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Comparative evaluation of *Dioscorea bulbifera* genotypes grown in Western Himalayas

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Abstract
Dioscorea bulbifera (aerial yam) is a valuable species of Western Himalayan region used for food and in traditional medicine. Assessment of the genetic variability of a plant species can contribute significantly to the crop conservation and improvement. Tubers of *Dioscorea bulbifera* were randomly collected from 6 different agro-ecological zones of Uttarakhand State for the study. Qualitative and quantitative morphological traits, and yield parameters were assessed to evaluate genetic diversity in *Dioscorea bulbifera* genotypes from different agro-ecological regions. Desirable agronomic traits such as bulbil yield, higher number of bulbils per plant, greater bulbil weight, higher number of branches on the main stem were used for selection of superior genotype. Genotype DG5 was the most productive with bulbil yield of 2213 g/plant. The least productive genotype was DG1 with bulbil yield of 291 g/plant. Varietal diversity was observed in *Dioscorea bulbifera* cultivated at different locations in the Western Himalaya.

Keywords: Dioscorea bulbifera, genotypes, bulbils, yield, morphological traits

1. Introduction
The Western Himalayan region in India is rich in plant biodiversity and the tribal communities are dependent on local flora for their food and medicine. A number of wild and native vegetable crops have excellent medicinal and nutritional properties. Roots and tubers are cultivated and consumed widely in rural areas and contribute significantly for food security and traditional medicine.

Dioscorea bulbifera L. is a crop of significant food and medicinal value cultivated in the Western Himalayas [1]. *Dioscorea bulbifera* belongs to the family Dioscoreaceae and is also known as aerial yam or air potato. It is characterized by edible aerial bulbils which develop at the base of the leaf petioles [2, 3]. It is a glabrous, non-spiny, annual climber plant species originating from Asia and Africa [4, 5].

Yams (*Dioscorea* spp.) are one of the world's most important tuber with high food and economic potential [6]. Nutritionally, yam tubers contain mainly starch and serve as the staple carbohydrate source for millions of people [7]. Other essential dietary nutrients in *Dioscorea* species are proteins, lipids, vitamins, and minerals [8]. It is consumed in different forms like boiled, pounded, fried or roasted [9]. Yam is a major source of energy in the diet of most people in the tropics. Dietary calories, more than 200 per capita daily is contributed by yam to more than 150 million people in West Africa[10]. It is consumed as food by about 300 million people throughout the world [11].

Different parts of aerial yam plant have profound therapeutic potential and are used in traditional and modern medicine [12, 13]. It is used in traditional Indian, African and Chinese medicine for the treatment of sore throat [14]. In India, tubers are used for treatment of piles, dysentery, inflammation and ulcers. Tubers of *Dioscorea bulbifera* possess diuretic and antihelmintic properties [15]. They are also used for healing of wounds, cuts and boils [16]. Stems and leaves of *Dioscorea bulbifera* are used for treatment of conjunctivitis, diarrhoea and dysentery [17]. Crushed bulbils and tubers are mixed with palm oil and used for relieving rheumatic pain [18].

Dioscorea bulbifera with wide spectrum of benefits requires conservation of useful plant genetic resource germplasm. Characterization and evaluation of available germplasm is required to assess genetic variability for its improvement and conservation. The objective of this study was to evaluate genetic variability in *Dioscorea bulbifera* cultivated in diverse agro-ecological Western Himalayan region.

2. Materials and Methods
Collection of Plant Material
Planting material consisted of the bulbils of *Dioscorea bulbifera* collected from different locations of the Western Himalayan regions to obtain exhaustive genotypes. Six villages located in diverse agro-ecological zones in Uttarakhand state of India were randomly selected for collection of planting material. The collection sites were Auli (30.53°N, 79.57°E), Bageshwar (29.84°N, 79.77°E), Champawat (29.33°N, 80.10°E), Dharchula (29˚50′54″N, 80°32′34.8″E), Munsiyari (30.07°N, 80.24°E) and Pithoragarh (30º00′N, 80°20′E). The elevations are 2800 m for Auli, 1004 m for Bageshwar, 1615 m for Champawat, 915 m for Dharchula, 2200 m for Munsiyari and 1627 m for Pithoragarh above sea level. Tubers of varying sizes were selected for each genotype by simple randomization from a bulk of freshly harvested tubers. Approximately, 100 tubers were collected from each genotype for the field experiments.

Field Experiment
The study was conducted during 2019 and 2020 in the experimental field of DIBER Field Station, Pithoragarh, India. The experimental site is located at 30°00′N latitude and 80°20′E

longitude and at a mean altitude of 1627 m above sea level. Selected seeds of 6 genotypes of *Dioscorea bulbifera* from Auli (DG1), Bageshwar (DG2), Champawat (DG3), Dharchula (DG4), Munsiyari (DG5) and Pithoragarh (DG6) were sown at seed row distance of 1.5 m and seed to seed distance of 1.5 m. Data on plant growth and fruiting were recorded periodically. Average length of plants of different genotypes was recorded at 80 and 110 days after sowing. Fruits of *Dioscorea bulbifera* were harvested at 165 days. Yield was recorded in different genotypes.

Evaluation of Qualitative and Quantitative Traits

The qualitative and quantitative traits of different genotypes of *Dioscorea bulbifera w*ere assessed. The qualitative traits for stem consisted of colour of the young stem, colour of mature stem, roughness, thorniness and the twining direction. In leaves, the colour of the young leaf, colour of the adult leaf, leaf type and shape, leaf lobes, leaf vein colour of upper surface, leaf vein colour of lower surface and colour of mature petioles were recorded. The shape, skin colour and surface texture were recorded for bulbils of different genotypes. Observations for quantitative traits for stem, leaves and bulbils were based on the average measurement of various phenotypic characters in each individual plant. The number of branches per plant on main stem, the diameter of stem, number of leaves per meter length of the plant, length of the leaves, width of the leaves, average diameter of bulbil and the average thickness of bulbil from the selected plants were measured.

Statistical Analysis

Field experiment was laid out in Random Block Design with 25 replicates for each of the six evaluated *Dioscorea* genotypes. The data on morphological traits and yield and, yield attributing traits were analyzed for Analysis of Variance (ANOVA) using Crop Stat program developed by IRRI, Philippines. The mean values were compared for statistical significance using Duncan's New Multiple Range Test (DNMRT) at $P \leq 0.05$.

3. Results and Discussion

Performances of six *Dioscorea* genotypes collected from different locations were evaluated for morphological and, yield and yield attributing traits under field conditions during the months of March to October in 2019-2020 at DIBER Field Station Pithoragarh, Uttarakhand, India. The morphological characteristics of young stem and mature stem of different genotypes of *Dioscorea bulbifera* is presented in Table 1. Colour of the young stem was purplish green in DG1; pale green in DG2; green in DG3, DG6; brownish green in DG5 and brown in DG4 (Figure 1). However, the stem colour at maturity was green in all the genotypes Thorns were not observed on the stems of all the 6 genotypes. However, pointed and small outgrowths were observed in *Dioscorea bulbifera* genotypes DG2 and DG3. Clockwise twining direction was observed in all the genotypes.

Morphological characteristics of the leaves of different genotypes are presented in Table 2. Simple, large, elongate, alternate, embossed, ovate and broad leaves with smooth margin were observed in all the genotypes with variation in the colour of the young leaf. Colour of the young leaf was purplish green in genotype DG1, DG3, DG4; brown green in DG2; pale green in DG5 and yellow in DG6 (Figure 2). Variable lobe shapes in the leaves of different genotypes were recorded. The 2 lobes are

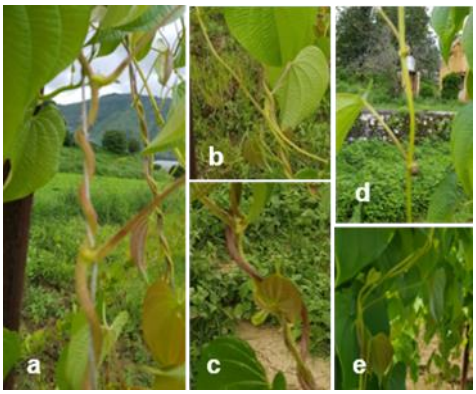

Fig 1: Morphological features of stem of different *Dioscorea bulbifera* genotypes (a) purplish green with clockwise twining direction; (b) brownish green (c) brown (d) pale green (e) green

Round oval in shape near petiole attachment in DG1, DG4, DG5 and DG6. However, the 2 lobes are round in shape in DG2 and DG3. Leaf apex is acute in all the genotypes. Petiole is brownish green with dark brown spot at base in DG1, green with brownish base in DG2, pale green with purple base in DG3, green with purple base and red spots on some points in DG4, green when young and yellowish green at maturity in DG5 and green with purple base in DG6. Shape, colour and texture of bulbils of different genotypes of *Dioscorea bulbifera* were recorded (Table 3). Bulbils were irregular round shape with rough texture in genotypes DG1, DG2 and DG5. Light brown skin colour and smooth texture of bulbils was observed in DG3, DG4. Bulbils in DG6 were characterized by rough and wrinkled texture (Figure 3). Flesh colour of the bulbils is yellow in genotypes DG1, DG2, DG3, DG4 and creamish in genotypes DG5, DG6.

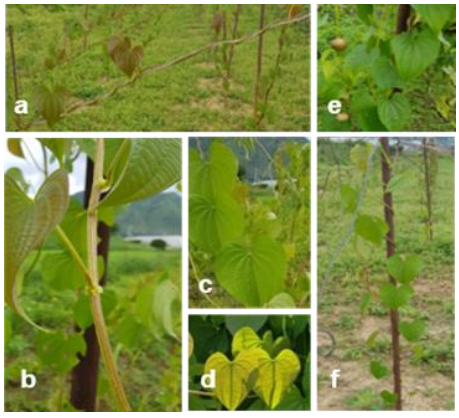

Fig 2: Morphological features of leaves of different *Dioscorea bulbifera* genotypes (a) young leaves brown green; (b) young leaves purplish green; (c) young leaves pale green; (d) young leaves yellow; (e) Mature leaves green; (f) alternate leaves

Genotypic differences for the morphological traits were evaluated. *Dioscorea* genotypes showed differences for the various studied morphological traits (Table 4). Number of

branches per plant on the main stem was higher in the genotype DG4 (11.20 ± 2.93) than the rest of the genotypes. The genotype DG1 produced the least number of branches per plant (7.30 ± 4.24) than the rest of the genotypes.

Table 1: Qualitative morphological traits of the stem of different genotypes of *Dioscorea bulbifera.*

Genotype	Characteristics
DG1	Young stem colour purplish green, turns green when mature; stem surface rough with brown spot on the base of the branch; no thorns on stem.
DG2	Young stem colour pale green, turns green when mature; stem surface smooth when young which turns rough at maturity; no thorns on stem but pointed outgrowth near branches.
DG3	Young stem colour green, stem surface rough; no thorns on stem but small outgrowth at nodes.
DG4	Young stem colour brown, turns green when mature; rough with ridges along the margin; less branch; brown spots on whole length of the stem; no thorns or hairs on stem.
DG5	Young stem colour brownish green, turns green when mature; rough with ridges; reddish and irregular spots at the base of the branch; no thorns on stem; hairs present on young stem.
DG6	Stem colour green, stem rough with ridges and wrinkles; no thorns; small hairs present on young stem.

Table 2: Qualitative morphological traits of the leaves of different genotypes of *Dioscorea bulbifera.*

Genotype	Characteristics
DG1	Young leaf colour purplish green, mature leaf green; 2 lobes near petiole attachment; leaf apex acute; leaf vein colour of upper surface green and of lower surface pale green; petiole brownish green with dark brown spot at base.
DG2	Young leaf colour brown green, mature leaf green; 2 lobes near petiole attachment; leaf apex acute; leaf vein colour of upper surface greenish and of lower surface green; petiole green with brownish base.
DG3	Young leaf colour purplish green, mature leaf green; 2 lobes near petiole attachment; leaf apex acute; leaf vein colour of upper surface greenish and of lower surface green; petiole pale green with purple base.
DG4	Young leaf colour purplish green, mature leaf green; 2 lobes near petiole attachment; leaf apex acute; leaf vein colour of upper surface yellowish and of lower surface greenish; petiole green with purple base, red spots on some points.
DG5	Young leaf colour pale green, mature leaf green; 2 lobes near petiole attachment; leaf apex acute; leaf vein colour of upper surface yellowish and of lower surface greenish; petiole green when young, yellowish green at maturity.
DG6	Young leaf colour yellow, mature leaf green; 2 lobes near petiole attachment; leaf apex acute; leaf vein colour of upper surface green and of lower surface green; petiole green with purple base.

Table 3: Morphological traits of the bulbils of different genotypes of *Dioscorea bulbifera.*

Genotype	Characteristics
DG1	Bulbils yellowish brown in colour when young, brown at maturity; irregular round; smooth texture when young and rough at maturity.
DG2	Bulbils dark brown in colour; irregular round; smooth texture when young and rough at maturity.
DG3	Bulbils light brown at maturity; round with ridges; smooth texture.
DG4	Bulbils light brown in colour; irregular oblong cylindrical; smooth texture.
DG5	Bulbils dark brown in colour; mostly round at maturity; rough texture.
DG6	Bulbils greenish brown in colour when young, dark brown at maturity; irregular round shape; rough and wrinkled texture.

The genotype DG4 also had the greater stem diameter (3.02 ± 0.67 cm) than the rest of the genotypes. The genotype DG4 produced more leaves per metre length of the plant (15.10 ±2.47) indicating denser vegetation than the rest of the genotypes. The higher leaf density in the genotype DG4 was also associated with the greater leaf length (16.95 ± 1.50 cm) than the rest of the genotypes except the genotype DG6 (19.55 ± 1.67 cm). The leaf width was higher in the genotype DG6 (18.00 ± 1.75) and DG4 (15.60 ± 2.03 cm) than the rest of the genotypes.

The average diameter of bulbil was also higher in the DG 6 (6.05 ± 0.68 cm) and DG4 (5.98 ± 0.55 cm) than the rest of the genotypes. The average thickness of the bulbil was higher in the genotype DG6 (19.00 ± 2.14 cm) followed by DG5 (18.45 ± 3.11 cm) and DG4 (17.98 ± 4.23 cm) than the rest of the genotypes.

Genotypic differences for yield and attributing traits was observed (Table 5).

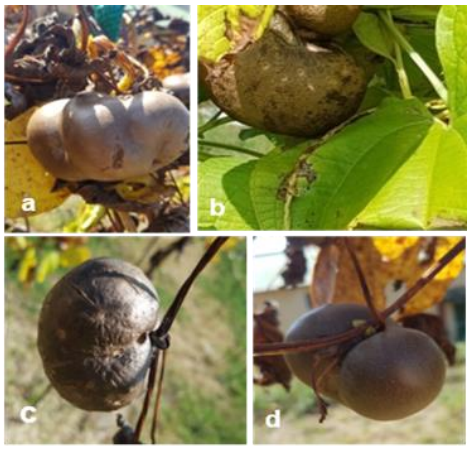

Fig 3: Morphological features of mature bulbils of different *Dioscorea bulbifera* genotypes (a) light brown, smooth with ridges; (b) greenish brown, rough with wrinkles; (c) dark brown, rough; (d) brown, smooth

Table 4: Quantitative traits of different genotypes of *Dioscorea bulbifera.*

Traits	DG1	DG2	DG3	DG4	DG5	DG6
Number of branches per plant on main stem	7.30±4.24	8.90±3.51	8.30±4.86	11.20±2.93	9.90±4.18	9.80±3.49
Stem diameter (cm)	1.60±0.18	1.67±0.24	1.50±0.27	3.02±0.67	1.77±0.20	1.57±0.27
Number of leaves per metre length of plant	12.60±2.56	12.20±2.52	13.20±2.23	15.10±2.47	12.60±2.58	12.90±2.43
Leaf length (cm)	12.80±0.75	11.60±1.02	14.40±2.42	16.95±1.50	14.10±2.02	19.55±1.67
Leaf width (cm)	11.20±0.98	11.00±0.89	12.40±1.85	15.60 ± 2.03	12.55±2.04	18.00±1.75
Average diameter of bubil (cm)	5.75±0.78	5.01±0.91	5.87±0.99	5.98±0.55	5.02±0.93	6.05±0.68
Average thickness of bulbil (cm)	12.67±1.48	15.73±2.87	14.18±1.56	17.98±4.23	18.45±3.11	19.00±2.14

The initial plant height recorded 80 days after plantation was significantly (P≤0.05) the highest in genotype DG1 (341.4 ± 11.0 cm) than the other genotypes. The plant height recorded subsequently at 110 days after plantation was significantly higher in the genotypes DG4 (562.0 ± 12.7 cm), DG5 (568.8 ± 12.7 cm) and DG6 (578.0 ± 12.7 cm) than DG1 (392.0 ± 12.7 cm) and the rest of the genotypes. The number of the fruits per plant recorded was also significantly higher in DG4 (57.0 ± 1.5), DG5 (56.1 ± 1.5) and DG6 (57.4 ± 1.5) than the DG1 (9.9 ± 1.5) and other genotypes. The number of fruits per plants was at par for the genotypes DG1, DG2 and DG3. Weight per fruit was significantly the highest for the genotype DG3 (70.9 ± 1.9 g) followed by DG2 (54.2 ± 1.9 g), DG5 (42.5± 1.9 g) and rest of the genotypes. The yield per plant was significantly the highest in genotype DG5 (2212.8 ± 88.5 g) followed by DG6 (1815.6 ± 88.5 g) and DG4 (1730.4 ± 88.5 g). The yields per plant for the rest of the genotypes DG1 (290.6 ± 88.5 g), DG2 (437.2 ± 88.5 g) and DG3 (445.6 ± 88.5 g) were considerably lower than the genotypes DG5, DG4 and DG6.

Table 5: Yield and attributing traits of different genotypes of *Dioscorea bulbifera.*

Genotype	Plant Height (cm)		Fruits per plant (Nos)	Weight per fruit (g)	Yield per plant (g)
	80 Days	110 days			
DG1	341.4	392.0	9.9	28.9	290.6
DG2	278.2	366.8	8.4	54.2	437.2
DG3	269.8	341.2	6.7	70.9	445.6
DG4	257.4	562.0	57.0	30.5	1730.4
DG5	254.4	568.8	56.1	42.5	2212.8
DG6	261.6	578.0	57.4	30.9	1815.6
SE (N=25)	11.0	12.7	1.5	1.9	88.5
5% LSD	30.7	35.5	4.1	5.3	247.9

Assessment of genetic diversity in a plant species is vital for breeding and development of superior cultivars. The present study assessed the variations in *Dioscorea bulbifera* genotypes from different locations in Western Himalayan region. Large variations were observed for qualitative traits, quantitative traits and the yield components. This significant variability among the six *Dioscorea bulbifera* genotypes is observed due to the sources of genotypes from different agro-ecological locations. Existence of important genetic variation among *D. bulbifera* accessions from different locations and agro-ecological sites has been reported [19]. Morphological and genetic variability has also been observed for other *Dioscorea* species [20, 21]. Variability observed in *Dioscorea* species may be attributed to mutations and natural selection in different agro-ecological zones with distinct environmental conditions.

4. Conclusions

Genetic diversity in *Dioscorea bulbifera* using morphological approaches and field evaluation was studied. The study suggests wide diversity among *Dioscorea bulbifera* genotypes grown at different agro-ecological sites in Western Himalaya. Desirable genotypes with high yield parameters can be selected for conservation, and effective utilization for food and medicine.

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References

1. Singh A, Rana S, Singh R. Wild and cultivated vegetables of the Indian Himalaya and their use as vegetables and in traditional medicine. International Journal of Vegetable Science. 2020; 26(4):385-407.
2. Croxton MD, Andreu MA, Williams DA, Overholt WA, Smith JA. Geographic origins and genetic diversity of air-potato (*Dioscorea bulbifera*) in Florida. Invasive Plant Science and Management. 2011; 4:22-30.
3. Silva DM, Siqueira MVBM, Carrasco NF, Mantello CC, Nascimento WF, Veasey EA. Genetic diversity among air yam (*Dioscorea bulbifera*) varieties based on single sequence repeat markers. Genetics and Molecular Research. 2016; 15:15027929.
4. Lebot V. Tropical root and tuber crops: Cassava, sweet potato, yams and aroids. Crop Production Science in Horticulture No. CABI Publishing, UK. 2009; 7:413.
5. Govaerts R, Wilkin P, Saunders RMK. World checklist of Dioscoreales – Yams and their allies. The Board of Trustees of the Royal Botanic Gardens, Kew, London, 2007, 1-65.
6. Ikiriza H, Ogwang PE, Peter EL, Hedmon O, Tolo CU, Abubaker M *et al*. *Dioscorea bulbifera*, a highly threatened African medicinal plant - A review. Cogent Biology. 2019; 5:1631561.
7. Mignouna HD, Dansi A, Zok S. Morphological and isozymic diversity of the cultivated yams (*Dioscorea cayenensis / Dioscorea rotundata* complex) of Cameroon. Genetic Resources and Crop Evolution. 2002; 49:21-29.

8. FAO. FAOSTAT Database. Food and Agriculture Organization, Rome, Italy, 2010. Available online at URL: www.fao.org
9. Lawal OO, Agiang MA, Eteng MU. Proximate and anti-nutrient composition of white Guinea yam (*Dioscorea rotundata)* diets consumed in Ibarapa, South West region of Nigeria. Journal of Natural Product and Plant Resources. 2012; 2(2):256-260.
10. Babaleye T. Raising the status of the yam, a major food crop in West Africa. ANB-BIA Suppl Issue. 2003; 463:1-3.
11. Ettien DJB, Koné B, Kouadio KKH, Kouadio NE, Yao-Kouamé A, Girardin O. Mineral fertilization of ferralsols for yam production in Guinean Savanna zone of West Africa: The case of traditional varieties of yam on dystric ferralsols Centre Côte d'Ivoire. Journal of Applied Biosciences. 2009; 23:1394-1402.
12. Narula A, Kumar S, Bansal KC, Srivastava PS. *In vitro* micropropagation, differentiation of aerial bulbils and tubers and diosgenin content in *Dioscorea bulbifera*. Planta Medica. 2003; 69:778-779.
13. Ghosh S, Ahire M, Patil S, Jabgunde A, Dusane MB, Joshi BN *et al*. Antidiabetic activity of *Gnidia glauca* and *Dioscorea bulbifera*: Potent amylase and glucosidase inhibitors. Evidence-Based Complementary and Alternative Medicine. 2012; 929051:10.
14. Sharma LN, Bastakoti R. Ethnobotany of *Dioscorea* L. with emphasis on food value in chepang communities in Dhading district, central Nepal. Botanica Orientalis-Journal of Plant Science. 2009; 6:12-17.
15. Adeniran AA, Sonibare MA. *In vitro* potential anthelmintic activity of bulbils of *Dioscorea bulbifera* L. on earthworms and liverflukes. Journal of Pharmacognosy and Phytotherapy. 2013; 5:196-203.
16. Ezeabara CA, Anona RO. Comparative analyses of phytochemical and nutritional compositions of four species of *Dioscorea.* Acta Scientific Nutritional Health. 2018; 2(7):90-94.
17. Williams C. Medicinal plants in Australia. An antipodean apothecary. Rosenberg Publishing Science, New South Wales, Australia. 2013; 4:552.
18. Sahu SC, Dhal NK, Mohanty RC. Potential medicinal plants used by the tribal of Deogarh district, Orissa, India. Studies on Ethno-Medicine. 2010; 4:53–61.
19. Tewodros M, Getachew W. Agronomical evaluation of aerial yam (*Dioscorea bulbifera*) accessions collected from South and Southwest Ethiopia. Greener Journal of Agricultural Sciences. 2013; 3:693-704.
20. Bressan EA, Thiago BN, Maria IZ, Ronaldo JR, Veasey AE. Morphological variation and isozyme diversity in *Dioscorea alata* L. land races from Vale do Ribeira, Brazil. Scientia Agricola. 2011; 68:494-502.
21. Adeigbe OO, Ilori CO, Adewale BD. Phenotypic diversity and ploidy level of some *Dioscorea dumetorum* genotypes. IOSR Journal of Agriculture and Veterinary Science. 2015; 8:47-52.