waste (Table2).

Table 2: Effect of soil amendment on available P (mg/kg) 12 weeks after application.

Amendment and Levels	No of Weeks			
	2	4	7	12
7.5% w/w Parkia Husk (PAH)	5.5a	5.6d	5.9c	6.2d
10% w/w Parkia Husk (PAH)	5.6a	6.5b	6.7b	7.7b
7.5%w/w melon waste (MEW)	3.5b	5.4d	6.0c	6.7c
10% w/w melon waste (MEW)	6.0a	6.8a	7.8a	8.6a
7.5% w/w MEW+PAH	3.0b	5.4d	5.5d	5.9c
10% w/w MEW+PAH	5.8a	6.0c	6.8b	7.0c
Control (no amendment)	2.5c	2.5c	2.5c	2.6c
S.E.	0.53	0.21	0.39	0.30

Values in a column with the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at P<0.05
_____

Melon waste-amended soil at 10% had the highest increase in soil P level. At 7.5% MEW level, there were significant increases in available P up to seven weeks after treatment, beyond which there were no more significant increases. When 10% MEW was used, there were no significant increments in available P over time.

Available P resulting from all the treatments increased over time and were significantly different (P<0.05) from the control. However, there was no significant difference in the 7.5% level of both amendment and the control. Also, there were significant differences in increase in P level over time between 7.5% and 10% levels of amendment, as well as in the mixtures.

There was a sharp increase in the soil P level resulting from all the amendments right from the first two weeks after application, but the increase was more in the 10% treatments than in the 7.5% treatment. This may be due to the gradual release of P as the organic materials decomposed.

An increase in the organic matter content would have led to a surge in the population of soil micro-flora involved in the mineralization of organic matter, as observed and reported by Olaitan (1983). There was also a corresponding increase in soil pH (Table 3), which may be as a result of the release of organic products as the organic amendments mineralized. This also agrees with the report of Bathe and Arnebrant (1994) and Yusuf and Fawole (2006) that organic waste increased the soil nutrient status and soil pH and it also enhanced microbial activity. Adetunji and Okeleye (2007) worked on an Ultisol of South West Nigeria also reported that the incorporation of hedge-row pruning resulted in increase in the soil pH, organic matter, P, K, Ca and Mg content.

As shown in Table 2, the P content of the control pots which received no amendment was the same throughout the period of the study. It can be thus inferred that the increase in available P content of the soil was as a direct result of the plant waste incorporated into it.

Table 3: Effect of soil amendment on the pH of the soil studied

Amendment and level	No of weeks			
	2	4	7	12
10% PAH	6.20	5.90	6.40	6.35
7.5% PAH	6.25	6.50	6.70	6.42
10% MEW	6.19	6.40	6.50	6.53
7.5%MEW	6.20	6.30	6.60	6.50
10% PAH+MEW	6.35	6.70	6.50	6.56
7.5%PAH+MEW	6.15	6.25	6.20	6.19
Control (no amendment)	6.20	6.20	6.20	6.20

Note: initial soil pH = 6.

Effect of plant waste on soil organic carbon and organic matter content
Table 4 shows the different values of soil carbon obtained when the three different types and levels of treatments were used. It was observed that the higher the level of treatment, the lower the value of the soil carbon, with the exception of melon waste which had the same value of 0.21% for

both levels of amendment. The mean value for the two levels of amendment were in the order of: Control > PAH > PAH + MEW > MEW. However, PAH+MEW gave higher organic matter content than MEW alone. The low level of the carbon and organic matter observed in the amended soil could be attributed to the fact that the microorganisms which are involved in the degradation of the waste also assimilated carbon, utilizing the carbon released for protoplasmic build up. Also, plants were not raised in the pot. This would have enhanced carbon recycling. While carrying out a similar study, Marchner and Nobel (2000) also recorded a reduction in the organic carbon when an acid soil was incubated with leaf litter materials. They attributed the observation to increased microbial respiration stimulated by the added manure.

Table 4: Effect of type and rate of amendment on soil carbon and organic matter.

Amendment	Soil carbon			Soil organic matter		
	7.5%	10%	Source Mean	7.5%	10%	Source Mean
Parkia Husk	0.41	0.20	0.31	0.71	0.34	0.53
Melon waste	0.21	0.21	0.21	0.36	0.31	0.36
PAH + MEW	0.27	0.28	0.27	0.48	0.41	0.47
Control	0.60	0.60	0.60	1.03	1.03	1.03

Effect of plant waste on soil physical properties

Table 5 shows data on the effect of the treatment of soil with Parkia husk and Mellon waste on soil bulk density and water holding capacity. The treated soils at both 7.5% and 10% levels of wastes had significantly lower bulk densities than the control, to which no waste was applied. At the 10% level of amendment, melon waste-amended soil had the lowest bulk density of 0.65g/cm3, followed by Parkia Husk + Melon waste-amended soil which had 0.76g/cm^3 bulk density while soil amended with Parkia husk had a value of 0.96g/cm^3. This is in agreement with the report of Mbagwu (1992) that organic amendment in soil leads to enhancement of soil aggregation and porosity and also reduces soil bulk density. However, there was no significant difference in the water holding capacity of the soil at the two levels of amendment used in this study, although it was slightly lower in the un-amended soil. Nottidge *et al*. (2005) observed that soils with low bulk density will give rise to higher phosphorus and potassium uptake in soil. The higher P value obtained in the amended soil samples could be attributed to lower

bulk densities observed in them. For the un-amended soil which had a bulk density of 1.69g/cm^3, the low P value obtained could be due to the fact that at higher bulk density, P mineralization is reduced.

Table 5: Effect of amendments on some soil physical properties.

| Amendments | Rate of Application | | | |
| | Bulk density (g/cm^3) | | Water Holding Capacity (%) | |
	7.5%	10%	7.5%	10%
Parkia Husk	1.10b	0.96b	14.44	14.54
Melon Waste	0.89c	0.65c	14.36	14.92
PAH + MEW	0.84c	0.76d	14.62	14.75
Control	1.69a	1.69a	13.97	13.97
S.E.	0.03	0.04	NS	NS

Values in a column with the same letters are not significantly different
  (DMRT at 5% level of probability)

CONCLUSION

This study has shown that Parkia husk and melon waste have the potential for use as organic fertilizers, particularly in soils with low phosphorus level. The two levels of the wastes used significantly reduced the soil bulk density and significantly increased the soil available P content. However, melon waste treatment significantly improved soil properties more than Parkia alone or mixtures of both.

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Agricultural Productivity under Taungya and Non-Taungya Land-Use Options: A Case Study of Vandeikya Local Government, Benue State, Nigeria

[1] A.O. ADEGEYE,[2]S.O. JIMOH and [2]S.I.N . AGERA

[1]*Department of Forest Resources Management, University of*

Ibadan, Ibadan, Nigeria.
[2]*Department of Agricultural Extension Services, University of*
Ibadan, Ibadan, Nigeria.

ABSTRACT

Taungya farming is a special arrangement between the forestry department and farmers , which combines the production of both arable and forest tree cops simultaneously on a piece of land. The practice was adopted inVandeikya Local Government Area of Benue State Nigeria in mid 1950s up to 2000. Using Stratified random sampling, two sets of questionnaire were used to appraise the productivity of some arable crops and forest regeneration under taungya and non-taungya cultural practices. The yields of arable crops were significantly higher under taungya farming that non-taungya practice in the study area. There was however no significant difference in the total forest area regenerated under the two land-use systems. The apparent land hunger among farmers is a favourable factor for adoption of taungya as a land use option in the study area. There is need to adopt multi-species planting approach in future programmes sustainability of the programme. Also, the land tenure system which limits access to land by strangers needs to be reviewed and greater awareness on the programme needs to be generated among the farmers and forestry staff alike.

Key words: Taungya, Agroforestry, arable, productivity, forest*.*

INTRODUCTION

The principle of plant productivity has been viewed as a system of conversion of solar energy into chemical energy that can be transported, and stored through the process of photosynthesis (Nair, 1993). Management options for optimizing productivity in plant communities under *taungya* practice are based on the manipulation of solar radiation profile. The selection of species, their arrangement and maintenance determine the photosynthetic efficiency of the whole plant community. The traditional bush fallow system could be sustained with sufficient fallow length which allows the soil to replenish itself during the fallow period.

However, increases in human population leads to decrease in length of fallow and increase in cropping intensity. Okojie (1997) observed that shortened fallows caused by population explosion and excessive demand for farmland in many parts of Nigeria has led to over-cropping of available

land with various environmental consequences which include: degradation of rain-fed crop lands, fuel wood and fodder shortages, sheet and gully erosion. This in turn decreases soil fertility and productivity and keeps agricultural productivity at a marginal level.

Sanchez (1997) observed that high cost of fertilizer has compounded the problem of decreasing soil fertility and the accompanying declining crop productivity as most farmers cannot afford to buy fertilizers at high costs. Soil management practices should at this time be concerned with farming systems aimed at optimizing and sustaining productivity. T*aungya* farming as an aspect of agroforestry has the potential of meeting these criteria. Lamb (1997) and Olms (1999) affirmed that species mixtures instead of plantation monocultures should be used in order to improve regional biodiversity and maintain ecosystem resilience.
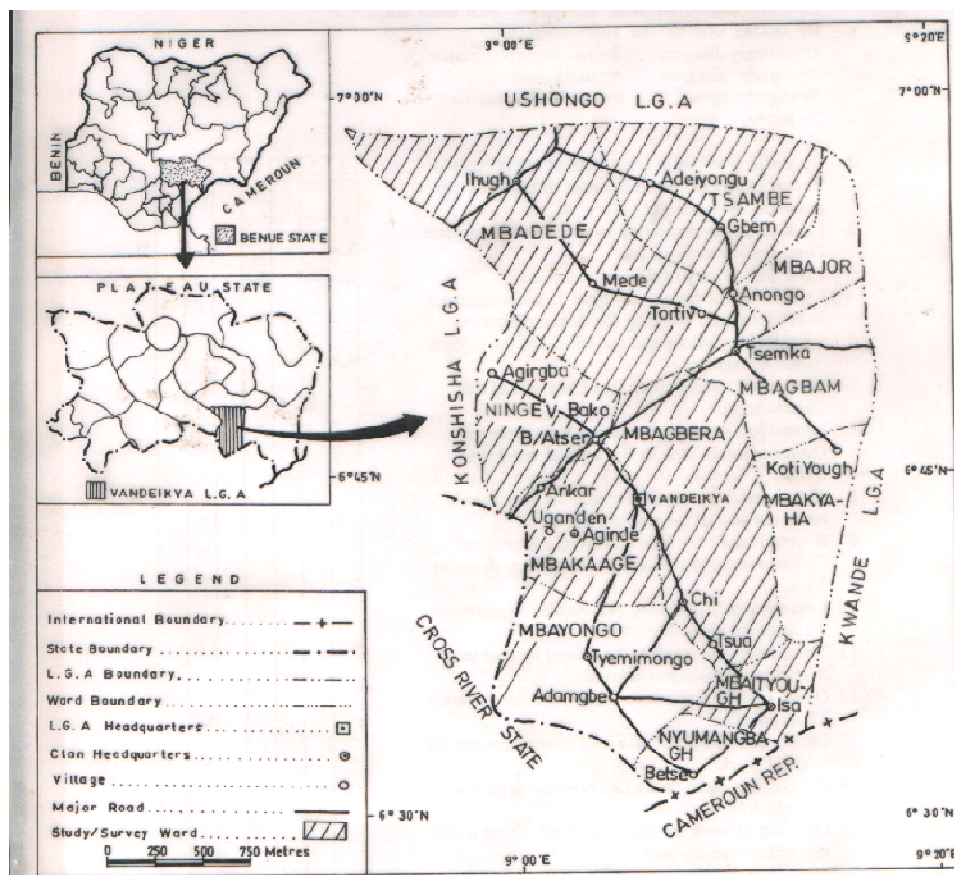

FIGURE 1: Map of *Vandeikya* Local Government Area Showing Survey Wards
Source :Department of Agriculture , Vandeikya Local Government Area, Benue State, Nigeria.

Higher crop yields have been observed when agricultural crops are planted near leguminous trees such as *Faidherbia* (Acacia) *albida (Del.)Chev* (Vandenbeldt, 1992, and FAO, 1994). The choice of trees and crops for inclusion in proposed *taungya* plantations should however take cognizance of the various intra and inter-specific interactions. It is thus the objective of this study to compare the yield of agricultural crops in *taungya* farming practice with non-*taungya* farming practice and to compare the success of forest plantation establishment under the two systems in *Vandeikya* Local Government Area, Benue State, Nigeria.

METHODOLOGY

Study Area

Vandeikya Local Government (VLGA) is located between longitude $8^0 45'$ – $9^0 00$ E and longitude $6^{0.}30'$ – $7^{0.}00'$ N. VLGA is made up of twelve administrative wards (Figure1). The projected population of the study area is about 532,881(www.benuestate.gov.ng May 2, 2010).

There are two seasons namely dry and wet seasons which occur from November to March and April to October respectively. The climate is the tropical humid type with very high temperatures between March and April. The cool, dry harmattan weather is witnessed between December and February. The terrain is undulating, low-lying, drained mainly by Rivers Aya, Sambe, Be and Uaghshu.

The Local Government Area has 48 forest estates unequally dispersed in the 12 wards. Most of these forest estates were established with the assistance of the host or neighbourhood communities through taungya system between 1945 and 1970 and were inherited from the defunct Gboko Division (formerly in Tiv Native Authority). For administrative convenience, the forest estates in each ward are grouped into a single management plan. This study is based on taungya operations within the forest estates owned by the local government council and does not include privately owned forest estates.

Data Collection

Primary data were obtained using structured questionnaires while the secondary data were obtained from the records of the Department of Agriculture of VLGA. The twelve wards in VLGA were listed in alphabetical order and all the six odd-numbered wards were selected through balloting. The six wards surveyed included: *Mbadede, Mbagbera , Mbaityough Mbakaage, Ningev* and *Tsambe* (Figure 1).

The two sets of questionnaire administered included: 200 for t*aungya* farmers on VLGA forest estates and 16 government officials working in VLGA forestry service. The universal population of the farmers was 562, while the

corresponding population of forestry staff was 16.   This implies approximately 36% sampling intensity for *taungya* farmers and 100% for forestry officials.

The questionnaires sought information on the productivity of agricultural crops grown under *taungya* and non-*taungya* plots as well as the forest areas regenerated through *taungya* farming and non-*taungya* plantation establishment techniques.   Through personal interviews, all the 216 questionnaire administered were retrieved. Edaphic and climatic properties between the various pairs of *taungya* and non-*taungya* plots were assumed to be fairly uniform enough to allow uniformity in crop productivity. Thus, any differences noticed in crop yields were ascribed to the cultural practices adopted.

Data Analysis

Descriptive statistics, students't-test and analysis of variance (ANOVA) were used for data analysis. Post-mortem analysis involving the use of Least Significant Difference (LSD) was also employed to validate any observed variation.

RESULTS

Table 1: T-test of Mean Crop yield per/ha for Taungya and Non-taungya Plots

Parameter	Mean yield per/ha (Kg)	t-cal	t-tab	Df	P
Yam (Dried chips) *Taungya* Non-*taungya*	1223.33 1075.00	2.45*	0.26	10	0.0342
Cassava (Dried Chips) Taungya Non-taungya	1698.33 1372.67	9.83*	0.26	10	0.0000
Rice (unmilled) Taungya Non-taungya	1155.00 833.33	7.05*	0.26	10	0.0000
Sweet Potatoes (Dried Chips) Taungya Non-taungya	1471.67 923.33	7.70*	0.26	10	0.0000

Maize
    Taungya
    Non-taungya
	1133.33
	710.00
		13.40*	0.26	10	0.0000

Groundnuts
(unshelled)
    Taungya
    Non-taungya
	1083.33
	756.67
		6.14*	0.26	10	0.0001

Soybeans
    Taungya
    Non-taungya
	620.00
	408.33
		5.18*	0.26	10	0.0004

Guinea corn
    Taungya
    Non-taungya
	725.00
	516.67
		5.73*	0.26	10	0.0001

Beans
    Taungya
    Non-taungya
	458.33
	408.33
		2.42*	0.26	10	0.0358

Pepper
    Taungya
    Non-taungya
	366.67
	320.00
		1.80*	0.26	10	0.1018

Melon
    Taungya
    Non-taungya
	306.67
	250.00
		2.07	0.26	10	0.0655

* Significant
** Each value represents the mean yields for 5 years

Forest Area Regenerated through *Taungya* and Non-*Taungya* Systems

Demographic Attributes of Respondents
The forestry members of staff were aged between 31 and 50 years; 87.50% of them were married. Majority of the staff had low levels of educational attainment with 68.75% having primary and secondary education without professional training. Over sixty two percent of the forestry staff had annual incomes of between ₦111, 000.00 and ₦150, 000.00. Twenty seven percent of the farmer respondents were females. Sixty eight percent of them were aged between 31 and 50 years. Eighty six percent of the farmer respondents were married with family sizes of 7-12. Thirty eight percent of the farmers were literate and 55% of them earned between ₦21, 000.00 and ₦40, 000.00 per annum.

Comparison of Crop Productivity on *Taungya and Non-taungya* Plots
        The mean yield per hectare of each of the crops for the six sampled wards are presented in Table 1. The mean yields of yam, cassava, rice, sweet potatoes, maize, groundnuts, soybeans, guinea corn, beans, pepper and

melon were significantly higher on *taungya* plots than non-*taungya* plots. Crop yield ranged from 306.67kg/ha to 1,698.33kg/ha. At P=0.05, t-values ranged from 1.80 to 9.82 at 10 degrees of freedom. The result of t-test analysis presented in table 1 indicates significant difference in crop yield on *taungya* non-*taungya* plots (P= 0.05). We therefore conclude that there were significantly higher yields on *taungya* plots than non-*taungya* plots.

The forest areas regenerated through *taungya* and non-taungya systems between 1955 and 2000 (for sampled years only) are as indicated in Table 2. A total of 63 hectares were regenerated through *taungya*, while a total of 74.7 hectares were regenerated through other means (Non-*taungya)*.

Table 2: Forest Regeneration Through *Taungya* and Non-*taungya* Methods

Forest Land Area Regenerated (Ha)			
Year	Taungya	Other Methods (Non-taungya)	Total
1955	3.0	1.0	4.00
1960	2.3	4.5	6.80
1965	6.0	7.5	13.50
1970	9.0	11.0	20.00
1975	9.0	7.9	16.90
1980	9.9	6.2	16.10
1985	3.2	9.1	12.30
1990	10.0	8.7	18.70
1995	5.6	7.1	12.70
2000	5.0	11.7	16.70
Total	63.0	74.7	137.70
Means	6.3	7.47	13.77

Source: Department of Agriculture Vandeikya LGA.

The mean forest areas regenerated through *taungya* and non-*taungya* practices between 1950 and 2000 were 6.30 and 7.47Ha per year respectively .These areas did not differ significantly (P = 0.05).
The reforestation efforts of VLG were centred on re-stocking with *Gmelina arborea* (Roxb), *Tectona* grandis (Linn. F) as well as *Faidherbia* species. The modal class of 41-60 and accounted for 46% of the farmers respondents. The class 61-80 had the least respondents (7%).
ANOVA computation in table 3 indicates that there were no significant differences in the number of trees planted among the six sampled wards (P> 0.05).

Table 3: Analysis of Variance Table for Tree seedlings Planted among the Six Wards

Source	DF	SS	MS	F	F-Tab	Remarks
Ward	5	641	128	0.27	3.02	ns
Error	194	93398	481			
Total	199	94039				

P> 0.05; ns: not significant

Reforestation outside forest estates of VLGA was low with only 6% of the farmers planting tree seedlings on both government forest estates and their own lands. 62.5% of the farmers were willing to practice *taungya* outside government forest estates but had no personal land while 31.5% of the farmer respondents were not favourably disposed to practicing *taungya* on their own lands. Land tenure and availability were identified as the major obstacles to *taungya* practice.

DISCUSSION

The higher crop yields observed on *taungya* plots could be attributed to better soil conditions in the forest reserves where the crops were raised. Undoubtedly, organic matter accumulation from decomposed litters and reduced leaching and erosion in the forest environment could contribute to greater soil productivity under the forest ecosystem. Fallows, incorporation of green manure, fodder and planting of grain legumes are known to have an over-all effect on increasing the soil organic matter, nutrient cycling, soil fertility, soil fauna, weed and pest control, as well as fuel wood production (Ogungbile and Manyong, 1998). Inter-cropping of agricultural crops among the tree seedlings can increase crop productivity through positive interactions among the inter-cropped species (Jordan, et al, 1992).The findings of the current study agrees with the observation of Anderson and Swift (1993) that plant litters high in nutrients (especially nitrogen) and which decompose rapidly increased crop productivity.
The low literacy rate among the farmers and low educational attainment of forestry service staff could slow down the adoption rate of *taungya* as a food production technology in the study area. Over 60% of the farmers had no personal land on which to practice *taungya* and had to rely on government estates to secure land for *taungya* practice. Joyce (1992) observed that the level of adoption of *taungya* practice may be low initially, but as population pressure on land increases, it would improve considerably over time. This is a favourable factor for the adoption of *taungya* in this area. Socio-cultural considerations if not taken seriously prior to the inception of *taungya* programmes could hinder the success of the programme.
Ecologists place a lot of premium on multi-species forest plantations compared to monoculture stands (Lamb, 1997).The fact that forest regeneration programes in this area are largely through mono-specific

plantations establishment is a major ecological draw-back for the programme(Taylor, 1999). Seventy six percent of the farmer respondents recalled existence of exotic monoculture stands on their allocated plots before such plots were cleared for *taungya*. The local communities and the forestry department need to be sensitised on the benefits of multi-species plantations as well as the benefits and demerits of sustainable *taungya* practice.

The manual nature of *taungya* requires large households that can share labour for agricultural production for expanded operation. Households capable of supplying farm labour are most likely to participate more meaningfully in *taungya* since there would be division of labour. The low participation of women in *taungya* farming could be attributed to the inability of women to pay for the initial high labour cost for land clearing.

CONCLUSION

An assessment of the productivities of some agricultural crops on *taungya* and non-*taungya* plots indicates that generally, farming on *taungya* plots is more productive than farming on non *taungya* plots. In VLGA, there are no significant differences in forest areas in respect of reforestation through *taungya* and non-*taungya* methods. An overwhelming majority (68.5%) of the farmers had no personal land on which to practice *taungya* farming. Reforestation efforts were tilted in favour of mono-species plantations without regard for ecological sustainability and species diversity expected of sustainable *taungya* practice.

Taungya farming is desirable in the study area as a means of forest regeneration and food production. It should be intensified and refined for better adoption by farmers. Land tenure laws have to be reviewed to give *taungya* farmers easy access to land. There is also need to recruit qualified forestry extension workers to provide necessary technical assistance to farmers for increased adoption of *taungya* practice.

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Performance and Grazing Pattern of West African Dwarf Sheep to

seasonally Variable Forage Supply and Quality

O. A. FASAE[+], I. A. ADEJOLA and O. M. ARIGBEDE *

Department of Animal Production and Health, University of Agriculture,

P.M.B. 2240, Abeokuta, Nigeria.

*Department of Pasture and Range Management, University of Agriculture,

Abeokuta, Nigeria.

[+] animalexp@yahoo.co.uk

ABSTRACT

Sixty (60) West African Dwarf sheep managed semi intensively and grazing on natural pastures were used in a study to determine the performance and grazing pattern to seasonal forage supply and quality. The animals were allowed to graze for about 6 hours daily for four months each in the dry and wet seasons, respectively. Results showed that field grazing time and active grazing time significantly increased (P<0.05) in the dry season with a corresponding increase in grazing distance traveled while the non active grazing time decreased (P<0.05) in the dry season. Season was observed to affect the forage quality and performance of sheep as the wet season resulted in the production of higher (P<0.05) quality forages compared to the dry season which led to a rapid increase (P<0.05) in the growth performance of the animals. The daily gain in weight (g/day) of the animals during the wet season was higher (P<0.05) relative to the dry season. It was therefore concluded that the performance and grazing pattern of sheep was influenced by season and forage density. Sheep grazing natural pasture should therefore be supplemented with high quality concentrate or/and drought resistance forages for optimum performance during the dry season.

Keywords: Sheep, grazing pattern, performance, forage quality, season

INTRODUCTION

The West African Dwarf sheep is a trypanotolerant and hardy animal with a compact body predominantly found in the humid south western part of Nigeria where they are reared mainly under the traditional systems of management (Adu and Ngere, 1985; Sowande and Sobola, 2008). The sheep possess adaptability traits which include ability to survive seasonal fluctuations, drought resistance, tolerance to diseases prevalent in the areas where they live (Oni, 2002). Profitable sheep production has been found to be highly dependent upon efficient production and use of forages. Harvesting of forage crops by sheep themselves, with as little supplemental feeding as possible, is the most practical and economical means to ensure the success of sheep operation (Luginbuhl *et al.,* 1998).

The productivity and long term viability of the production of these animals largely depends on quality of the animals and environmental factors. One of

the most important environmental factors is the diet because feeds can limit the productivity in terms of quality, quantity and distribution within the year (Derek *et al*, 1996). Natural grasslands are a major feed resource for sheep in Nigeria and they have continued to support grazing ruminants in terms of feed requirements both for maintenance and production. Their quality however, depends on many factors including soil, vegetative cover and season which in turn determine the intake and performance of ruminants. This study however examines the performance and grazing pattern of WAD sheep managed semi intensively to seasonally variable forage supply and quality in the South western part of Nigeria.

MATERIALS AND METHODS

The study was conducted in the Small Ruminant Experimental Unit of the Teaching and Research Farm, University of Agriculture, Abeokuta, Ogun State, Nigeria. The farm is situated in the humid zone of South Western Nigeria within latitude ($7^0$13'.49.46$^|$N) and longitude ($3^0$26'11.98$^|$E – $3^0$2.5$^|$E) with the annual rainfall of about 1000 to 1500 mm and mean temperature and humidity of 34.7^{0}C and 82%, respectively. Seasonal distribution of rain fall is approximately 44.96mm in late dry season (January to March), 259.3mm in late wet season (July – September); 48.1mm in early dry season (October – December).

The experiment was conducted for 8 months of 4 months each in both the dry (December to March) and wet season (May to August), respectively. A total of sixty (60) West African Dwarf sheep kept under the semi intensive system of management were grouped into four age groups as shown in Table 1. The animals were allowed to graze on natural pastures for about 6 hours daily between the hours of 9am to 2pm in the dry and wet seasons. Concentrate as supplements were given to the animals in the evenings after grazing with the provision of clean and cool water. Necessary preventive and disease control measures were carried out from time to time by the veterinarians to ensure good health status of the animals.

Table1: Animal grouping (years) of West African Dwarf sheep grazing natural pastures

Group	Age category (years)	Number of animals
T$_I$	0 -1	18
T$_2$	1 – 2	21
T$_3$	2 – 3	11
T$_4$	<3	10
Total		60

The time between the onset and end of grazing was recorded to determine the field grazing time (FGT) as described by Nweze (2003). Active grazing

time (AGT) was determined with the aid of a stop watch as the time the sheep spends grazing the forage materials of its choice to satisfy its appetite. The time spent on some other activities such as grooming while performing these activities was termed non- active grazing time (NGT) and was calculated as NGT = FGT-AGT. The AGT and NGT constitute the total time spent on field by the animal while grazing. The grazing distance traveled (GDT) was determined with the aid of a measuring tape.

The live body weight was however obtained using spring balance scale at the beginning of the experiment and subsequently weekly. Age in years was obtained using the dentition method as described by Devendra and McLeroy (1982) and confirmed through records kept on the farm. The environmental temperature and humidity were determined using a maximum and minimum thermometer placed at a corner of the grazing territory. Samples of the commonly grazed forages within the grazing territory were collected at each season and analyzed for its chemical components (AOAC, 1995).

All data collected were subjected to analysis of variance according to SAS (1999) and significant means separated using Duncan's multiple range test (Duncan 1955).

RESULTS AND DISCUSSION

The field grazing time (FGT), active grazing time (AGT) and non- active grazing time (NGT) of WAD sheep in the dry and wet season are shown in Table 2. FGT and AGT significantly increased (P<0.05) in the dry season with a corresponding increase in grazing distance traveled (GDT) compared to the wet season. The high (P<0.05) value of 345metres observed for GDT in the dry season could be due to scarcity of forage materials, which resulted to the sheep covering much distance in search of feed to satisfy them. The variation in FGT across the seasons suggested that sheep spend more time feeding in areas where they found the desired forage materials in abundance whereas they made more travel distance where these feeding materials were scarce. This shows that abiotic factors such as slope and distance to water can constrain animal grazing in some areas (Bailey *et al.,* 1996) as well as biotic factors such as composition of the forage species, plant morphology, productivity, and forage quality may also affect the grazing distribution. This observation supports the reports of Baile (1981) and Nweze (2003) that grazing time is positively correlated to the quantity of forage materials ingested by ruminant animals.

Seasonal variation was observed to affect the performance of WAD sheep (Figure 1). The wet season resulted in a rapid increase in the growth performance of the animals. The average gain in weight (g/day) of the animals during the wet season was higher (P<0.05) relative to the dry season. This suggests that rainfall influences the nutrient composition of the forages which resulted in an increase in its crude protein content with a

Table 2: Grazing pattern of West African Dwarf sheep, environmental temperature and humidity in the dry and wet seasons.
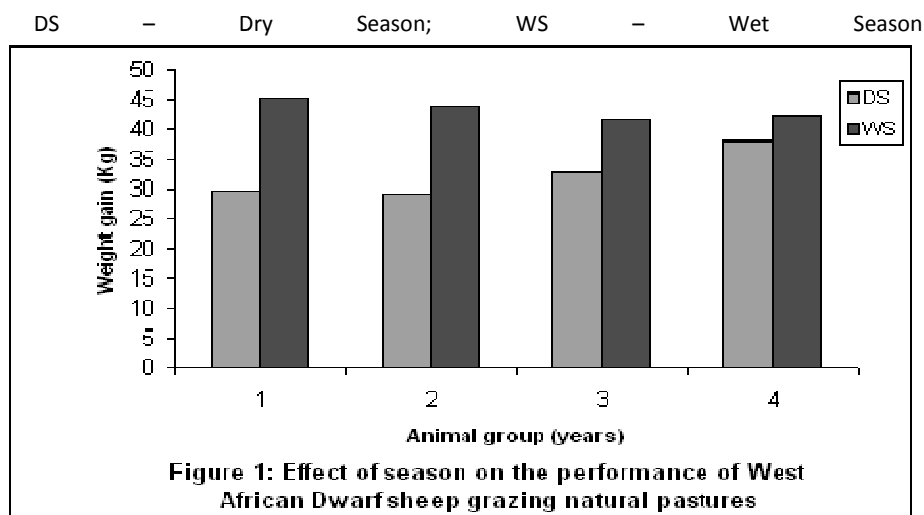
	Season		
Parameters	Dry season	Wet season	± SEM
Field grazing time (mins)	371[a]	314[b]	21.11
Active grazing time (mins)	280[a]	225[b]	17.34
Non- active grazing time (mins)	91	109	9.77
Grazing distance traveled (m)	345[a]	292[b]	19.32
Temperature ($0^{o}C$)	32.5	29	2.55
Humidity	57	65	3.89

a b values on the same row with identical superscripts are not significantly (P>0.05) different

corresponding increase in the weight of the sheep. This shows that the emergence of fresh forages in the rainy season could have led to high nutrient digestibility thereby having great beneficial impact on the sheep performance (Krysl *et al.,* 1987).

The poor sheep performance during the dry season could also be attributed to the fact that feeding stuffs for these animals were not sufficiently available, while those available were low in quality. And in searching for the desired forage materials, animals undergo stress which could lead to weight loss. Also, as a result of the presence of drought in the dry season which is commonly accompanied by a decrease in the nutrient contents of forages which may lead to reduced forage digestibility, higher level of gastro-intestinal tract fill and longer residence time of particulate and fluid digesta phase in the rumen (Demeyer, 1981) thereby eventually having effects on animal performance. However, the range in gain in weight of 29.22 to 38.02g/day observed in the dry season for the experimental sheep were lower than those earlier reported for the same breed of sheep subjected to different feedstuff and management systems (Alli-Balogun *et al.,* 2003; Taiwo *et al.,* 2005; Oduguwa *et al*., 2006) while values reported for the gain in weight in the wet season (41.56 - 45.25g/day) fell within the range reported by these authors. This however suggested that for better animal performance, adequate supplementation of forages with high quality concentrates and/or drought resistance forages is essential for grazing sheep during the dry season.

Concentrates fed to ruminants has been found to increase the feeding value of the entire diet by addition of energy over and above that supplied through low quality pastures (Ngwa and Tawah, 2002; Fasae *et al.,* 2005). Moreover, high environmental temperature could also have contributed to the low animal performance observed in the dry season as high temperature have been observed to cause late maturity of plants in the dry season which

DS   –   Dry   Season;   WS   –   Wet   Season

Figure 1: Effect of season on the performance of West African Dwarf sheep grazing natural pastures

increases the indigestible fibre material that gives little or no benefit to the animal (Holmas, 1989). Also, Forbes (1986) found that environmental temperature above 20^0C increases body temperature and associated heat stress in ruminants which depress intake, particularly in the short run with some acclimatization in the long run. Moreover, reduction in feed intake represents a major cause of reduced productivity in heat stressed ruminant animals (Robert Shaw, 1987). The dry matter, crude protein and neutral detergent fibre contents of common grasses grazed by the experimental sheep during the dry and wet seasons are shown in Table 3 while that of legumes and forbs are shown in Table 4.

Table 3: Seasonal effects on the dry matter, crude protein and fibre fractions (%) of common grasses grazed by West African Dwarf sheep

Chemical constituents	Common	grasses grazed by sheep			
	Imperata cylindrical		*Panicum maximum*		*Bahama grass*	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Dry matter	93.08±3.44[a]	85.72±3.12[b]	92.50± 3.24[a]	86.68±3.08[b]	91.04±3.19[a]	85.74±3.02[b]
Crude protein	13.40± 0.52[b]	15.67±0.75[a]	5.08± 0.31[b]	7.74±0.44[a]	7.09± 0.40[b]	9.94±0.42[a]
Neutral detergent fibre	50.01±1.92[a]	42.36±1.73[b]	63.98±1.92[a]	57.22±1.8[b]	54.22±1.67[b]	60.56±1.77[a]
Acid detergent fibre	35.49± 1.56[b]	39.59±1.61[a]	42.26± 1.75[b]	44.31±1.79[a]	34.57±1.59[b]	42.62±1.67[a]
Acid detergent lignin	7.56±0.37[a]	5.84±0.31[b]	9.67± 0.42[a]	8.33±0.39[b]	10.38±0.54[b]	12.94±0.59[a]

a b values on the same row with identical superscripts are not significantly (P>0.05) different

The chemical nutrients varied (P<0.05) with season and species of forages. Forage samples collected in the dry season produced poor (P<0.05) quality forage. The high DM content observed in the dry season compared to the

wet season might be as a result of reduced moisture content during this period.

Table 4: Seasonal effects on the dry matter, crude protein and fibre fractions of common legumes/forbs grazed by West African dwarf sheep.

	legumes/forbs grazed		by sheep			
	Calopgonium mucuniodes		*Tridax procumbens*		*Chameachrista spp.*	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
DM	89.45 ± 3.162^a	85.42 ± 3.12^b	89.50 ± 3.5^a	86.61 ± 3.32^b	91.22 ± 4.0^a	85.69 ± 3.43^b
CP	14.58 ± 0.56^b	18.26 ± 0.73^a	15.76 ± 2.3^b	18.65 ± 0.35^a	6.11 ± 0.2^b	8.24 ± 0.31^a
NDF	54.74 ± 1.67^a	49.61 ± 1.45^b	54.87 ± 1.7^a	47.89 ± 1.33^b	62.23 ± 1.9^a	60.33 ± 1.91^b
ADF	34.37 ± 1.01	36.95 ± 1.03	39.59 ± 1.1^b	42.26 ± 1.26^a	41.94 ± 1.3^b	43.81 ± 1.35^a
ADL	5.37 ± 0.33	6.76 ± 0.45	5.76 ± 0.41	6.24 ± 0.43	10.23 ± 0.5	11.34 ± 0.32

a b values on the same row with identical superscripts are not significantly (P>0.05) different
**;Chemical Constituents. DM=DryMatter, CP=Crude Protein, NDF=Neutral Detergent Fibre, ADF=Acid Detergent Fibre, ADL=Acid Detergent Lignin.
Performance and grazing pattern of West African Dwarf sheep

The crude protein content of the forages fell drastically during the dry season while there was corresponding increase (P<0.05) in the contents of fibre fractions. This supports the reports of Van Soest (1982) and Fasae *et al.* (2009) that protein content of forages increased (P<0.05) in the wet season with a decrease in the contents of the fibre fractions. This result also confirmed the work of Valentine (1990) that crude protein content of forages on a dry matter basis can be as high as 20% in new growth in the rainy season, but could be as low as 2.5% in cured and weathered grass in the dry season. This therefore suggests that the poor quality forage in the dry season could be as a result of high environmental temperature, which may cause dormancy in plant growth and increased indigestible fibre material. However, the wet season produced high quality forage as the onset of rainfall resulted into emergence of fresh and leafy forage with a rapid increase in the level of the protein content.

CONCLUSION

It was concluded that the performance and grazing pattern of sheep varied with season and forage density as animals performed best during the wet season when compared to the dry season. It could therefore be recommended that sheep grazing natural pastures should always be supplemented with high quality concentrate or/and drought resistance forages for optimum performance during the dry season.

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