

# Assessment of the Vegetative Reproduction Potential of Tulips (*Tulipa L.*)

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## ABSTRACT

The principal aim of this research was the assessment of the vegetative reproduction potential of different size tulip bulbs. Bulbs were arranged by size into 7 fractions. Vegetative reproduction capacity of different size tulip bulbs of 299 cultivars was calculated using a number of specific reproduction coefficients: total reproduction coefficient (TRC), generative bulb reproduction coefficient (GRC) and forcible bulb reproduction coefficient (FRC). Reproduction coefficients were calculated individually for each different bulb size class of the investigated tulip cultivars. TRC is a quantitative indicator specifying the mean number of all daughter bulbs per clone. GRC is a qualitative indicator specifying the mean number of bulbs per clone that is capable to blossom next year. FRC is a qualitative indicator specifying the mean number of forcible tulip bulbs per clone. By modulating the data on TRC, GRC and FRC of all cultivars of different size bulbs, indexed reproduction coefficient (IRC) was deduced. IRC indicates a comparative reproduction value. Empirical tulip cultivar dispersion analysis demonstrated that this coefficient most objectively reflects reproduction capacity of all bulbs of the studied tulip cultivars. Based on IRC, the investigated tulip cultivars were grouped into 5 classes of reproduction capacity. Most tulip cultivars were ascribed to 2<sup>nd</sup>–4<sup>th</sup> classes (correspondingly 24, 30 and 30%), whereas a small number of the studied cultivars were attributed to one of the outer classes 1<sup>st</sup> and 5<sup>th</sup> (8%).

**Keywords:** indexed reproduction coefficient, leaf length, reproduction coefficient, tulips, width and leaf area

**Abbreviations:** GRC, generative bulb reproduction coefficient, FRC, forcible bulb reproduction coefficient, IRC, indexed reproduction coefficient, TRC, total reproduction coefficient

## INTRODUCTION

Tulips (*Tulipa L.*) are considered to be a significant perennial bulbous ornamental herbaceous plant culture. Economic importance of the culture has increased markedly since the 6<sup>th</sup> decade of the last century when all-year-round bulbous flower forcing technologies were created by controlling temperature regime (De Hertogh and Le Nard 1993). In the majority of books on tulips the descriptions of cultivars include only the total bulb reproduction coefficient (Holitscher 1972; Kudriavceva 1987); however, they miss references on the size of the mother bulb. Besides, the total reproduction coefficient indicates only the quantitative character of yield without giving information on qualitative aspects. The value of such data is rather conditional and not very useful for comparisons, because the amount of large bulbs in a clone is absolutely unclear. We have not found research data on vegetative reproduction capacity estimation of different size tulip bulbs. Literature references indicate that Papendrecht (1955) investigated 445 tulip cultivars and classified them in 3 groups of reproduction bulbs capacity. The cultivars of the 1<sup>st</sup> group produced a large amount of daughter bulbs. The cultivars of the 3<sup>rd</sup> group yielded a large main bulb and few daughter bulbs, whereas the cultivars of the 2<sup>nd</sup> group were intermediate.

Hekstra (1968) presented a more comprehensive study on tulip bulb reproduction. He selected two size classes of bulbs from the cultivars 'Edith Eddy' (Triumph Tulips), 'Apeldoorn' (Darwin hybrid Tulips) and 'Pandion' (Single Late Tulips) for the research. Hekstra demonstrated that tulip reproduction capacity depends upon mother bulb size. A lot of scientific research work has been carried out on the analysis of how soil and air temperature, light intensity, assimilation surface and most of agro technical measures

(soil types, planting density, depth, time, fertilization, mulch) impact bulb productivity. These studies were reviewed by Rees (1969) and De Hertogh and Le Nard (1993). More profound investigations on tulip bulb productivity were accomplished with a small number of cultivars, whereas the experience has shown that the ascertained regularities should be applied only to the investigated cultivars. Although keen investigations on tulip growth have been carried out, we undertook this research work because of a lack of data on vegetative productivity of diverse size bulbs of different tulip cultivars. Tulip investigators have been involved in wide-ranging physiological and biochemical studies (e.g., Van Roosum 1998; Saniewski *et al.* 1999; Kamenetsky *et al.* 2003; Ohyama 2006).

## MATERIALS AND METHODS

Vegetative reproduction was measured in the period of 1982–1992 at Vilnius section of Bulbous Flowers of Kaunas Botanical Gardens (currently Field Floriculture Research Station). The bulbs were obtained from the Netherlands, the Lithuanian Institute of Agriculture, and the Main Botanical Gardens of Moscow Academy of Sciences. The investigated collection comprises 299 tulip species and cultivars. In accordance with the International nomenclature, tulips are divided into 15 classification groups (De Hertogh and Le Nard 1993). Tulip cultivars of 1–11 groups are analysed in this study. The experimental area consisted of cultivated sandy loam with an arable layer of 25–30 cm. The soil was fertilized yearly (mulch included) with decomposed middle coarse or small peat (80–100 t/ha). Besides, in 1979 the experimental area was fertilized with a litterless poultry manure (1 t/ha), and lime powder (2 t/ha). Repeatedly the field was limed in 1983 with chalk and in 1988 with lime powder (3 t/ha). Yearly the field was fertilized with bone meal (5–8 t/ha), and in 1986–1988 with poultry

manure (5–8 t/ha), too. Every autumn 2–3 weeks before planting, mineral fertilizers (kg/ha) were used as follows: N – 50; P<sub>2</sub>O<sub>5</sub> – 60; K<sub>2</sub>O – 75; MgO – 12. In autumn only one-third of nitrogen was used, the remainder – in early spring.

The bulbs were planted in 1-m wide 30-m long beds. The beds were north south directed. To assess the vegetative capacity of varying size tulip bulbs, they were arranged by size into 7 fractions (abbreviated as fr. throughout): E fr. bulbs diameter was 4.0 cm and more, I fr. – 3.5-3.99, II fr. – 3.0-3.49, III fr. – 2.5-2.99, IV fr. – 2.0-2.49, V fr. – 1.5-1.99 and VI fr. – 1.49 cm and less. The diameter of the bulbs in each fraction differed by 0.5 cm. On the average 4–5 replicates of every cultivar were planted. One replicate included: E fr. – 21, I fr. – 28, II fr. – 32, III fr. – 40, IV fr. – 60, V fr. – 60, VI fr. – 100 number of bulbs. E fr. bulbs were planted in three rows, whereas I–VI fr. – in four rows each.

The beds were mulched every autumn (5-cm peat layer). The experiment was carried out under monoculture conditions or every second year (tulips were planted after gladiolus, daffodils or black fallow). In dry growth seasons the plants were watered, periodically in all seasons sprayed with fungicides. The virus-injured and sickly-growing plants were isolated. The tulips were lifted from 25 June to 5–10 July. The number of daughter bulbs grown from one mother bulb make up a clone. The lifted clone number in every trial plot was registered at the moment of digging, while the total number of bulbs in a trial plot, total mass and bulb number as well as mass of every different size tulip bulbs were ascertained at gathering of the yield.

Tulip bulb vegetative reproduction capacity was established by total reproduction coefficient (TRC), generative bulb reproduction coefficient (GRC), forcible bulb reproduction coefficient (FRC) and indexed reproduction coefficient (IRC) (Baliūnienė and Juodkaitė 1991; Juodkaitė and Baliūnienė 2001; Juodkaitė *et al.* 2003). Reproduction coefficients were calculated individually for each studied fraction of the investigated tulip cultivars. TRC is a quantitative indicator specifying the mean number of daughter bulbs per planted bulb. TRC was obtained by dividing the number of lifted tulip bulbs by clone number. Clone - daughter bulbs who grown from one mother bulbs.

GRC (E–IV fr. bulbs) is a qualitative indicator specifying the mean number of bulbs capable to blossom next year per clone. GRC was obtained by dividing the number of lifted generating tulip bulbs by clone number. FRC (E–I fr. bulbs) is a qualitative indicator specifying the mean number of forcible tulip bulbs per planted bulb. FRC was obtained by dividing the number of lifted forcible tulip bulbs by clone number. By modulating the data on TRC, GRC and FRC of the whole mother bulb cross section, indexed reproduction coefficient (IRC) was deduced. To calculate this indicator, mean tulip mother bulb fr. coefficients and weighted factors were rated (Table 1).

IRC was obtained by the next algorithm: at first, the value of AsTRC (in the same way the values of AsGRC and AsFRC) was calculated by equation:

$$AsTRC = \frac{\sum_{i=1}^n \frac{TRC_i}{Atrc_i} Ptrc_i}{\sum_{i=1}^n Ptrc_i}$$

$n = 7$  (total of fractions),  $i$  – fraction number,  $Atrc_i$  – total average of fraction  $i$ ,  $Ptrc_i$  – weighted factor of fraction  $i$ ,  $TRC_i$  – TRC of

fraction  $i$ , (corresponding values of  $Atrc$  and  $Ptrc$ , also  $Agrc$ ,  $Pgrc$ ,  $Afrc$ ,  $Pfrc$  given in Table 1)

These three assembled parameters (AsTRC, AsGRC and AsFRC) show how many times the corresponding reproduction coefficient of a particular cultivar exceeds the corresponding average of all the investigated cultivars. Further these three quantities were integrated into one tulip cultivar value parameter IRC using weighted factors to each of them:

$$IRC = P_f \times AsFRC + P_g \times AsGRC + P_t \times AsTRC$$

Corresponding weighted factors:  $P_f = 0.182$ ,  $P_g = 0.455$ ,  $P_t = 0.364$ . The factors were chosen according to the tulip growers' survey data, which is partly subjective.

To analyse biological range of the investigated parameters (TRC, GRC, FRC and clone mass) and the type of cultivars dispersion, tulip bulbs of all the studied cultivars within the range of fractions were grouped into 5 grades of reproduction. Gradation was carried out by ranking the range of mean data on the cultivars of all different size tulip bulbs into 5 classes of reproduction capacity.

Boundaries between the clusters have been chosen with the aid of Cluster analysis tool of Statistica 5.5A.

This study was carried out at Vingis Department of the Botanical Gardens of Vilnius University. The data analysis was performed by using the statistical analysis tools of MS Excel 2002 (Microsoft Corp.) and Statistica 5.5A (StatSoft, Inc.) programmes.

## RESULTS AND DISCUSSION

Tulip vegetative reproduction capacity was estimated by analysing the 10-year research (1982–1992) data on 299 tulip cultivars of different classification groups: Group 1. Single Early Tulips (28), Group 2. Double Early Tulips (6), Group 3. Triumph Tulips (90), Group 4. Darwin hybrid Tulips (57), Group 5. Single Late Tulips (73), Group 6. Lily Flowered Tulips (16), Group 7. Fringed Tulips (15), Group 8. Viridiflora Tulips (1), Group 10. Parrot Tulips (8) and Group 11, Double Late Tulips (4 cultivars). To make a detailed assessment of reproduction of this large number of tulip cultivars, the obtained data analysis was carried out according to reproduction coefficients: TRC, GRC, FRC and IRC.

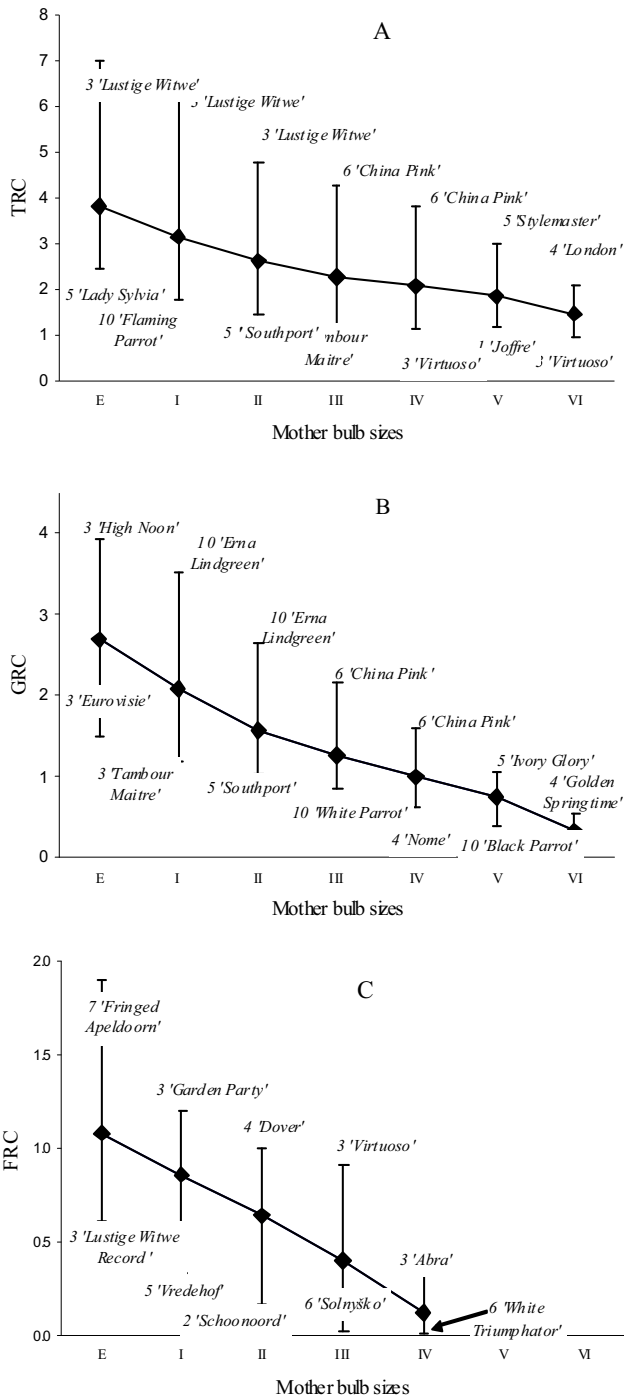
### Total reproduction coefficient

TRC of the investigated tulip cultivars ranged from 7.02 (3 'Lustige Witwe', E fr.) to 0.96 (3 'Virtuoso', VI fr.) through the whole mother bulb cross section (Fig. 1A). TRC range interval was 6.06, i. e. maximum index was 7.3 times higher than minimum. The results show that smaller mother bulbs had lower reproduction coefficient values and a correspondingly narrower TRC range interval. The ratio between maximum and minimum indices were: E fr. bulbs – 2.9, I fr. – 3.5, II fr. – 3.3, III fr. – 3.4, IV fr. – 3.4, V fr. – 2.6, VI fr. – 2.2 (Table 2). Under decreasing mass of mother bulbs, TRC ranged on average from 3.81 (E fr.) to 1.45 (VI fr.), or it decreased 2.6 times. These data indicate a very high reproductive capacity of small fraction bulbs, because IV fraction mother bulbs mass was 6.3 times lower than that of Extra fraction, V fr. – 12.2 times and VI fr. – even 32.2 times. TRC was highly correlated with mother bulb size

**Table 1** Average vegetative reproduction coefficients of all cultivars by fractions and corresponding weighted factors.

Mother bulb fraction	Mean values, standard errors and weighted factors								
	Atrc			Agrc			Afrc		
	M	SE	Ptrc	M	SE	Pgrc	M	SE	Pfrc
E	3.81	±0.05	0.221	2.68	±0.03	0.278	1.05	±0.02	0.343
I	3.15	±0.05	0.183	2.08	±0.03	0.215	0.86	±0.01	0.279
II	2.63	±0.04	0.153	1.56	±0.02	0.162	0.64	±0.01	0.210
III	2.26	±0.03	0.131	1.25	±0.01	0.130	0.40	±0.01	0.130
IV	2.08	±0.03	0.121	1.01	±0.01	0.105	0.12	±0.005	0.039
V	1.84	±0.02	0.107	0.75	±0.01	0.078	-	-	-
VI	1.46	±0.01	0.085	0.32	±0.01	0.033	-	-	-

Atrc, Agrc, Afrc – Averages of reproduction coefficients across the fractions; SE - Standard errors; Ptrc, Pgrc, Pfrc – weighted factors



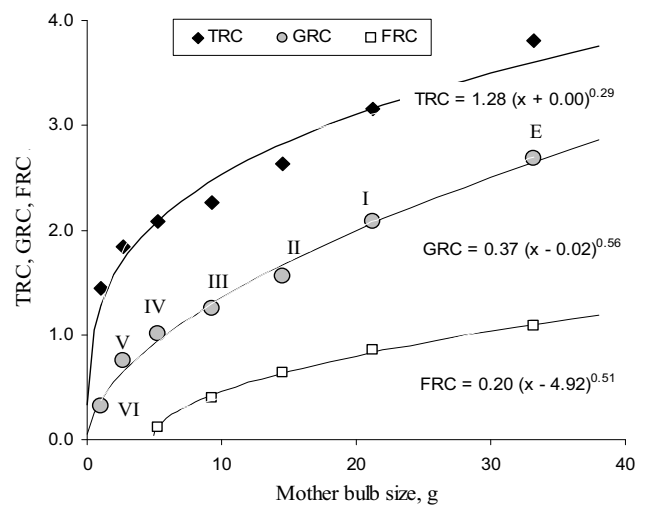
**Fig. 1** Total reproduction coefficient (A), Generative bulb reproduction coefficient (B) and Forcible bulb reproduction coefficient (C) dispersion range.

( $R^2=0.98$ ) (Fig. 2B).

To systematize all the investigated tulip cultivars TRC dispersion, the data on each bulb fraction were grouped into 5 grades of reproduction (Table 3). This kind of distribution manifests biological prolificacy range of varying mother bulb sizes of different tulip cultivars. TRC dispersion through the whole mother bulb cross section showed negative asymmetry, because 38% to 55% of the investigated cultivars were ascribed to 4<sup>th</sup> grade of reproduction. Within the range of the above-discussed grade of reproduction, the smallest number of cultivars in V and VI fractions was recorded, which also proves the tendency of relatively higher reproduction capacity of small fraction bulbs. There are in Table 9 column AsTRC underlined the highest TRC determined for the cultivars.

**Table 2** Dependence of total reproduction coefficient (TRC) dispersion on mother bulb size

Mother bulb fraction	TRC (average)	Maximum rate	Minimum rate
E	3.81	7.02 (3 'Lustige Witwe')	2.44 (5 'Lady Sylvia')
I	3.15	6.15 (3 'Lustige Witwe')	1.76 (10 'Flaming Parrot')
II	2.63	4.77 (3 'Lustige Witwe')	1.46 (5 'Southport')
III	2.26	4.26 (6 'China Pink')	1.24 (3 'Tambour Maitre')
IV	2.07	3.81 (6 'China Pink')	1.12 (3 'Virtuoso')
V	1.84	2.97 (5 'Stylemaster')	1.15 (1 'Joffre')
VI	1.45	2.08 (4 'London')	0.96 (3 'Virtuoso')



**Fig. 2** Correlation between tulip cultivars reproduction coefficients and mother bulb mass.

### Generative bulb reproduction coefficient

Tulip bulbs producing generative shoots increase qualitative value of yield more effectively to compare with TRC. GRC of the studied tulip cultivars ranged from 3.92 (3 'High Noon', E fr.) to 0.07 (10 'Karel Doorman', VI fr.). GRC range interval was 3.85 and the maximum index was even 56 times higher than the minimum. The smaller mother bulbs indicated the shorter GRC intervals between border cultivars of the same fraction (Fig. 1B). The ratios between maximum and minimum indices were: E fr. bulbs – 2.6, I fr. – 3.0, II fr. – 2.6, III fr. – 2.5, IV fr. – 2.6, V fr. – 2.7 and VI fr. – 7.9 (Table 4). It was established that GRC interval between border tulip cultivars on the upper part of mother bulb cross section was higher than that on the lower part. When mother bulbs of the investigated tulips were smaller, GRC mean decreased from 2.68 (E fr.) to 0.32 (VI fr.) or 8.4 times. GRC was highly correlated with mother bulb size ( $R^2 = 0.99$ ) (Fig. 2).

GRC data on each fraction were grouped into 5 grades of reproduction. GRC dispersion index in larger fractions (E – IV fr.) showed negative asymmetry, as far as most investigated cultivars were concentrated in 3<sup>rd</sup> – 5<sup>th</sup> grades, whereas most cultivars of V and VI fractions – 2<sup>nd</sup> and 3<sup>rd</sup> grades (Table 5). There are in Table 9 column AsGRC, the highest GRC determined for the cultivars underlined.

### Forcible bulb reproduction coefficient

FRC of the studied tulip cultivars ranged from 1.90 (7 'Fringed Apeldoorn', E fr.) to 0.01 (6 'White Triumphantor',

**Table 3** Range limits of tulip cultivars grades according to TRC and percentage distribution of cultivars by grades.

Mother bulb fraction	Grades of reproduction according to TRC									
	1		2		3		4		5	
	Range	% *	Range	%	Range	%	Range	%	Range	%
E	7.02-6.11	1	6.10-5.19	3	5.18-4.27	19	4.26-3.35	53	3.34-2.43	24
I	6.15-5.28	1	5.27-4.40	4	4.39-3.52	23	3.51-2.64	48	2.63-1.76	24
II	4.77-4.12	2	4.11-3.46	7	3.45-2.80	26	2.79-2.13	44	2.12-1.46	21
III	4.26-3.66	1	3.65-3.05	5	3.04-2.44	26	2.43-1.83	50	1.82-1.22	18
IV	3.81-2.28	1	3.27-2.74	5	2.73-2.20	27	2.19-1.66	55	1.65-1.12	12
V	2.97-2.61	2	2.60-2.24	9	2.23-1.87	33	1.86-1.50	42	1.49-1.15	14
VI	2.08-1.86	4	1.85-1.63	17	1.62-1.40	34	1.39-1.17	38	1.16-0.96	7

\* – percentage of total cultivars

**Table 4** Dependence of generative reproduction coefficient (GRC) dispersion on mother bulb size.

Mother bulb fraction	GRC (average)	Maximum index	Minimum index
Extra	2.68	3.92 (3 'High Noon')	1.49 (3 'Eurovisie')
I	2.08	3.52 (10 'Erna Lindgreen')	1.19 (3 'Tambour Maitre')
II	1.56	2.65 (10 'Erna Lindgreen')	1.03 (5 'Southport')
III	1.25	2.15 (6 'China Pink')	0.86 (10 'White Parrot')
IV	1.00	1.58 (6 'China Pink')	0.61 (4 'Nome')
V	0.75	1.05 (5 'Ivory Glory')	0.39 (10 'Black Parrot')
VI	0.32	0.55 (4 'Golden Springtime')	0.07 (10 'Karel Doorman')

**Table 5** Range limits of tulip cultivars grades according to GRC and percentage distribution of cultivars by grades.

Mother bulb fraction	Grades of reproduction according to GRC									
	1		2		3		4		5	
	Range	%*	Range	%	Range	%	Range	%	Range	%
E	3.90-3.45	5	3.44-2.97	20	2.96-2.49	37	2.48-2.01	33	2.00-1.53	5
I	3.52-3.06	1	3.05-2.59	14	2.58-2.12	30	2.11-1.65	39	1.64-1.18	16
II	2.65-2.33	1	2.32-2.00	7	1.99-1.67	25	1.66-1.34	42	1.33-1.01	25
III	2.15-1.90	1	1.89-1.64	3	1.63-1.38	20	1.37-1.12	54	1.11-0.86	22
IV	1.58-1.46	1	1.45-1.33	5	1.32-1.20	51	1.19-1.07	40	1.06-0.94	3
V	1.05-0.92	6	0.91-0.78	40	0.77-0.64	39	0.63-0.50	11	0.49-0.36	4
VI	0.55-0.46	7	0.45-0.36	30	0.35-0.26	39	0.25-0.16	21	0.15-0.06	3

\* – percentage of total cultivars

**Table 6** Dependence of forcible reproduction coefficient (FRC) dispersion on mother bulb size.

Mother bulb fraction	FRC (average)	Maximum index	Minimum index
E	1.08	1.90 (7 'Fringed Apeldoorn')	0.61 (3 'Lustige Witwe Record')
I	0.86	1.20 (3 'Garden Party')	0.34 (5 'Vredenhof')
II	0.64	1.00 (4 'Dover')	0.16 (2 'Schoonoord')
III	0.40	0.91 (3 'Virtuoso')	0.03 (6 'Solnyško')
IV	0.12	0.32 (3 'Abra')	0.01 (6 'White Triumphator')

**Table 7** Range limits of tulip cultivars grades according to FRC and percentage distribution of cultivars by grades.

Mother bulb fraction	Grades of reproduction according to FRC									
	1		2		3		4		5	
	Range	% *	Range	%	Range	%	Range	%	Range	%
E	1.90 – 1.65	0,5	1.64 – 1.39	7,5	1.38 – 1.13	33	1.12 – 0.87	45	0.86 – 0.61	14
I	1.20 – 1.04	6	1.03 – 0.87	42	0.86 – 0.70	40	0.69 – 0.53	9	0.52 – 0.34	3
II	1.00 – 0.84	7	0.83 – 0.67	40	0.66 – 0.50	39	0.49 – 0.33	10	0.32 – 0.6	4
III	0.91 – 0.74	1	0.73 – 0.56	12	0.55 – 0.38	46	0.37 – 0.20	29	0.19 – 0.02	12
IV	0.32 – 0.26	5	0.25 – 0.19	12	0.18 – 0.12	32	0.11 – 0.06	30	0.05 – 0	21

\* – percentage of total cultivars

IV fr.). FRC range interval was 1.89; consequently, maximum index of E fr. was 190 times higher than minimum index of VI fr. FRC range interval of border tulip cultivars from E fr. mother bulbs was 1.29 (Fig. 2). Under decreasing mother bulb mass (I, II and III fr.), range intervals were insignificant, correspondingly 0.86, 0.84, 0.88, whereas from IV fr. mother bulbs, FRC range interval was 0.11. The ratio between maximum and minimum indices were: E fr. – 3.1, I fr. – 3.5, II fr. – 6.3, III fr. – 30.3 and IV fr. – 32 (Table 6). Under decreasing mother bulb mass, FRC of the investigated tulips decreased on average from 1.08 (E fr.) to 0.12 (IV fr.), i.e., 9 times. Positive correlation between FRC and mother bulb size is based on high determination coefficient ( $R^2 = 0.99$ ) (Fig. 2).

Most of the investigated tulip cultivars were concen-

trated in 2<sup>nd</sup> – 4<sup>th</sup> grades of reproduction. E fr. mother bulbs FRC dispersion showed negative asymmetry, because 92% of the studied tulips occurred in 3<sup>rd</sup> – 4<sup>th</sup> grades, I and II fr. tulip cultivars were in 2<sup>nd</sup> – 3<sup>rd</sup> grades, whereas III and IV fr. tulip dispersion also revealed negative asymmetry, because most of the cultivars (correspondingly 87 and 83%) were in 3<sup>rd</sup> – 5<sup>th</sup> grades (Table 7). There are in Table 9 column AsFRC the highest FRC determined for the cultivars underlined.

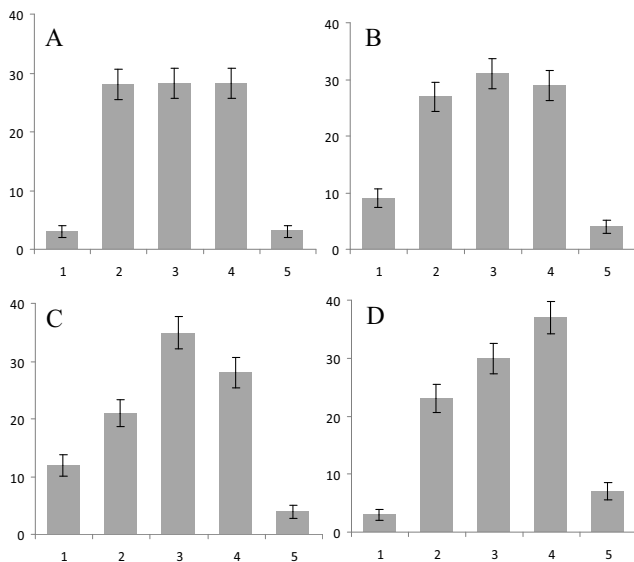
#### Indexed tulip bulb vegetative reproduction coefficient

The analysis of reproduction coefficients indicated that TRC, GRC and FRC of only few tulip cultivars of all inves-

**Table 8** Dependence of tulip bulb clone mass dispersion on mother bulb size.

Mother bulb fraction	Average clone mass (g)	Maximum clone mass (g)	Minimum clone mass (g)	Intervals *
E	48.16 ± 0.53	68.67 (5 'Temple of Beauty Maxima')	25.00 (6 'Maybole')	43.7
I	35.72 ± 0.36	57.00 (5 'Temple of Beauty Maxima')	19.69 (5 'Princess Elizabeth')	40.3
II	26.92 ± 0.27	41.28 (3 'Jacques Fath')	14.00 (7 'Arma')	27.3
III	19.95 ± 0.21	30.09 (4 'Golden Springtime')	12.00 (1 'Early Queen')	18.1
IV	13.34 ± 0.13	20.33 (4 'Golden Parade')	7.00 (6 'Aladdin')	13.3
V	8.58 ± 0.08	13.82 (8 'Groenland')	5.00 (5 'Port Said')	8.8
VI	3.76 ± 0.05	6.52 (4 'Dardanelles')	1.50 (5 'Vredehof')	5

\* - clone mass intervals between the border cultivars within the same fraction

**Fig. 3** Relative contribution (%) of Single Early (A), Triumph (B), Darwin hybrid (C) and Single Late (D) tulip cultivars into grades of reproduction by IRC.

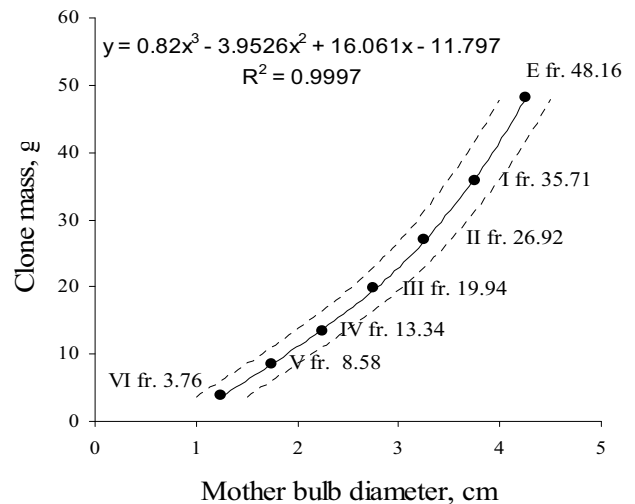
tigated sizes would occur in the same reproduction grade. This fact as well as wide mother bulb size dispersion of cultivars complicates the analysis of the obtained data. These reasons together with the necessity to convert tulip cultivar productivity of the different size tulip bulbs into one numerical value made us look for a resultant value. We called it Indexed reproduction coefficient (IRC). This resultant value reflects the comparative value of the whole mother spectrum productivity of the investigated cultivars. Empirical investigation of distribution tulip cultivar demonstrated that this coefficient most objectively reflects reproduction capacity of all fraction bulbs of the studied tulip cultivars. IRC ranged from 1.409 (6 'China Pink') to 0.668 (7 'Arma'). IRC range interval was 0.373, and maximum index was lower than minimum by 2.1 times.

Based on IRC, the investigated tulip cultivars were grouped into 5 grades of reproduction. Most tulip cultivars were attached to 2<sup>nd</sup> – 4<sup>th</sup> grades (correspondingly 24, 30 and 30%), whereas rather small number (8 %) of the studied cultivars occurred in 1<sup>st</sup> and 5<sup>th</sup> grades. The investigated cultivars of all classification groups by aid of Cluster analysis tool of Statistica 5.5 were divided in five IRC classes.

In the 1st grade of reproduction, 25 tulip cultivars were attributed. In the 2nd grade of reproduction, 70 tulip cultivars were attributed. In the 3rd grade of reproduction, 89 tulip cultivars were attributed. In the 4th grade of reproduction, 89 tulip cultivars were attributed. In the 5th grade of reproduction, 25 tulip cultivars were attributed (Table 9).

#### IRC-based analysis of tulip cultivars numbered among larger classification groups

Group 1. Single Early Tulips. 29 cultivars were investigated, which made up 10% of all studied tulip cultivars. Most of them (84%) were attributed to 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> grades (Fig. 3A). The most reproductive in this group were 'Hadley' and

**Fig. 4** Correlation between tulip bulb clone mass and mother bulb circumference.

'Orange Early Queen' cultivars. 'Couleur Cardinal' and 'Prinses Irene' were the least reproductive.

Group 3. Triumph Tulips. 90 cultivars were studied which came to 30% of all tulip cultivars under research. Most of the cultivars were ascribed to 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> grade (87%), the smallest number – 5th grade (Fig. 3B). The most reproductive tulip cultivars were as follows: 'Andes', 'Aureola', 'Blenda', 'High Noon', 'Lustige Witwe', 'Lustige Witwe Record', 'Olaf', 'Piccadilly'. IRC index of the cultivars 'Abra', 'Frederica', 'Ingmar Stenmark', 'Tambour Maitre' was very low.

Group 4. Darwin hybrid Tulips. 57 cultivars were investigated, which made up 19% of the studied tulip cultivars. Most cultivars were assigned to 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> grades of reproduction (84%). The lowest number was recorded in 1<sup>st</sup> and 5<sup>th</sup> grades (Fig. 3C). The most reproductive tulips in this group were 'Apeldoorn', 'Apeldoorn's Elite', 'Apeldoorn's Favourite', 'Beauty of Apeldoorn', 'Golden Apeldoorn', 'Golden Hoboken' and 'President Kennedy'. The lowest IRC indices were established for 'Golden Oxford' and 'Parade Record' cultivars.

Group 5. Single Late Tulips. 73 cultivars were studied, which came to 24% of the investigated cultivars. Most cultivars were attached to 3<sup>rd</sup> and 4<sup>th</sup> (67%) grade of reproduction (Fig. 3D). The most reproductive and valuable tulip cultivars were as follows: 'Avalanche', 'Avignon', 'Bartigon', 'Canabera', 'Copland's Purple', 'Cordell Hull', 'Gold Standart', 'Insurpassable', 'Psyche', 'Stylemaster', 'Vredehof', 'White Giant'. The lowest IRC indices were established for 'Dom Pedro', 'Esther', 'Lady Sylvia', 'Snowpeak', 'Wim van Est' tulip cultivars.

#### Average mass of different size tulip bulbs

A Tulip bulb clone consists of different mass, size and form bulbs. The investigated tulip bulb mass ranged from 52.81 g (5 'Temple of Beauty Maxima', E fr.) to 0.72 g (7 'Aleppo', VI fr.), whereas maximum indicator of bulb mass was even 73 times higher than minimum. Under decreasing mother

**Table 9** Indexed and assembled reproduction coefficients and their confidence intervals (95% significance).

No	Cultivars/species	IRC±CI	AsTRC ±CI*	AsGRC ±CI*	AsFRC ±CI*
<b>1<sup>st</sup> class of reproductivity</b>					
1	6 'China Pink'	1.41 ± 0.33	1.76 ± 0.17	1.51 ± 0.19	0.46 ± 0.12
2	4 'Apeldoorn's Favourite'	1.33 ± 0.07	1.25 ± 0.1	1.28 ± 0.09	1.43 ± 0.21
3	7 'Fringed Apeldoorn'	1.31 ± 0.08	1.25 ± 0.09	1.29 ± 0.09	1.38 ± 0.3
4	7 'Fringed Beauty'	1.3 ± 0.05	1.25 ± 0.1	1.31 ± 0.07	1.28 ± 0.14
5	5 'Stylemaster'	1.28 ± 0.09	1.34 ± 0.14	1.27 ± 0.11	1.11 ± 0.12
6	3 'Lustige Witwe'	1.27 ± 0.17	1.58 ± 0.28	1.21 ± 0.11	0.78 ± 0.22
7	4 'Beauty of Apeldoorn'	1.26 ± 0.05	1.24 ± 0.08	1.3 ± 0.1	1.18 ± 0.06
8	3 'High Noon'	1.25 ± 0.08	1.15 ± 0.1	1.33 ± 0.16	1.15 ± 0.11
9	3 'Andes'	1.24 ± 0.1	1.37 ± 0.06	1.15 ± 0.11	1.08 ± 0.39
10	3 'Lustige Witwe Record'	1.24 ± 0.16	1.55 ± 0.22	1.13 ± 0.12	0.75 ± 0.2
11	4 'President Kennedy'	1.23 ± 0.06	1.23 ± 0.1	1.22 ± 0.1	1.14 ± 0.17
12	4 'Golden Apeldoorn'	1.22 ± 0.03	1.18 ± 0.06	1.22 ± 0.05	1.21 ± 0.06
13	6 'Red Shine'	1.21 ± 0.12	1.39 ± 0.1	1.19 ± 0.14	0.84 ± 0.21
14	3 'Blenda'	1.21 ± 0.1	1.29 ± 0.09	1.23 ± 0.17	0.94 ± 0.12
15	10 'Erna Lindgreen'	1.2 ± 0.21	1.35 ± 0.18	1.28 ± 0.42	0.69 ± 0.09
16	4 'Apeldoorn's Elite'	1.19 ± 0.04	1.18 ± 0.06	1.21 ± 0.05	1.2 ± 0.17
17	4 'Apeldoorn'	1.19 ± 0.05	1.21 ± 0.07	1.19 ± 0.04	1.16 ± 0.2
18	1 'Hadley'	1.18 ± 0.08	1.21 ± 0.11	1.26 ± 0.14	0.95 ± 0.13
19	3 'Olaf'	1.18 ± 0.09	1.2 ± 0.11	1.19 ± 0.2	1.09 ± 0.09
20	3 'Aureola'	1.18 ± 0.16	1.35 ± 0.12	1.21 ± 0.26	0.74 ± 0.3
21	4 'Golden Hoboken'	1.17 ± 0.07	1.2 ± 0.05	1.19 ± 0.11	1.04 ± 0.21
22	5 'Inglescombe Yellow'	1.17 ± 0.07	1.23 ± 0.04	1.21 ± 0.11	0.94 ± 0.14
23	6 'Arkadia'	1.17 ± 0.16	1.41 ± 0.06	1.19 ± 0.13	0.61 ± 0.11
24	1 Orange Early Queen'	1.16 ± 0.07	1.13 ± 0.07	1.23 ± 0.11	1.05 ± 0.15
25	3 Piccadilly'	1.16 ± 0.08	1.18 ± 0.13	1.23 ± 0.09	0.95 ± 0.18
<b>2<sup>nd</sup> class of reproductivity</b>					
26	5 'Anna Priede'	1.16 ± 0.13	1.28 ± 0.14	1.18 ± 0.18	0.8 ± 0.14
27	3 'Los Angeles'	1.16 ± 0.08	1.12 ± 0.14	1.19 ± 0.16	1.08 ± 0.1
28	3 'Frankfurt'	1.15 ± 0.08	1.23 ± 0.12	1.1 ± 0.13	1.11 ± 0.1
29	5 'Alabaster'	1.15 ± 0.13	1.23 ± 0.19	1.21 ± 0.16	0.83 ± 0.14
30	7 'Sundew'	1.14 ± 0.17	1.26 ± 0.21	1.23 ± 0.14	0.72
31	3 'Preludium'	1.14 ± 0.08	1.19 ± 0.12	1.17 ± 0.16	0.99 ± 0.09
32	1 'Keizerskroon'	1.14 ± 0.07	1.13 ± 0.05	1.14 ± 0.11	1.19 ± 0.21
33	1 'Wintergold'	1.14 ± 0.22	1.34 ± 0.32	1.23 ± 0.26	0.52 ± 0.65
34	3 'Crater'	1.13 ± 0.08	1.22 ± 0.1	1.13 ± 0.13	0.99 ± 0.16
35	5 'Insurpassable'	1.13 ± 0.08	1.14 ± 0.15	1.21 ± 0.08	0.95 ± 0.1
36	1 'Galway'	1.13 ± 0.05	1.09 ± 0.09	1.13 ± 0.05	1.19 ± 0.11
37	1 'White Sail'	1.13 ± 0.12	1.27 ± 0.19	1.15 ± 0.15	0.78 ± 0.03
38	4 'Empire State'	1.13 ± 0.09	1.2 ± 0.08	1.09 ± 0.15	1.05 ± 0.24
39	3 'Rijnland'	1.12 ± 0.09	1.05 ± 0.15	1.14 ± 0.15	1.2 ± 0.12
40	6 'Burgundy'	1.12 ± 0.1	1.27 ± 0.1	1.07 ± 0.17	0.92 ± 0.13
41	4 'Golden Springtime'	1.12 ± 0.09	1.04 ± 0.09	1.13 ± 0.18	1.23 ± 0.1
42	3 'Hugo Schlooser'	1.12 ± 0.04	1.1	1.11	1.16
43	3 'Nivea'	1.11 ± 0.11	1.23 ± 0.03	1.15 ± 0.19	0.8 ± 0.18
44	1 'Fred Moore'	1.11 ± 0.12	1.13 ± 0.15	1.24 ± 0.17	0.77 ± 0.11
45	1 'Charles'	1.11 ± 0.07	1.18 ± 0.11	1.05 ± 0.09	1.11 ± 0.14
46	4 'Franklin D.Roosevelt'	1.11 ± 0.08	1.09 ± 0.09	1.05 ± 0.1	1.29 ± 0.15
47	11 'Miranda'	1.11 ± 0.1	1.11 ± 0.11	1.17 ± 0.17	0.92 ± 0.21
48	3 'Remagen'	1.1 ± 0.05	1.05 ± 0.09	1.13 ± 0.08	1.13 ± 0.09
49	1 'Christmas Marvel'	1.1 ± 0.05	1.18 ± 0.06	1.09 ± 0.06	0.97 ± 0.11
50	5 'Avalanche'	1.1 ± 0.07	1.15 ± 0.05	1.07 ± 0.18	1.06 ± 0.13
51	2 'Carlton'	1.1 ± 0.09	1.07 ± 0.05	1.09 ± 0.2	1.17 ± 0.19
52	5 'Copland's Purple'	1.1 ± 0.22	1.24 ± 0.05	1.24 ± 0.2	0.44 ± 0.06
53	5 'Golden Spike'	1.09 ± 0.07	1.04 ± 0.1	1.09 ± 0.08	1.2 ± 0.13
54	4 'Golden Deutschland'	1.09 ± 0.08	1.05 ± 0.09	1.07 ± 0.14	1.22 ± 0.13
55	4 'Oxford'	1.09 ± 0.06	1.03 ± 0.04	1.1 ± 0.09	1.2 ± 0.15
56	4 'Jewel of Spring'	1.09 ± 0.05	1.08 ± 0.07	1.05 ± 0.05	1.21 ± 0.12
57	3 'Paris'	1.09 ± 0.06	1.11 ± 0.1	1.06 ± 0.1	1.11 ± 0.16
58	7 'Blue Heron'	1.09 ± 0.08	1.16 ± 0.17	1.04 ± 0.06	1.06 ± 0.17
59	3 'Her Grace'	1.09 ± 0.05	1.06 ± 0.07	1.11 ± 0.1	1.05 ± 0.15
60	5 'Balalaika'	1.08 ± 0.07	1.19 ± 0.06	1.02 ± 0.1	1.02 ± 0.37
61	3 'Athlet'	1.08 ± 0.1	1.15 ± 0.08	1.12 ± 0.16	0.83 ± 0.2
62	4 'Spring Song'	1.08 ± 0.05	1.13 ± 0.09	1.04 ± 0.05	1.08 ± 0.12
63	3 'Paul Richter'	1.08 ± 0.03	1.05 ± 0.03	1.09 ± 0.05	1.1 ± 0.05
64	4 'General Eisenhower'	1.08 ± 0.07	1.03 ± 0.1	1.08 ± 0.15	1.17 ± 0.08
65	5 'Coplan's Record'	1.08 ± 0.09	1.12 ± 0.13	1.16 ± 0.12	0.78 ± 0.18
66	3 'Europe'	1.08 ± 0.06	1.03 ± 0.1	1.13 ± 0.11	1.02 ± 0.06
67	5 'Crem Star'	1.08 ± 0.08	1.04 ± 0.07	1.15 ± 0.17	0.98 ± 0.06
68	4 'Oxford's Elite'	1.08 ± 0.07	0.99 ± 0.02	1.06 ± 0.1	1.29 ± 0.12
69	3 'Teheran'	1.07 ± 0.07	1.08 ± 0.14	1.05 ± 0.06	1.12 ± 0.15
70	4 'London'	1.07 ± 0.07	1.04 ± 0.13	1.06 ± 0.09	1.16 ± 0.19

**Table 9** (Cont.)

No	Cultivars/species	IRC±CI	AsTRC ±CI*	AsGRC ±CI*	AsFRC ±CI*
<b>2<sup>nd</sup> class of reproductivity</b> (Cont.)					
71	5 'Canabera'	1.07 ± 0.15	1.23 ± 0.15	1.11 ± 0.24	0.67 ± 0.24
72	3 'Cassini'	1.07 ± 0.06	1.06 ± 0.11	1.09 ± 0.08	1.05 ± 0.15
73	4 'Dardanelles'	1.07 ± 0.08	1 ± 0.08	1.06 ± 0.1	1.23 ± 0.22
74	3 'Algiba'	1.07 ± 0.07	1.07 ± 0.14	1.13 ± 0.11	0.92 ± 0.02
75	5 'White Giant'	1.07 ± 0.19	1.26 ± 0.17	1.18 ± 0.25	0.43 ± 0.08
76	6 'Jacqueline'	1.07 ± 0.05	1.14 ± 0.04	1.02 ± 0.07	1.05 ± 0.1
77	5 'Cordell Hull'	1.07 ± 0.14	1 ± 0.19	1.09 ± 0.1	1.16 ± 0.58
78	3 'Prominence'	1.07 ± 0.05	1.16 ± 0.06	1.05 ± 0.09	0.95
79	3 'Coriolan'	1.07 ± 0.07	1.08 ± 0.12	1.08 ± 0.07	1.01 ± 0.2
80	5 'Vredehof'	1.07 ± 0.14	1.06 ± 0.08	1.18 ± 0.31	0.79
81	5 'Gold Standart'	1.07 ± 0.09	0.99 ± 0.08	1.06 ± 0.07	1.25
82	11 'Bonanza'	1.06 ± 0.06	1.05 ± 0.08	1.08 ± 0.11	1.06 ± 0.02
83	8 'Groenland'	1.06 ± 0.14	1.12 ± 0.06	1.14 ± 0.11	0.78 ± 0.34
84	5 'Avignon'	1.06 ± 0.1	1.07 ± 0.08	1.01 ± 0.12	1.19 ± 0.49
85	3 'Albino'	1.06 ± 0.21	1.22 ± 0.32	1.07 ± 0.22	0.73
86	3 'Garden Party'	1.06 ± 0.1	0.96 ± 0.07	1 ± 0.08	1.4 ± 0.1
87	4 'Ivory Floradale'	1.06 ± 0.07	1 ± 0.07	1.02 ± 0.02	1.27 ± 0.19
88	3 'Axel Munthe'	1.06 ± 0.07	1.05 ± 0.1	1.04 ± 0.09	1.12 ± 0.25
89	5 'Psyche'	1.05 ± 0.06	1.04 ± 0.06	1.03 ± 0.1	1.15 ± 0.13
90	3 'Berna'	1.05 ± 0.05	1.13 ± 0.04	1 ± 0.08	1.02 ± 0.08
91	7 'Laverock'	1.05 ± 0.07	1.12 ± 0.08	1.03 ± 0.12	0.96 ± 0.17
92	5 'Bartigon'	1.05 ± 0.07	1 ± 0.1	1.06 ± 0.06	1.12 ± 0.25
93	1 'Cramoisi Brilliant'	1.05 ± 0.12	1.02 ± 0.06	1.21 ± 0.2	0.71 ± 0.22
94	3 'Blizzard'	1.05 ± 0.05	1.04 ± 0.07	1.03 ± 0.07	1.1 ± 0.12
95	3 'Danton'	1.04 ± 0.1	0.96 ± 0.08	1.1 ± 0.2	1.09 ± 0.19
<b>3<sup>rd</sup> class of reproductivity</b>					
96	5 'Renown'	1.04 ± 0.09	1.06 ± 0.11	0.98 ± 0.19	1.15 ± 0.11
97	4 'Bolshoj Theatr'	1.04 ± 0.08	0.99 ± 0.11	1.02 ± 0.14	1.18 ± 0.16
98	10 'Blue Parrot'	1.04 ± 0.3	1.31	1	0.58
99	1 'Diana'	1.04 ± 0.13	1.19 ± 0.22	0.94 ± 0.1	0.96
100	11 'Mount Tacoma'	1.04 ± 0.04	1.01 ± 0.04	1.03 ± 0.04	1.08 ± 0.09
101	3 'Attila'	1.04 ± 0.05	1.02 ± 0.09	1.05 ± 0.06	1.02 ± 0.16
102	3 'Snowstar'	1.03 ± 0.05	1.11 ± 0.04	1.04 ± 0.03	0.86 ± 0.08
103	5 'Nocturno'	1.03 ± 0.15	1 ± 0.08	1.03 ± 0.35	1.09
104	3 'Thule'	1.03 ± 0.07	1.02 ± 0.11	1.03 ± 0.13	1.05 ± 0.11
105	3 'Negrita'	1.03 ± 0.05	1.03 ± 0.11	1.05 ± 0.05	0.98 ± 0.06
106	1 'Mozart'	1.03 ± 0.06	1.08 ± 0.11	1 ± 0.09	1.01 ± 0.16
107	2 'Stockholm'	1.03 ± 0.03	1.02 ± 0.03	1.03 ± 0.06	1.06 ± 0.1
108	3 'Edith Eddy'	1.03 ± 0.07	1 ± 0.13	1.04 ± 0.1	1.06 ± 0.14
109	4 'Gudoshnik'	1.03 ± 0.13	1.04 ± 0.11	0.96 ± 0.16	1.18 ± 0.37
110	4 'Yellow Dover'	1.03 ± 0.05	1.02 ± 0.12	1 ± 0.07	1.1 ± 0.09
111	4 'Striped Beauty'	1.03 ± 0.08	1.1 ± 0.1	0.99 ± 0.09	0.97 ± 0.23
112	5 'Smiling Queen'	1.02 ± 0.1	1.02 ± 0.12	1.05 ± 0.22	0.97 ± 0.22
113	4 'Dover'	1.02 ± 0.09	0.92 ± 0.09	0.97 ± 0.07	1.38 ± 0.15
114	4 'Cezanne'	1.02 ± 0.06	1 ± 0.08	0.98 ± 0.05	1.16 ± 0.18
115	4 'Gordon Cooper'	1.02 ± 0.04	0.98 ± 0.05	1.01 ± 0.04	1.12 ± 0.09
116	4 'Red Matador'	1.02 ± 0.06	0.99 ± 0.05	0.98 ± 0.07	1.18 ± 0.1
117	4 'Diplomate'	1.02 ± 0.1	0.9 ± 0.1	0.99 ± 0.13	1.3 ± 0.14
118	5 'Clara Butt'	1.02 ± 0.14	1.15 ± 0.1	1.08 ± 0.19	0.6 ± 0.06
119	3 'Peerles Pink'	1.02 ± 0.06	1 ± 0.06	1 ± 0.06	1.09 ± 0.22
120	3 'Robinea'	1.02 ± 0.05	0.96 ± 0.04	1.08 ± 0.08	0.98 ± 0.11
121	5 'Rosy Wings'	1.02 ± 0.07	1.03 ± 0.09	1.02 ± 0.13	0.98 ± 0.16
122	7 'Burgundy Lace'	1.01 ± 0.06	0.97 ± 0.1	1.03 ± 0.08	1.06 ± 0.14
123	5 'Rosa van Lima'	1.01 ± 0.11	1.1 ± 0.17	1.07 ± 0.12	0.7 ± 0.08
124	3 'Leen van der Mark'	1.01 ± 0.08	0.92 ± 0.07	1.03 ± 0.09	1.13 ± 0.21
125	5 'Ivory Glory'	1.01 ± 0.12	0.95 ± 0.17	1.02 ± 0.22	1.1 ± 0.25
126	5 'Twinkle'	1.01 ± 0.05	1 ± 0.07	0.97 ± 0.08	1.14 ± 0.13
127	7 'Fringed Elegance'	1.01 ± 0.07	1.04 ± 0.11	0.98 ± 0.1	1.02 ± 0.26
128	3 'Golden Melody'	1.01 ± 0.07	0.98 ± 0.11	0.99 ± 0.11	1.11 ± 0.14
129	5 'Aristocrat Imperial'	1.01 ± 0.1	1.01 ± 0.06	1 ± 0.23	1.03 ± 0.21
130	5 'Joan Cruickshank'	1.01 ± 0.1	0.98 ± 0.11	0.93 ± 0.11	1.27 ± 0.17
131	10 'Red Sensation'	1.01 ± 0.11	1.01 ± 0.14	0.93 ± 0.12	1.21 ± 0.36
132	5 'Kingsblood'	1.01 ± 0.13	0.96 ± 0.18	1.07 ± 0.31	0.94
133	4 'Beauty of Oxford'	1.01 ± 0.07	0.93 ± 0.05	1.01 ± 0.11	1.15 ± 0.12
134	5 'Queen of Night'	1.01 ± 0.08	1.01 ± 0.06	1.04 ± 0.11	0.91 ± 0.34
135	3 'Wildhof'	1 ± 0.24	1.13 ± 0.34	0.95 ± 0.46	0.9
136	5 'Henry Ford'	1 ± 0.1	1.06 ± 0.11	1.02 ± 0.14	0.85 ± 0.3
137	3 'Anne Claire'	1 ± 0.08	1.03 ± 0.08	0.99 ± 0.1	0.99 ± 0.49
138	5 'Zwanenburg'	1 ± 0.64	1.43	0.94	0.3
139	1 'Olga'	1 ± 0.07	0.95 ± 0.11	1.01 ± 0.13	1.08 ± 0.11
140	5 'Aristocrat'	1 ± 0.09	1.05 ± 0.07	0.93 ± 0.14	1.08 ± 0.31

Table 9 (Cont.)

No	Cultivars/species	IRC±CI	AsTRC ±CI*	AsGRC ±CI*	AsFRC ±CI*
<b>3<sup>rd</sup> class of reproductivity (Cont.)</b>					
141	4 'Kingwood Centre'	1 ± 0.1	0.89 ± 0.1	1.04 ± 0.12	1.11 ± 0.24
142	4 'Parade'	1 ± 0.09	0.91 ± 0.1	0.97 ± 0.13	1.25 ± 0.16
143	6 'Maybole'	0.99 ± 0.05	1.02 ± 0.05	1 ± 0.11	0.96 ± 0.03
144	3 'Hugo Schlosser'	0.99 ± 0.07	0.9 ± 0.05	0.99 ± 0.13	1.18 ± 0.12
145	4 'Canopus'	0.99 ± 0.07	0.93 ± 0.07	0.97 ± 0.09	1.19 ± 0.16
146	5 'Pink Attraction'	0.99 ± 0.07	0.94 ± 0.07	0.96 ± 0.13	1.17 ± 0.04
147	5 'Alma-Mater'	0.99 ± 0.06	1.06 ± 0.08	1 ± 0.07	0.82 ± 0.11
148	3 'Abu Hassan'	0.99 ± 0.06	1.02 ± 0.06	1.01 ± 0.1	0.88 ± 0.11
149	5 'Bo – Peep'	0.98 ± 0.07	1 ± 0.13	1.01 ± 0.09	0.88 ± 0.15
150	5 'Prunus'	0.98 ± 0.09	0.97 ± 0.05	0.89 ± 0.05	1.23 ± 0.25
151	1 'Merry Christmas'	0.98 ± 0.1	1.05 ± 0.09	0.97 ± 0.22	0.85 ± 0.09
152	3 'Bing Crosby'	0.98 ± 0.05	0.98 ± 0.1	1 ± 0.09	0.92 ± 0.02
153	4 'Eric Hofsjo'	0.98 ± 0.04	0.92 ± 0.07	0.99 ± 0.06	1.05 ± 0.02
154	5 'Panorama'	0.98 ± 0.16	0.98 ± 0.22	1.01 ± 0.11	0.87 ± 0.56
155	1 'Apricot Beauty'	0.97 ± 0.07	0.9 ± 0.07	1.02 ± 0.07	1.02 ± 0.22
156	1 'Christmas Dream'	0.97 ± 0.08	1.06 ± 0.09	0.96 ± 0.1	0.81 ± 0.18
157	4 'Vivex'	0.97 ± 0.1	0.82 ± 0.12	0.97 ± 0.18	1.26 ± 0.04
158	4 'Dawnglow'	0.97 ± 0.07	0.94 ± 0.06	0.93 ± 0.07	1.11 ± 0.22
159	3 'Henry Dunant'	0.97 ± 0.08	0.9 ± 0.07	0.92 ± 0.09	1.22 ± 0.22
160	6 'Marjolein'	0.97 ± 0.07	1 ± 0.1	0.93 ± 0.1	0.98 ± 0.14
161	6 'Linette'	0.97 ± 0.09	1.1 ± 0.09	0.91 ± 0.07	0.82 ± 0.39
162	5 'Port Said'	0.96 ± 0.09	0.91 ± 0.08	0.98 ± 0.19	1.01 ± 0.24
163	3 'Golden Mirjoran'	0.96 ± 0.02	0.97 ± 0.05	0.95 ± 0.04	0.97 ± 0.03
164	1 'Prince of Austria'	0.96 ± 0.08	0.83 ± 0.07	1 ± 0.08	1.13 ± 0.13
165	5 'Landseadel's Supreme'	0.96 ± 0.07	0.88 ± 0.08	0.95 ± 0.13	1.16 ± 0.13
166	3 'Princesses Beatrix'	0.96 ± 0.13	0.97 ± 0.16	0.93 ± 0.18	1.04 ± 0.48
167	3 'Van der Eerden'	0.96 ± 0.07	0.93 ± 0.05	1.02 ± 0.12	0.86 ± 0.24
168	4 'Golden Parade'	0.96 ± 0.09	0.86 ± 0.07	0.91 ± 0.1	1.25 ± 0.18
169	3 'Eurovisie'	0.96 ± 0.09	0.91 ± 0.1	0.89 ± 0.15	1.22 ± 0.16
170	3 'Orange Monarch'	0.95 ± 0.09	0.91 ± 0.16	0.95 ± 0.08	1.06 ± 0.18
171	4 'Scarborough'	0.95 ± 0.04	0.92 ± 0.08	0.94 ± 0.06	1.05 ± 0.04
172	3 'Prince Charles'	0.95 ± 0.06	0.89 ± 0.06	0.97 ± 0.08	1.03 ± 0.13
173	1 'Pink Trophy'	0.95 ± 0.05	0.99 ± 0.07	0.93 ± 0.02	0.93 ± 0.14
174	10 'Black Parrot'	0.95 ± 0.16	1.16 ± 0.09	0.92 ± 0.24	0.6 ± 0.4
175	3 'Mirjoran'	0.95 ± 0.07	0.92 ± 0.04	0.88 ± 0.05	1.17 ± 0.21
176	3 'Albury'	0.95 ± 0.09	0.89 ± 0.2	0.94 ± 0.12	1.08 ± 0.04
177	3 'Purple Star'	0.95 ± 0.1	0.88 ± 0.13	1.01 ± 0.07	0.92
178	7 'Swan Wings'	0.94 ± 0.09	1.06 ± 0.03	0.94 ± 0.09	0.74 ± 0.21
179	4 'Lefeber's Favourite'	0.94 ± 0.05	0.93 ± 0.08	0.97 ± 0.08	0.91 ± 0.14
180	6 'Astor'	0.94 ± 0.05	0.91 ± 0.06	0.98 ± 0.1	0.91 ± 0.12
181	3 'Lucky Strike'	0.94 ± 0.04	0.97 ± 0.05	0.93 ± 0.08	0.9 ± 0.07
182	3 'Sulphur Glory'	0.94 ± 0.1	1 ± 0.12	0.98 ± 0.15	0.73 ± 0.3
183	3 'Rosario'	0.94 ± 0.1	0.89 ± 0.05	0.89 ± 0.21	1.16 ± 0.2
184	4 'Floradale'	0.94 ± 0.06	0.9 ± 0.05	0.91 ± 0.08	1.1 ± 0.1
<b>4<sup>th</sup> class of reproductivity</b>					
185	3 'Telescopium'	0.94 ± 0.05	1.01 ± 0.06	0.86 ± 0.05	0.99 ± 0.17
186	1 'General de Wet'	0.94 ± 0.12	1.02 ± 0.06	0.99 ± 0.21	0.63 ± 0.3
187	4 'Kolner Dom'	0.93 ± 0.07	0.88 ± 0.07	0.89 ± 0.11	1.13 ± 0.09
188	5 'Marjorie Bowen'	0.93 ± 0.11	0.99 ± 0.12	0.96 ± 0.06	0.73
189	3 'Red Giant'	0.93 ± 0.06	0.89 ± 0.09	0.89 ± 0.09	1.1 ± 0.05
190	3 'Grevel'	0.93 ± 0.07	0.9 ± 0.09	0.92 ± 0.13	1 ± 0.13
191	5 'Queen of Bartignons'	0.93 ± 0.08	0.86 ± 0.09	0.91 ± 0.1	1.09 ± 0.24
192	3 'Aviator'	0.93 ± 0.08	0.82 ± 0.07	0.91 ± 0.08	1.17 ± 0.17
193	4 'Deutschland'	0.92 ± 0.09	0.9 ± 0.1	0.86 ± 0.14	1.13 ± 0.18
194	4 'Koningen Wilhelmina'	0.92 ± 0.09	0.91 ± 0.06	0.97 ± 0.22	0.84 ± 0.11
195	5 'La Tulipe Noire'	0.92 ± 0.16	1.07 ± 0.15	0.97 ± 0.21	0.51 ± 0.44
196	5 'Halcro'	0.92 ± 0.06	0.91 ± 0.05	0.91 ± 0.11	0.98 ± 0.18
197	3 'Meissner Porzellan'	0.92 ± 0.05	0.96 ± 0.08	0.87 ± 0.11	0.95 ± 0.06
198	2 'Arie Alkemade's Memory'	0.92 ± 0.06	0.89 ± 0.06	0.9 ± 0.11	1.03 ± 0.08
199	3 'Dreaming Maid'	0.92 ± 0.04	0.87 ± 0.06	0.94 ± 0.03	0.94 ± 0.14
200	2 'Electra'	0.92 ± 0.23	1.04 ± 0.35	1.02 ± 0.39	0.42
201	4 'Striped Oxford'	0.92 ± 0.05	0.85 ± 0.06	0.9 ± 0.06	1.1 ± 0.08
202	10 'Texas Flame'	0.92 ± 0.13	1.04 ± 0.06	0.95 ± 0.08	0.58 ± 0.26
203	3 'Winterpriede'	0.91 ± 0.11	0.94 ± 0.15	0.99 ± 0.1	0.67 ± 0.24
204	7 'Canova'	0.91 ± 0.07	0.95 ± 0.1	0.87 ± 0.11	0.95 ± 0.2
205	1 'Great City'	0.91 ± 0.11	0.92 ± 0.16	0.99 ± 0.19	0.71
206	5 'Copland's Favourite'	0.91 ± 0.12	0.84 ± 0.21	0.95 ± 0.14	0.97 ± 0.45
207	5 'Tarakan'	0.91 ± 0.07	0.92 ± 0.11	0.92 ± 0.11	0.88 ± 0.17
208	7 'Lucifer'	0.91 ± 0.23	1.1	0.72	1.03
209	4 'Olympic Flame'	0.91 ± 0.03	0.94 ± 0.06	0.91 ± 0.03	0.85 ± 0.06
210	3 'Ornament'	0.91 ± 0.13	0.95 ± 0.16	0.92 ± 0.22	0.81 ± 0.29
211	3 'Jacques Fath'	0.91 ± 0.11	0.79 ± 0.07	0.86 ± 0.16	1.26 ± 0.24



**Table 9** (Cont.)

No	Cultivars/species	IRC±CI	AsTRC ±CI*	AsGRC ±CI*	AsFRC ±CI*
<b>4<sup>th</sup> class of reproductivity</b> (Cont.)					
212	3 'Orient Express'	0.91 ± 0.22	0.84 ± 0.1	0.82 ± 0.09	1.26 ± 0.66
213	5 'Black Swan'	0.9 ± 0.14	0.86 ± 0.15	0.89 ± 0.15	1.03 ± 0.38
214	5 'Favorita'	0.9 ± 0.08	0.85 ± 0.07	0.94 ± 0.14	0.93 ± 0.18
215	4 'Nome'	0.9 ± 0.04	0.89 ± 0.08	0.92 ± 0.08	0.88 ± 0.07
216	1 'Lady Boreal'	0.9 ± 0.06	0.91 ± 0.14	0.92 ± 0.05	0.84 ± 0.13
217	5 'Princess Elizabeth'	0.9 ± 0.07	0.83 ± 0.11	0.91 ± 0.08	1 ± 0.19
218	5 'Dido'	0.9 ± 0.05	0.87 ± 0.05	0.92 ± 0.07	0.9 ± 0.16
219	3 'United Europe'	0.9 ± 0.09	0.8 ± 0.08	0.87 ± 0.1	1.15 ± 0.19
220	4 'Big Chief'	0.9 ± 0.08	0.83 ± 0.13	0.86 ± 0.1	1.11 ± 0.14
221	3 'Korneforos'	0.89 ± 0.11	0.8 ± 0.1	0.89 ± 0.2	1.09 ± 0.24
222	7 'Artesia'	0.89 ± 0.08	0.92 ± 0.09	0.96 ± 0.12	0.68 ± 0.19
223	3 'Invasion'	0.89 ± 0.1	0.83 ± 0.1	0.92 ± 0.2	0.96 ± 0.05
224	5 'Elegant Lady'	0.89 ± 0.11	1.03 ± 0.18	0.86 ± 0.02	0.68 ± 0.18
225	5 'Temple of Beauty'	0.89 ± 0.08	0.85 ± 0.1	0.85 ± 0.16	1.04 ± 0.06
226	1 'Joffre'	0.89 ± 0.13	0.74 ± 0.1	0.89 ± 0.16	1.15
227	5 'Southport'	0.89 ± 0.11	0.8 ± 0.12	0.88 ± 0.19	1.06 ± 0.25
228	1 'Christmas Beauty'	0.89 ± 0.06	0.83 ± 0.06	0.92 ± 0.08	0.9 ± 0.23
229	3 'White Virgin'	0.88 ± 0.18	1.09 ± 0.12	0.95 ± 0.06	0.29 ± 0.1
230	5 'Dillenburg'	0.88 ± 0.7	1.07	1.08	0.01
231	3 'Arguno'	0.88 ± 0.08	0.83 ± 0.03	0.85 ± 0.15	1.06 ± 0.18
232	6 'White Triumphator'	0.88 ± 0.07	0.89 ± 0.05	0.92 ± 0.09	0.76 ± 0.22
233	7 'Maible Queen'	0.88 ± 0.05	0.89 ± 0.08	0.92 ± 0.09	0.76 ± 0.06
234	4 'Scheffield'	0.88 ± 0.06	0.83 ± 0.06	0.92 ± 0.13	0.89 ± 0.14
235	4 'Holland's Glorie'	0.88 ± 0.11	0.83 ± 0.08	0.81 ± 0.15	1.16 ± 0.26
236	3 'High Society'	0.88 ± 0.08	0.79 ± 0.07	0.88 ± 0.1	1.06 ± 0.19
237	5 'Kriemhilde'	0.88 ± 0.19	1 ± 0.1	0.98 ± 0.2	0.4
238	3 'Orange Delight'	0.88 ± 0.19	0.79 ± 0.24	0.87 ± 0.44	1.07 ± 0.29
239	3 'First Lady'	0.88 ± 0.09	0.77 ± 0.06	0.84 ± 0.14	1.18 ± 0.16
240	1 'Bellona'	0.88 ± 0.06	0.91 ± 0.08	0.88 ± 0.12	0.8 ± 0.11
241	3 'Belgium'	0.87 ± 0.11	0.75 ± 0.07	0.86 ± 0.14	1.16 ± 0.19
242	3 'Rose Korneforos'	0.87 ± 0.07	0.8 ± 0.11	0.86 ± 0.07	1.06 ± 0.09
243	6 'Queen of Sheba'	0.87 ± 0.06	0.89 ± 0.07	0.84 ± 0.07	0.91 ± 0.22
244	3 'Kees Nelis'	0.87 ± 0.1	0.78 ± 0.09	0.9 ± 0.19	0.99 ± 0.09
245	5 'Gander'	0.87 ± 0.06	0.8 ± 0.05	0.86 ± 0.09	1.03 ± 0.08
246	3 'Fidelio'	0.87 ± 0.06	0.79 ± 0.08	0.87 ± 0.07	1.05 ± 0.04
247	6 'West Point'	0.87 ± 0.22	1.14 ± 0.02	0.9 ± 0.18	0.27
248	5 'General Ridgeway'	0.87 ± 0.07	0.9 ± 0.08	0.92 ± 0.09	0.67
249	4 'Oranjezon'	0.87 ± 0.09	0.81 ± 0.09	0.89 ± 0.14	0.93 ± 0.25
250	5 'Dix' Favourite'	0.87 ± 0.08	0.79 ± 0.08	0.88 ± 0.17	0.99 ± 0.08
251	4 'Elizabeth Arden'	0.86 ± 0.07	0.8 ± 0.14	0.84 ± 0.09	1.04 ± 0.02
252	6 'Marianne'	0.86 ± 0.1	0.94 ± 0.03	0.79 ± 0.19	0.9
253	3 'Tommy'	0.86 ± 0.05	0.83 ± 0.07	0.84 ± 0.06	1 ± 0.14
254	4 'Moscow'	0.86 ± 0.09	0.83 ± 0.13	0.82 ± 0.11	1.02 ± 0.2
255	4 'My Lady'	0.86 ± 0.09	0.88 ± 0.08	0.8 ± 0.17	0.97 ± 0.07
256	3 'Virtuoso'	0.86 ± 0.19	0.69 ± 0.06	0.8 ± 0.13	1.36 ± 0.52
257	3 'Ajax'	0.86 ± 0.13	0.97 ± 0.07	0.94 ± 0.14	0.43
258	2 'Schoonoord'	0.86 ± 0.2	1.02 ± 0.17	0.99 ± 0.23	0.19 ± 0.1
259	1 'Early Queen'	0.86 ± 0.1	0.93 ± 0.05	0.87 ± 0.09	0.67 ± 0.57
260	4 'Ad Rem'	0.86 ± 0.09	0.76 ± 0.12	0.81 ± 0.11	1.14 ± 0.12
261	4 'Helena Rubinstein'	0.85 ± 0.11	0.9 ± 0.09	0.94 ± 0.12	0.53
262	5 'Elsie Eloff'	0.85 ± 0.06	0.87 ± 0.07	0.84 ± 0.08	0.85 ± 0.22
263	3 'Makassar'	0.85 ± 0.09	0.7 ± 0.09	0.94 ± 0.13	0.94 ± 0.15
264	5 'Demeter'	0.85 ± 0.1	0.74 ± 0.04	0.87 ± 0.2	1.03 ± 0.16
265	5 'Bingham'	0.85 ± 0.1	0.73 ± 0.04	0.86	1.07 ± 0.13
266	5 'Temple of Beauty maxima'	0.85 ± 0.39	0.74	0.73	1.34
267	5 'Gander's Rhapsody'	0.84 ± 0.67	0.94	1.11	0.01
268	4 'Amoretta'	0.84 ± 0.05	0.82 ± 0.08	0.84 ± 0.07	0.93 ± 0.14
269	5 'Vesta'	0.84 ± 0.08	0.87 ± 0.09	0.88 ± 0.06	0.7 ± 0.22
270	5 'Silver Wedding'	0.84 ± 0.1	0.84 ± 0.13	0.85 ± 0.09	0.83 ± 0.3
271	3 'Topscore'	0.83 ± 0.05	0.88 ± 0.07	0.94 ± 0.08	0.5
272	1 'Brilliant Star'	0.83 ± 0.09	0.92 ± 0.12	0.89 ± 0.05	0.54 ± 0.02
273	5 'Hocus Pocus'	0.83 ± 0.3	0.7	0.79	1.2
274	5 'Maureen'	0.82 ± 0.19	0.82	0.93	0.6
<b>5<sup>th</sup> class of reproductivity</b>					
275	5 'Esther'	0.82 ± 0.04	0.84 ± 0.07	0.84 ± 0.05	0.75 ± 0.07
276	6 'Solnyško'	0.82 ± 0.21	1.07 ± 0.21	0.87 ± 0.25	0.21 ± 0.25
277	5 'Lady Sylvia'	0.82 ± 0.23	0.76 ± 0.32	0.8 ± 0.44	0.97 ± 0.58
278	2 'Willemsoord'	0.81 ± 0.18	1.01 ± 0.12	0.89 ± 0.18	0.25 ± 0.15
279	3 'Abra'	0.81 ± 0.08	0.76 ± 0.08	0.77 ± 0.15	1.02 ± 0.1
280	5 'Wim van Est'	0.81 ± 0.09	0.82 ± 0.12	0.83 ± 0.13	0.68 ± 0.28
281	7 'Fancy Frills'	0.8 ± 0.1	0.83 ± 0.09	0.81 ± 0.12	0.71

Table 9 (Cont.)

No	Cultivars/species	IRC±CI	AsTRC ±CI*	AsGRC ±CI*	AsFRC ±CI*
<b>5<sup>th</sup> class of reproductivity (Cont.)</b>					
282	10 'Flaming Parrot'	0.8 ± 0.07	0.72 ± 0.1	0.83 ± 0.1	0.86 ± 0.14
283	3 'Ingmar Stenmark'	0.79 ± 0.05	0.72 ± 0.03	0.87 ± 0.03	0.75 ± 0.09
284	4 'Parade Record'	0.79 ± 0.08	0.72 ± 0.06	0.74 ± 0.06	1.05 ± 0.21
285	6 'Aladdin'	0.78 ± 0.42	1.18	0.75	0.08
286	4 'Golden Oxford'	0.78 ± 0.07	0.78 ± 0.08	0.83 ± 0.08	0.7 ± 0.26
287	11 'Angelique'	0.77 ± 0.09	0.86 ± 0.17	0.82 ± 0.11	0.54 ± 0.04
288	7 'Aleppo'	0.76 ± 0.64	1.09	0.84	0.01
289	3 'Tambour Maitre'	0.76 ± 0.25	0.63 ± 0.09	0.72 ± 0.2	1.21 ± 0.39
290	1 'Couleur Cardinal'	0.75 ± 0.11	0.83 ± 0.04	0.87 ± 0.17	0.38
291	2 'Monte Carlo'	0.75 ± 0.06	0.78 ± 0.06	0.81 ± 0.1	0.58 ± 0.09
292	1 'Prinses Irene'	0.74 ± 0.05	0.74 ± 0.08	0.74 ± 0.05	0.76 ± 0.14
293	3 'Frederica'	0.73 ± 0.15	0.99 ± 0.13	0.82 ± 0.19	
294	10 'Karel Doorman'	0.72 ± 0.37	1.18 ± 0.18	0.64 ± 0.34	0.02
295	5 'Dom Pedro'	0.71 ± 0.28	0.83 ± 0.15	0.92 ± 0.26	0.01
296	10 'White Parrot'	0.7 ± 0.11	0.74 ± 0.09	0.77 ± 0.16	0.43 ± 0.18
297	6 'Alaska'	0.69 ± 0.13	0.94 ± 0.03	0.77 ± 0.2	
298	5 'Snowpeak'	0.68 ± 0.34	0.88 ± 0.24	0.81 ± 0.13	0.01
299	7 'Arma'	0.67 ± 0.21	0.84 ± 0.12	0.73 ± 0.22	0.17

\* CI – Confidence Interval at 95 % significance

bulb mass, correspondingly decreased average bulb mass: in E fr. it came to 33.21 g, I fr. – 21.22, II fr. – 14.55, III fr. – 9.25, IV fr. – 5.28, V fr. – 2.72 and VI fr. – 1.03 g.

### Average mass of tulip bulb clone

The investigated tulip bulb clone mass ranged from 68.67 g (E fr.) to 1.5 g (VI fr.). Maximum bulb clone mass was 12.8 times higher than minimum (Table 8). The ratio between maximum and minimum indices were: E fr. – 2.77, I fr. – 2.9, II fr. – 2.9, III fr. – 2.5, IV fr. – 2.9, V fr. – 2.8 and VI fr. – 4.3. Comparison of bulb clone mass from E fr. tulip bulbs with other fractions revealed that bulb clone mass from I fr. bulbs decreased on average by 17% or 1.4 times, accordingly II fr. – 40% or 1.8 times, III fr. – 56% or 2.4 times, IV fr. – 70% or 3.6 times, V fr. – 81% or 5.6 times and VI fr. – 91% or 12.7 times. Correlation between clone mass and mother bulb size is high ( $R^2 = 0.99$ ) (Fig. 4).

### Tulip leaf length, width and area

Tulip leaf length of the investigated cultivars ranged from 35.05 cm (5 'Twinkle', E fr.) to 10.18 cm (1 'Christmas Marvel', VI fr.). Under decreasing mother bulb mass, correspondingly decreased average leaf length: in E fr. it came to 24.67 cm, I fr. – 23.61, II fr. – 22.69, III fr. – 21.32, IV fr. – 19.66, V fr. – 19.88 and VI fr. – 16.60 cm. Comparison of tulip leaf length from E fr. with other fractions revealed that

tulip leaf from I fr. bulbs decreased on average by 1.04 times, accordingly II fr. – 1.1, III fr. – 1.2, IV fr. – 1.3, V fr. – 1.2 and VI fr. – 1.7 times.

Tulip leaf width of the investigated cultivars ranged from 16.19 cm (4 'Gudoshnik', E fr.) to 1.40 cm (1 'Pink Trophy', VI fr.). Under decreasing mother bulb mass, correspondingly decreased average leaf width: in E fr. it came to 10.78 cm, I fr. – 9.63, II fr. – 8.74, III fr. – 7.71, IV fr. – 6.77, V fr. – 6.28 and VI fr. – 3.72 cm. Comparison of tulip leaf width from E fr. with other fractions revealed that tulip leaf from I fr. bulbs decreased on average by 1.1 times, accordingly II fr. – 1.2, III fr. – 1.4, IV fr. – 1.6, V fr. – 1.7 and VI fr. – 2.9 times.

Tulip leaf area of the investigated cultivars ranged from 317.94 cm<sup>2</sup> (4 'Beauty of Oxford', E fr.) to 14.49 cm<sup>2</sup> (1 'Pink Trophy', VI fr.). Under decreasing mother bulb mass, correspondingly decreased average leaf area: in E fr. it came to 199.0 cm, I fr. – 170.0, II fr. – 148.6, III fr. – 100.6, IV fr. – 94.6, V fr. – 94.6 and VI fr. – 46.7 cm<sup>2</sup>. Comparison of tulip leaf area from E fr. with other fractions revealed that tulip leaf from I fr. bulbs decreased on average by 1.2 times, accordingly II fr. – 1.3 times, III fr. – 1.6, IV fr. – 2.0, V fr. – 2.1 and VI fr. – 4.3 times.

Positive correlation was established between: 1) lower leaf length and mother bulb circumference ( $R^2 = 0.95$ ); 2) lower leaf width and mother bulb circumference ( $R^2 = 0.98$ ); 3) lower leaf area and mother bulb mass ( $R^2 = 0.98$ ); 4) lower leaf area and mother bulb circumference ( $R^2 =$

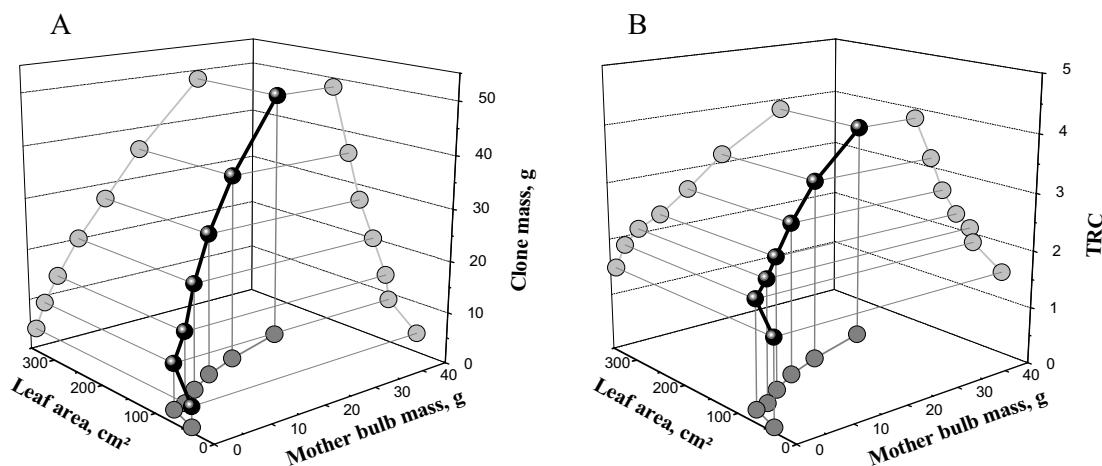


Fig. 5 Correlation between mean values of mother bulb mass, leaf area as well as clone mass (A) and TRC (B), mother bulb mass as well as leaf area of the investigated tulip cultivars. Each dot in bold corresponds mean value of one fraction for the whole tulip cultivars cross section in a system of three coordinates.

0.98); 5) lower leaf area and leaf length ( $R^2 = 0.99$ ); 6) lower leaf area and leaf width ( $R^2 = 0.99$ ); 7) bulb clone mass and leaf area ( $R^2 = 0.99$ ); 8) TRC and leaf area ( $R^2 = 0.99$ ); 9) GRC and leaf area ( $R^2 = 0.99$ ); 10) FRC and leaf area ( $R^2 = 0.85$ ). Lower leaf on the average made up about 75 % of tulip assimilation surface area. Correlation between biomorphometric indices and tulip bulb reproduction indices (leaf area, mother bulb mass, clone mass as well as leaf area, mother bulb mass and clone mass) is demonstrated on a three-dimensional diagram (Fig. 5).

## CONCLUSIONS

Based on long-term research (1982–1992) data on reproduction capacity of 299 tulip cultivars of the different size bulbs (7 fr.), a one-dimensional criterion IRC characterizing total derivative value of reproduction capacity for all sizes of bulbs was ascertained for the first time. TRC, GRC and FRC provide particular data on reproduction of each investigated fraction. Assessment of vegetative reproduction capacity of 299 tulip cultivars numbered among different classification groups was accomplished according to special reproduction coefficients: TRC, GRC, FRC. It was established that reproduction coefficient value depends upon mother bulb size and hereditary characteristics of cultivars. Total reproduction coefficient (TRC) is a quantitative indicator specifying the mean number of all daughter bulbs per clone. Under decreasing mother bulb mass, TRC ranged on average from 3.81 (E fr.) to 1.45 (VI fr.). The studied parameter highly correlated with mother bulb size ( $R^2 = 0.98$ ).

TRC dispersion of the same size bulbs of the studied tulip cultivars was very high and that proves the significance of hereditary characteristics upon the discussed parameter. E fr. TRC minimum index was 2.44 (5 'Lady Sylvia'), whereas the same maximum index of VI fr. came to 2.08 (4 'London'). The obtained differences in TRC values prove high reproduction capacity of small fraction bulbs.

Generative bulb reproduction coefficient (GRC) is a qualitative indicator specifying the mean number of bulbs per clone capable to blossom next year. Under decreasing mother bulb mass, GRC values ranged on average from 2.68 (E fr.) to 0.32 (VI fr.). GRC highly correlated with mother bulb size ( $R^2 = 0.97$ ). GRC values of 19% of the studied tulip cultivars were particularly high.

Forcible bulb reproduction coefficient (FRC) is a qualitative indicator specifying the mean number of forcible tulip bulbs per clone. Under decreasing mother bulb mass, FRC values ranged from 1.08 (E fr.) to 0.12. (VI fr.). FRC is highly correlated with mother bulb size ( $R^2 = 0.93$ ).

Indexed tulip bulb vegetative reproduction coefficient (IRC) is one-dimensional criterion specifying vegetative reproduction capacity of all different size tulip bulbs of all tulip cultivars. According to IRC, the studied tulip cultivars were grouped into 5 grades of reproduction. The obtained data enabled to objectively assess vegetative reproduction potential of the whole mother bulb spectrum and provided with an opportunity to make a proper selection. Tulips of 1<sup>st</sup>

– 3<sup>rd</sup> grades of reproduction are recommended to grow on commercial areas, whereas tulip cultivars of all grades of reproduction may be grown in collections.

Positive correlation between the indices of tulip lower leaf area, which makes up 75% of assimilation surface, and bulb reproduction (mother bulb mass, circumference, clone mass and reproduction coefficient) was ascertained.

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