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DUS CHARACTERIZATION OF IGKV RELEASED VARIETIES OF LINSEED (*LINUM USITATISSIMUM* L.)

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ABSTRACT

Large numbers of linseed varieties have been released from IGKV, AICRP on Linseed since 1967. In general, all varieties of linseed have greater similarity for their plant morphological features. Different varieties have unique characteristics, which can be preferred for distinguishing them. The need of distinctness, uniformity and stability are evaluated based on morphological characteristics. Describing the characteristics of a crop species based on standard descriptors is effective for better utilization and conservation of germplasm. Moreover, morphological characterization studies play an important role in the management of crop diversity. So, it is essential not only to conserve the genotypes but also to explore the gene pool of linseed for breeding purposes. Concentrating on the preceding facts study was undertaken for the characterization of 27 diverse linseed genotypes in Randomized complete block design with three replications during *rabi* season 2019-20 in twenty-seven IGKV released linseed genotypes at the Research Cum Instructional Farm, Department of Genetics & Plant Breeding, IGKV, Raipur (C.G.) to characterize the morphological characters based on DUS descriptors as per International Union for the Protection of New Varieties of Plants (UPOV) descriptors 2011, International Flax Data Base (IFDB) descriptors 2006 and catalogue on linseed germplasm, Project Coordinating Unit (Linseed), Kanpur 2010.

Keywords **:** Descriptor, characterization, genotypes, linseed, IGKV.

Introduction

Linseed (*Linum usitatissimum* L.) 2n=30 belongs the family of linaceae and order Geraniale having 300 species conveyed in 25 genera. Aside from developed *L.usitassimum*, there are five wild species in India have been accounted for *viz*., "*L.perenne, L.strictrum, L.mysorense, L.angustifolium and L.grandiflorum"*. Linseed is the most extravagant plant wellspring of the omega-3-poly unsaturated fat (n-3 PUFA) for example α-linolenic acid (ALA).

L. usitatissimum posses small tap root having fibrous branches with length 90 to 120 cm in light soils. It has simple, sessile, linear-pointed tapering leaves on stems and branches. Terminal raceme is the type of inflorescence. The flowers have "erect and long pedicels, are bisexual, have superior ovary *i.e.*, hypogynous state and composing of five sepals, five petals of variant colours like blue, violet and white, five stamens, and five carpels forming a compound pistil each separated by a false septum". The fruit type is globular capsules having 8-10 seeds. The seed is "oval, lenticular, 4-6 mm long with a smooth, shiny surface, and is brown to golden colour". Seeds composed of 35 to 45% oil and 20 to 25% protein content. Generally, the harvest index varies from 0.19 to 0.31. The test weight or thousand seed weight is nearly 4.5 g per 1000 seeds. Number of capsules per plant is an important trait used to determine yield and quality of linseed. Linseed oil used as key ingredient in fine oil paints, varnishes and stains, it preserves and provides outstanding protection to wooden marine products surfaces. Flax straw provides animal bedding, mulches, insulation board, loose-fill insulation, plastic

composite filler, heating fuel and also in pulp and paper industries.

Given increasing demand of linseed because of several benefits for health, there is steady need to increase genetic potential for oilseed yield. As per the Food and Agriculture Organization statistical data (FAOSTAT, 2021), currently overall world production of linseed is around 3.18 million tonnes, with Canada (34%), Russia (15%), and China (13%) being the major producers. In the world, India is the 6th largest producer adding 13% and 5.5% to global linseed area and production respectively. In world, India is the foremost growing country of linseed ranking 4th in area 3.20 lakh ha (11%) and production of 1.74 lakh tonnes followed by Kazakhstan, Russia and Canada, with annual area whereas, in terms of productivity India (543.8 Kg/ha) is far behind to Switzerland (2525 Kg/ha), Kyrgyzstan (2257.1 Kg/ha), Tunisia (2142.6 Kg/ha) and France (1909.1 Kg/ha) (FAOSTAT, 2021). In India, linseed is mostly occupied under rainfed (63%), utera (25%) and irrigated (17%) conditions and in famished conditions in the major linseed producing states of India are Madhya Pradesh, Chhattisgarh, Maharashtra, Jharkhand, Uttar Pradesh and Odisha. Currently, linseed is grown in Chhattisgarh in 29900 ha with 1030 tonnes production and average productivity 344 Kg/ha (INDIASTAT, 2018). Production and area wise, Chhattisgarh is one of the significant linseed producing states of India. In Chhattisgarh, Durg, Rajnandgaon, Bilaspur, Raigarh, Raipur, Dhamtari, Sarguja, Raipur and Kabirdham are the prime growing districts of linseed.

Area & production of linseed is being declined year by year due to non availability of identifiable variations for different varieties. Large numbers of linseed varieties have been released from IGKV, AICRP on Linseed since 1967. In general, all varieties of linseed have greater similarity for their plant morphological features. Different varieties have unique characteristics, which can be preferred for distinguishing them. This fact provides crucial place for "DUS testing, varietal identification and verification (Keefe, 1999)". The need of distinctness, uniformity and stability are evaluated based on morphological characteristics. Describing the characteristics of a crop species based on standard descriptors is effective for better utilization and conservation of germplasm (Diederichsen and Richards, 2003). Moreover, morphological characterization studies play an important role in the management of crop diversity. So, it is essential not only to conserve the genotypes but also to explore the gene pool of linseed for breeding purposes. Concentrating on the preceding facts study was undertaken for the characterization of 27 diverse linseed genotypes based on DUS descriptors or DUS guidelines as per "International Union for the Protection of New Varieties of Plants (UPOV) descriptors 2011, International Flax Data Base (IFDB) descriptors 2006 and catalogue on linseed germplasm, Project Coordinating Unit (Linseed), Kanpur 2010".

Materials and Methods

The field experiments were conducted in Randomized complete block design with three replications during *rabi* season 2019-20 in twenty-seven IGKV released linseed genotypes. The genotypes were collected from All India Coordinated Research Project (AICRP) on Linseed Department of Genetics & Plant Breeding functioning at the Research Cum Instructional Farm, College of Agriculture, IGKV, Raipur (C.G.) to characterize the morphological characters based on DUS guidelines. All the recommended package of practices was carried out to raise the good crops. All the genotypes were sown on 28th November, 2019 in plots of three rows each of 4 m length with row to row spacing of 30 cm and plant to plant spacing approximately 10 cm. five competitive plants have been randomly selected from each plot for taking observations. Observations on morphological traits based on "National guidelines for the conduct of tests for Distinctness, Uniformity and Stability in linseed, India" published as per Catalogue on linseed germplasm, Project Coordinating Unit (Linseed), Kanpur, (2010), the International Union for the Protection of New Varieties of Plants (UPOV), Geneva, Switzerland (2011) guidelines and descriptor of International Flax Database (IFDB), Czech Republic (2006) and characters related to seed yield and it components were recorded.

Table 1: Experimental material used in the present study

S. No.	Genotypes	Parentage	Source
1.	R-7	SELECTION OF No.55	AICRP on Linseed, Department of Genetics and Plant Breeding, IGKV, Raipur (C.G.)
2.	R-17	SELECTION OF No.55	
3.	KIRAN	AFGAN-0/R-1/AFGAN-0	
4.	R-552	No.55 × R-67	
5.	KARTHIKA	KIRAN × LCK 88062	
6.	DEEPIKA	KIRAN × AYOGI	
7.	IA-32	KIRAN × RLC-29	
8.	RLC-92	JEEVAN × LCK 9209	
9.	RLC-133	(NL-14 × Acc. 926) × LCK 9313	
10.	RLC-143	LCK 88062 × T 397	
11.	RLC-148	SIKO × KIRAN	
12.	RLC-153	LCK 88062 × EC-1424	
13.	RLC-161	AYOGI × GS-234	

14.	RLC-164	POLF 22 × JRF 5	
15.	RLC-165	KIRAN × T 397	
16.	RLC-167	T 397 × POLF 22	
17.	RLC-171	POLF 22 × JRF 5	
18.	RLC-172	GS 234 × R-552	
19.	RLC-173	KIRAN × RLC-92	
20.	RLC-175	RLC-92 × LCK 88062	
21.	RLC-176	POLF 22 × RLC-92	
22.	RLC-177	RLP-21 (RLC-92 × RLC-86)	
23.	RLC-178	GS 234 × RLC-92	
24.	RLC-179	R-552 × RLC-92	
25.	RLC-180	RLC-92 × T 397	
26.	RFC-2019-1	POLF 34 × RLC-92	
27.	RFC-2019-2	POLF 22 × AYOGI	

Table 2: DUS (Distinctness, Uniformity and Stability) descriptors for linseed genotypes under study as per Catalogue on linseed germplasm, Project Coordinating Unit (Linseed), Kanpur, 2010, the International Union for the Protection of New Varieties of Plants (UPOV) 2011 guidelines and descriptor of International Flax Database (IFDB), 2006.

S.No.	Characters	Range
1.	Flower colour	Blue (B) Tinge blue (TB) Light violet blue (LV) Violet (V) White (W)
2.	Flower shape	Disc (D) Funnel (F) Star (S)
3.	Flower size	Large (>20 mm) Medium (15-20 mm) Small (<15 mm)
4.	Flower aestivation	Valvate (VA) Twisted (TW) Semi twisted (ST)
5.	Anther colour	Blue (B) Grey (G) Cream (CR)
6.	Filament colour	White (W) White with blue below anther (WB)
7.	Style colour	White (W) Blue (B)
8.	Flower heart shape	Circular (C) Pentagonal (P) Circular to pentagonal (CP)
9.	Flower venation colour	White (W) Blue (B) Violet (V)
10.	Petal shape	Circular (C) Elliptical (E) Narrow (N)
11.	Petal margin	Even (EV) Crenate (CRN)
		Coarsely crenate (CC)
12.	Organ position	Anther surrounds stigma closely (AC) Anther surrounds stigma openly (AO)
13.	Plant type	Erect (ER) Semi erect (SE) Bushy (BU)
14.	Plant height	Tall (>70 cm) Medium (51-70 cm) Small (<50 cm)
15.	Capsule size	Bold (>8mm) Medium (7-8 mm) Small (<7 mm)
16.	Capsule dehiscence	Dehiscent (DE) Non dehiscent (ND)
17.	Capsule: shape of tip	Pointed (PO)
18.	Seed size	Large (>5 mm) Medium (4-5 mm) Small (<4 mm)
19.	Seed colour	Brown (BR) Light brown (LB) Dark brown (DB)

Result and Discussion

Morphological characterizations based on DUS descriptors

The data were recorded on qualitative and quantitative characters *viz*., colour of flower, shape of flower, flower size, petal aestivation, anther colour, filament colour, style colour, organ position, flower heart shape, petal venation colour, petal shape, petal margin shape, growth habit of plant, plant height, capsule size, capsule dehiscence, shape of tip of capsule, seed size and seed colour are presented in Table 2**.**

Flower colour

Out of 27 genotypes, eight genotypes (29.63%) were included in blue colour, seven genotypes (25.92%) having tinge blue colour, six genotypes (22.22%) were included in light violet blue colour, five genotypes (18.52%) having violet colour and one genotype (3.70%) having white coloured flower.

Flower shape

Out of 27 genotypes twelve genotypes (44.44%) grouped into disc shape, fourteen genotypes (51.85%) having funnel shape and one genotype (3.70%) having star shape flower.

Flower size

Size of flowers were recorded in peak flowering which included 2 groups as large size (>20mm) with fifteen genotypes (55.55%) and medium sized flower

(15-20mm) with twelve genotypes (44.44%).

Petal aestivation

Out of 27 genotypes, twelve genotypes (44.44%) categorized as twisted, eleven genotypes (40.74%) categorized as semi twisted and four genotypes (14.81%) categorized as valvate.

Anther colour

Out of 27 genotypes, twelve genotypes (44.44%) showed blue anther colour, fourteen genotypes (51.85%) showed grey coloured anther colour and one genotype (3.70%) showed cream anther colour.

Filament colour

27 genotypes were grouped into 2 classes *viz.,* white filament including thirteen genotypes (48.15%) and white with blue colour below anther including fourteen genotypes (51.85%).

Style colour

27 genotypes were grouped into 2 classes *viz.,* white style including thirteen genotypes (48.15%) and blue coloured style including fourteen genotypes (51.85%).

Flower heart shape

Out of 27 genotypes, fourteen genotypes (51.85%) were included in circular, eight genotypes (29.63%) were included in pentagonal and five genotypes (18.52%) were included in circular to pentagonal shape.

Petal venation colour

Out of 27 genotypes sixteen (59.26%) grouped in blue, ten genotypes (37.04%) grouped in violet and one genotype (3.70%) included in white.

Petal shape

Petal shape grouped into 3 categories *viz*., circular, elliptical and narrow. Out of 27 genotypes, eighteen genotypes (66.66%) were included in circular shape, eight genotypes (29.63%) were included in elliptical shape and one genotype (3.70%) was included in narrow shape.

Petal margin shape

Petal shape grouped into 3 categories *viz*., even, crenate and coarsely crenate. Out of 27 genotypes, seven genotypes (25.93%) were included in even margin, eighteen genotypes (66.66%) were included in crenate shape and one genotype (3.70%) was included in coarsely crenate shape.

Organ position

Out of 27 genotypes, twenty five genotypes (92.59%) grouped in anthers surrounds stigma closely and two genotypes (7.41%) grouped in anthers surrounds stigma openly.

Plant growth habit

Plant growth habit was classified into 3 groups *viz*., erect, semi erect and bushy. Out of 27 genotypes, eight genotypes (29.63%) grouped under erect, eighteen genotypes (66.66%) under semi erect and one genotype (3.70%) under bushy growth habit.

Plant height

The plant height was measured from the base to the tip of the main stem and unit of measurement was in centimeters. Plant height was grouped into 3 classes *viz*., tall (>70 cm), medium (51-70 cm) and short (<50 cm).

Out of 27 genotypes, four genotypes (14.81%) grouped under tall, twenty genotypes (74.07%) under medium and three genotypes (11.11%) under short height.

Capsule size

The size of capsule was measured in millimeters in fully matured capsules. According to this, it can be categorized into 2 classes as bold (>8 mm) and medium (7-8 mm). Out of 27 genotypes, nine genotypes (33.33%) grouped under bold and remaining eighteen genotypes (66.66%) grouped under medium.

Capsule: shape of tip

The observation was recorded as presence of pointed or blunt tip. All the twenty seven genotypes (100%) showed pointed capsule tip.

Seed colour

The seed colour was recorded visually and classified into 3 groups *viz*., brown, light brown and dark brown. Seventeen genotypes (62.96%) grouped under brown seeds, five genotypes (18.52%) under light brown and remnant five genotypes (18.52%) grouped under dark brown.

Earlier finding of Tammes *et al.* (1922), Martin and Petra (2008) and Nozkova *et al.* (2014) worked on seed morphology and revealed distinct classes for categorizing traits like seed size, seed colour and many other traits.

Similarly, Dubey *et al.* (2006) and Adugna *et al.* (2006) studied diverse genotypes of linseed using nine to ten morphological characters for distinguishing the genotypes.

Similar results were noticed by Negash *et al.* (2015) and Worku *et al.* (2015) who worked on 198

Ethiopian germplasm of linseed and characterized them on the basis of DUS descriptors on various agro-morphological traits as well as quantitative traits like days to 50% flowering and oil content.

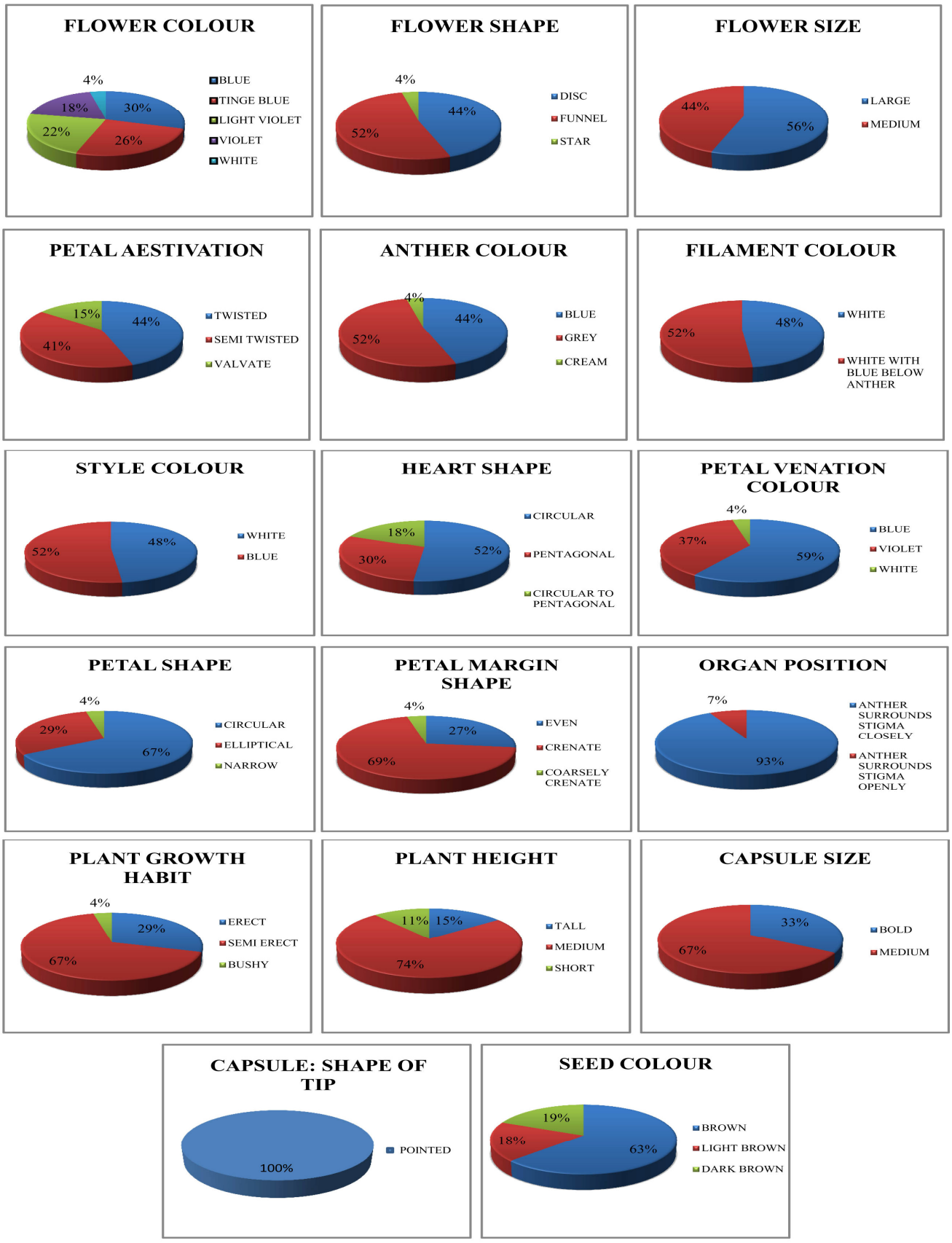
Similarly, Dhirhi *et al.* (2016) worked on 150 linseed genotypes for DUS testing using morphological traits and yield contributing traits.

Table 3: Morphological characters of IGKV released linseed genotypes during *rabi* 2019-20 at Raipur (C.G.)

S. N.	Genotypes	Flower colour	Flower shape	Flower size	Petal aestivation	Anther colour	Filament color	Style colour	Flower heart shape	Petal venation colour	Petal shape	Petal margin	Organ position	Plant growth habit	Plant height	Capsule size	Capsule dehiscence	Capsule: shape of tip	Seed colour
1.	R-7	V	F	L	TW	B	W	W	P	V	C	CRN	AC	SE	M	BO	ND	PO	BR
2.	R-17	V	F	L	TW	G	WB	B	P	V	C	CRN	AC	SE	SH	BO	ND	PO	BR
3.	KIRAN	V	F	M	TW	B	W	W	P	V	C	EV	AC	SE	SH	M	ND	PO	LB
4.	R-552	V	F	M	ST	B	W	W	CP	V	E	CRN	AC	SE	M	BO	ND	PO	BR
5.	KARTHIKA	LV	F	M	TW	G	WB	B	P	V	C	CRN	AC	SE	M	M	ND	PO	BR
6.	DEEPIKA	V	F	M	TW	G	WB	B	P	V	C	CRN	AC	SE	M	M	ND	PO	BR
7.	IA-32	LV	F	L	ST	G	WB	B	CP	V	C	EV	AC	BU	SH	BO	ND	PO	DB
8.	RLC-92	B	D	L	ST	B	W	W	C	B	C	CRN	AC	ER	M	M	ND	PO	BR
9.	RLC-133	W	S	M	VA	CR	W	W	C	W	N	CC	AC	ER	M	M	ND	PO	BR
10.	RLC-143	LV	D	L	ST	G	WB	B	CP	V	C	EV	AC	SE	M	M	ND	PO	LB
11.	RLC-148	LV	D	L	ST	G	WB	B	CP	V	C	EV	AC	SE	M	M	ND	PO	BR
12.	RLC-153	LV	F	L	ST	G	WB	B	CP	V	C	EV	AC	SE	M	M	ND	PO	DB
13.	RLC-161	B	F	M	TW	B	W	W	C	B	C	CRN	AC	ER	M	M	ND	PO	DB
14.	RLC-164	B	F	M	TW	B	W	W	C	B	E	CRN	AC	ER	M	M	ND	PO	BR
15.	RLC-165	B	F	L	TW	B	W	W	C	B	E	CRN	AC	ER	M	M	ND	PO	BR
16.	RLC-167	LV	F	M	VA	B	W	W	C	V	E	CRN	AC	ER	T	M	ND	PO	DB
17.	RLC-171	TB	D	L	VA	B	W	W	P	B	E	CRN	AC	SE	M	M	ND	PO	BR
18.	RLC-172	TB	D	L	VA	B	W	W	P	B	E	CRN	AC	SE	M	M	ND	PO	BR
19.	RLC-173	TB	D	L	ST	B	W	W	P	B	C	EV	AC	SE	T	BO	ND	PO	LB
20.	RLC-175	B	D	L	TW	B	W	W	C	B	C	EV	AC	SE	M	BO	ND	PO	BR
21.	RLC-176	B	D	L	TW	G	WB	B	C	B	C	CRN	AC	SE	M	M	ND	PO	BR
22.	RLC-177	TB	D	L	ST	G	WB	B	C	B	C	CRN	AC	SE	M	BO	ND	PO	DB
23.	RLC-178	TB	D	L	ST	G	WB	B	C	B	C	CRN	AC	SE	M	M	ND	PO	BR
24.	RLC-179	TB	D	M	ST	G	WB	B	C	B	C	CRN	AC	SE	M	M	ND	PO	BR
25.	RLC-180	TB	D	M	ST	G	WB	B	C	B	C	CRN	AC	SE	M	BO	ND	PO	BR
26.	RFC-2019-1	B	F	M	TW	G	WB	B	C	B	E	CRN	AO	ER	T	M	ND	PO	LB
27.	RFC-2019-2	B	F	M	TW	G	WB	B	C	B	E	CRN	AO	ER	T	M	ND	PO	LB

B- Blue
TB- Tinge blue
V- Violet
LV- Light blue violet
W- White
D- Disc
F- Funnel
S- Star
L- Large
M- Medium
VA- Valvate
ST- Semi twisted
TW- Twisted
G- Grey
CR- Cream
WB- White with blue below anther
C- Circular
P- Pentagonal
CP- Circular to pentagonal
E- Even
CRN- Crenate
CC- Coarsely crenate
AC- Anther surround stigma closely
AO- Anther surround stigma openly
ER- Erect
SE- Semi-erect
BU- Bushy
SH- Short height
T- Tall heighted
BO- Bold
ND- Non dehiscent
PO- Pointed
BR- Brown
LB- Light brown
DB- Dark browm

Fig 1: Graphical representation of morphological characters in IGKV released linseed genotypes through pie charts



Flower colour

Blue | Tinge Blue | Violet | Light Blue | White

Flower shape

Disc | Funnel | Star

Flower size

Large | Medium

Petal aestivation

Twisted | Semi-Twisted | Valvate

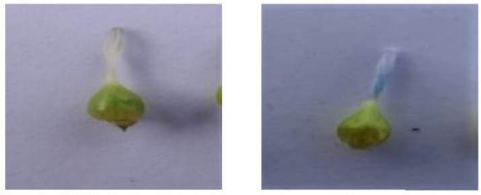
Filament colour

White | White with blue below anther

Anther colour

Blue | Grey | Cream

Style colour



White | Blue

Flower heart shape

Circular | Pentagonal | Circular to pentagonal

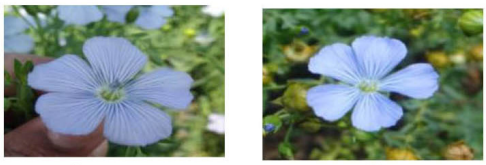
Flower colour

Blue | Tinge Blue | Violet | Light Blue | White

Flower shape

Disc | Funnel | Star

Flower size



Large | Medium

Petal aestivation

Twisted | Semi-Twisted | Valvate

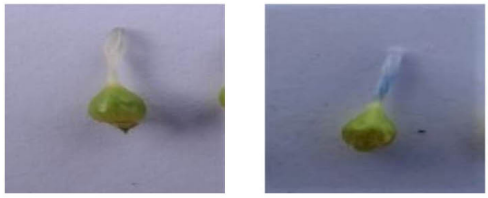
Filament colour

White | White with blue belov anther

Anther colour

Blue | Grey | Cream

Style colour



White | Blue

Flower heart shape

Circular | Pentagonal | Circular to pentagonal

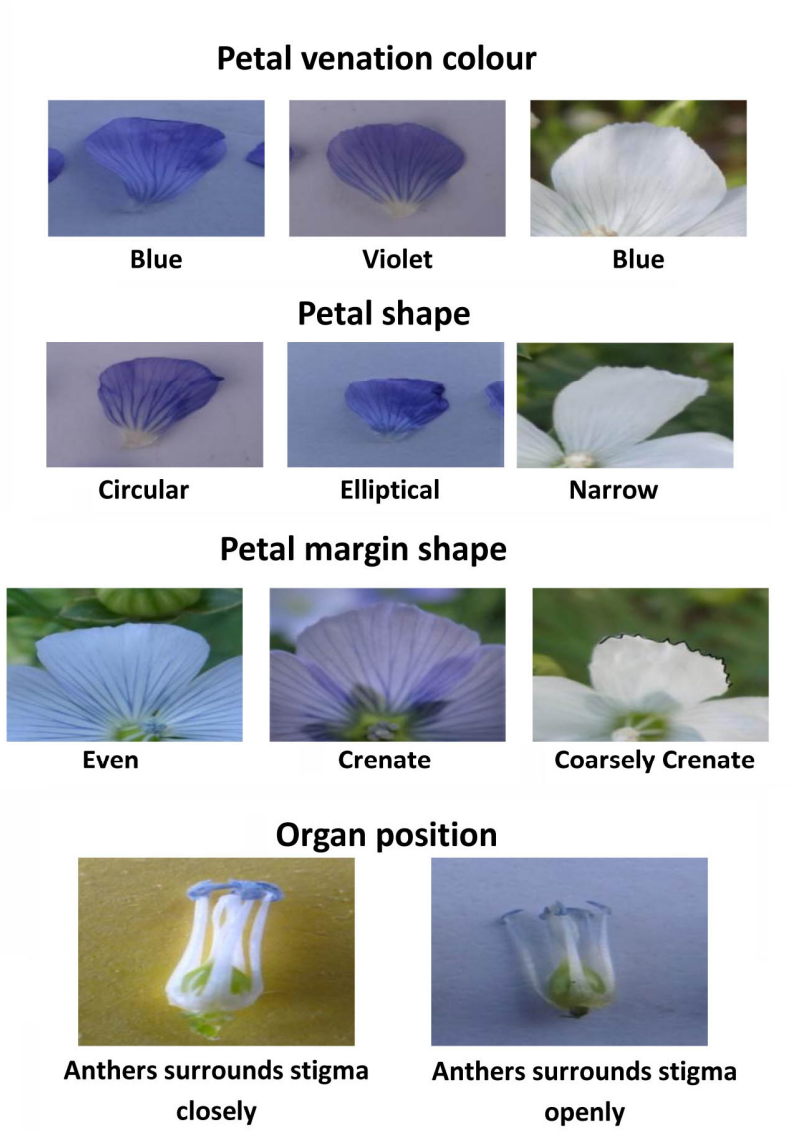


Figure 1: Photographs of different chararcters of linseed.

Conclusions

DUS testing of morphological characters of linseed showed significant amount of distinctiveness for characters *viz.*, flower colour, anther colour, petal aestivation, heart shape, petal venation colour, petal shape, petal margin and seed colour indicates that these characters play a crucial role in differentiating the genotypes morphologically. The characters like filament colour, style colour, growth habit showed lesser number of classes for distinctiveness indicates that these characters are useful to distinguish genotypes in broad level. The characters like capsule dehiscence and shape of tip of capsule showed uniformity in expression for all the genotypes. The descriptive characters could be useful for varietal purity testing and off types identification in seed production programmes. The identified stable distinct character used for DUS test could be utilized as mandate for variety registration and its release. This study should be carried out for few more years so that the disctinct characters could be fixed for identifying specific genotypes. The seed morphometric characters such as seed size and 1000 seed weight could be useful for regularization of sieve aperture size for processing of bold seeds to achieve physical purity.

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