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DUS characterization for lentil (*Lens culinaris*) genotypes

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Abstract
The present study was carried out to characterize the thirty lentil genotypes on the basis of thirteen agro-morphological characters following the guidelines from Plant Protection of Varieties and Farmer's Right Authority, GOI. The experimental material was planted in randomized complete block design (RCBD). No variation was observed for three traits *viz.*, leaf pubescence, plant height and pod anthocyanin colouration, whereas rest of the characters showed the variation in lentil genotypes. Erect plant type was exhibited by all the genotypes except LLS 21-194 which showed semi-erect. Ninety three percent genotypes showed violet flower colour with seed testa mottling. Only single genotype *i.e.,* LLS 21-218 showed yellow cotyledon colour and rest were found having orange cotyledon colour. Twenty-nine genotypes were found large seeded except one genotype *viz.,* LLS 21-210. Foliage intensity of green colour, leaflet size (length), seed testa colour showed trimorphic variation while stem anthocyanin and time of flowering showed dimorphic variation.

Keywords: DUS descriptors, lentil, agro-morphological characterization, phenotyping

Introduction
The lens-shaped seeds of lentil (*Lens culinaris*), the first domesticated annual cool season grain legume, have a relatively large genome size of 4 Gb. (Polanco *et al*., 2018) [7]. It is a self-pollinated, diploid (2n = 2X = 14) plant from the Fabaceae (Leguminosae) subfamily of Papilionacea (Arumuganathan and Earle, 1991) [1]. Lentil is a noteworthy source of vegetable protein, vital amino acids, and trace minerals. (Singh *et al*., 2011) [11]. It is frequently referred to as "poor man's meat" due to its high protein content and quick cooking qualities (Rani and Grewal, 2014) [8].

The world's top producer of lentils is Canada, which accounts for nearly 40% of global production (3.7 million tons), followed by India (1.2 million tons), Turkey (0.43 million tons), Australia, Nepal, and the United States of America (USA). In India, the output of lentils totals 1.22 million tons on a 1.36 million hectare area (FAOSTAT, 2019). Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Bihar, and West Bengal are major cultivating states. Eighty to ninety percent of the world's lentils are produced in these states.

The introduction of high yielding varieties poses a serious danger to the security of the long-standing practice of cultivating traditional varieties and landraces, which may have huge potential for different essential traits. (Song *et al*., 1999) [12]. Anyhow, many cultivars morphological descriptors are ambiguous. Characterizing lentil varieties is necessary for their protection under Plant Variety Protection (PVP) legislation because distinctness, uniformity, and stability (DUS) testing is the minimum requirement for granting protection of new plant varieties under the Protection of Plant Varieties and Farmer's Right (PPV&FR) Act of 2001. In recognition of the importance and value of varietal classification, the current study has been carried out to classify the various lentil genotypes based on DUS descriptors as per PPV & FRA, 2007.

Materials and Methods
Thirty lentil genotypes were planted on the Research Cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) during *Rabi* 2021-2022 in a Randomized Complete Block Design with three replications for DUS characterization. According to the specific features and National test recommendations for the DUS test in lentil, observations were made for the population as a whole.

The observation of various characterizations was recorded at their maximum expression stage, in accordance with the DUS test guidelines of the PPV & FR Act, 2007.

Table 1: List of thirty lentil genotypes used for morphological characterization

Sl. No.	Name	Sl. No.	Name
1.	LLS 21-192	16.	LLS 21-209
2.	LLS 21-193	17.	LLS 21-210
3.	LLS 21-194	18.	LLS 21-211
4.	LLS 21-195	19.	LLS 21-212
5.	LLS 21-197	20.	LLS 21-213
6.	LLS 21-198	21.	LLS 21-214
7.	LLS 21-199	22.	LLS 21-215
8.	LLS 21-200	23.	LLS 21-216
9.	LLS 21-201	24.	LLS 21-217
10.	LLS 21-202	25.	LLS 21-218
11.	LLS 21-204	26.	LLS 21-218 A
12.	LLS 21-205	27.	CG Masoor-1
13.	LLS 21-206	28.	IPL-316
14.	LLS 21-207	29.	DPL-62
15.	LLS 21-208	30.	L-4076

Result and Discussion

A total of thirty lentil genotypes were evaluated for thirteen morphological traits. Out of thirteen traits, three traits were found monomorphic. All the entries have shown presence of leaf pubescence and absence of pod anthocyanin similar result was obtained by Choudhury *et al.* (2014) [2]. The plant was recorded less than 40cm for all the genotypes and considered as dwarf (PPV & FRA, 2007).

For DUS characterization, the colour of the foliage's intensity of green is a distinctive, consistent, and stable characteristic. Lentil genotypes were categorized into light green, medium green and dark green. The medium green colour foliage was more prevalent among the genotypes and was observed in 50% of the genotypes; 30% showed light green and 20% found dark green foliage. Choudhary *et al*., (2017) [3] has reported that dark green plants persist for a long time and stay green during the advanced stages of crop growth, while light green plants mature and turn brown. A similar pattern was seen in the field during crop growth. Hoque *et al*. (2002) [5] reported one gene was responsible for determining the colour of the leaf, with dark green predominating over light green.

Erect plant habit was displayed by all the lentil genotypes except for one genotype, LLS 21-194, which exhibited semi-erect habitat. 40 percent genotypes showed stem anthocyanin and was absent in 60 percent. 33.3 percent of the genotypes were categorized into medium flowering (60-80 days), whereas 66.6 percent of the genotypes were found early flowered (<60 days). On the basis of leaflet size majority of genotypes (63.3%) found medium-sized leaflets, whereas 20% had small leaflets and 16.6% showed large leaflets. Ninety three percent genotypes showed violet flower colour except two genotypes, LLS 21-217 and LLS 21-218, which had white petals. On the basis of 100 seed weight the lentil genotypes were categorized as very large seeded (> 3.0 g), large seeded (2.6-3.0 g) and small (< 2g) seeded and were found as 73.3 percent, 33.3 percent and 3.3 percent respectively.

Seed testa colour, mottling, and cotyledon colour were measured as post-harvest observation. As their expression is least impacted by environment, testa colour and testa mottling were discovered to be the most stable and consistent features for verification of genetic purity (Choudhary *et al*., 2017) [3]. Sixty percent of the entries showed grey seed testa colour, 26.6 percent green and 13.3 percent found brown testa colour. The twenty-eight genotypes showed presence of testa mottling, whereas two genotypes, LLS 21-217 and LS 21-218, showed testa mottling absent. Vandenberg and Slinkard, (1990) reported that seed coat colour is controlled by two dominant genes at independent loci. Gray colour was determined by dominant gene at one of the loci while double dominant gene produce brown colour and double recessive gene produce green colour. The trait, seed testa mottling was governed by multiple alleles of single locus. Only single genotype, LLS 21-218 showed yellow cotyledon colour whereas, rest of the genotypes found having orange cotyledon colour.

Table 2: Frequency distribution of lentil genotypes for various DUS characters

S. No.	Descriptors	Observed phenotypic class	Number of genotypes	Frequency distribution (%)
1.	Foliage: Intensity of green colour	Light Medium Dark	9 15 6	30 50 20
2.	Stem: Anthocyanin colouration	Absent Present	18 12	60 40
3.	Time of flowering	Early (<60 days) Medium (60-80 days) Late (>80 days)	20 10 -	66.6 33.3 -
4.	Leaf: Pubescence	Absent Present	- 30	- 100
5.	Leaflet: Size (length)	Small Medium Large	6 19 5	20 63.3 16.6
6.	Plant: Growth habit	Erect (<30º) Semi-erect (30º-60º) Horizontal (>60º)	 29 1	 96.6 3.3
7.	Flower: Colour of standard	White Pink Blue Violet	2 - - 28	6.6 - - 93.3
8.	Plant: Height	Short (<40 cm) Medium (40-60 cm) Long (>60 cm)	30 - -	100 - -
9.	Pod: anthocyanin colouration	Absent Present	30 -	100 -
10.	Seed: Size (weight of 100 seeds)	Small (<2g) Medium (2-2.5 g) Large (2.6-3.0 g) Very large (>3.0 g)	1 - 7 22	3.3 - 23.3 73.3
11.	Seed: Testa colour	Green Grey Pink Brown Black	8 18 - 4 -	26.6 60 - 13.3 -
12.	Seed: Testa mottling	Absent Present	2 28	6.6 93.3
13.	Cotyledon: Colour	Yellow Olive green Orange	1 - 29	3.3 - 96.6

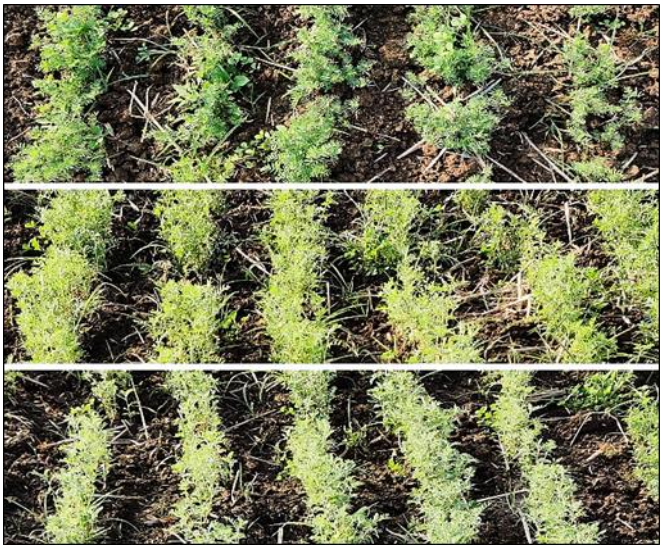


Fig 1: Foliage intensity of green colour

Fig 2: Stem anthocyanin

Fig 3: Leaf pubescence

Fig 4: Leaflet size

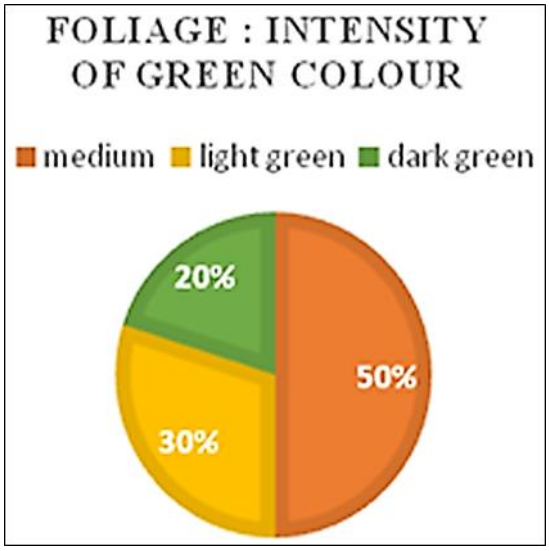
Fig 5: Plant growth habit

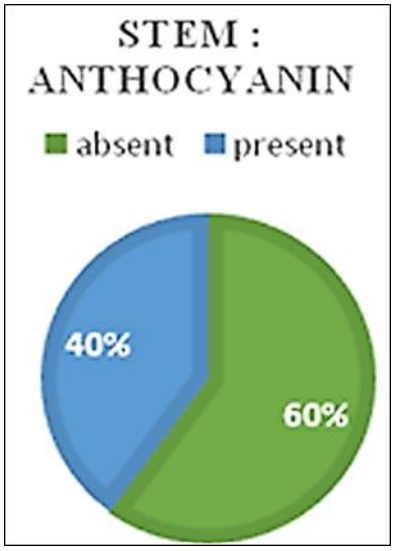
Fig 6: Flower colour

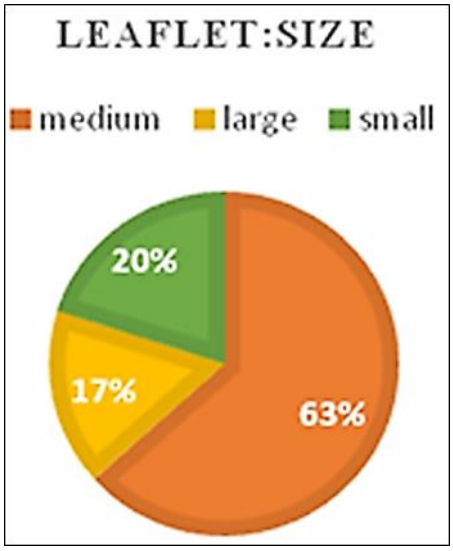
Fig 7: Seed testa colour

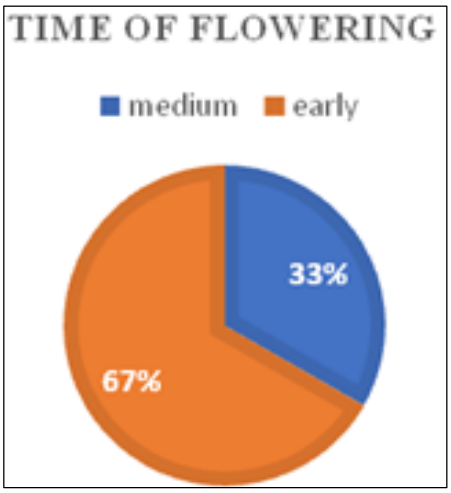
Fig 8: Seed testa mottling

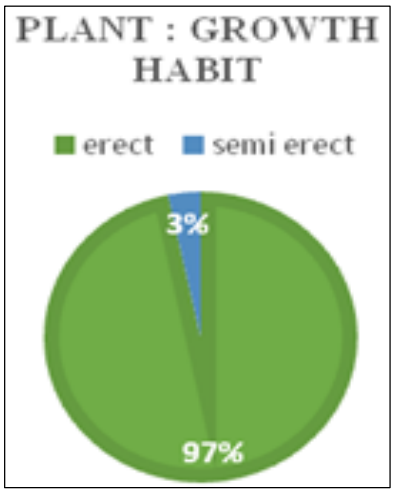
Fig 9: Cotyledon colour

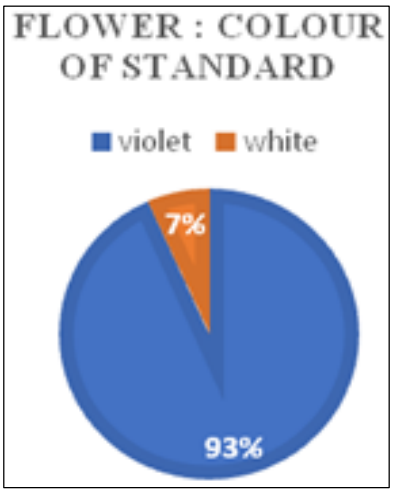












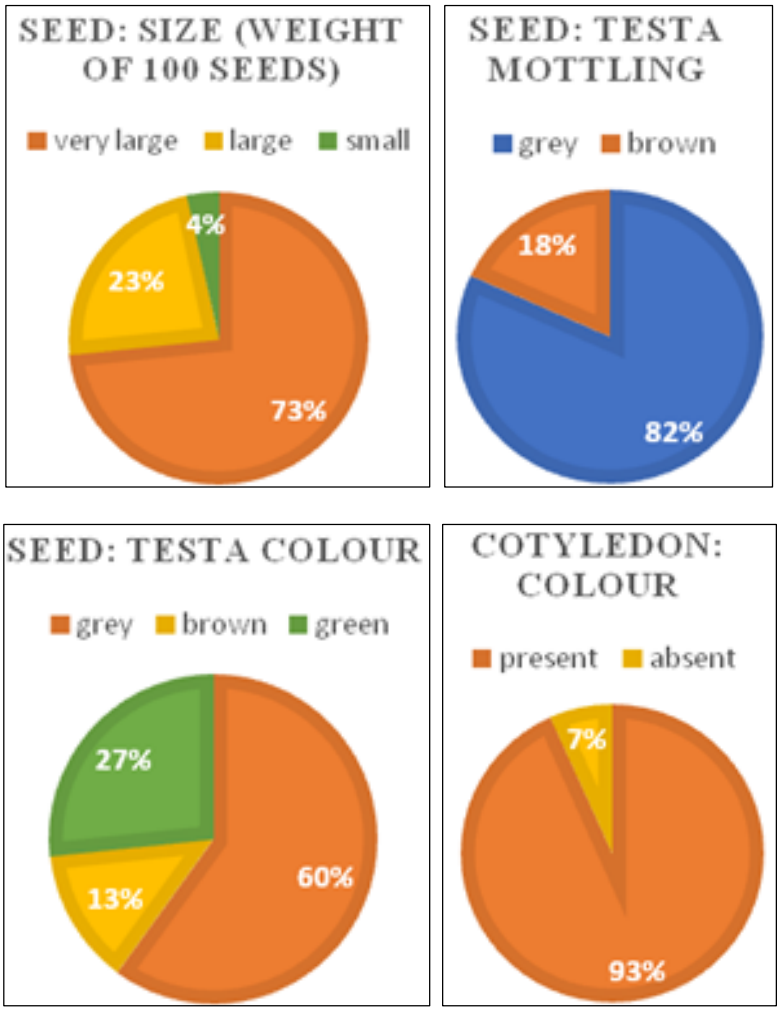


Fig 10: Frequency distribution based on DUS characteristics for 30 lentil genotypes

Conclusion

Morphological markers are very important for the breeders to identify specific parental material for specific traits. The present study revealed notable genetic variation for the agro-morphological traits. According to the PPV & FR Act of 2007, the information acquired will be helpful not only for varietal registration, but also in the wider context of varietal classification and clustering. The characterization data of lentil genotypes also serve as a valuable resource for lentil researches and open the avenues for their utilization in selection, molecular breeding and trait discovery.

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