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A New Nutrient Rich Biofortified Greater Yam Variety: Gujarat Greater Yam-1 (Hemlata)

Biofortified greater yam assumesan important role in achieving food security and prevent malnutrition and hunger issue in the population. About 800 million people suffer from hunger, but even more suffer from micronutrient malnutrition, also called "hidden hunger". Among these, iodine, vitamin A, iron and zinc malnutrition are the major concerns. Biofortification provides a comparatively cost-effective, sustainable and long-term means of delivering more micronutrients in relatively remote rural areas and it also delivers naturally-fortified foods to population groups with limited access to commercially-marketed fortified foods (Gomathi et al., 2017). Root and tuber crops, including cassava, sweet potato, greater yams, potato, cocoyam and other minor tuber crops are important to the agriculture and food security of many countries and are the major component of the diet for the billions of people as well as contributes to the animal feed and industry.

Greater yam belongs to genus *Dioscorea* of the family Dioscoreaceae under monocotyledons and are commonly known as yams. Out of the six commercially important edible species of yams, greater yam (*Dioscorea alata* L.) popularly known as *Ratalu*, is the most important edible yam in many parts of the world. Greater yam has a chromosome number of 2n=4x=40, a natural tetraploid and is a native of South-eastern Asia. Greater yam has superior characteristics like high yield potential (especially under low and average soil fertility), ease of propagation and higher shelf life of tubers. It is a sun loving plant and commercially propagated vegetatively through tubers. Many of the *Dioscorea*species serve as a 'life saving' plant group for the marginal farmers and forest dwelling communities, during periods of food scarcity. In India it is extensively cultivated in Madhya Pradesh, North-eastern states, West Bengal, Bihar, Odisha, Uttar Pradesh, Kerala, Tamil Nadu, Gujarat and Maharashtra as a commercial crop. In Gujarat, it is mainly cultivated in the districts of South and middle Gujarat. The edible portion ismainly rich in carbohydrates along with a good amount of minerals. It contains 18-20% starch with a mucilaginous substance and is extracted on a commercial basis. It also contains quite a good amount of alkaloids and steroids having pharmaceutical value and is used in Ayurvedic, Unani and Homoeopathy medicinal preparations. Besides, it is also ideal for fries, chips and flakes.Crop bio-fortification is a process which involves concentration of target nutrients in plants. By clonal propagation, we can choose parent line with a naturally high concentration of the target nutrient, which increases the availability of the nutrient to fight against malnutrition (Muthulisi et al., 2020). Besides the challenges, biofortified plants holds a bright future to address the malnutrition challenge (Garg et al., 2018).

The All India Coordinated Research Project on Tuber Crops (AICRP TC) is running in the Department of Vegetable Science, ASPEE College of Horticulture, Navsari Agricultural University (NAU), Navsari, Gujarat, has conducted amulti-location trial (MLT) on Gujarat Greater Yam-1 and it was evaluated during two seasons, *viz.*, 2016-2017and 2018-2019 at Navsari and Waghaicentre. The experiment was conducted in a randomized block design (RBD) with three replications. The spacing adopted was 90×90 cm. The purple flesh variety of greater yam was clonally selected and biochemically analyzed at Central Instrument Laboratory, Soil Science & Agricultural Chemistry, N.M.C.A., NAU, Navsari. The ISSR profile of 27 greater yam genotypes including the genotype, NGy-7 (Gujarat Greater Yam-1: Hemlata)was generated by using the primer, UBC-808 and the RAPD profile using the primer OPB-6. The twenty seven genotypes used for the study are given below:

1.	NGy-1	2.	NGy-2	3.	NGy-3	4.	NGy-4
5.	NGy-5	6.	NGy-6	**7.**	**NGy-7**	8.	NGy-8
9.	NGy-9	10.	NGy-10	11.	NGy-11	12.	NGy-12
13.	NGy-13	14.	NGy-14	15.	NGy-15	16.	NGy-16
17.	NGy-17	18.	IGDa-2	19.	IGDa-3	20.	IGDa-4
21.	Da-11	22.	Da-25	23.	Sree Roopa	24.	Da-199 (Sree Karthika)
25.	TRC	26.	Sree Keerthi	27.	Konkan Ghorkand		

Hemlata's plant type is climbing, skin colour of tuber is dark brown, shape of tuber is long and flesh colour of tuber is dark purple. It had recorded an average tuber yield of 18.48 t ha^{-1} which was 28.24% higher than the national check (NC) variety, Sree Karthika (14.41 t ha^{-1}). The purple flesh tuber of this clone is rich in total soluble sugars, crude fibre, anthocyanins, as well as the minerals phosphorus, potassium, ferrous, zinc and copper and

low in the anti-nutritional factor Diosgenin as compared to Sree Karthika (Table 1). The composition of the tuber on fresh and dry weight basis was as follows: anthocyanin (0.76 and 2.07 mg g^{-1}, respectively), crude fibre (1.14 and 3.20%, respectively), phosphorus (3.17 and 9.02%, respectively), potassium (5.84 and 17.53%, respectively), ferrous (0.80 and 2.53 mg kg^{-1}, respectively), zinc (0.08 and 0.23 mg kg^{-1}, respectively) and copper (0.07 and 0.20 mg kg^{-1}, respectively). The total soluble sugars (1.68%) was higher on fresh weight basis. It also recorded a total soluble sugar of 4.29% on dry weight basis.

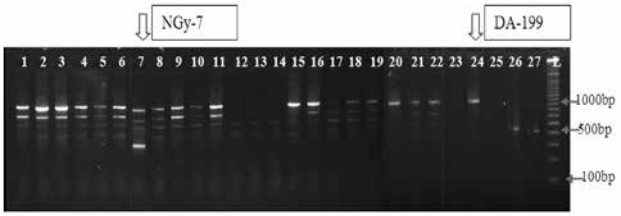
Anthocyanins are water soluble pigments which play a significant role in reproduction by attracting pollinators and act as protectants against biotic and abiotic stresses. In Gujarat Greater Yam-1 (Hemlata) variety, anthocyanin content was higher *i.e.*, 0.76 mg g^{-1} on fresh weight basis and 2.07 mg g^{-1} on dry weight basis than the variety Sree Karthika which had 0.31 and 1.01 mg g^{-1} respectively, of total anthocyanins.

These days, horticulture is moving from producing more quantity of food crops to producing nutrient-rich edible crops in sufficient quantities which will help in fighting the hidden hunger or micronutrient malnutrition especially in developing countries, where diets are dominated by micronutrient-poor staple food crops. Nutritional targets for biofortification include elevated mineral content, improved vitamin content, increased essential amino acid levels, better fatty acid composition, and heightened antioxidant levels in crops which are consumed by the poverty-stricken population of the world,which can significantly improve the amount of nutrients consumed by this target population (Garg et al., 2018). Food security, as defined by the Food and Agriculture Organization (FAO) of the United Nations, exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Cathie et al., 2011). From Table 1, it is clearly seen that Gujarat Greater Yam-1 variety released as in the name 'Hemlata' contains appreciable amounts of mineralsin the tubers (Fig. 1).

Fig. 1. Anthocyanin rich tuber of Gujarat Greater Yam-1(Hemlata)

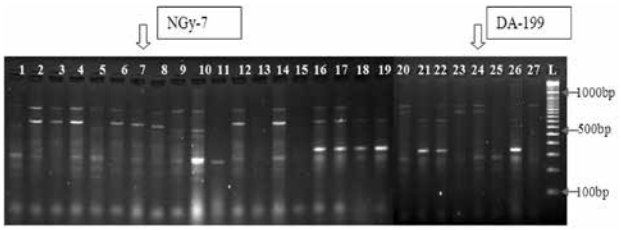
Tab. 1. Proximate composition and quality parameters (on fresh and dry wt. basis) of Gujarat Greater Yam-1 and Sree Karthika

Sl. No.	Parameter	Gujarat Greater Yam-1		Sree Karthika (NC)	
		fresh wt. basis	dry wt. basis	fresh wt. basis	dry wt. basis
1.	Total carbohydrates (%)	21.17	60.65	23.83	85.34
2.	Starch (%)	19.13	55.00	21.02	79.67
3.	β-carotene (μg g^{-1})	0.65	1.88	0.67	1.78
4.	Total soluble sugars (%)	1.68	4.29	1.24	5.11
5.	Crude fibre (%)	1.14	3.20	1.13	3.05
6.	Total anthocyanins (mg g^{-1})	0.76	2.07	0.31	1.01
7.	Phosphorus (%)	3.17	9.02	2.81	8.54
8.	Potassium (%)	5.84	17.53	4.18	13.83
9.	Fe (mg kg^{-1})	0.80	2.53	0.28	0.83
10.	Zn (mg kg^{-1})	0.08	0.23	0.07	0.18
11.	Cu (mg kg^{-1})	0.07	0.20	0.03	0.10
12.	Diosgenin (%)	0.09	0.28	0.14	0.93



RAPD profile of 27 greater yam genotypes generated by using primer OPB-6

Fig. 2. DNA finger printing of genotype NGy-7 (Gujarat Greater Yam-1: Hemlata) with primer OPB-6



ISSR profile of 27 greater yam genotypes generated by using primer UBC-808

Fig. 3. DNA finger printing of genotype NGy-7 (Gujarat Greater Yam-1: Hemlata) with primer UBC-808

The results are in agreement with the findings of Cathie et al., (2011), Gomathi et al., (2017), Garg et al., (2018), Parulekar et al., (2019) and Muthulisi et al., (2020).

In DNA Fingerprinting analysis, many cultivars showedunique fingerprint patterns indicating the utility of DNA finger printing incultivar identification. DNA fingerprinting profile of greater yam genotypes was carried out which is depicted in Fig. 2 and Fig. 3. It showed that genotype NGy-7 (Hemlata) is genetically distinct from the check variety, Sree Karthika (DA-199).

Combating micronutrient malnutrition is considered to be amongst the best investments that generate a high return socio-economic benefits according to 2008 Copenhagen consensus. The consensus listed bio-fortification, a method of breeding crops to increase their nutritive value, as one of its top five investments to address global challenges. Diversified and highly nutritive tuber crops are an affordable source for the poor people in the maintenance of their health and prevention of disease and have great potential in handling malnutrition and hunger issues. The nutrient rich bio-fortified greater yam variety, 'Hemlata' which was recommended for commercial cultivation for the state of Gujarat is possibly one of the ecofriendly and cost effectivesolution of malnutrition. Development as well as production and consumption of bio-fortified tuber crops needs to be popularized for preventing and controlling various health related issues also. So, this variety can help to achieve this goal to some extent.

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