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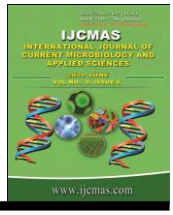

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Stability Analysis of Newly Evolved Genotypes of Chrysanthemum (*Dendranthema grandiflora* Tzvelev) for Cut Flower Production using Eberhart and Russel Model

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A B S T R A C T

Study was carried out to determine the stability of genotypes of chrysanthemum (*Dendranthema grandiflora* Tzvelev) for cut flower production at the experimental farm of Department of Floriculture and Landscape Architecture, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan and ICAR-IARI Regional Research Station, Katrain, Kullu Valley of H.P for two successive years 2017 and 2018 on nineteen genotypes of chrysanthemum, including 'Ajay' as check using Eberthart and Russel model. The character wise stable genotypes were ranked based on their stability for different characters 'UHFSChr132' recorded stable performance for days taken to flowering, plant spread, flower size 'UHFSChr122' for number of cut stems and weight of cut stems. Genotype 'UHFSChr125' for days taken to flowering, stem length.

Introduction

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is a multi use flower crop, belongs to family Asteraceae. It is native to northern hemisphere chiefly Europe and Asia. It is national flower of Japan and species in the genus chrysanthemum varies from 100 to 200. It ranks second after rose (Anonymous, 2017). In India during 2016-2017 the area under chrysanthemum was 20090 hectare and production of cut flower was 14930 MT (Anonymous, 2018). Total area under chrysanthemum in Himachal Pradesh for cut flower is 67.01ha and with annual production of 5360 lakh number of cut flower respectively during the year 2018-2019 (Anonymous, 2019).

It is most popular due to its wide range of flower colour, growth habit, size and shape. It is used for interior decoration and in bouquets. The tall growing plants are suitable for back ground planting in borders. The utility and popularity of chrysanthemum have increased immensely with the introduction of the techniques for year round blooming based on scientific research in the field of photoperiodism and genetics.

However, ability to produce chrysanthemum year round depends on an understanding the complex interaction between the plant and its environment. A sound knowledge of its physiology and management practices can ensure the continued success of chrysanthemum crop despite increasing production cost.

Somehow, the available cultivars could not fulfill the requirements in terms of new colors, forms, types and various characteristics. However, very little attention has been paid for its improvement. Therefore, there is urgent need to for identification of varieties suitable for growing in different agro climatic conditions for specific purposes. Hence, it is utmost important to develop such genotypes which are stable over wide range of environment conditions.

Therefore, an investigation was undertaken on "Stability analysis in chrysanthemum (*Dendranthema grandiflora* Tzvelev) as 'stability' reflects the suitability of genotype for general cultivation over wide range of environment for cut flower production".

According to the dynamic concept, a stable genotype is one which gives predictable performance to environments without any deviation (Becker and Leon, 1988). Identification of stable genotype will help the farmers for its successful commercial cultivation.

Materials and Methods

An experiment was conducted on stability analysis of newly evolved genotypes of chrysanthemum for cut flower production at experimental farm of Department of Floriculture and Landscape Architecture, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan and ICAR-IARI, Regional Research Station, Katrain, Kullu Valley of H.P for two successive years 2017 and 2018 on nineteen genotypes of chrysanthemum.

Genotype namely 'UHFSChr111', 'UHFSChr113', 'UHFSChr114', 'UHFSChr115', 'UHFSChr117', 'UHFSChr118', 'UHFSChr120', 'UHFSChr121', 'UHFSChr122', 'UHFSChr123', 'UHFSChr124', 'UHFSChr125', 'UHFSChr126', 'UHFSChr128', 'UHFSChr129', 'UHFSChr130', 'UHFSChr131', 'UHFSChr132' including 'Ajay' as check.

The plants were planted in three replications in Randomized Block Design in open field conditions using FYM 5 kg/m^2 and half dose of nitrogen and full dose of phosphorus and potassium was also mixed in the soil at the time of bed preparation.

The remaining half dose of nitrogen was applied 45 days after transplanting. Data were recorded in terms of different plant parameters viz., days taken for flowering, plant height (cm) recorded at the time of flowering and measured from bottom to tip of the plant, stem length, stem weight, flower diameter (cm) and duration of flowering.

The data was subjected to stability analysis by using Eberhart and Russell (1966) stability model. The model involves the estimation of mean, regression coefficient and deviation from regression.

Results and Discussion

Pooled analysis of data on stability analysis of nineteen genotypes of chrysanthemum for two years at two locations are presented in Table 1, Table 2, Table 3, Table 4, Table 5, and Table 6.

Data presented in Table 1 revealed that there were significant difference among genotypes for stability analysis with respect to plant height shows that genotypes 'UHFSChr114' (114.97cm), 'UHFSChr115' (114.90cm), 'UHFSChr117' (116.08cm), 'UHFSChr125' (90.33cm),'UHFSChr131'(87.00cm),'UHFSChr132'(88.33cm) recorded significantly high mean values than overall mean (86.78 cm). From among above mentioned genotypes 'UHFSChr115' was found to have phenotypic index (pi) 5.95, regression coefficient (bi) 1.40 and squared deviation from regression (S^2di) 0.08 and this genotype found stable for plant height.

Days taken to flower bud formation genotypes 'UHFSChr129' (135.35 days), 'UHFSChr120' (126.13 days), 'UHFSChr 114' (125.88 days), 'UHFSChr124' (125.08 days), 'UHFSChr130' (125.04 days) 'UHFSChr126' (124.73days), 'UHFSChr113' (124.60 days), 'UHFSChr125' (124.47 cm), exhibited significantly more mean values than overall mean (124.40 days).

From above mentioned genotypes 'UHFSChr126' observed value of phenotypic index (pi) 96.54, regression coefficient (bi) 0.99 and squared deviation from regression (S^2di) 0.96. Hence, this genotype was found stable for trait under study.

Days taken to flowering the genotypes 'UHFSChr129' (163.15 days), 'UHFSChr 120' (161.82 days), 'UHFSChr126' (161.23 days), 'UHFSChr113' (160.85 days), ('UHFSChr111' (160.75 days), 'Ajay' (160.47 days), UHFSChr132' (160.23 days), UHFSChr 125' (160.23days),UHFSChr124', (159.50days), 'UHFSChr114' (158.93 days) and 'UHFSChr115' (158.75cm) showed significantly high mean values than overall mean (158.23 days).The genotypes 'UHFSChr115', 'UHFSChr125' and 'UHFSChr132'recorded phenotypic index (pi) 99.43, 96.23 and 117.10 regression coefficient (bi) value 0.99 each and squared deviation from regression (S^2di) 2.79, 15.50 and 4.62 respectively revealed that these genotypes as rich environment.

Significant variation were noted for plant spread among genotypes across the environments and genotypes 'UHFSChr121' (38.29cm), 'UHFSChr114' (36.36 cm), 'UHFSChr122' (35.60 cm), 'UHFSChr117' (35.29 cm), 'UHFSChr128' (35.28 cm), 'UHFSChr120' (34.74 cm), 'UHFSChr125' (34.77 cm), 'UHFSChr130' (34.52 cm), 'UHFSChr132' (34.41 cm) recorded high mean values than the overall mean (34.37 days).The above mentioned genotypes did not fulfill the criteria to be stable, hence they were found to be unstable for plant spread.

The duration of flowering exhibited significant variations among genotypes 'UHFSChr126'(35.42 days), 'UHFSChr132' (35.33 days),'UHFSChr111' (35.00days), 'Ajay' (34.75 days), 'UHFSChr130' (34.67 days), 'UHFSChr124' (33.67 days), and 'UHFSChr120' (33.25 days), exhibited significantly high mean values than the overall mean (29.22 days).

Among above said genotypes 'UHFSChr132' revealed phenotypic index (pi) 1.18, regression coefficient (bi) 1.72 and 0.03 squared deviation from regression (S^2di) was found to be most stable for the trait under study.

A perusal of data presented in Table 3 revealed that there were significant variations in flower diameter. The genotypes

UHFShr124'(10.19cm), 'UHFSChr115' (6.33cm),'UHFSChr113'(6.05cm),'UHFSChr 123'(5.49cm),'UHFSChr129'(5.38cm),'UHF SChr120'(5.27cm),'UHFSChr126'(5.21cm),' UHFSChr111'(5.20cm), 'UHFSChr130'(5.14 cm) showed maximum diameter of flowers that overall mean (5.05 cm).Genotypes 'UHFSChr132' observed phenotypic index (pi) 1.18, regression coefficient (bi) 1.93 and squared deviation from regression (S^2di) 0.03.Hence this genotypes was found to be the most stable for flower size.

Data presented on stability analysis for stem length noted significant variations (Table 4) observed among genotypes 'UHFSChr115'(97.00 cm), 'UHFSChr114'(78.84 cm), 'UHFSChr125' (78.50 cm), 'UHFSChr117'(77.28 cm), 'UHFSChr122'(75.25 cm), 'UHFSChr121' (73.83 cm), 'UHFSChr132'(73.08 cm) 'UHFSChr123'(71.33 cm) recorded high values for stem length than overall mean value (71.28 cm).Among above specified genotypes 'UHFSChr123' and 'UHFSChr125'exhibited high phenotypic index (pi), regression coefficient (bi) 1.01, 1.65 and squared deviations from regression (S^2di) 9.73 and 4.70 respectively. It indicated that these two genotypes were suitable to rich environment.

For weight of cut stem (g) the genotypes 'UHFSChr111'(43.00 gm),'UHFSChr126' (42.08gm),'Ajay'(39.08gm)'UHFSChr132'(3 8.83gm),'UHFSChr122'(38.42gm),'UHFSCh r130'(38.25 gm), 'UHFSChr124'(32.25 gm) and 'UHFSChr128' (32.33 gm) recorded significant high mean values than the overall mean (31.93 gm).From above said genotypes 'UHFSChr122' and 'UHFSChr128' observed phenotypic index (pi) 12.27, 10.13, regression coefficient (bi) 1.32, 1.45 and squared deviation from regression (S^2di) -0.91, -0.05 showing that these genotypes were suitable for average environments.

Data for number of flowers per stem showed that genotypes 'UHFSChr128' (73.27), 'UHFSChr132' (71.22), 'UHFSChr117' (69.88), 'UHFSChr114' (56.25) 'UHFSChr122' (54.78), 'UHFSChr121' (47.55), 'UHFSChr113' (46.70), 'UHFSChr111' (46.25), and 'UHFSChr 131'(44.91) and 'UHFSChr125' recorded maximum mean values than the overall mean (40.63).

Among above mentioned genotypes 'UHFSChr121' recorded phenotypic index (pi) 11.34, high regression coefficient (bi) 1.98 and squared deviation from regression (S^2di) -6.90 was found stable with average environment.

The present study revealed that the genotypes 'UHFSChr132', 'UHFSChr122' and 'UHFSChr125' observed stable for days taken to flowering, duration of flowering and flower size. Genotype 'UHFSChr122'for number of stems per plant, weight of cut stem and genotype 'UHFSChr 125' days taken to flowering and stem length for cut flower.

These genotypes were less influenced by the season as well as environment and hence found to be stable across the locations and seasons. Similar results have been observed in different floricultural crops; chrysanthemum by Vaidya (2006), Priyanka (2012) and Kumar *et al.,* (2018); gladiolus; Ramberg and Chirva (1978), Arora and Sharma (1991), Desh Raj and Misra (1998 a, b); carnation by Pant and Lal (1998), Misra *et al.,* (2002); marigold by, Naik (2003), Patil *et al.,* (2011) in line with the present findings.

Table.1 Estimation of stability parameters in chrysanthemum for plant height (cm), days taken to flower bud formation

Genotype		Plant height(cm)				Days taken to flower bud formation		
	Mean	pi	Bi	S^2di	Mean	Pi	bi	S^2di
UHFSChr 111	68.15	-25.88	1.72	10.06	122.87	73.04	0.99	5.76
UHFSChr 113	83.67	12.79	1.54	-1.56	124.60	330.40	0.94	3.52
UHFSChr 114	114.97	-25.04	0.29	7.32	125.88	-3299.01	1.11	13.21
UHFSChr 115	114.90	5.95	1.40	0.08	124.27	-111.73	1.02	1.12
UHFSChr 117	116.08	15.68	0.78	-0.36	124.29	9.84	1.00	-0.57
UHFSChr 118	75.53	19.57	1.77	-0.55	124.00	97.52	0.99	-0.60
UHFSChr 120	71.33	18.21	0.16	-0.79	126.13	-66.56	1.02	-0.23
UHFSChr 121	84.68	14.67	-0.01	1.08	122.70	177.91	0.97	0.74
UHFSChr 122	82.31	8.52	1.50	-0.46	123.98	371.52	0.93	4.97
UHFSChr 123	82.53	20.41	0.89	-0.62	119.55	-942.99	1.15	43.44
UHFSChr 124	70.42	20.12	0.56	-0.64	125.08	30.77	1.00	9.16
UHFSChr 125	90.33	10.12	0.17	1.87	124.47	70.15	0.99	-1.13
UHFSChr 126	82.75	-20.99	1.25	8.47	124.73	96.54	0.99	0.96
UHFSChr 128	84.68	13.48	2.47	0.01	124.07	82.40	0.99	-0.94
UHFSChr 129	85.08	-25.57	-1.07	14.35	130.35	807.16	0.84	5.59
UHFSChr 130	85.27	-0.84	0.88	7.02	125.04	181.28	0.97	1.86
UHFSChr 131	87.00	-22.24	1.65	9.10	123.63	-52.22	1.01	0.77
UHFSChr 132	88.33	-68.99	1.54	26.98	124.12	-22.29	1.01	2.05
Ajay	80.85	7.59	1.52	16.35	123.78	-533.93	1.10	5.33
Pooled Mean	86.78		SE(m)=1.56 SE(b)= 0.91 Mean of b=1.00		124.40		SE (m)=1.51 SE(b)= 0.05 Mean of b=1.00	

Table.2 Estimation of stability parameters in chrysanthemum for days taken to flowering and plant spread

Genotype		Days taken to flowering				Plant spread (cm)		
	Mean	pi	bi	S^2di	Mean	pi	bi	S^2di
UHFSChr 111	160.75	445.87	0.88	20.39	34.94	15.83	0.49	-1.53
UHFSChr 113	160.85	-49.20	1.02	28.23	33.87	6.32	1.86	2.97
UHFSChr 114	158.93	-2463.48	1.17	9.78	36.36	-5.28	-4.02	-0.30
UHFSChr 115	158.75	99.43	0.99	2.79	33.86	11.45	4.13	-0.68
UHFSChr 117	149.68	300.29	0.81	192.62	35.29	-21.43	14.04	1.33
UHFSChr 118	158.57	213.92	0.96	-0.98	33.94	-2.30	8.63	1.59
UHFSChr 120	161.82	-257.25	1.09	1.48	34.74	-17.64	4.32	13.74
UHFSChr 121	155.35	-156.67	1.06	5.30	38.39	-46.16	-14.29	13.13
UHFSChr 122	153.20	-276.84	1.10	-1.53	35.60	10.91	-3.08	0.20
UHFSChr 123	156.75	-386.80	1.12	10.18	33.43	12.68	3.33	-0.82
UHFSChr 124	159.50	-346.82	1.09	44.48	26.75	-27.53	-9.03	13.65
UHFSChr 125	160.23	96.23	0.99	15.50	34.77	1.36	-1.78	5.48
UHFSChr 126	161.23	204.50	0.95	23.99	34.98	11.34	-3.15	-0.05
UHFSChr 128	158.95	129.08	0.99	-1.23	35.28	13.99	0.55	-0.61
UHFSChr 129	163.15	209.37	0.96	7.69	33.58	7.08	6.10	-0.11
UHFSChr 130	156.09	-48.45	1.03	6.86	34.52	10.96	2.91	0.25
UHFSChr 131	151.92	442.32	0.75	209.41	34.33	10.56	-5.61	-1.39
UHFSChr 132	160.23	117.10	0.99	4.62	34.41	-6.14	5.03	7.45
Ajay	160.47	-129.46	1.05	13.95	34.06	-2.09	8.56	1.59
Pooled Mean	158.23		SE (m)=3.31 SE(b)= 0.13 Mean of b=1.00		34.37		S E(m)=1.24 S E(b)= 5.35 Mean of b=1.00	

Table.3 Estimation of stability parameters in chrysanthemum for duration of flowering (days) and flower diameter (cm)

Genotype		Duration of flowering (days)				Flower diameter (cm)		
	Mean	pi	bi	S^2di	Mean	pi	bi	S^2di
UHFSChr 111	35.00	3.18	-0.10	-0.62	5.20	0.76	-1.62	-0.02
UHFSChr 113	25.92	-0.90	3.99	-0.48	6.05	-0.07	2.06	0.28
UHFSChr 114	25.08	-1.64	-0.06	-0.25	4.03	-0.09	0.47	-0.01
UHFSChr 115	25.92	3.32	1.05	-0.82	6.33	-1.56	3.67	0.38
UHFSChr 117	27.00	3.85	-0.54	-0.99	3.59	1.03	0.88	-0.02
UHFSChr 118	25.67	3.85	0.81	-1.03	3.90	0.43	-0.81	0.28
UHFSChr 120	33.25	-30.24	9.33	5.74	5.27	1.04	0.14	0.02
UHFSChr 121	24.50	-0.04	2.34	0.34	4.15	0.69	1.59	0.02
UHFSChr 122	27.50	3.51	0.84	-0.87	4.98	-0.32	0.47	0.69
UHFSChr 123	26.67	3.85	-0.32	-0.97	5.49	-8.24	5.76	2.33
UHFSChr 124	33.67	-6.82	-5.78	0.41	10.19	1.11	0.07	-0.01
UHFSChr 125	24.75	3.76	-0.28	-0.92	4.29	0.21	2.30	0.07
UHFSChr 126	35.42	3.32	0.04	-0.69	5.21	-0.10	0.49	0.58
UHFSChr 128	25.83	2.18	-0.61	-0.17	3.63	1.00	-0.75	0.01
UHFSChr 129	26.17	0.85	3.27	-0.73	5.38	0.42	1.82	0.10
UHFSChr 130	34.67	-1.04	4.52	-0.94	5.14	1.10	-0.44	-0.02
UHFSChr 131	28.08	0.65	-3.13	-0.53	4.06	0.54	-0.67	0.24
UHFSChr 132	35.33	1.18	1.72	0.03	4.97	0.90	1.05	0.02
Ajay	34.75	3.10	1.93	-1.02	4.03	-0.01	2.51	0.10
Pooled Mean	29.22		SE(m)=0.53 SE(b)= 1.86 Mean of b=1.00			5.05	SE (m)=0.32 SE(b)= 1.46 Mean of b=1.00	

Table.4 Estimation of stability parameters in chrysanthemum for stem length (cm) and number of cut stems per plant

Genotype		Stem length(cm)				Number of cut stems per plant		
	Mean	pi	bi	S^2di	Mean	Pi	bi	S^2di
UHFSChr 111	56.33	339691.27	-0.82	-0.61	4.75	0.45	-0.90	0.03
UHFSChr 113	63.58	339827.79	-1.44	2.54	6.17	0.42	-0.25	0.09
UHFSChr 114	78.84	-6453927.63	6.99	79.18	6.58	-0.53	0.52	0.06
UHFSChr 115	97.00	338814.02	-1.40	15.50	6.00	-1.24	4.00	-0.07
UHFSChr 117	77.27	339794.77	1.27	-1.25	6.50	0.87	-0.29	-0.14
UHFSChr 118	65.17	339637.46	4.37	1.12	4.48	0.45	0.03	0.08
UHFSChr 120	64.58	339084.68	1.72	11.97	5.53	0.81	1.13	-0.18
UHFSChr 121	73.83	339839.91	-0.70	0.45	5.42	-1.10	3.48	0.10
UHFSChr 122	75.25	339741.46	2.80	18.81	6.67	0.76	1.12	-0.15
UHFSChr 123	71.33	339839.49	1.01	9.73	5.18	0.84	0.44	-0.13
UHFSChr 124	58.58	339614.16	-0.68	26.25	3.92	-2.88	-0.85	1.70
UHFSChr 125	78.50	339778.57	1.65	4.70	6.00	-0.13	-2.17	0.08
UHFSChr 126	70.67	339807.49	0.32	21.56	5.70	0.39	0.21	0.11
UHFSChr 128	70.92	339830.60	-0.88	7.29	5.60	-0.50	3.25	-0.11
UHFSChr 129	71.00	339840.60	-0.24	-0.72	4.92	-0.88	3.85	-0.18
UHFSChr 130	71.08	339815.02	-1.52	5.88	5.12	0.03	2.42	-0.07
UHFSChr 131	70.17	339839.04	0.23	0.79	5.67	0.09	2.33	-0.08
UHFSChr 132	73.08	339782.91	3.36	26.20	6.75	0.67	0.77	-0.07
Ajay	67.08	339494.60	2.97	4.37	4.18	0.50	-0.09	0.06
Pooled Mean	71.28		SE (m)=2.24 SE(b)= 2.24 Mean of b=1.00		40.63	5.35	SE(m)=0.29 SE(b)= 1.39 Mean of b=1.00	

Table.5 Estimation of stability parameters in chrysanthemum for weight of cut stem (g) and number of flowers per stem

Genotype		Weight of cut stem (g)			Number of flowers per stem			
	Mean	pi	bi	S^2di	Mean	Pi	bi	S^2di
UHFSChr 111	43.00	14.57	-0.25	-1.09	46.25	49.69	-0.46	3.95
UHFSChr 113	27.83	5.80	-1.74	1.56	46.70	50.54	0.74	0.83
UHFSChr 114	24.17	-3.00	0.00	-0.33	56.25	-212.07	-0.17	98.31
UHFSChr 115	25.00	5.24	0.80	3.24	32.67	53.93	1.05	-5.40
UHFSChr 117	30.67	-55.20	-6.65	8.08	69.88	6.16	0.90	20.87
UHFSChr 118	26.83	14.24	-0.50	-1.04	29.81	50.13	0.38	4.30
UHFSChr 120	27.58	2.49	0.75	4.66	32.10	20.30	1.23	8.20
UHFSChr 121	26.50	14.24	0.55	-1.06	47.55	11.34	1.98	-6.90
UHFSChr 122	38.42	12.27	1.32	-0.91	54.78	-207.79	3.90	10.71
UHFSChr 123	25.50	4.91	2.19	1.00	11.99	68.02	0.46	-5.24
UHFSChr 124	33.25	9.82	2.01	-1.02	9.20	44.56	1.12	-1.87
UHFSChr 125	29.00	10.57	0.54	0.78	41.19	14.90	-0.27	22.47
UHFSChr 126	42.08	-59.73	7.87	-0.03	39.68	44.15	0.75	3.84
UHFSChr 128	32.33	10.13	1.45	-0.05	73.27	-118.52	2.01	57.11
UHFSChr 129	30.83	-6.20	4.24	-1.13	21.58	32.83	1.23	1.92
UHFSChr 130	38.25	-10.84	3.80	3.23	19.99	51.06	1.13	-5.37
UHFSChr 131	27.42	12.49	-0.14	-0.02	44.91	-1.78	2.17	-6.67
UHFSChr 132	38.83	4.02	-0.03	4.22	71.22	-74.12	0.25	67.09
Ajay	39.08	-1.95	2.80	2.64	22.97	40.64	0.62	7.04
Pooled Mean	31.93		SE (m)=1.00 SE(b)= 1.61 Mean of b=1.00		40.63		SE (m)=2.71 SE (b)= 1.16 Mean of b=1.00	

Table.6 Character wise stable performance of chrysanthemum genotype

Sr No.	Characters	Cut flower
1.	Plant height (cm)	UHFSChr115
2.	Days taken to flower bud formation	UHFSChr126
3.	Days taken to flowering	UHFSChr115, UHFSChr125, UHFSChr132
4.	Plant spread (cm)	-
5.	Duration of flowering (days)	UHFSChr132
6.	Flower size (cm)	UHFSChr132
7.	Stem length (cm)	UHFSChr123,UHFSChr125
8.	Number of cut stems /shoots per plant	UHFSChr120, UHFSChr122
9.	Weight of cut stem (g)	UHFSChr122, UHFSChr128
10.	Number of flowers per stem	UHFSChr121

The character wise stable genotypes and ranking of genotypes based on their stability for different characters are given in Table 6. For cut flower genotypes 'UHFSChr132' recorded stable performance for days taken to flowering, plant spread, flower size 'UHFSChr122' for number of cut stems and weight of cut stems. Genotype 'UHFSChr125' for days taken to flowering, stem length.

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