International Journal of Research in Agricultural Sciences
Volume 8, Issue 1, ISSN (Online): 2348 – 3997

Plectranthus Edulis (Vatke) Agnew in Ethiopia: A Review

Nitsuh Aschale [1*] and Kalkidan Tesfu [1]
[1] Ethiopia Institutes of Agricultural Research, National Agricultural Biotechnology Research Center, P.O. Box 249, Holeta, Ethiopia.
[*]Corresponding author email id: nitsuhyo@gmail.com

Date of publication (dd/mm/yyyy): 20/01/2021

Abstract **– Ethiopia is one of the richest genetic resource centers in the world. *Plectranthus edulis* (vatke) Agnew locally know as Ethiopian dinich (potato) is one of the most economically edible tuber crops in Ethiopia. Its indigenous tuber crops and mostly grown in the highland of the country. It's usually called ' hunger crops' as it fills the shortage of food gab between the period before the harvest of cereal crops that occur from August to November. It is traditionally recommended as a special food in the community for people who are recovering from illness. The aim of this review indicates that the general over view of *Plectranthus edulis* (vatke) Agnew in Ethiopia.**

Keywords **– Ethiopia, *Plectranthus Edulis*, Tissue Culture, Micro Propagation.**

I. INTRODUCTION

Plectranthus edulis is one of the most important indigenous tuber crops in Ethiopia. The genus *Plectranthus* belongs to the family *Labiatae (Lamiaceae*). It is a large genus containing about 300 species mostly found in Tropical Africa, Asia and Australia (Paton *et al.*, 2004). Among 300 species of *Plectranthus*, 62 species are used as medicines, ornamentals, foods, flavors, etc.

Plectranthus edulis is a diploid, dicotyledonous plant and also occurs as wild. It can grow at the mid to high altitudes areas in the south, north and south-west of Ethiopia. Its height reaches up to 1.5 m and produces edible tubers on below-ground stolons. This growing habit of *P. eduils* looks like that of the Irish potato (Mulugeta Taye, 2008). It has a long history of local usage and is important to the cultural, social and economic life of households (Abebe Demissie, 1988). It is traditionally recommended as a special food in the community for people who are recovering from illness, probably owing to its high digestibility. It is also reported that it has no impact on the stomach whatever amount is consumed (Yeshitila Mekbib and Webiull, 2012) and serves as medicinal plant, eating the boiled root can avoid loss of appetite (Megersa *et al.*, 2013).

In addition to the above uses, *Plectrathus* species are also used as food plants by the larvae of some Lepidoptera species including the Engrailed (*Ectropies crepusularia*) (Lukhoba *et al.*, 2006).

In many countries, tuber plants are used as major calorie contributors and have the highest rate of dry matter production per day. It is not only enriching the diet of the people but also possesses medicinal properties to cure many diseases. In addition to the above advantages, many tropical tuber crops contribute in the preparation of stimulants, tonics, carminatives and expectorants. It is also rich in dietary fiber and carotenoids (Edison *et al.*, 2006).

In Ethiopia, Farmers and the Ministry of Agriculture claim that the total tuber production has declined considerably over the last few decades. However, information on the growth and development of *P. edulis* and cultural practices of this tuber plant is scarce. Even basic knowledge on the crop is not available (Mulugeta Taye, 2008).

Vegetativelly propagated crops are mostly affected by diseases like virus, fungi, bacteria, insects and nematodes (Wharton and Kirk, 2007; IAEA, 2004). Thus diseases are problems that contribute significantly to yield loss in tubers crops among which *P. eduils* is the one. Application of modern biotechnologies in *P. eduils* would be decisive to improve the quality as well as quantity of this tuber by means of producing plants resistant to insect, herbicide, fungi, bacteria and nematode through *in vitro* screening and genetic engineering. These are performed by utilization (exploitation) of gene transfer by genetic transformation and somatic hybridization which requires the control of plant regeneration from tissue culture techniques. Then, development of a reliable *in vitro* plant regeneration procedure is a pre-requisite for its improvement by creating genetic variability via biotechnological methods involving direct gene transfer (Sihachakr *et al.*, 1997). Success of any transformation strategy depends largely upon the regeneration capability of the target explants (Chugh and Khurana, 2003).

II. LITERATURE REVIEW

2.1. *Taxonomy and Morphology of Plectranthus Edulis*

P. edulis (*Coleus edulis*) is a tuber crop that belongs to the family Labiatae (Lamiaceae). It is small hairy, succulent herb about a maximum of 150 cm high, with ovate and shallowly serrate leaves that are cultivated on small-scale basis (Yeshitila Mekbib, 2007).

P. edulis is highland crop that has different shapes, colour and size. Among the different species of *Plectranthus*, *P. edulis* (Vatke) Agnew (syn. *Coleus edulis* (Vatke), is a diploid, dicotyledonous plant, locally called Oromo potato (Oromo dinch), Wolaita dono (Wolaita dinich), Gurage Dinch, Agew Dincha and Ethiopian potato (Mulugeta Taye *et al.*, 2007; Yeshitila Mekbib, 2007). It is originated in Ethiopia (Dandena Gelmesa, 2010; IBC, 2005).

It is composed of the mother tuber piece, sprouts, main stems, branches, leaves, inflorescences, fruits, seeds, roots, stolon, and tubers. The stolon are very long and are initiated on buds of main stems and primary branches, first only on below-ground nodes, but later also on the lower aerial nodes. Tubers are produced upon swelling of the tip or middle part of stolons. Tubers that are formed from along the stolon are longer than the stolon tip. The tubers of *P. edulis* are stem tubers, like those of Irish potato. Hence, the colour of the vegetative parts, stolons and tubers varied depending on the cultivar (Taye *et al*., 2012). Ontogeny of the tuber crop *Plectranthus edulis* (*Lamiaceae*).

There are different local cultivars that have been identified by farmers (Mulugeta Taye *et al.*, 2007). Similarly, Yeshitila Mekbib (2007) reported that earlier farmers of Wolaita had been growing a wider diversity of local cultivars of *P. edulis* for various reasons. These days, however, they have specialized on few cultivars that they thought would meet their needs best. At least six local cultivars, namely, ‘Lofuwa’, ‘Unnuka’, ‘Chenkuwa’, ‘Chedia’, ‘Merchia’ and ‘Keytaria’, currently growing by farmers and all of them had been selected by them (Yeshitila Mekbib and Webiull, 2012).

Among those, the three local cultivars, namely ’Chenkuwa’, ’Lofuwa’ and ’Unnuka’ were found to be common and widely and evenly distributed in all the growing areas of Wolaita. The dominance of the three major local cultivars was found to be associated with the specific qualities attached to each cultivar (Yeshitila Mekbib and Webiull, 2012). Their differences are indicated below in Table 1.

Table 1. Descriptions of local Ethiopian potato (*plectranthus edulis* (vatke) agnew) varieties by farmers in Sodo zuria district, South Ethiopia.

Characters	Lofuwa	Unnuka	Chenkuwa
Drought tolerant	Poor	Good	Very good
Maturity	Early	Intermediate	Late
Taste	Good	Intermediate	Very good
Disease resistance	Good	Good	Good
Tuber yield	Good	Good	Intermediate
Tuber size	Big	Intermediate	Small
Tuber colour	Cream	White	Red purple
Plant height	Tall	Short	Intermediate
Shelf life	Poor	Intermediate	Very good
Marketability	Seasonal	Seasonal	All times

Source: Ethiopian Health and Nutrition Research Institute (EHNRI, 1997).

2.2. *Origins and Growing Condition*

In terms of crop diversity, Ethiopia is one of the richest genetic resource centers in the world. This is principally attributed to the diverse farming systems, socio-economics, cultures and agro-ecologies. Crop plants such as coffee (*Coffea arabica*), safflower (*Carthamus tinctorius*), Tef (*Eragrostis tef*), noug (*Guizotia abyssinica*), Anchote (*Coccinia abyssinica*), Enset (*Ensete ventricosum*), *Plectranthus edulis* (Vatke) Agnew (syn. *Coleus edulis* Vatke) are known to have originated in Ethiopia (Dandena Gelmesa, 2010; IBC, 2005 and 2007). Enset, Irish potato, sweet potato, yam, cassava, taro and *Plectranthus edulis* are tuber crops, which are the major source of food in Southern Ethiopia (Andargachew Gedebo *et al*., 2011).

Consumption of *P. edulis* was related with the coming of the negroid people in 3000 BC, who penetrated the plateau from the west, bringing with them agriculture of the Sudanic type (sorghum, cowpea, yam, okra, etc.) (Murdock, 1959 cited in Mulugeta Taye, 2008).

It has been grown in mid and high altitude areas ranging from 1880 to 2200 meters above sea level (Abebe Demissie, 1988) in the North, South and West of Ethiopia and is primarily cultivated for its tubers (Mulugeta Taye, 2008). The genus *Plectranthus* occurs both as wild and cultivated species. Thirty two wild species are found in Ethiopia (Hedberg *et al*., 2006). The wild species are found throughout the country (PGRC, 1995; IBC, 2007). These tubers are a good source of carbohydrates consumed after cooking (Mulugeta Taye *et al.*, 2007).

2.3. *Significance and Uses*

P. edulis has been grown and used as a major source of food in many parts of Ethiopia and is a main source of carbohydrates for the farming community specially in Northern part (EHNRI, 1997). The tubers are rich in energy and have a slightly higher carbohydrate concentration after cooking than Irish potato (EHNRI, 1997; Mulugeta Taye, 2008). The leaf is cooked and eaten as vegetable in some western parts of Ethiopia, particularly in the Kefa area (Zemede Asfaw and Zerihun Woldu, 1997) and also used as a traditional medicine to cure different diseases.

Additionally, farmers highly appreciate *P. edulis* and indicate it satisfies one's hunger better than other tuber crops. They believe that this tuber is very important for it makes them energetic, and leads them to have more children (Mulugeta Taye, 2008).

P. edulis is one of the most preferred foods and often served to esteemed guests. It is traditionally recommended as a special food in the community for people who are recovering from illness, probably owing to its high digestibility. It is also reported that it has no impact on the stomach whatever amount is consumed (Yeshitila Mekbib and Webiull, 2012).

Yeshitila Mekbib (2007) indicated that *P. edulis* is eaten during Meskel Holiday, a popular religious holiday in Ethiopia, as one component of the diversified dishes prepared for celebration. The cultivations of *P. eduils* tubers largely depend on these popular religious holidays. This is because, as a tradition, people start to eat *P. edulis* shortly after the end of this religious holiday. In addition to the above advantage, the dried stems are also used as firewood whenever there is shortage of wood. It is one of the main important tuber plants to reduce the consumption of other wood for the purpose of fire.

According to Yeshitila Mekbib and Webiull (2012), most farmers reported that *P. edulis* contributes less to household food security as compared to other root crops such as *Solanum tuberosum* and *Ipomoea batatas*. This is mainly attributed to its short shelf life. Because of this reason people use *P. edulis* to fill a gap during times of food shortage.

P. edulis has sufficient amounts of micro and macro nutrients with relatively higher food energy when cooked than *S. tuberosum*, and the fat and calcium contents are higher than that of *S. tuberosum*. In addition to the above unique properties, *P. eduils* also contains protein as much as twice that of *Ipomoea batatas* when cooked. Therefore, the cooked tubers have more energy, fiber and carbohydrate compared to the raw tuber (Yeshitila Mekbib and Webiull, 2012). However, the latter is richer in nitrogen, protein, calcium, phosphorous, iron and niacin than the cooked ones (EHNRI, 1997).

Table 2. Nutritional content of *Plectranthus edulis*, *Solanum tuberosum* and *Ipomoea batatas* (all values per 100 g of edible portion).

Composition	***P. eduils***		***S. tuberosum***		***I. batatas***	
	Raw	**Cooked**	**Raw**	**Cooked**	**Raw**	**Cooked**
Food energy (calories)	69.00	100.60	103.70	89.70	136.00	134.20
Moisture (%)	81.90	73.80	73.10	76.80	67.40	65.60
Nitrogen (g)	0.30	0.24	0.30	0.26	0.30	0.13
Protein (g)	1.50	1.00	1.30	1.10	1.30	0.50
Fat (g)	0.20	0.20	0.10	0.10	2.00	0.20

Composition	*P. eduils*		*S. tuberosum*		*I. batatas*	
	Raw	**Cooked**	**Raw**	**Cooked**	**Raw**	**Cooked**
Carbohydrate (incl. fiber) (mg).	15.30	23.70	24.40	21.10	28.20	32.60
Fiber (g)	0.70	1.00	1.40	0.90	1.10	1.50
Ash (g)	1.10	1.30	1.10	0.90	1.10	1.10
Calcium (mg)	29.00	19.00	14.00	9.00	52.00	35.00
Phosphorous (mg)	90.00	62.00	57.00	49.00	34.00	54.00
Iron (mg)	9.30	1.10	2.30	1.50	3.40	0.90
Thiamin (mg)	-	0.11	0.08	0.05	0.08	0.06
Riboflavin (mg)	-	0.32	0.08	0.09	0.05	0.01
Niacin (mg).	0.70	0.30	1.00	0.80	0.90	0.40

Source: Yeshitila Mekbib, 2007.

2.4. *Harvesting and Seed Tuber Storage*

Depending on the type of cultivar, the crop is harvested 6-8 months after planting. The harvesting time stretches from September to November. Tubers were harvested by digging them up with a digging hole. It takes place gradually depending upon the need of the family. Bulk harvesting can be done but the crop is more often harvested as needed. The process involves completely pulling up or digging out the plants. The tubers are long, brittle and finger-like and are easily broken (Mulugeta Taye *et al.*, 2012).

No research has been published on the effect of different storage conditions on the seed tuber performance of *P.eduils* (Mulugeta Taye, 2008); farmers store their produce (whether for consumption, sale or seed) in the production beds. This is the only traditional storage technique used. However, farmers' traditional knowledge and practice on seed tuber storage techniques are used like to keep the tubers alive until the next planting seasons by covering the fields with available mulching materials to protect them from direct sunlight (Yeshitila Mekbib, 2007). Farmers also store in the ground, i.e. in the place where the crop was planted, for a maximum period of five months, but usually for a shorter time (Mulugeta Taye *et al.*, 2007).

2.5. *Market Demand of Plectranthus Edulis in Ethiopia*

P. edulis is propagated vegetatively by tubers, and the seed tuber for planting was obtained from individually selected tubers of the previous harvest or bought in the market. Market demand is another selection criterion to use this tuber crop. The farmers usually sell their produce during two peak seasons. These are from September to November at harvest and during the planting time of March and April (Yeshitila Mekbib and Webiull, 2012).

Farmers reported that there is a direct relationship between palatability and shelf life. The early maturing cultivars often have larger tuber sizes but have relatively short shelf life. These cultivars can be consumed and sold only in the right physiological maturity (i.e. mostly in September). Otherwise the contents of the tubers will be changed to fiber. As a result, its market value will be low. Thus, farmers prioritize their local cultivars depending on their objective (i.e. for market or home consumption). Those local cultivars which can be consumed for a relatively long period of time without a significant reduction in their food qualities often get a better price regardless of season. As a matter of fact, it was common to see local cultivars with specific demands and price variation (Yeshitila Mekbib, 2007).

2.6. *Vegetative Propagation and Management Practices*

P. edulis has seeds which are brown or black, ovoid-shaped and smaller than 1.0 mm. The fruit consisted of four seeds included in the persistent calyx (Mulugeta Taye *et al.,* 2012). But, it is propagated vegetativelly by using the edible parts, i.e. the tubers, by planting 2−3 tuber pieces of a broken seed tuber in one planting hole. Cultural practices include tipping (removal of the apical stem parts), earthing up (piling up of the soil around the stems) and manuring (Mulugeta Taye *et al.,* 2007) also used during planting.

The tuber pieces, which can be planted as sprouted or unsprouted are principally obtained from the previous crop or market. Most farmers said that the cultivation technique of *P. edulis* is laborious (Yeshitila Mekbib and Webuil, 2012). But, in general traditional methods are considered to be complex in nature and take comparatively a longer period to produce a variety with desired characters (Grafius and Douches, 2008).

2.7. *Major Problems Associated with P. edulis Production*

Propagation from vegetative parts, grafting and sap can transmit viruses from one plant to another. Many varieties of vegetativelly propagated crops decline in performance with viral accumulation and must be discarded. Since the viruses do not produce visible symptoms, they cannot be destroyed by using plant protection chemicals. However, the presence of viruses in plants can reduce the yield and results in poor quality of crops (IAEA, 2004). The use of virus resistant varieties or eradicated disease free initial seed production material is preferred for avoiding crop yield or quality losses (Danci *et al.*, 2011).

In some areas, the most important economic damage to potato is caused by insects and nematodes, which loses quality and becomes susceptible to soil pathogens (Gregory, 1977). *P. edulis* plant is attacked by diseases and insect pests like other vegetativelly propagated tubers. A variety of methods now exist for crop improvement, among them genetic transformation is the one. Novel gene sequencing, cloning and insertion, as well as functional genomics, are tools that will benefit the improvement of economically important potato cvs. and dihaploid genotypes through reliable transformation protocols (Tican *et al.*, 2007). Genetic transformation is an important tool in addressing increasing worldwide demands for crops with higher agricultural production and more nutritional value. For a genetic transformation system to be effective, it is not only necessary to have a suitable transformation mechanism to deliver the foreign DNA, but it is also essential to develop a rapid and efficient regeneration protocol (Chakravarty *et al.*, 2007). Because, establishment of an efficient *in vitro* regeneration protocol is a pre-requisite to facilitate successful plant genetic transformation (Soto *et al.*, 2007). Hence, it is better to develop an effective *in vitro* regeneration protocol for *P. eduils* for further work like other tuber plants.

2.8. *Tissue Culture*

Plant Tissue Culture is the science of aseptic (free from any microorganisms) growing of any plant protoplast, cell, tissue and organ from mother plant on sterilized artificial growth media (Singh, 2000; George *et al.*, 2008). It produces elite plants for multiplication, disease free and stable plants with well-developed root system and their establishment and growing capacity are very high. It is also important for production of high quality planting material which is uniform, healthy, disease free and having accelerated growth (Neal, 2008).

It is classified into two; namely: cultures of unorganized tissues and cultures of organized tissues. Cultures of unorganized tissues are: callus cultures, cell suspension cultures, protoplast culture and microspore culture. In another cases, culture of shoot, root, embryo, nodal, leaf sheath, fruit and flower cultures are classified as cultures of organized tissues (George *et al*., 2008).

Tissue culture provides need of embryo culture (rescue) in which viable offspring is obtained from seeds with a tendency for embryo abortion or when a viable seeds are limited in number (Gamborg and Phillips, 1995). It offers several advantages over conventional propagation techniques.

It enables to produce millions of uniform and disease or pathogen free plants from a single explant and this has got a great advantage in realizing improved varieties within a short period of time for commercial as well as consumption purpose (Neal, 2008).

Plant tissue culture techniques are also central to ground-breaking areas of applied plant science, including plant biotechnology and agriculture. For example, selected plants can be cloned and cultured as suspended cells from which plant products can be harvested (Mineo, 1990).

2.9. *Tissue Culture of P. Edulis*

Micro propagation of *P. edulis* has been reported by many researchers like Mesfin Tsegaw, 2012 Belete Kebede and Balcha Abera, 2014 and Nitsuh Aschale and Tiley Feyissa, 2019). I*n vitro* plant regeneration from cells, tissues, and organ cultures is a fundamental process for the application of plant biotechnology to plant propagation, plant breeding and genetic improvement (Alejo, 2001).

Callogenesis and plant regeneration from cultured tissue explants are basic requirements for the application of tissues culture for genetic improvement. It can be regenerated from explants such as leaves, stems, petioles and tubers following an intermediate callus phase (Prematilake and Mendis, 1999).

Callus formation is central to many investigative and applied tissue culture procedures. It is a potential source to create genetic variability in micropropagated plants (Yasmin *et al.*, 2011). Additionally, callus can be multiplied and later used to clone numerous whole plants. Various genetic engineering protocols employ callus initiation procedures after DNA has been inserted into cells; transgenic plants are then regenerated from transformed callus. In other protocols, callus is generated for use in biotechnological procedures such as the formation of suspension cultures from which valuable plant products can be harvested (Mineo, 1990).

In addition to the above advantages, today availability of this method for *in vitro* callus culture opens new possibilities for establishing a continuous cell culture system for easy and rapid isolation of bioactive compounds. Large scale suspension cultures, in a manner similar to that of microbial fermentation, will be suitable for industrial production of useful plant-derived photochemical commonly used as pharmaceutics, cosmetics and food additives (Sutan *et al.*, 2010). This is one of the decisive indications for other important plants in order to extract chemicals by using continuous subculture of callus.

On other cases, plants can be regenerated from protoplasts which have more variability than those directly regenerated from other explants (Jones, 1994). Accordingly, some authors have argued that plants regenerated from direct somatic embryogenesis and organogenesis ought to contain fewer mutations than those regenerated via callus phase (Gloriada *et al.*, 1999).

Hence, indirect organogenesis is often associated with somaclonal variation (Chen and Henny, 2006). But, plants regenerated through callus culture are genetically identical to the source materials free from pathogen and it is possible to produce a huge number of plantlets in a very short period of time. It is also a pre-requisite to facilitate successful plant genetic transformation (Soto *et al.*, 2007) and identify factors that affect transformation (Tileye Feyissa *et al.*, 2007).

According to Gonzalez *et al.* (1999), leaves had a higher regeneration frequency compared to stem. Therefore, it considers that leaves are suitable target explants in transformation studies based on this organogenesis-mediated protocol. In addition to the above, *in vitro* regeneration is fundamental to protect the aseptic culture from infection and to prevent desiccation of the plant and the nutrient medium, because it is carried out in closed vessels, which unintentionally restrict the exchange of gases between the vessel atmosphere and the outside air (Joosten and Woltering, 1994).

Liu *et al.* (1993), states that genetic transformation offers great potential for improving the disease or pest resistance and nutrition quality of sweet potato (*Ipomoea batatas* (L) Lam.). Additionally, somaclonal variation in potato calli can be utilized to find suitable variants with desired characters, such as drought or salt stress tolerance (Ehsanpour *et al*., 2006 cited in Munir *et al*., 2011). It is an appropriate method to eliminate fungus and bacteria. It is also useful in genetic variation and selection for desired trials performed *in vitro* (Khatun *et al*., 2003).

In potato transformation, early identification of somaclonal variants can be beneficial in eliminating undesired variants that may affect morphological characters and agronomic functions (Munir *et al.*, 2011). Hence, an efficient regeneration protocol from the callus cultures is a pre-requisite for successful application of genetic engineering technologies for crop improvement in potato (Tejavathi and Indira, 2013; Yasmin *et al*., 2003).

III. Conclusion

P. eduils is one of the local tubers in Ethiopia and has a long history of local usage. It is important to the cultural, social and economic life of households and cure different diseases. The application of genetic engineering technologies creates new opportunity for improvement of this crop.

References

[1] Abebe Demissie (1988). Potentially valuable crop plants in a Vavilovian center of diversity: Ethiopia. pp. 89-98 in *Crop Genetic Resources of Africa*.
[2] Alejo, N.O. and Malagon, R.R. (2001). *In vitro* chili pepper biotechnology. *In Vitro Cell. Dev. Biol. Plant* **37**: 701-729.
[3] Andargachew Gedebo, Admasu Tsegaye, Girma Akalu, Asmund, B. and Maigull, A. (2011). Nutrient composition and effect of processing on antinutritional factors and mineral bioavailability of cultivated *amochi* in Ethiopia. Ethiopian Health and Nutrition Research Institute, Addis Ababa, Ethiopia. *J. Sci. Develop.* **1**: 21-29.
[4] Chen, J. and Henny, R. J. (2006). Somaclonal variation: An important source for cultivar development of floriculture crops. *IJPFR*. **1**: 14-22.
[5] Danci, O., Baciu, A., and Danci, M. (2011). Potato (*Solanum tuberosum* (*L.*)) regeneration using the technique of meristem tip culture. *J. Hort., For. and Biotechnol.* **15**: 175-178.
[6] Edison, S., Unnikrishnan, M., Vimala, B., Santha, V.P, Sheela, M.N., Sreekumari, M.T. and Abraham, K. (2006). Biodiversity of tropical tuber crops in India. National Biodiversity Authority, Chennai, India.
[7] EHNRI (Ethiopian Health and Nutrition Research Institute). (1997). Food composition table for use in Ethiopia. Ethiopian Health and Nutrition Research Institute, Addis Ababa. *Japan J. Breed*. **38**: 205-211.

[8] Ehsanpour, A.A, Madani, S., Hoseini, M. (2006). Detection of somaclonal variation in potato callus induced by UV-C radiation using RAPD-PCR. *General. App. Plant Physiol.* **33**: 3-11.

[9] Gamborg, O.L. and Phillips, G. C. (1995). Embryo Culture or Embryo Rescue for Wide Cross Hybrids. Text-books for Trai1.ning, Education and Research in Applied and Basic Plant Biotechnology. Springer-Verlag, New York.

[10] Ganesan, M. and Jayabalan, N. (2005). *In vitro* plant regeneration from the callus of shoot tips in cotton (*Gossypium hirsutum* L. cv. SVPR 2). *Iranian J. Biotechnol.* **3**: 620-624.

[11] George, E. F., Michael, A. H., and Klerk, G. J. (2008). Plant Propagation by Tissue Culture, 3rd edition, pp 1-28. Spring, Netherland.

[12] Gloriada, A. B., Vieira, C. L. M., and Dornelas, C. M. (1999). Anatomical studies of *in vitro* organogenesis induced in leaf-derived explants of passion fruit. *Pesq. Agropec. Bras. Brasília.* **34**: 2007-2013.

[13] Grafius, E. J. and Douches, D. S. (2008). The present and future role of insect-resistant genetically modified potato cultivars. pp. 195-22. **In**: Integration of Insect Resistant Genetically Modified Crops within IPM Programmes. Romeis, J., Shelton, A. M., Kennedy, G. G. (eds.), Springer Science B.V.

[14] Hedberg, I., Ensermu Kelbessa, Edwards, S., Sebsebe Demissew and Persson, E. (2006). *Flora of Ethiopia and Eritrea*, Vol. 5. The National Herbarium. Addis Ababa, Ethiopia.

[15] IBC (Institute of Biodiversity Conservation). (2005). National Biodiversity Strategy and Action Plan. Addis Ababa.

[16] IBC (Institute of Biodiversity Conservation). (2007). Second Country Report on the State of Plant Genetic Resources for Food and Agriculture to FAO. Addis Ababa.

[17] Jones, M. G. K. (1994). *In vitro* culture of potato. **In**:"*Plant Cell and Tissue Culture*" pp. 363-378 (Vasil, K. and Thorpe, T. A., eds.). Kluwer, Netherlands.

[18] Joosten, B.M.C. and Woltering, E.J. (1994). Components of the gaseous environment and their effects on plant growth and development *in vitro*. Agrotechnological Research Institute Wageningen, Netherlands.

[19] Khatun, N., Bari, M.A., Islam, R., Huda, S., Siddique, N.A., Rahman, M.H., and Mollah, M.U. (2003). Callus induction and regeneration from nodal segment of potato cultivar Diamant. *J. Biol. Sci.* **3**: 1101-1106.

[20] Liu, Q.C., Luo, J.Q., Zhou, H.Y. and LU, S.Y. (1993). High frequency of somatic embryogenesis and plant regeneration in sweet potato (*Ipomoea batatas* (L.) Lam.). *J. Agr. Biotechnol*. **1**: 84-89.

[21] Lukhoba, C.W., Simmonds, M.S.J. and Paton, A. P. (2006). *Plectranthus*: A review of ethnobotanical uses. University of Nairobi, Nairob. *J. Ethnopharmacology* **103**: 1–24.

[22] Mesfin Tsegaw (2012). Micro propagation of *Plectranthus edulis* (Vatke) Agnew from Meristem Culture. M. Sc. Thesis. Addis Ababa University, Addis Ababa.

[23] Mineo, L. (1990). Plant tissue culture techniques. **In:** Tested studies for laboratory teaching. **11**: 151-174.

[24] Moa Megersa, Zemede Asfaw, Ensermu Kelbessa , Abebe Beyene and Bizuneh Woldeab (2013). An ethnobotanical study of medicinal plants in Wayu Tuka District, East Welega Zone of Oromia Regional State, West Ethiopia. Journal of Ethnobiology and Ethnomedicine; 9:68.

[25] Mulugeta Taye (2008). Studies on agronomy and crop physiology of *Plectranthus edulis* (Vatke) Agnew. Ph.D. Thesis. Wageningen University, Wageningen.

[26] Mulugeta Taye, Lommen, W. J. M. and Struik, P. C. (2007). Indigenous multiplication and production practices for the tuber crop *Plectranthus edulis* in Chencha and Welaita, Southern Ethiopia. *Expl. Agric*. **43**: 381–400.

[27] Mulugeta Taye, Lommen, W. J. M. and Struik, P. C. (2012). Ontogeny of the tuber crop *Plectranthus edulis* (*Lamiaceae*). *African J. Agric. Res.* **7**: 4236-4249.

[28] Munir, F., Naqvi, S.M.S. and Mahmood, T. (2011). *In vitro* culturing and assessment of somaclonal variation of *Solanum tuberosum* var. desiree. *Turk J. Biochem*. **36:** 296–302.

[29] Murdock, G. P. (1959). Africa, its peoples and their culture history, New York. **In**: Westphal, E. 1975. Agricultural systems in Ethiopia. Agricultural Research Reports 826. Centre for Agricultural Publishing and Documentation, Wageningen.

[30] Neal, C. S. J. (2008). Plant Biotechnology and Genetics: Principles, Techniques, and Applications. USA, New Jersey.

[31] Nitsuh Aschale and Tileye Feyissa (2019). *In vitro* regeneration of *Plectranthus edulis* (vatke) from leaf derived callus. International Journal of Research in Agricultural Sciences: 6(2); 2348-3997.

[32] Paton, A.J., Springate, D., Suddee, S., Otieno, D., Grayer, R.J., Harley, M.M., Willis, F., Simmonds, M.S.J., Powell, M.P., Savolainen, V. (2004). Phylogeny and evolution of basils and allies (Ocimeae, Labiatae) based on three plastid DNA regions. *Molecular Phylogenetics and Evolution* **31**: 277–299.

[33] PGRC (Plant Genetic Resources Center). (1995). Ethiopia: country report to the FAO international technical conference on plant genetic resources. Addis Ababa, Ethiopia.

[34] Prematilake, D. P. and Mendis, M. H. (1999). Microtubers of potato (*Solanum tubersoum* L.): *In vitro* conservation and tissue culture. *J. Nat. Sci. Foundation Sri Lanka* **27**: 17-28.

[35] Singh, B. D. (2000). Plant Breeding Principles and Methods. 6 ed. Kaliyani, New Delhi.

[36] Soto, N., Enriquez, G. A., Ferreira, A., Corrada, M., Fuentes, A., Tiel, K. and Pujol, M. (2007). Efficient transformation of potato stem segments from cv. Desiree using phosphinothricin as selection marker. *Biotechnol. App.* **24**: 139-144.

[37] Sutan, A. N., Popescu, A. and Isac, V. (2010). *In vitro* culture medium and explants type effect on callogenesis and shoot regeneration in two genotypes of ornamental strawberry. *Romanian Biotechnol.* **15**: 1

[38] Taye, M., Lommen, W. J. M. and Struik, P. C. (2013). Crops and Soils Research Paper Effects of Breaking Seed Tubers on Yield Components of the Tuber Crop *Plectranthus Edulis*. Journal of Agricultural Scienc; 151: 368–380.

[39] Tejavathi, D. H. and Indira, M. N. (2013). Regeneration of shoots from leaf callus cultures of *Drymaria cordata* (L.) Willd ex Roem and Schult. *Indian J. Funda. and App. Life Sci.* **3**: 111-115.

[40] Tican, E.R., Aurori, C.M., Dijkstra, C., Thieme, R., Aurori, A., Davey, M.R. (2007). The usefulness of the *gfp* reporter gene for monitoring *Agrobacterium*-mediated transformation of potato dihaploid and tetraploid genotypes. *Plant Cell Rep.* **26**: 661–671.

[41] Tileye Feyissa, Zhu, L.H., Legesse Negash and Welander, M. (2007). Regeneration and genetic transformation of *Hagenia abyssinica* (Bruce) J.F. Gmel. (Rosaceae) with rol B gene. *Plant Cell Tiss. Organ Cult*. **88**: 277–288.

[42] Wharton, P. and Kirk, W. (2007). Potato diseases. Department of Plant Pathology, Michigan State University, Michigan.

[43] Yasmin, A., Jalbani, A. A. and Kumar, R. (2011). Regeneration potential of 6-benzyl amino purine (BAP) induced calli of *Solanum tuberosum. Pak. J. Agri., Agril. Engg. Vet. Sci.* **27**: 13-17.

[44] Yasmin, S., Nasiruddin, K. M., Begum, R., and Talukder, S. K. (2003). Regeneration and establishment of potato plantlets through callus formation with BAP and NAA. *Asian J. plant Sci.* **2**: 936-940.

[45] Yeshitila Mekbib (2007). Phenotypic variation and local customary use of Ethiopian potato (*Plectranthus edulis* (Vatke) Agnew). M. Sc. Theses. Uppsala University, Sweden.

[46] Yeshitila Mekbib and Webuil, J. (2012). Local customary use and management of Ethiopian potato (*Plectranthus edulis* (Vatke) Agnew in Sodo Zuria District, South Ethiopia. *Ethnobot. Res. & App.* **10:** 381-387.

[47] Zemede Assefaw and Zerihun Woldu (1997). Crop associations of home-gardens in Welayta and Gurage in Southern Ethiopia. *SINET: Ethiop. J. Sci*. **20:** 73-90.

AUTHOR'S PROFILE

First Author
Nitsuh Aschale, Researcher of Plant Biotechnology, Ethiopian Agricultural Research Institute, National Agricultural Biotechnology research center P.O. Box, 249, Skype: 0910679714, Tel: +251112610095, Holeta, Ethiopia.
email id: nitsuhbiotech@yahoo.com

Second Author
Kalkidan Tesfu, Researcher of Plant Biotechnology, Ethiopian Agricultural Research Institute, National Agricultural Biotechnology research center, P.O. Box, 249, Tel: +251112610095, Holeta, Ethiopia. email id: kalkidantesfu11@gmail.com