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- Potential of Bio-Organic Mix
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Discovering Thoughts, Inventing Future

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# Native Mycorrhizh-Forming Fungi Associated with Cultivated Forage Plants in the Central Valley of Catamarca, Argentina

By Di Barbaro Gabriela, Andrada Horacio, Viale Sixto, González Basso Valeria, Alurralde Ana, Del Valle Eleodoro & Brandán de Weth Celia
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*Abstract-* Mycorrhizae are a symbiosis between the roots of some plants and certain soil fungi, where both participants in this association obtain benefits. The plant provides the fungus with carbohydrates, proteins, and lipids, and in turn, the fungus allows the plant to better uptake nutrients from the soil and water. The objective was to determine the existence of mycorrhizal associations between native fungi and forage crops in the Central Valley of Catamarca. Root colonization of Melilotus officinalis, Avena sativa, Hordeum vulgare, Secale cereale, Panicum maximum, and Cenchrus ciliaris from field crops in the Central Valley of Catamarcawas studied. Fungal infection or colonization was quantified using the line intersection method and the frequency of appearance of fungal structures. Endomycorrhizal structures of the arbuscular vesicle type were observed, with continuous mycorrhizal hyphae, some of them with rosary lipids inside and vesicles with fat globules. In addition, dark septate endophytic fungi were observed. The association of mycorrhizae is described in six forage species cultivated in the Central Valley of Catamarca and the co-occurrence of arbusculo-vesicular mycorrhizae and native dark septate endophytes.

*Keywords: oatmeal; barley; rye; gatton panic; buffalo-grass.*

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NATIVEMYCORRHIZHFORMINGFUNGIASSOCIATEDWITHCULTIVATEDFORAGEPLANTSINTHECENTRALVALLEYOFCATAMARCAARGENTINA

*Strictly as per the compliance and regulations of:*

# Native Mycorrhizh-Forming Fungi Associated with Cultivated Forage Plants in the Central Valley of Catamarca, Argentina

Di Barbaro Gabriela [α], Andrada Horacio [σ], Viale Sixto [ρ], González Basso Valeria [Ѡ], Alurralde Ana [¥], Del Valle Eleodoro [§] & Brandán de Weth Celia [χ]

*Abstract-* Mycorrhizae are a symbiosis between the roots of some plants and certain soil fungi, where both participants in this association obtain benefits. The plant provides the fungus with carbohydrates, proteins, and lipids, and in turn, the fungus allows the plant to better uptake nutrients from the soil and water. The objective was to determine the existence of mycorrhizal associations between native fungi and forage crops in the Central Valley of Catamarca. Root colonization of *Melilotus officinalis*, *Avena sativa*, *Hordeum vulgare*, *Secale cereale*, *Panicum maximum,* and *Cenchrus ciliaris* from field crops in the Central Valley of Catamarcawas studied. Fungal infection or colonization was quantified using the line intersection method and the frequency of appearance of fungal structures. Endomycorrhizal structures of the arbuscular vesicle type were observed, with continuous mycorrhizal hyphae, some of them with rosary lipids inside and vesicles with fat globules. In addition, dark septate endophytic fungi were observed. The association of mycorrhizae is described in six forage species cultivated in the Central Valley of Catamarca and the co-occurrence of arbusculo-vesicular mycorrhizae and native dark septate endophytes.

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## I. Introduction

Mycorrhizae are symbioses between plant roots and certain soil fungi. The term mycorrhiza describes the group made up of the absorption structures of plants and the fungal symbionts that colonize them in a distinctive way (Sánchez de Prager, 2007; Perez *et al.,* 2010), generating a structural and metabolic integration typical of a symbiosis. The absorption of nutrients is affected by these associations that also influence plant health, productivity, and the adaptation of plants to environmental conditions (Sánchez de Prager, 2007).

The plant provides the fungus with carbohydrates, proteins, and lipids, necessary for its development, and in turn, the fungus allows the plant to better capture water and nutrients from the soil, both macronutrients and micronutrients, especially those few mobile, such as phosphorus (Sánchez de Prager, 2007).

Endo mycorrhizae and ectomycorrhizae are two types of mycorrhizae that occur naturally (Sieverding, 1983; García *et al*., 2000; Biaus, 2017). Endomycorrhizae are more frequent in nature and are characterized by the colonization of cortical cells by a mycosymbiont, which lives between them and within them, inter and intracellularly (Montenegro Gómez *et al*., 2017). Among the different types of endomycorrhizal, the most widespread within plant species are vesicular-arbuscular mycorrhizae (VAM) or arbuscular mycorrhizae (AM) and some more specific forms such as orchidoids and ericoid (Sánchez de Prager, 2007; Montenegro Gómez *et al*., 2017).

Arbuscular mycorrhizal fungi (AMF) and vesicular-arbuscular fungi (HMVA) do not develop in pure culture media because they are not capable of growing in the absence of a host plant (Aguilar-Ulloa *et al*., 2016), so they are considered obligate symbionts, this biological condition that represents an obstacle to their massive propagation. These fungi are propagated using trap plants, which after a period of growth, the roots and soil are collected for use as inoculant of endomycorrhizal fungi (De la Rosa-Mera*et al.,* 2012).In recent decades, the study of these organisms has become important for apply them to the ground, as biofertilizers to increase the productivity in crops (Covacevich and Echeverria, 2010; Reyes Tena *et al.,*2015; Aguilar-Ulloa *et al*., 2016; Ordoñez-Castañeda *et al.,* 2021) and in phytoremediation, programs to correct contaminated soils (Pérez *et al*., 2021; Colombo *et al*., 2020; Quiroz-Mojica *et al*., 2021). The colonization of roots by endomycorrhizal fungi is the most used parameter as a quick indicator of the presence of mycorrhizal symbiosis (Covacevich and Echeverría, 2010).

Several plant species have been investigated as trap crops to produce mycorrhizae, to find plants that can be colonized and allow the rapid growth of mycorrhizae (Aguilar-Ulloa *et al*., 2016). The appropriate trap crop must be a fast-growing plant that adapts to the environmental conditions where it will grow, must be

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easily colonized by the mycorrhizal fungus, and produce many roots in a relatively short time (45-60 days) (Siqueira Martins *et al*., 2017).

The association established by AMF is not specific, which allows the same fungus to colonizes different plant species to generate symbiosis (Aguilar-Ulloa *et al*., 2016). Also, there is a preference that certain AMF colonize and spread better in certain plant species (Covacevich and Echeverría, 2010). Furthermore, using the same fungal species is probably not optimal for all crops. For this reason, it is convenient to evaluate the MVA in each trap crop species.

Because the interactions between different VMAs with soil microorganisms are complex, it is necessary to determine their behavior in the field under the growth conditions of each crop. The use of native MVA is recommended due to its adaptation to prevailing conditions, avoiding ecological risks associated with introducing exotic species (Sánchez de Prager, 2007).

The objective was to determine the existence of mycorrhizal associations between autochthonous soil fungi and forage crops planted in the Central Valley of Catamarca and to evaluate the biological aspects of the interactions found.

## II. Materials and Methods

Colonization of mycorrhizae in plant roots of six commonly cultivated forage species in the region was studied. The sowings were carried out in the locality of Miraflores, Department of Capayán, in the Central Valley of Catamarca, in plots of native forest or with agricultural history without application of mycorrhizal fungi. The species evaluated were: clover (*Melilotus officinalis* L.), oats (*Avena sativa* L.), barley (*Hordeum vulgare* L.), rye (*Secale cereale* L.), Gatton panic (*Panicum maximum* Jacq.), and buffel grass (*Cenchrus ciliaris* L.).

In the laboratory, the roots of each of the collected plants were extracted and washed with running water. The thinnest were selected, those that were clarified and stained following the methodology of Phillips and Hayman (1970) to determine fungal colonization and detection of mycorrhizal structures. Staining was performed with Gueguén's triple dye solution, allowing fungi to stain proteins blue simultaneously, starch violet, fats red (Sarasola and Rocca, 1975), and glycogen in mahogany (Verna and Herrero, 1952).

In each specimen, the percentage of fungal colonization by MVA and the percentages of the content of arbuscules (A) and vesicles (V) were quantified by the line intersection method of Giovannetti and Mosse (1980), and the frequency of appearance of A and V (Covacevich *et al*., 2001). For each specimen, 15 segments of the colored roots were taken, and distributed randomly on a grid slide. By means of microscopic observation (10x and 40x), the presence-absence of mycorrhizal structures (A and V) was recorded in the horizontal and vertical intersections between roots and grid lines. Three repetitions of each species were performed, quantifying at least 100 intersections per preparation to later calculate the frequency of mycorrhizal infection, according to Giovannetti and Mosse (1980).

$$\text{MGiovannetti (\%)} = \text{No. SI} \times 100 / \text{No. SO}$$

Where:

*SI:* number of infected segments (hyphae + arbuscules + vesicles) and

*SO:* numberof total segments observed (hyphae + arbuscules + vesicles + no infection).

Also, the percentage of hyphae of dark septateendophytes (ESO) and the percentage of microsclerotia were recorded.

## III. Results and Discussion

In the six analyzed forage species, typical structures of endomycorrhizal fungi of the MVA type (hyphae, arbuscules, and vesicles), and of ESO fungi (with septate, melanized hyphae, and numerous microsclerotia) were observed.

In all species there were continuous thin and thick hyphae, with intracellular and intercellular growth and some of them with lipids in a rosary inside.

In clover, arbuscular distributed throughout the bark were observed, involved in the bidirectional transfer of nutrients (Smith and Read, 1997). Numerous vesicles of diverse morphology (spherical, oval, tapered) were also observed in this legume, so it is inferred that the roots are colonized by various species or genera of native HMVA. Vesicles with light blue (saccule) and red (single or multiple globules) colorations were observed. These structures are related to the carbon storage of in the form of lipids and fatty acids. For this reason, vesicles are defined as reserve organs of the fungal symbiont (Sieverding, 1983).

A high level of fungal colonization was determined in the six forage plants, obtaining the highest values of mycorrhizal colonization (MC) in clover and barley roots (Table 1). The highest frequency of appearance of arbuscules (FAA) was observed in clover, while the lowest number of arbuscules was determined in oats. The highest frequency of vesicle appearance (FAV) was also observed in clover, with average values of 20% (Table 1). These results coincide with the statements of Covacevich and Echeverría (2010) that indicate that there is a preference for certain AMF to better colonize certain plant species.The more signicant colonization in clover is explained by the fact that Rhizobios-arbuscular mycorrhizae (AM) associations occur in legumes that act synergistically in infection, mineral nutrition, and plant growth (Fitter & Garbaye, 1994; Barea, 1997). The main effect of AM in enhancing rhizobia, activity is through a generalized stimulation of plant nutrition, some more localized effects may occur at the root (Melo de Miranda *et al*., 2008; Spagnoletti *et al*., 2021).

*Table 1:* Fungal colonization in forage species from the Central Valley of Catamarca

| Species | Mycorrhizal Fungi | | | Fungi ESO |
|---|---|---|---|---|
| | MC[1] (%) | FAA[2] (%) | FAV[3] (%) | FAM[4] (%) |
| Clover | 89 | 47 | 20 | 15 |
| Barley | 89 | 17 | 15 | 15 |
| Rye | 83 | 27,7 | 16 | 13 |
| Buffalograss | 76,5 | 20 | 8 | 2 |
| gatton panic | 75,8 | 32 | 9,8 | 1,7 |
| Oatmeal | 75 | 10 | 12 | 4 |

*[1](MC): Mycorrhizal colonization. [2](FAA) Frequency of appearance of arbuscules. [3](FAV): Frequency of appearance of vesicles. [4](FAM): Frequency of appearance of microsclerotia of dark septate fungi.*

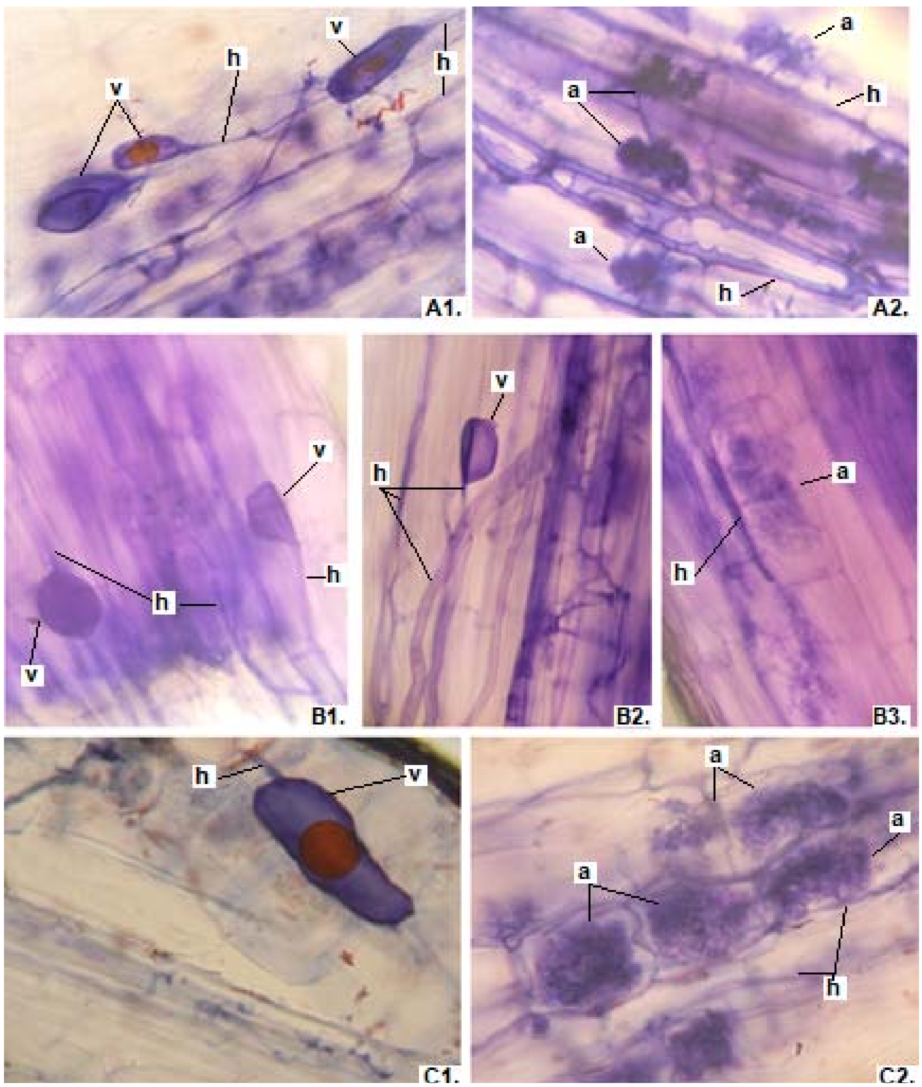


*Figure 1:* Photomicrographs of mycorrhizal structures in roots of forage species. (A: Clover; B: Barley; C: Rye). (a: Arbuscle; h: hyphae; v: Vesicle).(Magnification: 40x)

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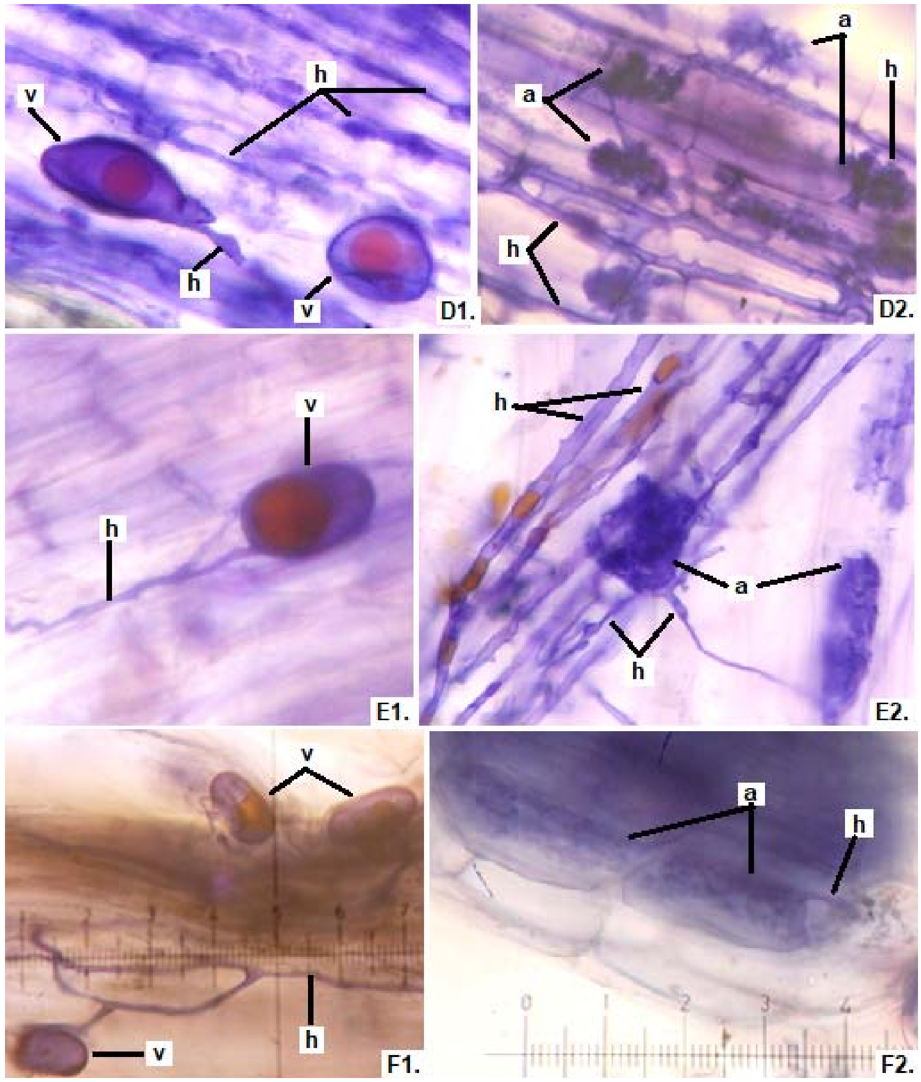


*Figure 2:* Microphotographs of mycorrhizal structures in roots of forage species. (D: Oats; E: Buffel Grass and F: Gatton Panic). (a: Arbuscle; h: hyphae; v: Vesicle). (Magnification: 40x)

In addition, in all the forage species analyzed, another type of hyphae was observed: septate, melanized, and with numerous microsclerotia of the kind ESO fungi (Peterson *et al*., 2004). In clover, barley, and rye roots, similar values of FAM of ESO (between 15 and 13%) were determined (Table 1).

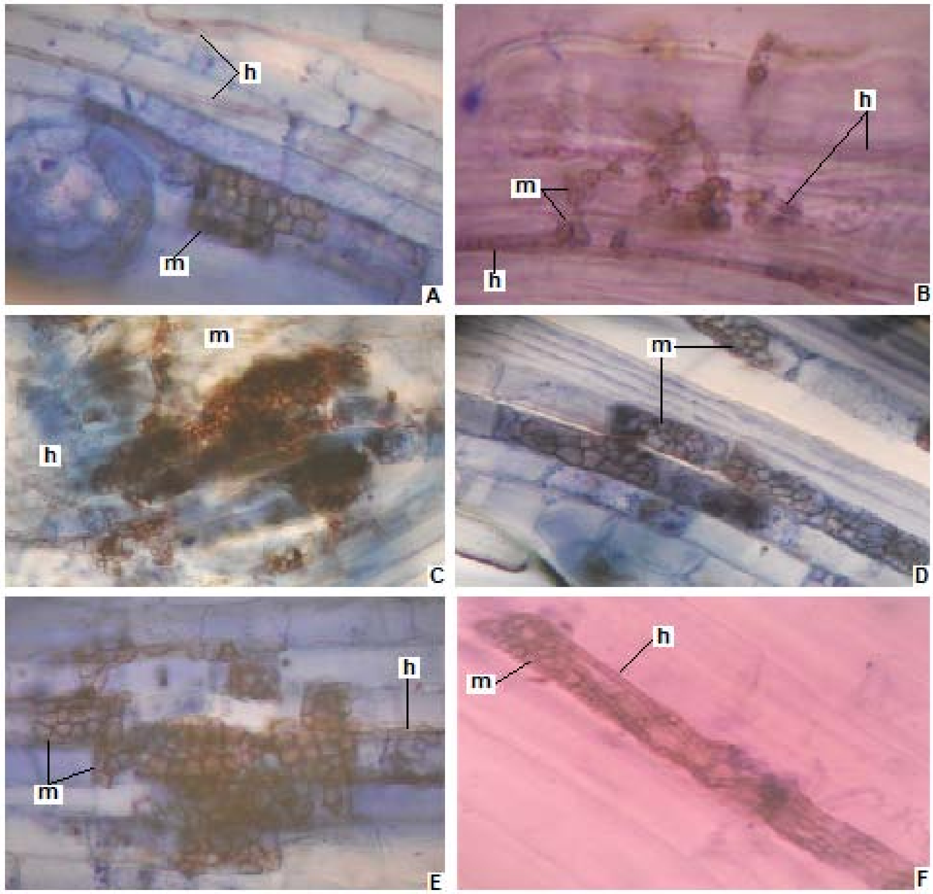


*Figure 3:* Photomicrographs of dark septate fungal structures on roots of forage species. (A: Clover; B: Barley; C: Rye; D: Oats; E: Buffel Grass and F: Gatton Panic). (m: Microsclerosia; h: hypha). (Magnification: 40x).

In all the plants studied, their roots were simultaneously colonized by both endophytes, MVA and ESO hyphae, also detecting the presence of vesicles, arbuscules typical of VA mycorrhizae, and ESO microsclerotia. This was also observed in other plants including ferns, mono, and dicots that are simultaneously colonized by MVA and ESO. (Urcelay *et al*., 2005; Lugo *et al*., 2011; Lizárraga *et al*., 2015; Di Barbaro *et al*., 2017).

Therefore, MVA and other fungal structures developed in all the forage species studied. This coincidence could be due to the fact that all these crops were carried out in contiguous lots with identical soil characteristics and environmental conditions, and because the fungal colonization developed from the native microflora, with the ability to associate and generate MVA, which is consistent with what expressed by Aguilar -Ulloa *et al.* (2016) where they explain that the same fungus can colonize different plant species to generate symbiosis.

These mycorrhizal-forming fungi can be considered as potential constituents of biofertilizers. Diaz Franco *et al.* (2019) achieved the reduction of inorganic fertilization through the inoculation of FAM in the sorghum crop. The higher yield of sorghum obtained allows considering the inclusion of FAM as a viable practice that guarantees greater profitability, as well as the agroecological conservation of production systems.

## IV. Conclusion

The association of mycorrhizae in six forage species cultivated in the Central Valley of Catamarca and the co-occurrence of vesicular-arbuscular mycorrhizae and native dark septate endophytes is described.

High levels of mycorrhizal colonization were obtained in all the evaluated forage species. The suitability of *Melilotus officinalis* as a trap species is highlighted as it is easily colonized by mycorrhizal fungi and generates rapid mycorrhizal growth.

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# Potential of Bio-Organic Mix as an Alternative to Inorganic Fertilizer in Maize Production in Africa

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POTENTIALOFBIOORGANICMIXASANALTERNATIVETOINORGANICFERTILIZERINMAIZEPRODUCTIONIN AFRICA

# Potential of Bio-Organic Mix as an Alternative to Inorganic Fertilizer in Maize Production in Africa

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*Abstract-* Maize (Zea mays L.) is the most abundantly produced and consumed cereal in the world. Major challenge in maize production in Africa is low soil fertility due to lack of sustainable soil fertility restoring inputs among others. This study investigated the potentials of Moringa-banana- maize mix, a biodegradable, environment friendly and abundantly available free gifts of nature in soil fertility improvement. The objective of this study was to investigate the effects of the mixture of Moringa *olifera* leaves (MO) +Banana Peels (BL) +Maize Stalks (MS) on yield and profitability of maize production. Specifically, to choose the right combination of the mix and determine the correct mode of application. Field and screen house experiments were conducted in 2020 planting seasons, at the Teaching and Research Farm of Kwara State University, Malete. Four treatments were considered and each represented a technology on field/screen trials. These include; A=100N+40P+30K, B= 120N+50P+40K, C= 70N+30P+ 20K and the control using the national recommended dose of 90kg/ha of NPK fertilizer (for comparison). The experiment was laid out in a randomized complete block design (RCBD) with three replicates. Data were collected on maize growth parameters; crop yield, cost and returns. These were subjected to statistical and economic viability analyses. Results showed that application of the mixed MO leaves +BP+MS at the rate of B= 120N+50P+40K significantly ($P < 0.05$) increased the maize net income. It had the highest net income across the trials (₦1,733,500 (US$3,467). It was also discovered that the mixture was most effective when applied in solid form and in the open field. On the basis of these findings the use of moringa/banana/maize mixture a bio-organic fertilizer applied at the rate of 120N+50P+40K was recommended for adoption by maize farmers.

*Keywords: maize, yield, economic performance, moringa leaves, banana peels, and maize stalks.*

## I. Introduction

### *a) Background to the study*

Maize (Zea mays L.) (corn) is the most abundantly produced and consumed cereal in the world. It ranks first worldwide with wheat and rice following in terms of importance (OECD-FAO, 2016). Maize grains are useful raw materials in pharmaceuticals, food industries, domestic fuel and animal feed production (Relief Web, 2017) This makes it one of the crops with the highest demand in the world (IITA 2019). According to Urassa, (2015) the demand for maize worldwide hits 3Billion Metric Tonnes while the global production was about 1.1 Billion Metric Tonnes thereby leaving a deficit of 1.9 Billion Metric Tonnes. Hence the need for increased maize production.

Maize is the most important cereal crop in Africa. It is critical to more than 300 million small holder livelihoods and accounted for 30-50 percent of Africa expenditure (FAO, 2019).

Nigeria in 2019 was the second largest maize producer in Africa. It had an average maize production volume of about 11 million Metric Tonnes (MMT) after South Africa with 16 MMT and Ethiopia third with 8.4 MMT (USDA Data 2020). However, as of January 2021, Nigeria is ranked 40$^{th}$ largest maize importer in the world, importing about 400,000Metric Tonnes of maize on yearly basis (Premium Times 2021). This is because the local demand is more than the national production. In 2019, while total production was 11 MMT, total demand was more than 12 MMT leaving a deficit of more than 1MMT (Federal Ministry of Agriculture (2019).

This may not be unconnected with the fact that more than 80 percent of maize production in Africa is carried out by small holders whose major challenge is low soil fertility(Urassa,2015). Low soil fertility results from; continuous cropping, removal of crop residues for animal feed and shelter, bush burning, leaching as a result of torrential rain and lack of soil fertility restoring inputs to balance soil nutrients there by resulting into low crops yield and low income. (Adams *et al*., 2015). Unfortunately, the traditional measures of restoring soil fertility including bush fallowing and land rotation are no longer fashionable as a result of population pressure. Farmers therefore, embraced the use of inorganic fertilizers to augment soil nutrient and boost yield. However, inorganic fertilizers are mostly unavailable, and when available, are very expensive, hence, out of the reach of about 70% farmers (FAO, 2019; Urassa, 2015) who are responsible for feeding the people. Inorganic fertilizer besides promoting the luxuriant growth of pest habouring weeds which compete with and inflict injury on our crops on the field, produce weed seeds that contaminate stored grains, it is also associated with land degradation, increase in soil acidity, breakdown of microbial activities in the soil, and environmental pollution. According to Loks *et al*., (2015) ccontinuous use of inorganic fertilizer results in its reduced nutrient release efficiency thereby leaving behind in the soil large proportion of unused nutrients which are likely to damage the soil and the environment.

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The persistent exorbitant cost of fertilizer, over dependency on the use of inorganic fertilizers as a source of plant nutrients by farmers, land and soil degradation and environmental pollution have necessitateda serious demand for sustainable soil nutrient replenishment options in Africa which will be inexpensive, environment friendly and improves crops yield.This research was therefore, initiated in order to explore the potentials of the moringa/ banana/ maize technology- a natural organic fertilizerto serve as the best alternative to the expensive, scarce and hazardous chemical fertilizers. Moringa/banana/ maize technology is a low-cost bio-fertilizer which combines moringa leaves, banana peel and maize stalk in different ratios and different forms(solid or liquid) to replenish soil nutrients

*b) Justification for the Study*

The current study is a continuation of a baseline study on Moringa Technology carried out in 2016/17 by the author and team members. The moringa Technology a biofertilizer that emanated from the felt needs study carried out by the author's department (Agricultural Economics and Extension services) in 2013 where the community farmers lamented seriously on lack of access (in terms of cost and availability) to chemical fertilizers.

The baseline study ran a trial on the use of Moringa leaves, poultry manure and NPK 15-15-15 individually and their combinations at various levels. It was discovered that Moringa leaves alone could not support maize production 100% except when combined with NPK inorganic fertilizer. This was because Moringa leaves have high content of N (2.56%) and relatively low content of P (0.22%) and K (1.13%)(Moringa leave analysis in 2016).The relatively low level of other essential plant nutrients P and K in moringa leaves necessitated the inclusion of maize stalks and banana peels in the current study since the aim is to use only organic sources. Banana peels and maize stalks have been discovered to have large quantities of phosphorus (P) and potassium (K) but do not have usable Nitrogen (N) which makes the combination more perfect.

The current study is therefore, combining the three organic sources of soil nutrients to replace the use of inorganic fertilizer. So as to reduce cost of producing maize through complete removal of the cost of inorganic fertilizer which is the most expensive farm input on maize farms (Urassa, 2015). The outcome of this study will not only reduce cost of maize production in Africa, it will also produce maize cobs with acceptable taste and enhance sustainable income among maize farmers.

## II. Objective of the Study

The general objective of the study is to explore the possibility of using MO, MS and BP mix to optimize maize crop production for increased sustainable income of small-scale farmers.

Specifically, to;

1. Investigate the effect of the different combinations of MO - MS -BP mix on the growth and yield of maize
2. Estimate the cost and benefit of the different combinations of MO- MS-BP technology
3. Determine the optimum combination of MO-MS-BP that will maximize net farm income.
4. Determine the best mode of application of MO + BP +MS mix that produces the highest yield.

## III. Components of the Moringa Technology

*a) Moringa oleifera leaves*

Moringa *oleifera* Lam (family: Moringaceae) christened 'Miracle tree', is a prestigious multipurpose tree found in the tropics and subtropics (Morton, 1991) with highly abundant uses (Adebayo et al., 2011; Moyo et al., 2011). It is considered as one of the world's most useful trees, as almost every part of the tree has an impressive effect in food, medication and industrial purposes (Adebayo et al., 2011., Mishra et al., 2011). M. oleifera has remarkably great potential as organic fertilizer (Jahn 1988). It is a renewable, biodegradable, sustainable and environmentally friendly organic fertilizer that thrive on marginal lands (Adebayo et al., 2011) *M. oleifera* used in its natural form as organic fertilizer performs two functions, it releases nutrient just as required by plant for uptake thus preventing buildup of acidity in the soil. It also improves soil health, structure, pores for air and water retention and micro and macro-organism activities hence, promoting a balanced and sustainable ecosystem at the long run (Jahn 1988). Moringa leaves as organic fertilizer is unparalleled as it does not only contain macro and micro nutrients, but also contain growth hormones such as cytokinin and antioxidants (Abdalla and El-Khoshiban, 2012; Su and Chen, 2020). Empirical evidence abound on use of moringa leaves either in liquid or solid organic fertilizer with favorable and significant results in vegetable crops like rape, cabbage and tomato, and field crops like maize and common beans. Andrew (2011) demonstrated that the liquid spray of M. *oleifera* increased the crop production by 20-35%. Also, it's fast-growing nature makes it a good green manure especially when ploughs into the soil during land preparation. Thus, enriching depleted soils, saving farmers funds ought to be expended in buying inorganic fertilizer and increase quality and yield of food crops that will command higher market price and consequently increase in farmers' income.

*b) Banana peels*

Banana (*Musa spp*) is a tropical large herbaceous plant belonging to the family Musaceae with very tender stem which is a cylinder of leaf-petiole sheaths, reaching a height of (6-6.5 m) and arising from a fleshy rhizome or corm. Suckers spring up around the main plant forming a clump or "stool", the eldest sucker replacing the main plant when it fruits and dies, and this process of succession continues indefinitely. Bananas have a great economic impact in the world as one of the most popular fruits which is high in nutritive value and as cash export (Stone, 2015). Empirical evidence showed that banana peels contain 4.4 – 6.3% dry weight potassium (K) with significant amounts of Calcium, Magnesium and Sodium along with a number of other trace elements accounting for 9/15 of the commonly tested for elements (Hussain et al., 2019)). Banana peels according to Stone, 2015., Doran and Kaya, 2003 contain 42% potassium, making it one of the highest organic sources of potassium, and even higher than wood ash. Crops like tomatoes and peppers, which have a low nitrogen need respond well to banana peel fertilizer (Stone, 2015).The calcium in banana peel helps in N uptake, manganese aiding photosynthesis, the sodium helps in water movement between cells and magnesium and sulfur both helping in the chlorophyll formation. As important as bananas are, many African countries (Nigeria inclusive) after eating the flesh often toss the peels in the garbage. Banana residues being organic in nature are rich source of macro and micronutrient that can be recycled to prevent their disposal in environment, thus sustaining the balance between economic development and environmental protection (Memon et al., 2012). Application of banana waste improves soil structure, texture, aeration, water holding capacity, porosity, increases stress tolerance and productivity of sorghum bicolor (Mawahib et al., 2015) In addition to improving soil health, it also reduces the use of chemical fertilizers (Hussain et al., 2019) thus saving huge amount of foreign exchange incurred for import of fertilizers.

*c) Maize stalk*

Maize is cultivated in large quantum in the tropics for food and other uses. Each year, enormous quantity of debris results after harvest especially where maize stalks are not fed to animals or used for sheds and shelters. However, maize stalk has high potential use in organic fertilizer as it contains high content of Phosphorus (P) and Potassium (K) 370 and 1020 (mg/kg) respectively (Galila et al., 2012). The level of K in maize stalk can be increased by ten folds when fermented with fungi while some other mineral components also increased but by a lesser fold (Galila et al., 2012). However, the continuous removal of maize stalks makes the nutrients in maize stalks unavailable to the soil for crop use. The phosphorous in maize stalk is not easily available for plant use (Woldesenbet and Haileyesus 2016). Decomposition and grinding to reduce organic materials to particle size improve nutrient availability in the soil and uptake by plants as they increase the surface areas of organic materials.

Both maize stalk and banana peel do not contain usable nitrogen, hence, serve as perfect combination with Moringa oleifera for nutrient loving crops like maize, hence, Moringa- Banana peel – maize stalk technology has a great potential for cost effective, long- term, sustainable impact in improving maize productivity, soil fertility, structure and income of the resource-poor rural dwellers in Africa.

## IV. Materials and Methods

*a) Experimental Site*

The Teaching and Research Farm, Kwara State University, Malete, (08° 42'48.5''N and 004°26'17.9''E) Ilorin, Nigeria was used for the experiment. The area is in the southern guinea savanna zone of Nigeria. It has an annual rainfall of about 1200 with a dry spell from December to March. Mean maximum temperature varies between 33°C and 34°C. The soil is slightly acidic (PH 6.5), sandy loam, low in organic matter (8.76g/kg) and deficient in nitrogen (0.7g/kg), phosphorus (9.7mg/kg) and potassium (0.41cmol/kg). The site is mainly used for experimentation.

*b) Materials and Collection*

The materials for the experiment are; maize seeds, moringa leaves, maize stalks and banana peels and NPK 15-15-15 (control)Maize seeds, variety BR9928 DMR-SR (Yellow, Downy Mildew Streak Resistance) were collected from IITA Ibadan, Moringa leaves and maize stalks were collected from Kwara State University Teaching and Research Farm, Malete while banana peels were obtained from women selling roasted plantain by the road sides. N, P and K for the experiment were sourced from Moringa leaves (MO), maize stalk (MS) and banana peel (BP) respectively.

*c) Measurement of variables*

- *Maize plot:* The area of maize plot was a $3m^2$ divided into three replicates laid out in randomized complete block design (RCBD). Data were collected on ten plants at the middle.
- *Number of leaves(NoL):* were counted at two, four, six and eight weeks after planting WAP
- *Plant height(PLTH):* was taken from the base of the plant to tip stem at 2, 4,6 WAP and the base of the tassel at 8 WAP using meter rule
- *Grain yield:* This was estimated and expressed in ton/hectare.

$$\text{Grain yield (t/ha)} = \frac{\text{field weight (kg) x (100- grain moisture content) (\%) x 10,000}}{\text{85 x 3 x 1000}}$$

15% moisture content

Where shelling % = 85

1 hectare = 10,000$m^2$

1 tonne = 1,000kg

Stalk lodging (%) It is the percentage of plant stalks that broke below the ear two weeks before harvest.

*d) Source of materials*

Moringa leaves and maize stalks came from the university farm at no cost

Banana peels were collected from Ipata (a local market in Ilorin) through roasted plantain sellers

N was sourced from moringa

P sourced from banana peel

K sourced from maize stalk

Inorganic fertilizer was bought from the market

*e) Experimental Design and procedure*

The experimental design involved a screen house and field experimentation both at the Kwara state University Teaching and Research Farm. The Screen house experiment was laid out in complete randomized design (CRD) while the field experiment was randomized complete block design (RCBD) both in three (3) replicates.

The experimental site was cleared and prepared manually and then divided into plots using a randomized complete block design with split plot arrangement in three replications. The size of each plot was 3.0 X 3.0 (9 $m^2$) with an inter-plot space of 0.5m. The fertilizer treatments consisted of four different nutrients combinations including; - (A) = 70N+30P+ 20K, (B) = 100N+40P+30K, (C) = 120N+50P+40K and a control, (D) = 90kg NPK 15-15-15, a recommended rate for maize. The N, P and K experimental content came from the mixture of Moringa leaves, maize stalk and banana peel. The fertilizer was incorporated into the soil and also applied as foliar. The solid fertilizer obtained from the air-dried and grounded moringa leaves and other components were incorporated into the soil a week before planting while the foliar fertilizer were applied 2 and 6 weeks after planting to reduce being washed off by rain. To form the foliar fertilizer, each of the plant components was dissolved in a litre of water in a jar and covered for three days, thereafter, sieved into sprayer tank containing 1 litre of water and sprayed on the foliar part of the plants. All required agronomic standard practices were used before and after the crop emergence. Maize crop was harvested fresh manually after maturity.

*f) Analysis of Soil*

Soil samples were randomly taken from the experimental site before planting with the aid of auger, bulked, air dried and ground to pass through a 2mm sieve. Soil analyses were carried out using (Okalebo2002). Soil particle size distribution was determined by hydrometer method using Calgon solution as dispersing agent. Soil pH was determined by using 1:1 soil: water ratio suspension with pH meter. Soil organic carbon was determined by modified wet oxidation method by Wilkey and Black, (1934.) and converted to organic matter by multiplying with 1.724. Total nitrogen was determined by the micro-kjeldahi digestion and distillation method. Available phosphorus was determined by the bray 1 Acid Fluoride Solution. Exchangeable cations were extracted with 1.1 ml Ammonium acetate at pH7.Na and K were measured with flame photometer while Ca and Mg were measured with atomic absorption spectrophotometer. Cation exchangeable capacity was measured by Ammonium acetate technique

*g) Financial Analysis*

The farm budgetary technique (Olukosi, 2006) was used to determine the net farm income for each treatment to allow for selection of the best alternative. The model for estimating farm budgeting is outlined thus;

$$NFI = GI - (TVC+TFC)$$

Where,

NFI is the net farm income

GI = Gross Income (Expected Total Revenue)

TVC= Total Variable Cost

TFC= Total Fixed Cost

Expected Total Revenue =yield in t/ha * price per tonne

One tonne of maize is # 250,000 (market price)

*Total variable cost of production (TVC);* Variable costs incurred were on labour, herbicide, transportation, harvesting, weed management, grinding and fertilizer& fertilizer application and maize seeds.

2 bags of NPK = #15,000

Maize Seeds = 5kg = #6000 /ha

Grinding = #3,000

Total Transportation=#18,000

For each of the other operations, labour cost = #15,000/3$m^2$ *1,000 $m^2$

Note;-1 US$ = #500

*Total fixed cost (TFC);* Depreciation on land and equipment, expenses on land preparation (clearing, ploughing and ridging),

To obtain the worth of each of the fixed cost items the straight-line method of depreciation was used.

The formula for depreciation using straight line method is given as;

Depreciation = Purchase/No of Useful Years of the Asset

*h) Data Analysis*

All data collected were subjected to analysis of variance and correlation analysis. Significant mean values were separated with Duncan's Multiple Range Test. All data were analyzed using SAS program.

*i) Procedure for data recording*

Collection of data commenced from 2weeks and followed by4, 6 and 8 weeks after planting (WAP) after when fresh maize was harvested. To record plant height of maize, ten plants were randomly selected from each plot and measured from the ground level to the tip of the plant. Average Number of Leaves and proportion of plants were physically counted and recorded. The yield was determined by measuring cob weight and dry grain weight of 100 grains. Cost of materials used and price of maize were determined through reigning market prices. The US$ equivalent was obtained using official exchange of US$1 to N500 (as at December 2021)

## V. Results and Discussion

*a) Soil Analysis*

*Table 1:* Physical and chemical properties of the experimental soil

| Physical properties | Soil test value |
|---|---|
| pH ($H_2O$) | 6.8 |
| Sand | 82.4 |
| Silt | 6.4 |
| Clay | 11.2 |
| Textural class | Sandy loam |
| Chemical properties: Exchangeable Bases (cmol/kg) | |
| Ca | 1.65 |
| Mg | 1.02 |
| K | 0.3 |
| Na | 0.57 |
| ECEC | 3.59 |
| Base saturation (%) | 98.61 |
| Total N (%) | 0.08 |
| Total Organic C(%) | 0.66 |
| Available P(mg/kg) | 33.13 |
| Micro nutrients (mg/kg) | |
| Mn | 32.33 |
| Fe | 8.5 |
| Cu | 0.55 |
| Zn | 0.78 |

*Source; field survey 2020*

Maize is an exhaustive crop, demanding nutrients at all stages of its growth. Among the most essential nutrients required by maize crop for healthy growth and high yield are; nitrogen (N), phosphorus (P) and potassium (K). N plays a vital role in overall production (Abbas et al., 2016) as it is linked with dark green color of vegetative parts, branching and leaf production. P is considered to be the second important nutrient, as it influences the growth and yield related traits of plants that are ultimately allotted to the embryo to improve seed vigor (Seyyedi et al., 2015). K plays an important role in persistently keeping the plants standing during strong winds and its deficiency or inadequate supply always result into stunted growth and reduced yield (Wikkipaedia, 2018). However, most Nigerian soils including the experimental site are deficient in NPK nutrients (Olowoake et al., 2015), these nutrients therefore need to be supplied. The finding implies that maize crop will respond positively to nutrient treatment.

*b) Analysis of Moringa leaves, Banana peels and Maize stalks*

The different treatments in the study involves the use of, Moringa oleifera leaves (MO), Banana Peels (BP) and Maize Stalks (MS) and these are shown in Table 2 to possess nutrients (NPK) beyond the critical requirement for maize good performance (Ayodele and Omotosho 2008)

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*Table 2:* Proximate analysis of Moringa leaves, Banana peels and Maize stalks

| Mineral content | N | P | K |
|---|---|---|---|
| Moringa leaves | 2.56 | 0.10 | 1.93 |
| Banana peels | 1.736 | 0.09 | 7.61 |
| Maize stalks | 1.256 | 0.05 | 0.99 |
| Maize stalks after fermentation | ND | 3.75 | 10.232 |

*Source; field survey 2020, ND; not determined*

c) *Number of maize leaves*

i. *Number of leaves of Maize plant as influenced by fertilizer types in 2020 cropping season*

Table3 revealed that nutrient application resulted into production of varying number of leaves which are the precursors of grain yield. The finding implies that grain yield and subsequently farmers income can be improved through the application of nutrients in the study area. Among the experimental treatments both on the field and screen house, more number of leaves per plant were recorded under the control treated with 90kg NPK fertilizer but closely followed by treatment B=120N+50P + 40K, followed by treatment A=100N+40P+30K while treatment C=70N+30P+20K had the least number of leaves per plant. Although, the control treated with 90kg NPK fertilizer produced a greater number of leaves it was discovered that there were no significant differences between the number of leaves on the NPK treatment and A&B treatments for each mode of application.

ii. *Comparison of number of leaves under different methods of fertilizer application and site of the experiment in 2020 cropping season*

Tables 3&4 showed the number of leaves under different methods of fertilizer application and site of the experiment (i.e., solid vs foliar and field vs screen+) in 2020 cropping season. The analysis revealed that the number of leaves per plant differed significantly ($P < 0.05$) among the different modes of fertilizer application and the site of the experiment. The number of leaves was higher on the plots treated with solid fertilizer applied one week before planting than foliar application 2 and6 weeks after planting both on the field and in the screen house. This result is similar to Dahiru et al., (2016) in his study on crop growth and mode of nutrients application reported that incorporated fertilizer a week before sowing had superior performance with regards to vegetative traits compare to foliar spray on maize. The significance difference between the two modes of nutrient application was explained by Machado et al., (2011) also had similar finding in their study and explained that organic fertilizer release nutrients slowly and the nutrient might have been washed off by rain even before the nutrients are released and absorbed by plants.

*Table 3:* Number of leaves of Maize/ plant under different treatment, mode of nutrient application and site of the experiment (Field)

| Mode of Nutrient Application/site | Solid on field | | | | Spray on field | | | |
|---|---|---|---|---|---|---|---|---|
| Mean no of leaves in WAP per Treatment | A | B | C | D | A | B | C | D |
| NOL 2 | 7.2a | 7.3a | 7.3a | 7.5a | 5.50b | 5.60b | 4.98b-e | 6.90a |
| NOL 4 | 14.60a | 14.80a | 14.6a | 15.0b | 11.20b | 11.60b | 9.92b-e | 13.80a |
| NOLL6 | 23.50a | 23.80a | 23.12a | 23.75a | 17.73b | 17.62b | 15.71b-e | 21.85c-e |
| NOL 8 | 24.33a | 24.33a | 24.33a | 25.00a | 18.67b | 18.33b | 16.53b-e | 23.00a |

*Source; Field analysis, 2020*

Mean having the same letter across the rows indicate no significant difference using Duncan's multiple range tests at 5% probability level. Treatments are; A= 100N+40P+30K; B= 120N+50P+40K; C=70N+30P+20K; D=90kg NPK. WAP = weeks after planting

*Table 4:* Number of leaves of Maize/ plant under different treatment, mode of nutrient application and site of the experiment (Screen)

| Mode of fertilizer Application | Fertilizer solid in screen house | | | | Fertilizer spray screen house | | | |
|---|---|---|---|---|---|---|---|---|
| Mean No of leaves in WAP Treatment | A | B | C | D | A | B | C | D |
| NOL2 | 5.87a | 5.98a | 5.97a | 6.30a | 4.46d | 3.58b | 4.26b | 5.87a |
| NOL4 | 11.70a | 11.80a | 11.97a | 12.30a | 8.82b | 6.49d | 7.66b-d | 10.98a |
| NOL6 | 19.68a | 19.81a | 19.88a | 20.43a | 15.25b | 11.71e | 13.51b-e | 18.79a |
| NOL8 | 21.60a | 21.90a | 21.90a | 22.50a | 16.80b | 12.90e | 14.88b-e | 20.70a |

*Source; Field analysis, 2020*

Mean having the same letter across the rows indicate no significant difference using Duncan's multiple range tests at 5% probability level. Treatments are; A= 100N+40P+30K; B= 120N+50P+40K; C=70N+30P+20K; D=90kg NPK. WAP = weeks after planting

*d) Maize Plant Height*

i. *Maize plant height as influenced by nutrient levels*

In the study, maize plant height was significantly influenced by the variation in the level of nutrients and mode of fertilizer application (Table 4). The height of the maize plants under each treatment ranged in the following order; 120N+50P+40K>100N+40P+30K 90kg NPK > 70N+30P+20K with C= 70n+30p+20k having the least height. This finding is synonymous with karasus, 2012 who discovered that vegetative growth increased with increased nutrient application.

ii. *Maize plant height as influenced by mode of nutrient application*

The plants treated with solid fertilizer incorporated in the soil one week before planting appeared taller than the plants treated with foliar application both on the field and in the screen house. However, the plants on the field have more luxuriant growth than those in the screen house. The height of the maize plants under inorganic fertilizer NPK 15-15-15 were the tallest, but as in the case of number of leaves (Table 3) there were no significant differences in the maize height under 120N+50P+40K &100N+40P+30K treatments.

*Table 5:* Maize plant height (cm) as influenced by fertilizer types and mode of fertilizer application on the field in 2020 cropping seasons

| Mode of fertilizer Application | Fertilizer solid on field | | | | Fertilizer spray on field | | | |
|---|---|---|---|---|---|---|---|---|
| Mean Plant height/Treat ment | A | B | C | D | A | B | C | D |
| PLTH2 | 19,83ab | 19.90ab | 16.30c | 19.70ab | 17.20a | 14.43ab | 15.73ab | 13.83ab |
| PLTH4 | 49.58ab | 49.70a | 40.75c | 49.25ab | 43.00a | 36.08ab | 39.33ab | 34.58ab |
| PLTH6 | 119.60ab | 119.80a | 97.80c | 118.20ab | 103.20a | 86.60ab | 94.40ab | 83.00ab |
| PLTH8 | 198.33ab | 198433a | 163.00c | 197.00ab | 172.00a | 144.33a | 157.33ab | 1386.33ab |

*Source; Field analysis, 2020*

Mean having the same letter across the rows indicate no significant difference using Duncan's multiple range tests at 5% probability level. Treatments are; A= 100N+40P+30K; B= 120N+50P+40K; C=70N+30P+20K; D=90kg NPK. WAP = weeks after planting

*Table 6:* Maize plant height (cm) as influenced by fertilizer types and mode of fertilizer application in the screen house in 2020 cropping seasons

| Mode of fertilizer Application | Fertilizer solid in screen | | | | Fertilizer spray in screen | | | |
|---|---|---|---|---|---|---|---|---|
| Mean Plant height WAP/ Treatment | A | B | C | D | A | B | C | D |
| PLTH2 | 15.70ab | 15.90a | 12.51ed | 15.63a | 13.20a | 11.48ab | 12.32a | 10.59ab |
| PLTH4 | 38.37ab | 38.63ab | 31.47c-g | 37.00a-e | 33.07a | 28.00ab | 30.00ab | 26.00ab |
| PLTH6 | 84.57a-g | 84.67ab | 70.77d | 88.42a | 76.82a | 61.33a-c | 67.33a-c | 58.12bc |
| PLTH8 | 155.27a | 155.33a | 128.40d-e | 145.00a-c | 133.67a | 114.33ab | 123.00ab | 108.80ab |

*Source; Field analysis, 2020*

Mean having the same letter across the rows indicate no significant difference using Duncan's multiple range tests at 5% probability level. Treatments are; A= 100N+40P+30K; B= 120N+50P+40K; C=70N+30P+20K; D=90kg NPK. WAP = weeks after planting, PLTH =plant height

*e) Maize Grain Yield*

i. *Grain yield on the basis of different nutrients levels*

Table 7 shows that after the control of 90kg inorganic fertilizer, treatment B =120N+50P+40K produced the highest total grain yield (4.76 t/ha and2.81 t/ha) on the field and screen house respectively, this was followed closely by treatment A = 100N+40P+30K with (4.50 t/ha on field and 2.67 t/ha screen house) while treatment C= 70N+30P+20K had the least yield (4.43t/ha on field and 2.72t/ha) in screen house). This finding shows that vegetative growth and grain yield in maize increase with increased nutrient application (karasus, 2012)

ii. *Grain yield on the basis of mode of fertilizer application*

Table 7 also shows that, the maize grain yield differed significantly ($P < 0.05$) among the different modes of fertilizer application. The maize grain yields under fertilizer solid on the field and in the screen, were significantly higher than the maize grain yields under fertilizer spray on both sites. This finding agrees with Machado et al., (2011) who explained that since organic fertilizer releases nutrients slowly, its application as spray, might encourage washing off by rain even before the nutrients are released and absorbed by plants.

iii. *Differences in yield of field and screen*

Comparatively, the maize grain yields under fertilizer solid and fertilizer spray in the screen are significantly($p<0.05$)lower than the yields from the field(Table 5).The implication is that foliar application of organic fertilizer had no influence on yield of maize. Incorporated fertilizer applied a week before sowing had superior performance on maize grain yield. Reason for this could be because of the serious lodging that occurred on the different treatment pots in the screen house. Serious lodging according to Symons et al., (2008) and Bänziger et al., (2006) occurs as a result of etiolation (weak stems) of the maize stands due to water stress or abiotic stress such as Nitrogen. When this happens, maize cobs are rendered susceptible to rodent attack and decay which could reduce grain yield. (Ajala et al., 2018), Xu et al. (2017) and Bänziger et al. (2006)also reported reduced yield in the screen house compared to the open field.

*Table 7:* Maize grain yield (T/Ha) under different treatments and modes of fertilizer application on the field and in the screen house

| Mode of fertilizer Application | Fertilizer solid on field | | | | Fertilizer spray on field | | | |
|---|---|---|---|---|---|---|---|---|
| Mean yield (t/ha)per Treatment | A | B | C | D | A | B | C | D |
| Field | 4.5 de | 4.76 bc | 4.43 def | 4.87 ab | 2.67efg | 2.81 ef | 2.72 efg | 3.33 b |
| Screen House | 1.92bc | 1.94bc | 1.86bc | 2.1ab | 1.43f-h | 1.49f-g | 1.45f-h | 2.1ab |

*Source; Field survey 2020*

i. *Differences in yields of control and experimental treatments*

Quantitatively, the control- inorganic NPK fertilizer produced higher yield than each of the three organic fertilizer treatments both as solid or spray, on the field or in the screen house. However, statistically, there was no significant difference between grain yield produced from the recommended 90kg/ha NPK inorganic fertilizer and the 120N+50P+40K organic fertilizer when applied under solid mode on the field. The finding implies that the organic fertilizer applied at the rate of 120N+50P+40K competes very well with NPK 15-15-15 and may be used in place of the inorganic fertilizer and still get about the same quantity of output.

*f) Economic Performance of Maize*

*Table 8:* Economic performance of maize using different Treatments under solid and spray on the Field

| Economic performance Indicators | Yield (T/ha) | Revenue/ maize treatment ₦/ha | Total Variable cost (₦/ha) | Total Fixed cost (₦/ha) | Total cost (₦/ha) | Net farm income₦/ha | Rev/cost ratio |
|---|---|---|---|---|---|---|---|
| Treatment under Solid on field | | | | | | | |
| A | 4.5de | 1,570,000 | 18,500 | 8,000 | 26,500 | 1,543,500 | 59:1 |
| B | 4.76bc | 1,760,000 | 18,500 | 8,000 | 26,500 | 1,733,500 | 66:1 |
| C | 4.43def | 1,502,000 | 18,500 | 8,000 | 26,500 | 1,475,500 | 56:1 |
| D | 4.77ab | 1,870,000 | 200,000 | 8,000 | 208,000 | 1,662, 000 | 9:1 |

i. *Economic performance of maize using different Treatments under solid and spray on the Field*

There were variations in the economic performance among the different treatments using solid or foliar fertilizer application on the field. Tables 8 & 9 show that treatments under solid fertilizer application performed better than those under foliar application. The following Net Farm Income were obtained for treatments under solid application; A = 100N+40P+30K = #1,543,500 ($3,087), B =120N+50P+40K = # 1,733, 500 ($3,467), C= 70N+30P+20K = # 1,475,500 ($2,951) and D=NPK 15-15-15= #1,662, 000 ($3,324). However, under foliar application on the field the Net Farm Incomes are; A = 100N+40P+30K = #641,000 ($1,282), B = 120N+50P+40K = # 676,000 ($1,352), This result shows that treatment B = 120N+50P+40K = # 1,733,500 which gave the highest net income has the highest economic value especially when incorporated as solid fertilizer one week before planting. The reason for poor economic performance of the different combinations of moringa technology under screen house may have been as deduced by Machado et al., (2011) that organic fertilizer releases nutrients slowly, its application as spray, might encourage washing off by rain even before the plants absorbed the nutrients.

*Table 9:* Economic performance of maize under different treatments using spray on the Field

| Economic performance Indicators | Yield (T/ha) | Revenue/ maize treatment ₦/ha | Total Variable cost (₦/ha) | Total Fixed cost (₦/ha) | Total cost (₦/ha) | Net farm income₦/ha | Rev/cost ratio |
|---|---|---|---|---|---|---|---|
| Treatment | | | | | | | |
| A | 2.67efg | 667,500 | 18,500 | 8,000 | 26,500 | 641,000 | 25:1 |
| B | 2.81ef | 702,500 | 18,500 | 8,000 | 26,500 | 676,000 | 26:1 |
| C | 2.72efg | 680,000 | 18,500 | 8,000 | 26,500 | 653,500 | 25:1 |
| D | 3.33 | 832, 500 | 200,000 | 8,000 | 208,000 | 632,500 | 4:1 |

ii. *Economic Performance of Maize Under Fertilizer Solid and Foliar in the Screen House*

Economic performance of maize under fertilizer application as solid or as spray in the screen house are significantly ($p<0.05$) lower than the performance on the field(Tables 8&9).This finding followed the same pattern as previously discussed under differences in the growth traits and yields between the plants on the field and those in the screen house. Reason for this could be explained by the fact that there was too much lodging of maize plants in the screen house. This led to maize cobs decay which reduced the total yield. Since yield determines sales, it implies that revenue will be low when yield is low and so will be net income.

*Table 8:* Economic performance of maize under different Treatments (Screen House)

| Economic performance | Yield (T/ha) | Revenue/ maize treatment ₦ | Total Variable cost (₦) | Total Fixed cost (₦) | Total cost (₦) | Net farm income₦ | Rev/cost Ratio |
|---|---|---|---|---|---|---|---|
| Treatment: Solid screen house | | | | | | | |
| A | 1.92be | 480,000 | 18,500 | 8,000 | 26,500 | 453,500 | 18:1 |
| B | 1.94bc | 485 ,000 | 18,500 | 8,000 | 26,500 | 458,500 | 18:1 |
| C | 1.86bc | 465,000 | 18,500 | 8,000 | 26,500 | 438,500 | 17:1 |
| D | 2.12a | 525,000 | 200,000 | 8,000 | 208,000 | 317,000 | 3:1 |
| Treatments: Spray screen house | | | | | | | |
| A | 1.43f-h | 357,500 | 18,500 | 8,000 | 26,500 | 331,000 | 13:1 |
| B | 1.49fg | 372,500 | 18,500 | 8,000 | 26,500 | 346,000 | 14:1 |
| C | 1.45fh | 362,500 | 18,500 | 8,000 | 26,500 | 336,000 | 13:1 |
| D | 2.1ab | 525,000 | 200,000 | 8,000 | 208,000 | 317,000 | 3:1 |

*Field analysis, 2020*

iii. *Economic performance of maize under Organic and inorganic fertilizers using solid approach on the field*

Table 8 shows variations in the economic performances of maize under organic and inorganic fertilizers applied as solid on the field. The performance followed the earlier discussions on maize yield and other agronomic traits except that the control (D= the inorganic fertilizer) with the highest yield gave way to treatment B =120N+50P+40K in terms of economic performance. Treatment B had the highest net income because of its low cost. The net income from treatment B =120N+50P+40K stood at N 1,733,500 per hectare while that of control with the recommended dose 90kg/ha of NPK 15-15-15 was N1,662,000 per hectare Although there was no significant difference ($p<0.05$) between the two. The implication of this outcome is that Moringa /banana / maize mixture (organic fertilizer) at the rate of 120N+50P+40K competes well with inorganic fertilizer and can replace it use conveniently. Also, that the adoption and use of this organic mixture at the recommended rate of 120N+50P+40K will facilitate sustainable income of maize farmers.

## VI. Summary

The study was carried out to investigate the possibility of optimizing maize crop production in Africain order to maximize net farm income of rural farmers using moringa leaves/bananapeels/maize stalk technology. Also, to specifically investigate the effect of different rate of combining the mixtures (treatments) on the growth, yield and net returns of maize with a view of choosing appropriate combination that will maximize net farm income. And to also compare the yield and economic performance of maize on the field and screen house. Four treatments were considered and each represented a technology on field/screen trials conducted in 2021. These include; A=100N+40P+30K, B= 120N+50P+40K, C= 70N+30P+20K and the control using the national recommended dose of 90kg/ha of NPK fertilizer. Results of the study showed that:

1. Application of organic fertilizer in solid form incorporated into the soil a week before planting produced the highest number of leaves, tallest plants, and heaviest cobs on both the field and screen house experiments. The observed variations across the treatments follow the order of 90kg NPK >120N+50P+40K > 100N+40P+30K while 70N+30P+20K was always having the least.
2. Economic performance of the treatments under solid fertilizer application were better than those under foliar application.
3. Economic performance of maize under the or application as solid or as spray in the screen house are significantly ($p<0.05$) lower than the performance on the field
4. The result of the study showed variation in the economic performances of maize under organic and inorganic fertilizers applied as solid on the field. The inorganic fertilizer applied at the national recommended dose of 90kg/ha NPK had excellent performance in all the agronomic traits (highest number of leaves, tallest plants biggest grain yield) but failed in the area of net farm income. Treatment B = 120N+50P+40K had the highest net farm income of. # 1,733,500 ($3,352) while inorganic fertilizer had N1,662,000 ($3,324) both per hectare respectively.

## VII. Conclusion and Recommendation

The outcome of the study revealed that; Moringa-banana peel-maize stalk fertilizer incorporated in the soil in solid form, a week before planting at the rate of 120N+50P+40K on the open field provided sustainable, eco-friendly, and cost-effective alternative to inorganic NPK fertilizer at national recommended rate. On the basis of these findings the use of moringa based fertilizer: MO+MS+BL at the rate of 120N+50P+40K was judged more economical in the study area and was recommended for adoption by maize farmers

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# A Liana-Like Formation of a Grape Plant

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*Abstract-* The article analyzes the main disadvantages of traditional short-trunk formations of grape plants. Strong negative biological consequences of such formations for grapes are noted and a new innovative approach to this question is proposed.

*Keywords:* *grapes, bush, shaping system, bush management system, biological efficiency.*

*GJSFR-D Classification:* *DDC Code: 791.4372 LCC Code: PN1995.9.F35*

ALIANALIKEFORMATIONOFAGRAPEPLANT

*Strictly as per the compliance and regulations of:*

# A Liana-Like Formation of a Grape Plant

A Yu Vaulin

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## I. Introduction

The technology of growing of any cultivated crop, including grapes, should take into account biological regularities in complex and multifaceted processes of their growth and development as much as possible. Technological methods must help plants to optimize the conditions of their passage, and only then the technology will give the maximum economic effect. Unfortunately, under the oppression of centuries-old stereotypes, we do not always do so. A striking example of this is the traditional shaping of grape plants.

Shape of bushes and ways of their management are the strongest tools in control of productive process of grape plants [1, p.148]. Of course, various shaping forms, taking into account varietal peculiarities, specificity of the plot, and cultivation technology, have been developed and applied in each region [2, p. 30, 3, p. 134, 4, p. 28], but as is known, nothing is perfect. Therefore, at present, an active search of approaches to improve and optimize the existing and develop new systems of vine bush formation and management is going on.

Of course, new systems of formation and management of grape bushes should contribute to a greater extent to the realization of the biological potential of the grape plant. And in our opinion in this direction there are great reserves not used by us yet.

## II. Research Objective

All existing traditional industrial formations have conceptually wrong prioritization of problems to be solved in the process of formation and maintenance of grape bushes. In the first place is the habitus of the plant, although it seems logically correct at first glance, because we need compact plants for large-scale cultivation on large areas, which can fit on trellises no higher than 2-2.5 meters to facilitate the care of plantations. But as we remember in the classification by life forms, grapes belong to the group of woody lianas, which in natural conditions have the habitus of plants of tens of meters. But in all the traditional formation, by very strong pruning, we turn grapes into a two-meter bush, which obviously cannot but have serious biological consequences. It is well known that the growth and development of the above-ground part of any plant, including grapes, is closely correlated with similar processes in the root system. When the above-ground habitus of a grape bush intensively grows during the vegetation period, it is necessarily accompanied by an increase in the habitus and root system. As a result, nutrients are naturally accumulated and conserved in a large root system in autumn for the beginning of growth and development of several hundreds of buds. But as a result of traditional strong autumn pruning, at best a few dozen buds remain on the above-ground part of the bush, i.e. growth points capable of consuming the nutrients stored in the roots are reduced at least tenfold. But even I.V. Michurin noted in his works [5, p.110] that it was absolutely inadmissible to strongly reduce the habit of above-ground parts of a plant at once (in case of grafting a mature tree in one spring, he recommended to extend this procedure for 3-4 years). He believed that in spring all the nutrients in roots are discounted and directed to the buds on the above-ground parts of the plant. f there are too few of these points, some of the carbohydrates that are not demanded by consumers are digested in the tissues of the roots, causing them to die off.

It turns out that the grape bush after a very strong pruning of traditional formations tries to eliminate the strong difference between the volume of roots and the above-ground part by more intensive growth of the remaining buds in spring. But biological buffering in this case is clearly not enough, and a significant part of the root system dies in the spring from self-deprecation. And in summer the grape plant is forced to direct a significant part of newly created plastic substances not to the growth of above-ground parts and the formation of yield, which is so necessary for it especially in the short summer of the northern regions of its cultivation, but to restore the dead part of the root system.

The second conceptual disadvantage of traditional shaping is also related to very heavy pruning and is obvious to everyone. The process of annual removal of the fruit arrow on the sleeve is not possible without inflicting very large wounds. Even if this is done correctly on one side, in 5-10 years almost all the conductive bundles will die off on this side of the sleeve, and it can only work half-heartedly and needs to be replaced. And we by our wrong actions again force the

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grape plant to make unproductive expenditures, created by them plastic substances and let them not for the formation of the harvest, but for the renewal of the sleeves.

From the above even a brief analysis, it is clear that the approach to vine plant formation in traditional formations from a biological point of view is far from ideal and requires a deep rethinking.

## III. Consideration of Options for Solving the Problem

The result of rethinking of abovementioned problem was conceptually new approach to vine plant formation. The essence of this approach is as follows - if in nature grapes are multimeter liana, then let it remain, fully realizing its biological potential, and by shaping measures we should make it technological in care and harvesting.

This approach was implemented in a new innovative shaping called "Liana-like method of shaping grapes". For this method a patent under number 2535734 registered in the State Register of Inventions of the Russian Federation on October 16, 2014 [6].

The method is carried out as follows. At the first stage, during 3 years after planting, initially two non-branching shoots are formed on the grape plant (figure 1).

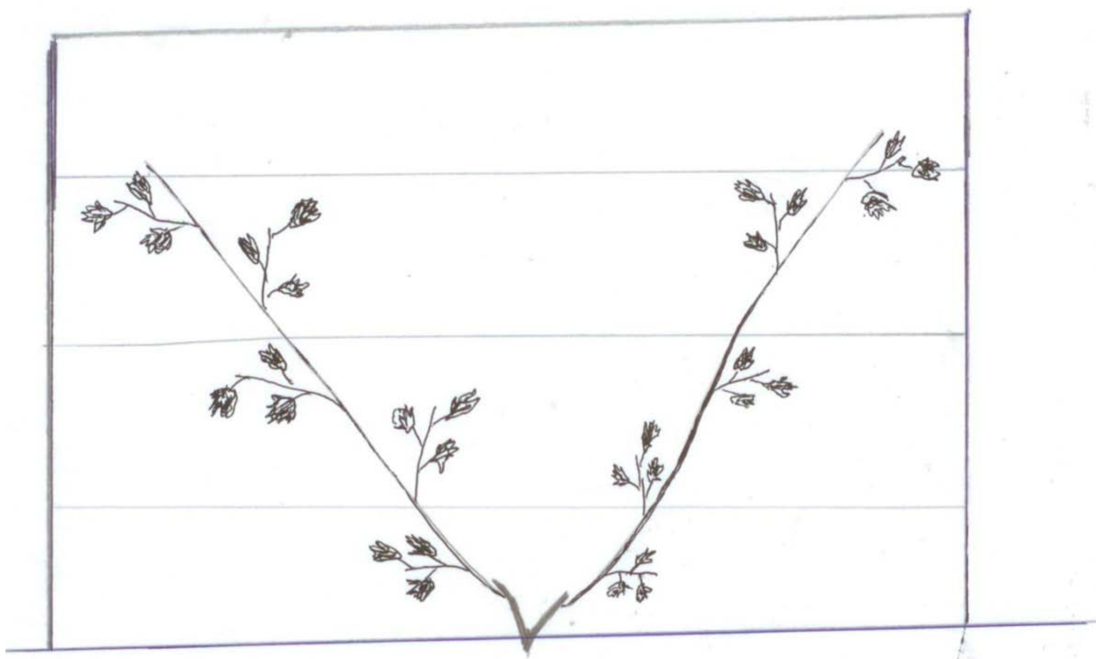

*Figure 1:* First stage of sleeve formation

For this purpose, growth of all stems on current year shoots is strongly limited (no more than 3 leaves), and development of shoots on perennial wood is not allowed at all. Steps on shoots of the current year, up to half of its length, are removed in late autumn. The remaining stepchildren in the following spring and in June are subjected to strong growth-limiting formation, and as the habitus of the next year's growth increases, they are to be gradually removed. By early July, all stems on the previous year's growth should be completely removed.

From the 4th year, the second stage of formation of vines-like sleeves begins (Figure 2). For this purpose, four zones are distinguished and formed on each arm. The lower perennial part of the arm (older than one year) is called the first zone or reserve zone. Its habit increases every year, which ensures the growth of biomass of above-ground and regular underground parts of the grape plant, which allows to form a powerful plant with much higher productive potential than in traditional formations.

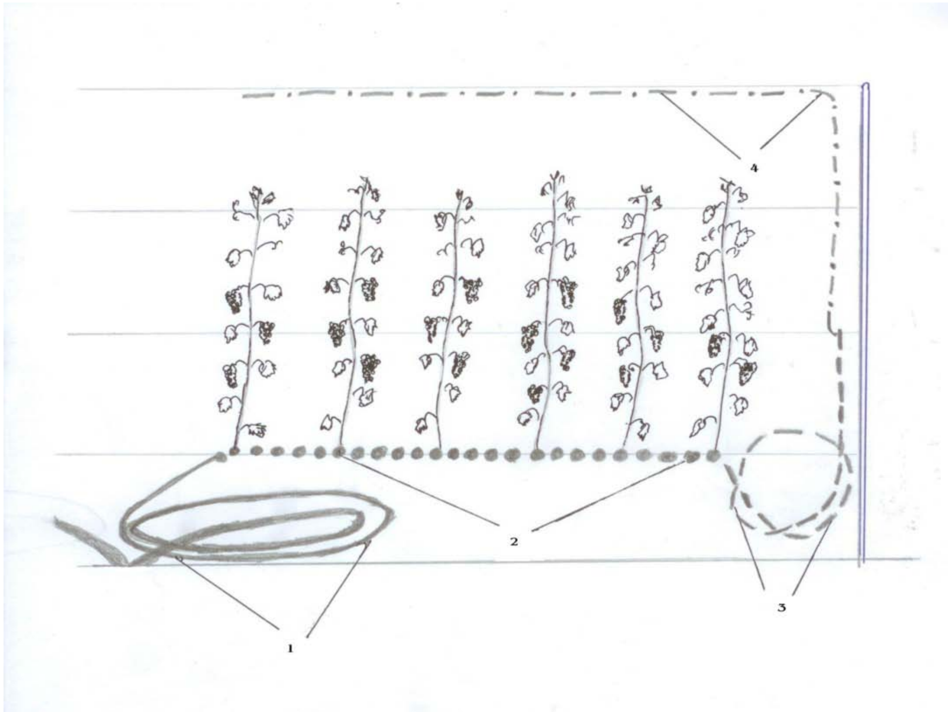


*Figure 2:* The second stage of formation of sleeves

No shoots are allowed to develop in the reserve zone, except if it is necessary to restore the annual vine in case of its damage or death. The excess length of perennial wood in the reserve zone can be used to move the second zone on the sleeve (fruiting zone) at any distance from the place of planting, which allows this method to grow grapes on the roof, pergola, balcony of a high-rise house and other places inaccessible to conventional formation. This is a very important advantage of the method, because thanks to him on a garden plot you can grow dozens of varieties and get hundreds of kilograms of grapes almost without taking up space, so necessary for other crops. If this is not necessary (in commercial cultivation on a trellis), the excess of the reserve zone is rolled up into rings and placed at the base of the bush. The diameter of the rings and the number of turns in the reserve spiral are chosen depending on the total length of the reserve zone at this time, so that the base of one-year growth is at the beginning of the left or right parts of the arms development at the height of the first trellis wire.

From the base of the one-year shoot on the sleeve and up to about half of its length, the second zone or fruiting zone is distinguished. This part of the annual shoot is tied strictly horizontally to the first wire of the trellis. Its size regulates the load on the sleeve. Formation of fruiting shoots in this zone is carried out according to the technology of traditional formations, regulating their habitus and rationing, if necessary, the amount of yield on each shoot.

Up to 6 years of age, removal of fruit-bearing shoots from the second zone (fruiting) is carried out in stages, half in autumn, and the other half after limiting formation in early next summer and gradually, as shoots grow back in the fruiting and growth zones of the next year. Starting from the 7th year after planting, it is possible to remove all fruit-bearing shoots in the fruiting zone from autumn. This becomes possible because the sleeve becomes long enough, and the removed shoots will no longer constitute such a significant part of the above-ground crown already present in the grape plant, and therefore there will be no depression of its root system next spring.

Further, on the one-year shoot, the third zone or stimulation zone is distinguished on its second half. All appearing shoots are to be removed on it. It is started after completion of weeping (shoots of this zone allow to fulfill its first task at the beginning of vegetation - to increase the number of sugar consumption points from roots, and after passing the critical period for the root system, they should be removed). Regular and complete removal of shoots allows to successfully solve the second task of this zone - to create a large stock of plastic substances, for very intensive development of the latter on the sleeve - the growth zone. The shoot length of the stimulation zone is used to transfer the position of the vine from horizontal to vertical, but slightly away from the place of development of fruiting shoots. If length allows, it is better to curl the shoot of this zone in a ring.

And the last one on the annual vine is the fourth zone or growth zone. At the beginning of the period, it is only one well-developed terminal shoot of our sleeve continuation. Because of good nutrition, due to

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stimulation zone and vertical position, the continuation shoot has prevailing growth processes. For better bud formation on this shoot, the stems should not be removed completely, but rather they should be pruned behind the 5th-6th leaf. In the case of the stems appearing on them, pruning should be carried out after 2-3 leaves. After the continuation shoot reaches the top of the trellis, it begins to be led along the top wire of the trellis into the inner part of the bush above the pruned fruiting shoots. Horizontal position of the end part of an annual shoot in the second half of the growing season restrains the growth processes and contributes to better maturation of its wood. To stimulate this process even more a month before the end of vegetation, remove the growth point on this shoot. When pruning in autumn, all the stems on the growth shoot must be completely removed.

From the given description of formation of a sleeve of a new type, it is clear that the function of a fruit link on it performs its one-year growth the first half of it is a fruit arrow, and its second half, respectively, is a replacement twig.

The proposed formation is unusually simple and clear. Elimination in it of sharp fluctuations of volumes of above-ground part of a grape plant allows reducing oppression of its root system by pruning measures and considerably optimizes the use of plastic substances created by it.

Since in the new formation only single and small shoots are removed, the wounds from them remain small in size, they are not concentrated in one place and therefore do not have a significant impact on the conductive ability of sleeves, which allows several times longer productive life.

The new formation strongly stimulates the underground stem of the vine bush to awaken buds and emergence of new shoots from which additional arms are formed as the strength of the bush grows. Their number when placed on the permanent V-shaped trellis that we developed can reach 12 when growing commercially. In this case, the grape plant will need 6 meters of space in a row for their normal growth and development. Accordingly, the use of liana-like formation with such a number of sleeves in the bush allows several times to reduce the cost of planting material in the establishment of new industrial plantations, and without losing the level of yields. Special interchangeable trellises, allow to significantly reduce labor costs for the care of young vine plantation due to the possibility of mechanized inter-row treatment in two directions.

In addition, these trellises provide protection of grape plants from winter frosts without the use of soil, using modern non-woven materials (winter protection for roses to cover sleeves, film mix anicondensate 100 to cover the side planes of the lower parts of trellises). The high thermal insulating capacity of these materials and snow quickly, accumulated and retained in the base of trellises successfully solve this problem. In spring, the same materials turn the lower part of trellises into small greenhouses, protecting young shoots on the vine from damage by spring return frosts.

On a V-shaped permanent trellis, a large slope of the planes allows to bring the bunches out of the leaf canopy, which optimizes microclimate in their zone, the lighting regime significantly reduces the amount of manual work on their clarification.

In addition, their use makes it possible to carry out mechanized harvesting, and even table varieties with combines combing type, developed at our university.

The jet-pitch irrigation method, developed and patented in our university, stimulates well the creation of a powerful root system in grape plants [7]. Moreover, even a gravity, mobile variant has been developed, which allows to use the existing canal network in farms for surface irrigation of vine plantations.

It is possible to switch to a new formation in 5-6 years and on existing vine plantations, where traditional formations were previously used. When renewing sleeves from shoots, already liana-like sleeves are formed, according to the above described technology with a gradual replacement of the old sleeves with new ones. It is especially advisable to do this in old thinning plantations, where this method will not make replanting in the places of falling out and will allow to remove some of the sick weakened bushes with low productivity.

## IV. Conclusions

The proposed new method of formation more corresponds to biological features of grapes as a liana plant, and therefore all physiological processes are more successful, which in turn provides the formation of a very resilient, super productive and durable organism, much more resistant to all negative influences of environmental factors. Introduction of new developments of our university in growing grapes: shaping, trellises, irrigation method can allow significantly increasing the yield and quality of products, and repeatedly reducing the costs of planting, care and harvesting of grape plantations.

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# The use of Information and Communication Technologies among Farmers in Ekiti State, Nigeria

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*Summary-* This study evaluated the use of information and communication technologies (ICTs) among arable farmers in Ekiti State, Nigeria. A multi-stage sampling procedure was employed for the selection of 240 respondents in the study area. Collection of primary data from the respondents was through a well-structure interview schedule. Descriptive and inferential statistics were used to analyse data. The result of the findings revealed that more than one-third of the respondents(66.7%) were male. The mean age of the respondents was 47years and had a mean household size of 5 persons. Mostly (95.8%) had formal of education and a mean farming experience of 23 years. Farmers were aware of mobile phone (3.75), radio (3.59), television (3.41), internet (2.59) and video recorder (2.57).The mostly used ICTs tools by the respondents were mobile telephone (3.77), radio (3.57) and television (3.33).Farming experience, household size and level of awareness on ICTs had significant influence on level of usage of ICTs among arable farmers. Limited finance, high cost of ICTs facilities, unstable power supply, limited technical know-how, language illiteracy, inadequate infrastructure and inadequate access to agricultural information were major constraints to the use of ICTs by the farmers. Government should therefore create more awareness to sensitize, provide adequate training on the use of ICTs and incentives to enhance ICTs usage by these farmers for better productivity.

*Keywords: information, communication, technologies, farmers.*

*GJSFR-D Classification: FOR Code: DDC Code: 371.3078 LCC Code: LB1028.3*

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*Strictly as per the compliance and regulations of:*

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*Keywords: information, communication, technologies, farmers.*

## I. Introduction

Agricultural information is crucial to the development of rural populace who are mainly farmers. Information and communication technology (ICT) is crucial in the dissemination of agricultural information to farmers in improving their livelihoods.ICT is an effective solution to problems that militate against the development of agricultural industry, such as weak marketing linkages, poor information management, low productivity, low income and lack of diversity (Ramli et al., 2015).

The ICT devices which are of potential dissemination of agricultural information in farming activities include like radio, television, cellular phones, computers, and networks among others (Pande and Deshmukh, 2015). According to Ramli et al. (2015) stated that the Internet and web-based applications are extensively utilized in spreading of agricultural knowledge, marketing of goods and services. Researchers observed that mass media are utilized to disseminate agricultural technologies to the farmers at rapid rate (Leeuwis and Van den Ban as cited in Hasanet al., 2019)).

Crop production as an important sub-sector in Nigeria agriculture has contributed largely to the development of Nigeria's agricultural sector (Odefadehan et al., 2019). Arable farming as a type of crop production involves the production a wide range of annual crops. Dissemination of useful agricultural information to the farmers will enhance arable crop production. ICT provide recent knowledge and information on agricultural technologies, best practices, markets, price trends, and weather conditions (Yimer, 2015). New approach for improving access to relevant agricultural information could be achieved through the use of information and communication technologies (Olaniyi and Ismaila, 2016). Farmers need information on improved farm inputs, modern farming technologies, and climate changeto enhance food production for ever-increasing population. Important agricultural information such as sowing, improving soils, profit maximization and control pests and diseases will empower the farmer and their decision making capabilities (Lokeswari, 2016).

In recent times, ICTs have gained more recognition in Nigeria as a whole and particularly, Ekiti State. The use of ICTs can be very time-effective in disseminating relevant information to farmers to aid agricultural extension services in Nigeria (Anyoha et al., 2018). However, the potential of these ICT tools is under-utilized especially among the farming households (Olaniyi and Ismaila, 2016). Poorly disseminated information and knowledge as a result of certain constraints may hinder agricultural development of any community (Li, 2013). In Ekiti State, farmers are faced with some constraints which are limiting them in the use of ICTs in order to gain access to relevant information on improved technologies for enhanced productivity and improved income. Therefore, it is of empirical importance to carry out this study on the use of Information and Communication Technologies among arable farmers in Ekiti State. The broad objective of the study was to investigate the use of ICTs among farmers

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in Ekiti State, Nigeria. The specific objectives of the study were to; describe the socio-economic characteristics of arable crop farmers in the study area; determine the farmers' awareness of various ICTs among the respondents in the study area; determine the level of use of ICTs among the respondents in the study area, determine factors influencing the use of ICTs among farmers in the study area; and identify the constraints to the use of ICTs among farmers.

## II. Materials and Method

The study area was Ekiti State. The state is located in the Southwest Nigeria within the tropics. It is predominantly an agrarian state with food crops grown such as cassava, yam, cocoyam, vegetables, and grains such as maize, rice etc. The state has two main seasons i.e. the rainy season and dry season. A multi-stage sampling procedure was employed in the selection of the respondents in the study area. Firstly, four Local Government Areas (LGAs)were randomly selected. The second stage involved selecting three farming communities from each LGAs randomly. Lastly, there was a random selection of ten (10) arable farmers from each of the communities, making a sample size of one hundred and twenty (120) arable farmers. A well-structured interview schedule was employed in the collection of primary data. Descriptive statistics such as mean, frequency counts and percentages were used to analyse objective 1. Likert-type scale was employed to measure objective 2as Very Much Aware (4), Much Aware (3), Aware (2), and Not Aware (1). The mean score of the scaling statement is 2.5. Therefore, any mean score value greater or equal to 2.5 was regarded as Aware while any mean score value less than 2.5 was regarded as Not Aware. Objective 3 was also measured using Likert-type scale as Regularly used (4), Occasionally used (3), Rarely used (2), and Not used (1) with any mean score value greater or equal to 2.5 was regarded as used while any mean score value less than 2.5 was regarded as Not Used. Objective 5 was also measured using Likert-type scale as Very Severe (4), Severe (3), Less Severe (2), and Not Severe (1). The mean score point of the scaling statement was 2.5 and ranked in descending order.

Inferential statistics such as Multiple Regression analysis was used to analyse objective 4.
The model was specified in its explicit form thus;

$$Y = f(b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + e)$$

Y = Use of ICTS by the respondents
$b_o$ = Constant $b_1 - b_6$ = Coefficients of multiple regression
$X_1$ = Age of the respondents (years)
$X_2$ = Farming experience (years)
$X_3$ = Gender (male=1, female= 0)
$X_4$ = Educational level (formal education = 1, no formal education =0)
$X_5$ = Household size (persons)
$X_6$ = Level of awareness of ICTs
e = Error term

## III. Results and Discussion

*a) Socio-economic characteristics of the respondents*

The mean age was 47years. This implies that most of the respondents were in their active age. The result revealed that most of the respondents were males (66.7%), married (73.3%), and had a mean household size of 5 persons. It was also that the respondents mostly (95.8%) had formal education. This could enhance the utilization of ICTs among the farmers. The mean years of experience for the respondents was 23 years and mostly (55.8%) had contact with extension agents.

*Table 1:* Socio-economic characteristics of the respondents

| Socio-economic Variables Age (years) | Frequency | Percentages | Mean |
|---|---|---|---|
| ≤ 30 | 10 | 4.2 | 47 |
| 31 – 40 | 32 | 13.3 | |
| 41 – 50 | 64 | 26.7 | |
| 51 – 60 | 60 | 25.0 | |
| ≥ 61 | 74 | 30.8 | |
| Gender | | | |
| Male | 160 | 66.7 | |
| Female | 80 | 33.3 | |
| Marital Status | | | |
| Single | 12 | 5.0 | |
| Married | 176 | 73.3 | |
| Divorced | 30 | 12.5 | |
| Widowed | 22 | 9.2 | |
| Household size (persons) | | | |
| ≤ 3 | 40 | 16.7 | 5 |
| 4-6 | 142 | 59.2 | |
| 7-9 | 54 | 22.5 | |
| >9 | 4 | 1.7 | |
| Educational level | | | |
| No Formal Education | 30 | 12.5 | |
| Primary Education | 56 | 23.3 | |
| Secondary Education | 70 | 29.2 | |
| Tertiary Education | 84 | 35.0 | |
| Farming Experience (years) | | | |
| ≤ 10 | 18 | 7.5 | 23 |
| 11-20 | 86 | 35.8 | |
| 21-30 | 54 | 22.5 | |
| 31-40 | 52 | 21.7 | |
| ≥ 41 | 30 | 12.5 | |
| Contact with extension agents | | | |
| Contact | 67 | 55.8 | |
| No contact | 53 | 44.2 | |

*Source: Field Survey, 2021*

*b) Level of respondents' awareness of ICTs*

The result revealed that mobile phone has the highest mean score of 3.75 indicating that the arable farmers are aware of mobile phone. Radio had a mean score of 3.59, followed by Television (3.41), Internet (2.59) and Video recorder (2.57) which implies that the respondents were aware of the radio, television, internet and video recorder as an ICT tools respectively with a grand mean of 2.75. This finding agrees with the findings of Nnenna (2013) that the farmers were aware of phone, radio and television.

*Table 2:* Level of respondents' awareness of ICTs

| ICTs | Very much aware | Much aware | Aware | Not aware | Mean |
|---|---|---|---|---|---|
| Mobile Telephone | 206(85.8) | 20(8.3) | 4(1.7) | 10(4.2) | 3.75 |
| Radio | 168(70.0) | 52(21.7) | 14(5.8) | 6(2.5) | 3.59 |
| Television | 130(54.2) | 84(25.0) | 20(8.3) | 6(2.5) | 3.41 |
| Video recorder | 22(9.2) | 110(45.8) | 92(38.3) | 16(6.7) | 2.57 |
| Projector | 18(7.5) | 82(34.2) | 78(32.5) | 62(25.8) | 2.23 |
| Telegram | 12(5.0) | 52(21.7) | 80(33.3) | 96(40.0) | 1.91 |
| Computer | 40(16.7) | 58(24.2) | 78(32.5) | 64(26.7) | 2.31 |
| Internet | 42(17.5) | 90(37.5) | 76(31.7) | 32(13.3) | 2.59 |
| Print media | 38(15.8) | 66(27.5) | 86(35.8) | 50(20.8) | 2.36 |

*Percentages are in parenthesis*
*Grand mean = 2.75*
*Source: Field Survey, 2021*

*c) Level of usage of ICTs by the respondents*

The result presented in Table 3.3 indicated that the farmers had level of usage of mobile phone (3.77), radio (3.57), television(3.33) implying that mobile phone, radio and television are highly used by arable farmers in the study area. This finding corroborates the finding Olaniyi and Ismaila, 2016 who reported that the most available ICT tools for accessing information by farmers were cell phone, radio and television. The result further agrees with Nnenna (2013) who found that the most readily available ICT facilities owned, accessed and utilised by most farmers were radio, television and phones were. In addition, this finding is in line with Anyoha *et al.,* (2018) who reported that mobile phone is the most readily available (ICT) device and this is followed by radio.

*Table 3:* Level of usage of ICTs by the respondents

| ICTs | Regularly used | Occasionally used | Rarely used | Not used | Mean |
|---|---|---|---|---|---|
| Mobile Telephone | 202(84.2) | 22(9.2) | 14(5.8) | 2(0.8) | 3.77 |
| Radio | 160(66.7) | 58(24.2) | 20(8.3) | 2(0.8) | 3.57 |
| Television | 124(51.7) | 80(33.3) | 28(11.7) | 8(3.3) | 3.33 |
| Video recorder | 22(9.2) | 76(31.7) | 108(45.0) | 34(14.2) | 2.35 |
| Projector | 10(4.2) | 50(20.8) | 68(28.3) | 112(46.7) | 1.82 |
| Telegram | 14(5.8) | 40(16.7) | 66(27.5) | 120(50.0) | 1.78 |
| Computer | 36(15.0) | 52(21.7) | 82(34.2) | 70(29.2) | 2.25 |
| Internet | 36(15.0) | 74(30.8) | 90(37.5) | 40(16.7) | 2.44 |
| Print media | 34(14.2) | 26(10.8) | 88(36.7) | 92(38.3) | 2.01 |

*Percentages are in parenthesis*

*Grand mean = 2.59*

*Source: Field Survey, 2021*

*d) Factors influencing the use of ICTs among arable farmers*

Multiple regression analysis result in showed that $R^2$ was 0.645. This means that about 64.5 percent variation in the dependent variable was caused by changes in independent variables included in the regression model. The low value of Durbin-Watson constant (1.745) indicates absence of autocorrelation meaning that since important variables were included in the regression model. Statistically reliable and dependable result was shown by the low value of standard errors of the estimates (0.3069). The results indicated that farming experience was significantly influencing the use of ICTs among arable farmers at 1% level of significance and had a positive coefficient of 0.012. This implies that a unit increase in farming experience would increase the use of ICTs by 0.012 unit. This might be due to the fact that experienced farmers would have sought for and acquired the knowledge and skill on ICTs over time to utilize ICTs as a source of agricultural information. This finding is in consonance with findings of Williams and Agbo (2013) that years of farming experience significantly influencing the use of ICTs among farmers.

It was also revealed that the coefficient of household size (0.076) was significant at 10% level of significance and had positive relationship with use of ICTs among farmers. This implies that a unit increase in household size would cause an increase in the use of ICTs by 0.076 unit. This is because farmer with high household size might engage in more agricultural activities than farmers with low household members which might result to more reasons to use ICTs. This finding concords with Adegbidi et al. (2012) who reported that household size is a determinant factor in the use of ICTs among farmers. Furthermore, level of awareness had a significant influence on use of ICTs among farmers at 1% level of significance and had a positive coefficient of 0.677 implying that a unit increase in the level of awareness of ICTs would cause an increase in the use of ICTs by 0.677 unit. This finding supports with the findings of Hasan et al. *(*2019) that there is a positive and significant influence between awareness of ICTs and the use of ICTs.

*Table 4:* Factors influencing the use of ICTs among arable farmers

| Variables | Coefficients | Standard error | T-value | Significance |
|---|---|---|---|---|
| (Constant) | 0.508 | 0.242 | 2.102 | 0.007 |
| Age | -0.003 | 0.004 | -0.730 | 0.467 |
| Level of education | -0.111 | 0.142 | -0.778 | 0.438 |
| Marital status | -0.111 | 0.066 | -0.166 | 0.869 |
| Household size | 0.076* | 0.043 | 0.102 | 0.081 |
| Farming experience | 0.012*** | 0.004 | 2.777 | 0.006 |
| Extension contact | 0.023 | 0.051 | 0.450 | 0.653 |
| Level of awareness | 0.677*** | 0.053 | 12.791 | 0.000 |

*R = 0.803, $R^2$ = 0.645, standard error of the estimates = 0.3069, Durbin-Watson constant (1.745)*
****Significant at 1%; * Significant at 10%*
*Source: Field Survey, 2021.*

e) *Constraints to the Use of ICTs by the respondents*

Table 13 shows that limited finance (3.23), high cost of ICTs facilities (2.90), unstable power supply(2.88), limited technical know-how (2.69), language illiteracy(2.68), inadequate infrastructure(2.61) and inadequate access to information (2.52) were indicated as major constraints to the use of ICTs by the arable crop farmers and ranked as 1st, 2nd, 3rd, 4th, 5th and 6th respectively. The study agrees with Anyoha et al. (2018) that high cost of ICT devices, widespread illiteracy, insufficient income and language illiteracy are constraints to the use of ICTs among farmers.

*Table 5:* Constraints to the use of ICTs by the respondents

| Constraints | Very severe | Severe | Less severe | Not severe | Mean | Rank |
|---|---|---|---|---|---|---|
| Limited Finance | 122(50.8) | 66(27.5) | 36(15.0) | 16(6.7) | 3.23 | 1st |
| High cost of ICTs facilities | 72(30.0) | 90(37.5) | 60(25.0) | 18(7.5) | 2.90 | 2nd |
| Unstable power supply | 70(29.2) | 84(35.0) | 74(30.8) | 12(5.0) | 2.88 | 3rd |
| Limited technical know-how | 28(11.7) | 122(50.8) | 78(32.5) | 12(5.0) | 2.69 | 4th |
| Language illiteracy | 36(15.0) | 108(45.0) | 80(33.3) | 16(6.7) | 2.68 | 5th |
| Inadequate infrastructure | 30(12.5) | 104(43.3) | 88(36.7) | 18(7.5) | 2.61 | 6th |
| Inadequate access to information | 18(7.5) | 100(41.7) | 110(45.8) | 12(5.0) | 2.52 | 7th |
| Accessibility of ICT tools | 28(11.7) | 72(30.0) | 100(41.7) | 40(16.7) | 2.36 | 8th |
| Availability of ICTs | 20(8.3) | 64(26.7) | 130(54.2) | 26(10.8) | 2.33 | 9th |
| Our culture and tradition are not in support of ICT usage | 22(9.2) | 36(15.0) | 80(33.3) | 102(42.5) | 1.91 | 10th |

*Percentages are in parenthesis*
*Source: Field Survey, 2021*

## IV. Conclusions

The mean age of the respondents was 47years, mostly males (66.7%) and had a mean household size of 5 persons. Mostly (95.8%) had formal of education and a mean farming experience of 23years. Farmers were aware of mobile phone (3.75), radio (3.59), television (3.41), internet (2.59) and video recorder (2.57). The mostly used ICTs tools by the respondents were mobile telephone (3.77), radio (3.57) and television (3.33). Farming experience, household size and level of awareness on ICTs had significant influence on level of usage of ICTs among arable farmers. Limited finance, high cost of ICTs facilities, unstable power supply, limited technical know-how, language illiteracy, inadequate infrastructure and inadequate access to agricultural information were major constraints to the use of ICTs by the farmers. Government should therefore increase awareness to sensitize, provide adequate training and incentives such as credit facilities, subsidies etc. on ICTs tools to enhance the use of ICTs by these farmers for better productivity.

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*Abstract-* Wild plants have received considerable attention regarding ethnobotanical and pharmacological aspects. However, the potential of wild edible plants in terms of their nutritional and bioactive benefits has been investigated in only a few cases, despite being an important food source. This study aims to be a reference to promote the inclusion of two undervalued food plants as a nutritional alternative for balanced and healthy diets. The nutritional composition and bioactive components of *Poriphyllum ruderale* and *Portulaca oleracea*, two Mediterranean species, have been evaluated under wild and organic farming conditions. The quantification of nutrients and bioactive compounds was carried out with leaves and small stems of fresh plants. The proximal and mineral composition was determined with the official methods. The analysis of antioxidants was carried out with the DPPH technique and of total phenolic compounds by Folin-Ciocalteu. Other chemical components such as nitrates, pH and total acidity were determined.

*Keywords:* *undervalued species, nutritional composition, bioactive compounds, P. ruderale, P.oleracea.*

*GJSFR-D Classification:* *DDC Code: 581.35 LCC Code: QK981*

INFLUENCEOFCULTIVATIONCONDITIONSONTHENUTRITIONALCOMPOSITIONANDBIOACTIVECOMPONENTSOFTWOUNDERVALUEDEDIBLEPLANTSPOROPHYLLUMRUDERALEANDPORTULACAOLERACEA

# Influence of Cultivation Conditions on the Nutritional Composition and Bioactive Components of Two Undervalued Edible Plants (*Porophyllum Ruderale* and *Portulaca Oleracea*)

Tamara Fukalova Fukalova [α], María Dolores García Martínez [σ] & Maria Dolores Raigón Jiménez [ρ]

*Abstract-* Wild plants have received considerable attention regarding ethnobotanical and pharmacological aspects. However, the potential of wild edible plants in terms of their nutritional and bioactive benefits has been investigated in only a few cases, despite being an important food source. This study aims to be a reference to promote the inclusion of two undervalued food plants as a nutritional alternative for balanced and healthy diets. The nutritional composition and bioactive components of *Poriphyllum ruderale* and *Portulaca oleracea*, two Mediterranean species, have been evaluated under wild and organic farming conditions. The quantification of nutrients and bioactive compounds was carried out with leaves and small stems of fresh plants. The proximal and mineral composition was determined with the official methods. The analysis of antioxidants was carried out with the DPPH technique and of total phenolic compounds by Folin-Ciocalteu. Other chemical components such as nitrates, pH and total acidity were determined. The most representative nutritional components were crude fiber and carbohydrates under wild conditions for *P. ruderale* and under cultivated conditions for *P. olerace*a. The most abundant mineral macroelements were calcium and magnesium in cultivated P. ruderale and wild *P. olerace*a. For both species, the outstanding microelement was iron in wild conditions. In addition, both species stood out for a high content of antioxidants and chlorophyllin wild conditions. Finally, these undervalued plants showed significant nutrient content and are a good source of antioxidants and phenolic compounds for a healthy diet. The results suggest that both undervalued plants have a considerable nutritional potential and high content of bioactive compounds, highlighting antioxidants, they also have the potential to diversify production and as an attractive ingredient in healthy diets.

*Keywords: undervalued species, nutritional composition, bioactive compounds, P. ruderale, P.oleracea.*

## I. Introduction

Among the seventeen Sustainable Development Goals (SDGs), the third is focused on health and wellness (ONU, 2015). Undervalued wild species could be a means of sustainable use of local resources and diversify healthy diets, contributing to this SDG.

The Mediterranean diet as a world heritage (González-Turmo and Medina, 2012) stands out for the consumption of wild vegetables that are still part of traditional diets. It is especially worth remembering the health benefits provided by the Mediterranean diet and on which several nutritional studies corroborate (Mosconi et al., 2014; Safouris et al., 2015; Gardener and Caunca, 2018; Gubert et al., 2020).

Many of these wild species are appreciated for their organoleptic and nutritional-medicinal properties. However, globally its uses have often been relegated to a local environment. The abandonment of species that at some points were an important component of food, gives them the status of undervalued or forgotten, increasing food poverty and loss of agrobiodiversity heritage. At the same time, the loss of these resources and the absence of adequate links between conservation and their use are a major danger for future food security (Torrija-Isasa and Matallana-González, 2016).

Today, agricultural crops have displaced many previously known and appreciated wild species. However, traditions have made it possible for some wild plant resources to continue to be present in the diet of many people and to form part of traditional gastronomy (Tardío *et al*., 2006). In this context, preserving the selection of traditional local products, the transmission of knowledge, traditional culinary activities are part of the resilience to the current globalized and changing world. In addition, wild plants contain phytochemical compounds that, in combination with nutritional compounds, act synergistically, improving the effects for the prevention of many chronic diseases(van Breda y de Kok, 2018;Demasi *et al*., 2021).

As Medina (2017) points out, the food heritage (Mediterranean diet in this case), must be constantly recreated, and this within cultural frameworks in continuous evolution, which demands adaptation capacity. In this way, all the studies that advance in the knowledge of traditional foods consumed locally are very valuable from the cultural and nutritional point of

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view. Thus, the influence of the cultivation conditions of two undervalued food plants inherent to the spring-summer period in Mediterranean conditions was studied: purslane (*Portulaca oleracea* L.) and quirquiña (*Porophyllum ruderale* (Jacq.) Cass). According to the previous ethnobotanical review, these two species have been rooted in the traditional gastronomy of the Valencian coast (Spain).As objectives of this research, it was established to compare in organic farming conditions and in wild conditions:1) the nutritional characteristics of two species; 2) the bioactive components present. Since wild species are well adapted to local environmental conditions, they can ensure constant production under adverse environmental conditions and could be considered as vegetables for the local productive structure, as well as a beneficial source for health.

## II. Materials/Méthods

*a) Plant material and sample preparation*

The harvest was carried out in the spring-summer season of 2020 under two growing conditions: 1) organic farming conditions; 2) wild conditions in the same area of the Valencian coast within latitudes N 39º45'13" and longitudes W 0º12'21".The wild plants were collected in the areas close to the cultivation area and their brief description is summarized in Table 1.

*Table 1:* Description of studied plants

| | | |
|---|---|---|
| Scientific name | ***Portulaca oleracea* L.** | |
| Common name | Purslane, Verdolaga | |
| Scientific classification | Order: Caryophyllales<br>Family: Portulacaceae | Genus: Portulaca<br>Species: oleracea |
| Characteristics | Annual plant. Habitat: can be found in any unshaded area. In some regions it is considered a weed. Succulent stems and leaves | |
| Food uses | Parts used: leaves, stem (raw or cooked). Young leaves are very acceptable for salad. The leaves have a somewhat sour, salty and purgent taste. Being mucilaginous, it is used in soups. | |
| Scientific name | ***Porophyllum ruderale* (Jacq.) Cass** | |
| Common name | Quirquiña, Cilantro boliviano, Papaloquelite | |
| Scientific classification | Order: Asterales<br>Family: Asteraceae | Genus: Porophyllum Guett.<br>Species: ruderale |
| Characteristics | Annual plant. Habitat: native to the American continent, warm climate, grows in a wide variety of soil. Smooth stems and leaves with oil glands. | |
| Food uses | Parts used: leaves, raw stems in salads and hot sauces, as a vegetable. The leaves have a very strong and characteristic flavor. | |

*P. oleracea* is a widespread edible and medicinal plant with expanding interest as some previous research indicates that its shoots are a rich source of bioprotective nutrients (Spina *et al*., 2008; Yang *et al*., 2009; Franco *et al*., 2011; Iranshahy *et al*., 2017; Li *et al*., 2019).

*P. ruderale*has also been used in traditional medicine (Conde-Hernández y Guerrero-Beltrán, 2014),although the review work by Marques *et al.* (2020) highlights the lack of scientific work on this plant, except for some research on the chemical characterization of its essential oil (Fonsceca *et al*., 2006; Santos *et al*., 2016).

The phytochemical constituents of the studied plants have some bioactive properties that are summarized in Figure 1.

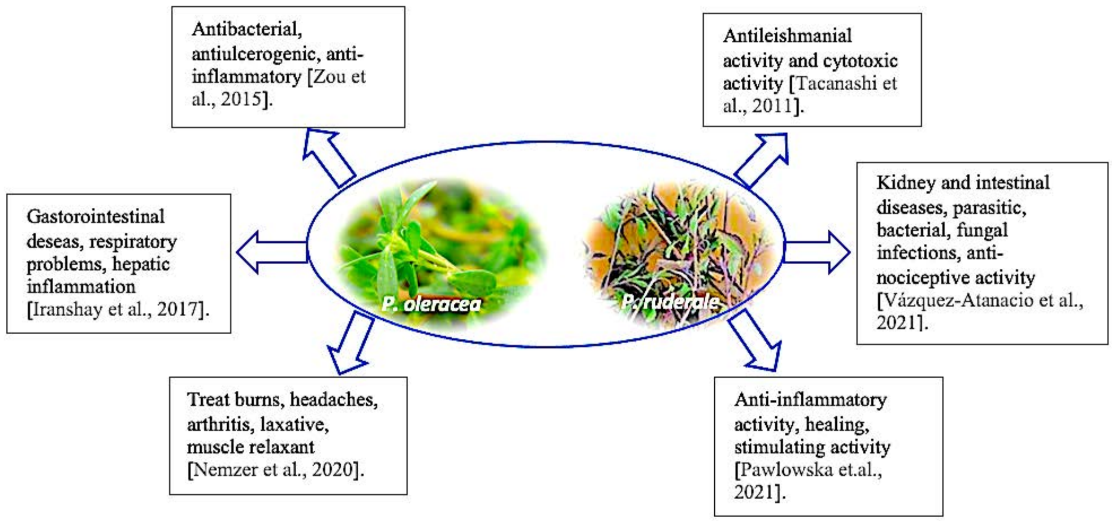


*Figure 1:* Biological activitiesof phytochemicals from *P.oleracea* y *P. ruderale*

Approximately 1 kg of each species was collected. The leaves and tender stems were separated and used for the extraction and quantification of bioactive compounds: total antioxidants, total polyphenols, chlorophylls and other chemicals (pH, nitrates, total acidity).The rest of the plant material was dehydrated in an oven at 70 ºC (J.P.Selecta) and subsequently ground (Retsch KG-5657 Haan Remscheid Germany) for proximal analysis.

*b) Reagents and Standards*

The 80% (v/v) methanol and 80% (v/v) acetone solutions were prepared from the analytical grade purity reagents. Sodium carbonate; citric acid, boric acid, sulfuric acid, hydrochloric acid and phosphoric acid; lanthanum(III) chloride, sodium hydroxide from Scharlau. Trolox (6-hydroxy-2,5,7,8-tetramethyl-chroman-2-carboxylic acid); 2,2´-azobis-2-methyl-pro-panimidamine; 1,1-diphenyl-2-picrylhydrazyl (DPPH); Folin-Ciocalteu reagent, gallic acid from Sigma-Aldrich Co.

*c) Proximate analysis and minerals determination*

The analysis were carry out by the official methods: moisture (AOAC 984.25), proteins (AOAC 984.13), fat (AOAC 983.23), fiber (AOAC 991.43) and ashes (AOAC 923.03). Digestion was performed according to AOAC method 985.35. Carbohydrate content was calculated by difference. The minerals were analyzed by atomic absorption spectroscopy. (Thermo Elemental AAseries), except for phosphorus, which was analyzed by colorimetry (AOAC, 2005)

*d) Bioactive components evaluation*

All analytical methods applied were optimized and validated for specific vegetal samples analyzes. The total antioxidant content was determined by the DPPH method following the modified methodology of Brand - Williams (1995): the extract was obtained by mixing 0.8 g of the sample with 5 mL of 80%methanol for 1 hour at room temperature in orbital shaker SO1 (Stuart Scientific); then an aliquot of the extract (100 µL) was allowed to react for 45 minutes in the dark with the reagent (0.025 g/L of DPPH methanolic solution). The absorbance was measured at 515 nm (Schott UVline9400). The calibration curve was obtained with Trolox as standard. The results were expressed in *µ*moles of Trolox equivalent in 100 g of fresh weight (*µ*mol TE 100 g-1 fw).

The total phenolic content was performed by mixing an aqueous extract aliquot (0.5 mL) with the Folin-Ciocalteu reagent and sodium carbonate. The absorbance was measured at 750 nm in the UV/V spectrophotometer (JENWAY 6715/UV-Vis) after 1 hour of incubation. Gallic acid was used for the calibration curve. The results were expressed as mg of gallic acid equivalents in 100 g of fresh weight (mg GAE 100 $g^{-1}$ fw).

The chlorophylls content was determined using the adapted Hansmann method (1973): the extract was obtained with 80% acetone. Once filtered, the absorbance was measured at 645nm, 653nm and 663nm (Schott UVline9400). The results were expressed as milligrams of chlorophyll in 100 g of fresh weight (mg·100 g-1 fw).

*e) Other chemicals: nitrates, pH and total acidity*

Aqueous extracts of aerial parts were prepared in 1:2 w/v ratio (plant/80%acetone).Nitrates and pH were measured directly with the respective electrodes by pH and ION-Meter GLP 22+ equipment (CRISON).The total acidity was determined potentiometrically with a 0.05 N NaOH solution. The results were expressed as a percentage of citric acid.

*f) Statistical analysis*

Each sample was analyzed in triplicate. The analysis of variance and the significant difference between means were tested by multivariate ANOVA at asignificant level of p<0.05. Differences between groups were determined by comparisons of means (Tukey contrast). All analysis was processed using Statgraphics Plus version 5.1 (Manugistics Inc., Rockville, MD, USA).

## III. Resultados y Discusión

*a) Proximate analysis*

Table 2 shows the percentage contents of the nutrients, as well as the macro and microminerals values.

*Table 2:* Nutritional and mineral components of the aerial parts of each species: mean ± standard error and probability (p-value) for the significance differences between growth conditions

| | | *P. ruderale* | | | *P. olerace* | | |
|---|---|---|---|---|---|---|---|
| | | Wild | Cultivate | *p*-value | Wild | Cultivate | *p*-value |
| Nutrients(g 100 g$^{-1}$fw) | Moisture | $84.70^{a}\pm0.43$ | $76.64^{b}\pm0.02$ | 0.0000 | $88.39^{a}\pm0.24$ | $83.12^{b}\pm1.09$ | 0.0014 |
| | Ash | $1.49^{b}\pm0.02$ | $2.33^{a}\pm0.02$ | 0.0020 | $2.62^{b}\pm0.02$ | $3.39^{a}\pm0.06$ | 0.0084 |
| | Crude protein | $1.89^{a}\pm0.00$ | $1.19^{b}\pm0.01$ | 0.0002 | $1.56\pm0.00$ | $1.49\pm0.00$ | 0.1988 |
| | Fat | $0.66^{a}\pm0.00$ | $0.41^{b}\pm0.01$ | 0.0156 | $0.32^{b}\pm0.00$ | $0.99^{a}\pm0.00$ | 0.0000 |
| | Crude fiber | $5.50\pm1.88$ | $3.57\pm0.66$ | 0.1003 | $2.39\pm0.01$ | $2.60\pm0.89$ | 0.7178 |
| | Carbohydrates | $6.80^{b}\pm3.49$ | $17.55^{a}\pm0.63$ | 0.0008 | $4.72^{b}\pm0.21$ | $8.41^{a}\pm0.90$ | 0.0183 |
| | Energetic value (kcal 100 g$^{-1}$) | $40.70\pm1.16$ | $78.65\pm0.22$ | - | $28.00\pm0.07$ | $48.51\pm0.30$ | - |
| Minerals (mg 100 g$^{-1}$fw) | Calcium | $439.29^{b}\pm119.86$ | $687.49^{a}\pm19.22$ | 0.0240 | $186.67^{a}\pm28.36$ | $110.59^{b}\pm16.02$ | 0.0005 |
| | Magnesium | $131.15^{b}\pm9.22$ | $185.54^{a}\pm21.10$ | 0.0150 | $165.33^{a}\pm9.50$ | $91.68^{b}\pm18.91$ | 0.0000 |
| | Potassium | $515.28\pm49.22$ | $477.75\pm40.99$ | 0.3676 | $776.67^{a}\pm171.50$ | $271.91^{b}\pm34.37$ | 0.0000 |
| | Phosphorus | $56.48^{b}\pm3.31$ | $84.57^{a}\pm3.96$ | 0.0007 | $33.67^{b}\pm0.93$ | $58.73^{a}\pm7.56$ | 0.0000 |
| | Sodium | $7.19\pm1.21$ | $8.21\pm1.60$ | 0.4337 | $16.60^{a}\pm0.03$ | $0.81^{b}\pm0.06$ | 0.0000 |
| | Iron | $1.80\pm0.12$ | $1.70\pm0.17$ | 0.4495 | $1.80\pm0.18$ | $1.35\pm0.18$ | 0.1960 |
| | Copper | $0.17^{b}\pm0.01$ | $0.37^{a}\pm0.01$ | 0.0000 | $0.14^{b}\pm0.01$ | $0.36^{a}\pm0.05$ | 0.0000 |
| | Zinc | $0.51^{a}\pm0.04$ | $0.39^{b}\pm0.03$ | 0.0157 | $0.99^{b}\pm0.06$ | $1.08^{a}\pm0.14$ | 0.0011 |

*Note: $^{a\text{-}d}$ superscript indicatea significant difference exists (p<0.05)*

It is observed that the wild species (*P. ruderale* with 84.70% and *P. oleracea* with 88.39%) have a higher humidity level than their cultivated counterparts with a significant difference (p=0.0000).On the contrary, the ash content is higher in *P. oleracea* than in *P. ruderale* and in both species it is lower in wild conditions *vs.* cultivated conditions.

Crude protein had a higher value in *P. ruderale* under wild conditions, and in *P. oleracea* no significant differences were observed for this nutrient according to the growth system. The fat content in *P. ruderale* was higher in wild conditions (5.50%) *vs.* cultivated conditions (3.57%), while in *P. oleracea* the same parameter was higher in cultivated conditions (0.99%).For both species, the differences between cultivation systems were significant with p=0.0156 (*P. ruderale*) and p=0.0000 (*P. oleracea*). Crude fiber did not present significant differences between the growing systems in any of the species, showing the highest level in *P. ruderale* (5.50%).Carbohydrates indicated high levels in cultivated conditions *vs*. wild conditions for both species.

The characterization of the nutrients in vegetables is an important contribution to the daily requirements of a balanced diet. Moisture content determines freshness of vegetables and color characteristics appreciable by consumers (Kibar *et al*., 2021). On the other hand, the stability and quality of food are also affected by the moisture content. Its higher levels in the wild conditions for both species are probably related to their ability to retain water when exposed to higher stress agroclimatic conditions than their cultivated counterparts. Moisture values similar to those found in this study are reported for conventional vegetables such as parsley (88%)(BEDCA, 2022),and higher values have been found in *P. oleracea* (97.3%) from Sudan(Obied *et al*., 2003).

Ash is the inorganic part of the plant that is closely related to the mineral content. The ashes presented a variation between 0.44-0.67% in *P. ruderale*, values lower than those reported by Carillo (2014) for the same Mexican species (2.04%). The variation between 2.62-3.39% in *P. oleracea* is much higher than that reported by USDA (2019) for the same American species (1.36%).

Crude protein showed a significant difference between the growth conditions in *P. ruderale* (p=0.0002) and no difference in *P. oleracea.* These results that both species are not a protein source of alternative nutrition, unlike other wild edible species such as *C. album* (26.42%) or the genus *Amaranthus* (21.38%) (Ozbucak *et al., 2007).*In general, the amount of protein in the species studied is close to that of common lettuce (1.13%) or escarole (1.6%) (BEDCA, 2022).

The fat content was significantly influenced by the growth conditions in *P. ruderale* and *P. oleracea*, where the value found tripled that of the organic growth conditions.The fat content is very similar to that reportedfor the wild species *P. oleracea* Portuguese (0.39%) by Pinela *et al.*(2017).In general, all the values were below 1.0%, confirming that the plants studied are a low-fat source, which could be considered to design healthy diets(Kaur *et al*., 2014; Marrelli *et al*., 2020).

The crude fiber varied between 2.39-5.50%, without presenting differences between cultivation systems for any of the species. The fiber content in this study can be considered high since it exceeds the range reported by Kim *et al.*(2016) for iceberg, romaine, green and purple leaf lettuce from 0.9 to 2.1 g 100 $g^{-1}$ in fresh weight or reported by Tardío *et al.* (2016) for *P. oleracea* Mediterranean (1.20%). These results indicate that the aerial parts of both species are a good source of crude fiber whose daily intake is beneficial for health.

Carbohydrate concentration varied in the range 4.72-8.41% (*P. oleracea*) and 6.80-17.55% (*P. ruderale*). The carbohydrate content in *P. oleracea* exceeded that reported by Tardío *et al.*(2016) for the same species with 1.98%. The estimated caloric values of the plants studied in two growth conditions fluctuated between 28.0-78.65%, where *P. ruderale* had the highest caloric value in cultivated conditions (Table 1). However, both species are oriented as low-calorie foods and 100 g of their consumption contributes only about 4% considering the referenced energy value (2000 kcal/day for adults) (Regulation (EU) No 1169/2011). In this way, the studied species are appropriate food for low-calorie diets.

*b) Minerals*

Human nutritional requirements require at least 23 elements that are differentiated into macrominerals (they require higher daily amounts) and microminerals (their required daily amounts are very small) (Quintaes y Díez-García, 2015).The mineral composition of the two undervalued species is presented in Table 1.The calcium (Ca) range is between 110.59 mg·100 $g^{-1}$(*P. oleracea)* and 687.49 mg·100 $g^{-1}$(*P. ruderale),* both under cultivated conditions. Species *P. ruderale* stood out as a source of calcium since 100 g fresh edible portion represents a contribution of more than 55% of daily requirements for adults of this element when estimating the reference dietary intake of Ca in 1200 mg per day(WHO, 2004).Vegetables rich in calcium are kale, broccoli, and watercress, which provide between 100 and 150 mg per 100 g (Cormick and Belizán, 2019), although the impact that food has on total calcium intake depends on food consumption patterns of the population.

Magnesium (Mg) was between 91.68 mg 100 $g^{-1}$(*P. oleracea*) and 185.54 mg 100 $g^{-1}$(*P. ruderale),* both cultivated, and between 131.15 mg 100 $g^{-1}$ and 165.33 mg 100 $g^{-1}$, respectively, in their wild counterparts. The amount of magnesium depends more on the growth conditions in *P. oleracea* than in *P. ruderale* with a significant difference (p=0.0000).In general, magnesium is a critical element in many cellular functions, being a cofactor in more than 300 enzymes in the body and has functions that affect nerve conduction (Nielsen, 2018).Studies indicate that Mg intake below 237 mg/day is associated with poor bone health(Nielsen *et al*., 2011).

The mean value of potassium (K) ranged between 515.28 and 776.67 mg·100 $g^{-1}$ in the wild species. The functions of this element in plants are related to osmotic regulation and electroneutrality of cells (Renna *et al*., 2015).The superiority of K under wild conditions is possibly related to its availability in more rustic areas.

The phosphorus concentration ranged from 33.67 to 84.57 mg·100 g-1 with significant differences between the culture systems in both species, surpassing the cultivated ones *vs.* the wild ones. In the case of wild conditions its low content may be related to deficient levels of this element in the soil and, in the case of cultivation conditions, it may be influenced by agricultural practices and the contributions made in the form of organic matter.

In relation to sodium, the significant difference (p=0.0000) was only observed in *P. oleracea,* doubling its content in wild *vs.* cultivated conditions. In general, for humans, sodium plays a vital role in regulating fluid balance and blood pressure (Renna *et al*., 2015).The WHO (2006) recommends its intake below 2 g per day to prevent cardiovascular diseases attributed to high blood pressure. The result of the present study showed that all the species analyzed can be considered as contributors of low daily sodium intake.

Among the microminerals, the one with the highest concentration was iron (Fe) for both species under wild conditions, followed by zinc (Zn).In the human body, Fe acts as an oxygen carrier and its deficiency is the most common nutritional disorder. Considering that the requirement of its daily intake is 8 and 10 mg (WHO, 2004), the species in this study could provide around 18% of the requirement..Zn is also an essential component for humans since it participates in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids. Its central role in the immune system is supported by several studies (WHO, 2004).If the recommended daily amount of Zn (10 mg/day, Odhav *et al.,* 2007) is considered, the study plants can provide between 4.5-10% of what is recommended.

The microelement with the lowest concentration was copper (Cu) in wild conditions for both plants. On the contrary, a high content of Cu was found in both species collected under cultivated conditions, exceeding by more than 2.5 times the content of this element in their wild counterparts. This element is vital for certain enzymes and proteins (Renna *et al*., 2015), as well as it is required in the synthesis of collagen and mobilization of iron (Kibar y Temel, 2015).The edible parts of the plants studied are shown to be a moderate source of this trace element, which represents 15.6% (wild species) and 41.1% (cultivated species) of 100 g of their fresh consumption, considering that the recommended daily consumption is 0.9 mg/day (Pinela *et al*., 2017).

*c) Bioactivecomponents*

The bioactive components of this study that are antioxidants, phenolic compounds, and chlorophylls, in plants are involved in growth, reproduction and defense against pathogens and known as secondary metabolites. For humans, these compounds exert beneficial effects due to their biological activity that promotes health (Pandey y Rizvi, 2009).Therefore, these bioactive molecules affect the nutritional quality of foods since they provide functionality to the food.

The content of total antioxidants (TAO), total phenolic compounds (PFT) and total chlorophyll (Chl) of the undervalued wild plants are presented in Figure 2.

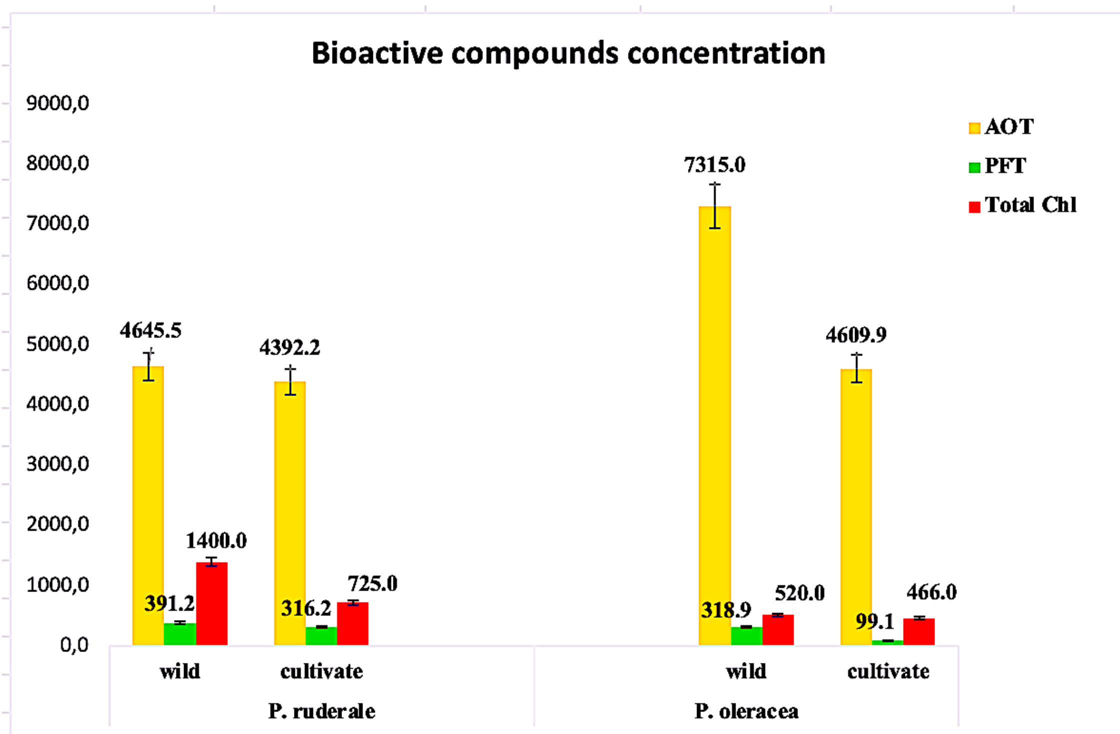


*Figure 2:* Bioactive compounds: mean values: AOT=total antioxidants (μmol TE·100 g$^{-1}$pf); PFT= total polyphenols (mg GAE·100 g$^{-1}$); total Chl=total chlorophyll (as chlorophyll *a* +*b*) (mg·100 g$^{-1}$)

The amount of total antioxidants in the fresh samples of both plants ranged from 4645.53 to 7135.0 (μmol TE·100 g$^{-1}$) for the wild species compared to their cultivated counterparts (4392.2-4609.9 μmol TE·100 g$^{-1}$) with significant differences between both growth systems. On the contrary, the content of total phenolic compounds did not present significant differences between the growth systems for *P. ruderale* species. However, in *P. oleracea* asignificant difference were observed between cultivated (99.1 mg GAE·100 g$^{-1}$) and wild (318.9 mg GAE·100 g$^{-1}$). The amount of chlorophylls in the fresh samples was higher in the wild species of both plants, although there were only significant differences in *P. oleracea.* In general, both species exhibit high levels of bioactive compounds, especially total antioxidants, which are higher in wild species. In some plants, antioxidant activity is correlated with phenolic compounds. (Conde-Hernandez yGuerrero-Beltrán, 2014).In our study the positive correlation was only observed in the case of the species *P. oleracea*. The total content of phenolic compounds is much higher than that reported by Kim *et al*. (2016) for the green leaves of the “Simpson Elite” variety lettuce (65-67 mg 100 g$^{-1}$) and the red leaves of the “Red Cross” variety (250-260 mg 100 g$^{-1}$).In contrast, the wild leaves of Tunisian *P. oleracea* studied by Dabbou *et al.*(2020) contain a higher amount of phenols than that found in this study for the same species. The leaves of Mediterranean *P. oleracea* reported by Tardío et al. (2016) showed results in phenolic compounds (270 mg 100 g$^{-1}$) lower than that of this study, for the same species in wild conditions and higher than in its cultivated counterpart.

Chlorophylls were analyzed in this study as part of the bioactive compounds and are the pigments responsible for the green color of leaves. In all the samples analyzed, the concentration of chlorophyll *a* was higher than that of chlorophyll *b*, and the sum of both corresponds to the amount of total chlorophyll. Its quantity prevailed in the wild species of both plants and its range was between 520 (*P. oleracea*) and 1400 mg·100 $g^{-1}$ pf (*P. ruderale*). The study on total chlorophyll in the leaves of Tunisian *P. oleracea* (742 mg in 100 g) carried out by Dabbou *et al*. (2020) reported an amount of total chlorophyll greater than that found in this study.

The higher amount of bioactive compounds under wild conditions is probably due to the fact that these secondary metabolites are responsible for the plant defense system. Being subjected to conditions of greater stress, the total content of phenols in the leaves can be increased. Also, the stage of harvest has a significant effect on the total phenolic content, as well as the age of the plant(Petropoulos *et al*., 2019).Chlorophyll content is one of the most significant parameters to evaluate the physiological state of plants that can be used as an index of the nutritional and stress state of the plant(Silla *et al*., 2010).As bioactive compounds, chlorophylls have antioxidant and antimutagenic activity, as well as cancer prevention(Kang *et al*., 2018).Its use is better when the plants are consumed fresh, since these natural pigments are thermolabile and are destroyed by heat.

*d) Other chemicals*

Determined in this study are nitrates, pH and total acidity and their content is shown in Table 3. Nitrates and pH showed significant differences ($p<0.05$) between growth systems, both in the species *P. ruderale* and in the species *P. oleracea*. On the contrary, total acidity did not present significant differences between plants growth systems.

*Table 3:* Other chemicals of the aerial parts of each species: mean values ± standard error, coefficient of variability(CV) and p- value for the significance of differences between growth conditions

| | | *P. ruderale* | | | | | *P. oleracea* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | wild | CV (%) | cultivate | CV (%) | *p*-value | wild | CV (%) | cultivate | CV (%) | *p*-value |
| Other chemicals | Nitrates (mg $NO_3^-$·$kg^{-1}$ pf) | $777.33^a$±91.10 | 11.72 | $304.40^b$±66.50 | 21.85 | 0.0019 | $470.99^a$±33.32 | 7.07 | $114.63^a$±25.32 | 22.09 | 0.0001 |
| | pH | $5.93^a$±0.05 | 0.84 | $5.29^b$±0.05 | 0.94 | 0.0002 | $6.57^a$±0.02 | 0.30 | $3.58^a$±0.20 | 5.59 | 0,0001 |
| | Acidity total (% citric acid) | $0.10^b$±0.01 | 10.00 | $0.19^a$±0.01 | 5.00 | 0.0337 | $0.14^{ab}$0.02 | 14.28 | $0.19^{ab}$±0.03 | 15.79 | 0.1079 |

*Note:[a, b]superscript indicate that a significant difference exists between the growth conditions*

As there is a natural nitrogen cycle in plants, it can be modified by applied agronomic practices and climatic conditions, as well as by storage conditions during post-harvest. The toxicity of nitrates increases when reduced to nitrites. However, the WHO/FAO indicates that the acceptable daily intake of nitrates expressed as ions is 3.7 mg $NO_3^-$kg-[1] of body weight. Hence the importance of determining the amount of nitrates in edible plants. All these chemicals interfere with the organoleptic qualities of the species and are considered the internal quality parameters of vegetables in the agri-food industry(Cajamar, 2014).

## IV. Conclusions and Recommendations

The influence of growth conditions on the nutritional composition and bioactive components of two undervalued wild plants *P. ruderale* and *P. oleracea* was evaluated. The proximal analysis of the aerial parts revealed a high content of crude fiber and carbohydrates. In the mineral content, the concentration of calcium and potassium stood out with its higher level in the cultivated conditions for *P. ruderale* and in the wild conditions for *P. oleracea*. The trace element iron was relevant in both plants and in both growth conditions. Likewise, significant levels of bioactive compounds were found in the two species studied that can provide functionality when consuming these vegetables. These results suggest that undervalued wild plants can be part of diets as an alternative to commonly used vegetables, reinforcing regional practices of consumption of wild species. Simultaneously, they can be postulated as new crop sources.

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Associates can use the honored title of membership. The “ASFRC” is an honored title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., ASFRC or William Walldroff, M.S., ASFRC.

Career | Credibility | Exclusive | Reputation

## Recognition on the Platform

### Better visibility and citation

All the Associate members of ASFRC get a badge of "Leading Member of Global Journals" on the Research Community that distinguishes them from others. Additionally, the profile is also partially maintained by our team for better visibility and citation. All associates get a dedicated page on the website with their biography.

Career | Credibility | Reputation

## Future Work

### Get discounts on the future publications

Associates receive discounts on the future publications with Global Journals up to 60%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

Career Financial

## GJ Internal Account

### Unlimited forward of Emails

Associates get secure and fast GJ work emails with unlimited forward of emails that they may use them as their primary email. For example,
john [AT] globaljournals [DOT] org.

Career Credibility Reputation

## Premium Tools

### Access to all the premium tools

To take future researches to the zenith, fellows receive access to almost all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

## Conferences & Events

### Organize seminar/conference

Associates are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent. Additionally, they get free research conferences (and others) alerts.

Career Credibility Financial

## Early Invitations

### Early invitations to all the symposiums, seminars, conferences

All associates receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

## Publishing Articles & Books

### Earn 30-40% of sales proceeds

Associates can publish articles (limited) without any fees. Also, they can earn up to 30-40% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.

Exclusive Financial

## Reviewers

### Get a remuneration of 15% of author fees

Associate members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

## And Much More

### Get access to scientific museums and observatories across the globe

All members get access to 2 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 5 GB free secure cloud access for storing research files.

| Associate | Fellow | Research Group | Basic |
|---|---|---|---|
| $4800<br>**lifetime designation** | $6800<br>**lifetime designation** | $12500.00<br>**organizational** | APC<br>**per article** |
| **Certificate,** LoR and Momento<br>2 discounted publishing/year<br>**Gradation** of Research<br>10 research contacts/day<br>1 **GB** Cloud Storage<br>**GJ** Community Access | **Certificate,** LoR and Momento<br>**Unlimited** discounted publishing/year<br>**Gradation** of Research<br>**Unlimited** research contacts/day<br>5 **GB** Cloud Storage<br>**Online Presense** Assistance<br>**GJ** Community Access | **Certificates,** LoRs and Momentos<br>**Unlimited** free publishing/year<br>**Gradation** of Research<br>**Unlimited** research contacts/day<br>**Unlimited** Cloud Storage<br>**Online Presense** Assistance<br>**GJ** Community Access | **GJ** Community Access |

# Preferred Author Guidelines

**We accept the manuscript submissions in any standard (generic) format.**

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

## Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

**Declaration of Conflicts of Interest**

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

## Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

## Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

**Changes in Authorship**

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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**Appealing Decisions**

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

**Acknowledgments**

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

**Declaration of funding sources**

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

## Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

***Manuscript Style Instruction (Optional)***

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

***Structure and Format of Manuscript***

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

## Format Structure

***It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.***

All manuscripts submitted to Global Journals should include:

**Title**

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

**Author details**

The full postal address of any related author(s) must be specified.

**Abstract**

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

**Keywords**

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

**Numerical Methods**

Numerical methods used should be transparent and, where appropriate, supported by references.

**Abbreviations**

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

**Formulas and equations**

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

**Tables, Figures, and Figure Legends**

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

**Figures**

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

## Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

## Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

***1. Choosing the topic:*** In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

***2. Think like evaluators:*** If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

***3. Ask your guides:*** If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

***4. Use of computer is recommended:*** As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

***5. Use the internet for help:*** An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

***6. Bookmarks are useful:*** When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

***7. Revise what you wrote:*** When you write anything, always read it, summarize it, and then finalize it.

***8. Make every effort:*** Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

***9. Produce good diagrams of your own:*** Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

***10. Use proper verb tense:*** Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

***11. Pick a good study spot:*** Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

***12. Know what you know:*** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

***13. Use good grammar:*** Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

***14. Arrangement of information:*** Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

***15. Never start at the last minute:*** Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

***16. Multitasking in research is not good:*** Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

***17. Never copy others' work:*** Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

***18. Go to seminars:*** Attend seminars if the topic is relevant to your research area. Utilize all your resources.

***19. Refresh your mind after intervals:*** Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

***20. Think technically:*** Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

***21. Adding unnecessary information:*** Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

***22. Report concluded results:*** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

***23. Upon conclusion:*** Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

## Informal Guidelines of Research Paper Writing

***Key points to remember:***

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

**Final points:**

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

**The discussion section:**

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

**General style:**

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

**To make a paper clear:** Adhere to recommended page limits.

*Mistakes to avoid:*

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

**Title page:**

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

*Reason for writing the article—theory, overall issue, purpose.*

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

**Approach:**

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

**Introduction:**

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

*The following approach can create a valuable beginning:*

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

**Approach:**

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

**Procedures (methods and materials):**

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

**Materials:**

*Materials may be reported in part of a section or else they may be recognized along with your measures.*

**Methods:**

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

**Approach:**

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

**What to keep away from:**

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

**Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

**Content:**

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

**What to stay away from:**

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

**Approach:**

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

**Figures and tables:**

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

**Discussion:**

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

 

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

**Approach:**

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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|---|---|---|---|
| | **A-B** | **C-D** | **E-F** |
| ***Abstract*** | Clear and concise with appropriate content, Correct format. 200 words or below | Unclear summary and no specific data, Incorrect form<br><br>Above 200 words | No specific data with ambiguous information<br><br>Above 250 words |
| ***Introduction*** | Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited | Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter | Out of place depth and content, hazy format |
| ***Methods and Procedures*** | Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads | Difficult to comprehend with embarrassed text, too much explanation but completed | Incorrect and unorganized structure with hazy meaning |
| ***Result*** | Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake | Complete and embarrassed text, difficult to comprehend | Irregular format with wrong facts and figures |
| ***Discussion*** | Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited | Wordy, unclear conclusion, spurious | Conclusion is not cited, unorganized, difficult to comprehend |
| ***References*** | Complete and correct format, well organized | Beside the point, Incomplete | Wrong format and structuring |

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