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Ravindra Kumar Kasana
Linseed Project Co-ordinated Unit, Department of Genetics & Plant Breeding, CSAUA&T-Kanpur, Uttar Pradesh, India

PK Singh
Linseed Project Co-ordinated Unit, Department of Genetics & Plant Breeding, CSAUA&T-Kanpur, Uttar Pradesh, India

Amit Tomar
Linseed Project Co-ordinated Unit, Department of Genetics & Plant Breeding, CSAUA&T-Kanpur, Uttar Pradesh, India

Shiva Mohan
Linseed Project Co-ordinated Unit, Department of Genetics & Plant Breeding, CSAUA&T-Kanpur, Uttar Pradesh, India

Sonu Kumar
Department of Genetics & Plant Breeding, NDUA&T-Kumarganj, Faizabad, Uttar Pradesh, India

Correspondence
Ravindra Kumar Kasana
Linseed Project Co-ordinated Unit, Department of Genetics & Plant Breeding, CSAUA&T-Kanpur, Uttar Pradesh, India

Genetic diversity (D^2) analysis in linseed (*Linum usitatissimum* L.)

Ravindra Kumar Kasana, PK Singh, Amit Tomar, Shiva Mohan and Sonu Kumar

Abstract
The present experiment was conducted using 151 genotypes/varieties of diverse origin were tested in randomized block design with two replications at Nawabganj, Research form of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during rabi 2014-15. Observations were recorded on eleven character namely, days to 50% flowering, size of corolla, number of primary branches per-plant, plant height, capsule size, days to maturity, number of capsules per plant, number of seeds per capsule, 1000-seed weight, oil content and grain yield per plant. Genetic divergence was suggested that cross between the genotypes of II and XIII clusters may give better results during hybridization programme.

Keywords: genetic diversity, linseed, *Linum usitatissimum*

Introduction
The linen fiber (flax) comprises small elements of cell consisting of cellulose, fibre diameter ranged from 12 to 25 p. Fibre length ranges from 1 to 120 mm (Tammes, 1907). Fiber is used for making handkerchiefs, duck and drills materials for suits and dresses, napery, uphoestery, drappery, cushion, covers, wall covering, decorative articles. They are also used for manufacturing of rough textiles like blankets, carpets, mats, mattresses etc. Linseed is good source of calcium and phosphorus with their contents as 170 and 370 mg/100g respectively. India is largest linseed growing country in the world and production wise its rank third in the world after Canada and China. Among Rabi oilseed crops in India, linseed happens to occupy the second position i.e. next to rapeseed-mustard in importance from the view point of area as well as production.

Germplasm utility depends on the information generated by evaluation. It covers the whole range of activities starting from the receipt of the material by the curator and its growing out for seed increase, characterization and preliminary evaluation, and also further evaluation, documentation, utilization and maintenance. The use of proper descriptors, characterization, preliminary evaluation and further evaluation is stressed. Emphasis is laid on linseed germplasm maintenance, population size, experimental design, rejuvenation, and information management and documentation of data. The value of core collection and pre-breeding concept is pointed out. The coordinated role of NBPGR in evaluation activities has been highlighted.

The study of genetic diversity plays significant role by providing basis in making selection of parents for hybridization programme in crop improvement programme. The more diverse parents with in overall criterion of fitness are supposed to give higher amount of hybrid vigour and wide range of variability in segregating population. To measure the degree of divergence among group genotypes based on multiple characters and for selecting efficient parents for hybridization programme in out-breeding and self-pollinated crops, became possible due to Mahalanobis D^2 statistics based on multivariate analysis of quantitative traits which is a powerful tool (Rao, 1952; Murty and Anunachalam, 1966).

Materials & Methods
The experiment consisting of one hundred fifty one strains/genotypes of linseed was conducted at Oilseed Research Farm, Nawabganj, Kanpur is a Randomized Block Design (RBD) with two replications during rabi 2014-2015. The experiment was sown on 30th October, 2014. Each strain/genotype was sown in a plot of 5.0 m long and 2 m wide. Within the plot, plant x plant (P x P) and row x row (R x R) distances were kept 5 cm and 25 cm, respectively. Recommended agronomical practices and plant protection measures were adopted to raise the good crop. Ten plants were taken randomly from each plot for recording

the observations. Observations were recorded for eleven characters namely; days to 50% flowering, size of corolla (cm), number of primary branches per plant, plant height (cm), capsule size (cm), days to maturity, number of capsules per plant, number of seeds per capsule, 1000-seed weight (g), oil content (%) and seed yield per plant (g). D^2 analysis has following important steps as per Mahalanobis (1928) [3].

Results & Discussion

151 genotypes of Linseed (*Linum ussitatisimum* L.) were grouped into thirteen clusters under normal sown condition. The genotypes from one source of origin clustered with the genotypes of other source of origin. This indicated that there was no parallelism between geographical distribution and genetic diversity. Payasi (2000) and Fulkar *et al.* (2007) [6, 1] also found the similar trend. The grouping of genotypes from same geographical origin into different clusters may be due to the different genetic backgrounds and wide divergence in features. Different genetic background is perhaps due to the free exchange of materials among different regions of country for breeding purpose; genetic drift and selection in different environments could be the other important factors contributing to the divergence. Kumarik & Rao (2008) [2] and Rafiq *et al.* (2008) [2]. Also reported similar reasons for genetic diversity.

In present investigation, on the basis of magnitude of D2 values, 151 genotypes of Linseed were grouped into thirteen clusters. The distribution of genotypes in both the environments was different. Maximum genotypes (21) were present in cluster-XIII. The perusal of Table-1, 2, 3, 4 & 5 revealed that the maximum inter cluster distance was observed between cluster-II and cluster-XIII (271.45) indicated wide diversity between these groups. Hybridization among the genotypes separated by high inter cluster distance will result in most heterotic crosses. The estimates of genetic divergence for most of the characters under study are in accordance with earlier reports. The maximum intra cluster distance was observed for cluster-XII (47.45) followed by cluster-II (45.80) and cluster-I (38.76). The maximum intra cluster value indicated maximum divergence among various genotypes within the cluster. A comparison of cluster mean for eleven characters under study revealed considerable genetic differences between the clusters regarding one or more characters. The maximum character contribution towards divergence was observed for Plant height (15.12 %) followed by days to 50 % flowering (14.69 %) and size of corolla (13.22). Similar findings were also reported by Pal *et al.* (2000) [5] and Meshram *et al.* (2008) [4].

Table 1: Distribution of 151 genotypes of Linseed in different clusters.

Clusters	Strain/variety	Number
I.	1541, CI-1968, EC-1433, EC-22850, EC-23592, EC-41627, EC-384154, L-48 and NP.25RRSK.	9
II.	BEHAMPUR and BUAPUR LOCAL.	2
III.	A-449, BENGAL-62 and ICI-14577.	3
IV.	50125, A-375, A-404, A-117, A-434, CI-15-B, CI-1972, EC-115178 and ILS-150	9
V.	164/1, A-49, A-198, CI-1427, CI-2010, BIGNOAHI, BC-5238, EC-1639B, GS-178, GS-194, GANGROOCHI, L-14, L-43, LC-1044 and NP-88.	15
VI.	A-10-2-2, A-388, A-459, RL-975, CI-1554, CI-J-5635, EC-1434, EC-15298, EC-12077B, EC-22583, GS-204, GS-337, GUNAWAL LOCAL, H-11, IC/6387, L-4, LMH-379, NO-3, NP.8 and NP23K.	20
VII.	BR-14, BS-2, BUAPUR LOCAL, C-429-3, CI-765, CR-M-6X22-9, EC-589, EC-1187, EC-41577, PB-3-NO3, FR-11, GS-206, GS-280, IC-15888, L-18 and L-21.	16
VIII.	5620A, BAULK, BR-1, B2-3-62, BENGAL-23, BENGAL-70, BILASPUR, CC-12, CI-540, EC-1389, EC-99029, ES-16381, H-25, Hyb-603-2 and HANAMAN SAGAR.	15
IX.	A-465, ARNY, CI-2056, CI-2067, GS-121, GS-134, KL-169 and LCK-254.	8
X.	A-170, CI-1597, EC-1410, EC-22684, EC-22848, EC-99009, EC-99025, EX-131-10, GS-219, AYOGI, KARAM BANDA and LCK-3532.	12
XI.	68-IC-32676, A-385, EC-564, EC-41733, GS-183, H-8, KANPUR LOCAL, L-53, NO-11, NO.18XRR-9, NO.55, NO.356 and NP-59.	13
XII.	9X12, EX-6-3, GS-401, L-108, LCK-152, LCK-87312, LCK-88311 and NP-89.	8
XIII.	191XRR-9/2, A-23-1-1, A-180, A-210, A-396A, ARNY, EC-561, EC-569, EC-9832, EC-99080, EC-41561, EC-41656, EC-41704, EC-99007, ES-1534, GLC-1-2, ILS-153, JABALPUR-367, LS-1, NO.335 and NP-48	21

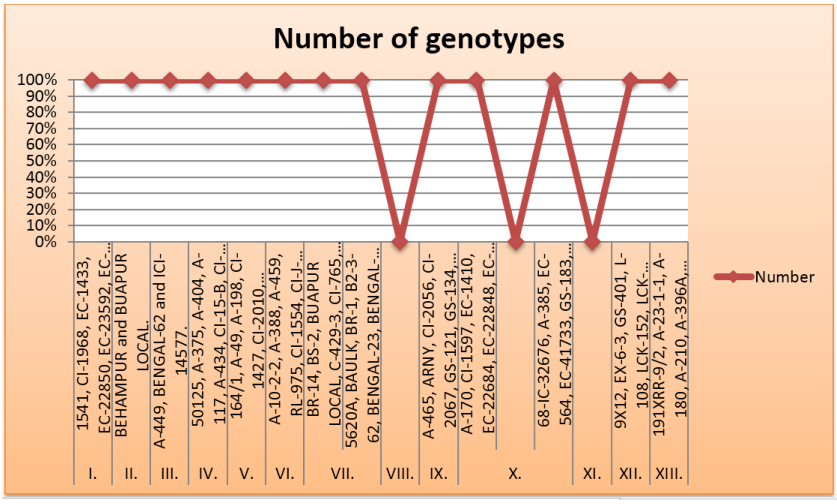

Fig 1.1: Graphical representation of distribution of 151 genotypes of Linseed in different clusters.

Table 2: The average intra and inter cluster distance values of different clusters in Linseed.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I cluster	38.76	75.28	56.48	92.76	90.38	64.46	107.73	62.29	85.83	101.66	120.15	148.13	186.34
II cluster		45.80	87.32	178.49	158.13	145.26	224.25	138.31	163.17	192.73	226.10	249.45	271.45
III cluster			33.55	57.19	56.00	55.57	99.98	67.20	56.84	91.90	84.25	104.03	103.26
IV cluster				35.83	52.57	48.14	65.31	64.93	55.87	91.73	57.79	80.82	83.91
V cluster					35.70	50.21	72.22	63.48	56.47	71.35	53.77	70.07	88.88
VI cluster						31.71	59.19	52.40	48.99	60.03	63.73	76.61	119.39
VII cluster							29.20	62.71	65.06	68.43	58.20	119.02	136.05
VIII cluster								37.64	80.52	84.82	72.92	113.52	155.03
IX cluster									30.17	47.66	51.68	73.52	73.09
X cluster										35.69	61.94	82.26	118.06
XI cluster											33.49	61.18	68.84
XII cluster												47.45	77.62
XIII cluster													32.72

Table 3: Cluster mean of 151 genotypes of Linseed for eleven characters.

Clusters	Days to 50% flowering	Size of corolla (mm)	No. of Primary Branches/ plant	Plant height (cm)	Capsule size (mm)	Days to maturity	No. of capsules/plant	No. of seeds/capsule	1000-Seed weight (g)	Oil content (%)	Grain yield (g)
Cluster I	54.83	21.24	3.90	60.22	5.25	137.33	46.93	7.73	5.57	37.58	11.69
Cluster II	57.00	21.27	3.68	49.58	4.97	136.64	38.32	7.83	5.58	36.40	11.10
Cluster III	63.46	23.00	3.72	61.43	5.26	137.28	45.39	7.67	5.47	36.92	11.32
Cluster IV	54.31	22.51	3.78	65.01	5.54	134.47	69.53	7.81	5.41	37.26	11.86
Cluster V	59.70	21.65	3.94	65.08	5.34	132.46	46.85	7.72	5.59	36.67	11.66
Cluster VI	52.03	22.89	3.53	56.57	5.08	134.85	42.56	7.67	5.50	35.18	11.20
Cluster VII	69.00	22.16	4.50	49.26	5.08	136.00	58.50	7.72	5.59	36.57	12.03
Cluster VIII	66.50	25.04	5.00	51.39	5.05	138.50	34.00	7.50	5.68	35.56	11.75
Cluster IX	54.50	22.17	4.50	62.93	4.74	141.00	81.50	7.93	4.85	38.46	10.23
Cluster X	63.54	19.25	3.46	52.52	5.14	137.07	42.68	7.64	5.66	36.02	11.85
Cluster XI	58.40	21.24	4.25	65.17	5.67	132.20	88.50	7.98	5.07	36.88	11.52
Cluster XII	49.50	24.99	3.50	59.72	5.18	126.50	24.50	7.97	5.97	38.34	11.72
Cluster XIII	59.00	23.30	5.00	67.86	4.75	143.00	23.00	7.72	5.72	39.34	10.52

Table 4: Range among cluster mean for different characters in Linseed.

Range	Days to 50% flowering	Size of corolla (mm)	No. of Primary Branches/ plant	Plant height (cm)	Capsule size (mm)	Days to maturity	No. Of capsules /plant	No. of seeds/ capsule	1000-Seed weight (g)	Oil content (%)	Grain yield (g)
Lower	50.22	18.39	3.25	47.75	4.85	129.62	34.37	7.61	4.77	33.11	10.58
Upper	66.00	23.80	4.50	66.35	5.67	137.75	101.87	8.03	5.89	38.04	12.54

Table 5: Contribution of each character to words divergence.

S.N.	Characters	Days to 50% flowering	Size of corolla (mm)	No. of Primary Branches/ plant	Plant height (cm)	Capsule size (mm)	Days to maturity	No. of capsules /plant	No. of seeds/ capsule	1000-Seed weight (g)	Oil content (%)	Grain yield (g)
1.	Number of time appearing 1st time	1664	1497	57	1712	72	422	3597	203	374	763	964
2.	Per-cent (%) contribution	14.69	13.22	0.50	15.12	0.64	3.73	31.76	1.79	3.30	6.74	8.51

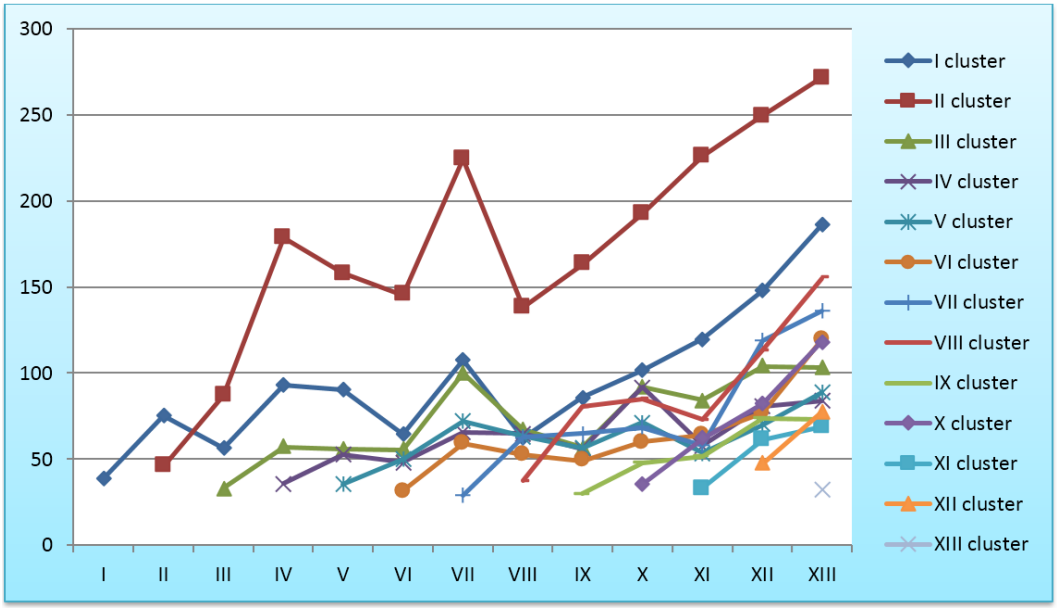

Fig 1.2: Graphical representation of the average intra and inter cluster distance values of different clusters in Linseed.

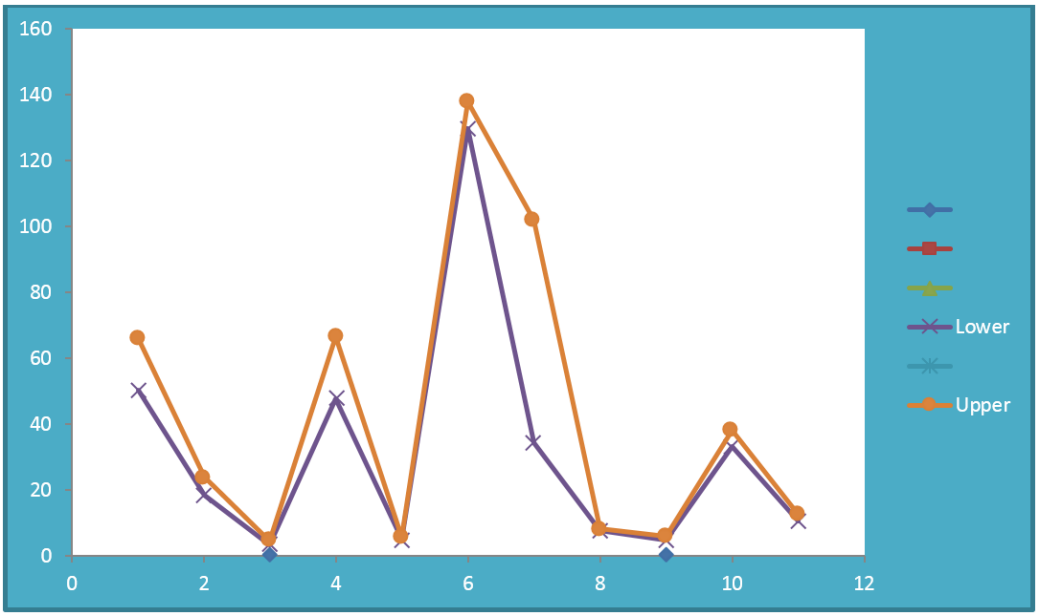

Fig 1.3: Graphical representation of range among cluster mean for different characters in Linseed.

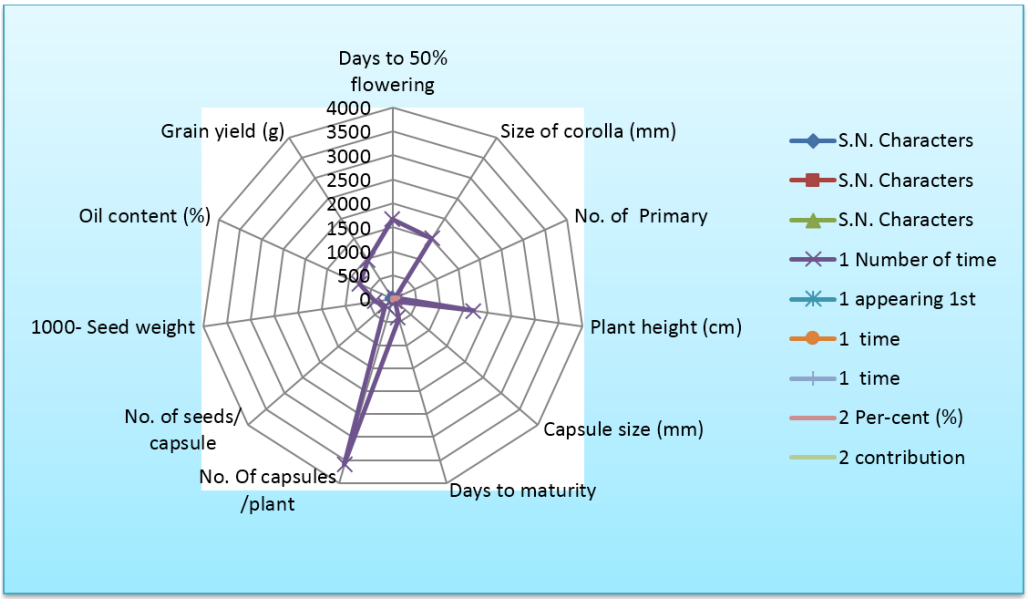

Fig 1.4: Graphical representation of contribution of each character to words divergence.

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