PROTECTION OF GENETIC RESOURCES OF POMOLOGICAL PLANTS AND SELECTION OF GENITORS WITH TRAITS VALUABLE FOR SUSTAINABLE FRUIT PRODUCTION

Journal of Fruit and Ornamental Plant Research vol. 12, 2004 Special ed.

FACTORS INFLUENCING MARKETABLE YIELD AND BERRY SIZE IN SHORT-DAY STRAWBERRY VARIETIES IN TWO FRUITING SEASONS

Dina Shokaeva

All Russian Research Institute of Horticultural Breeding
tel. (7) (0862) 41 4479; fax: (7) (0862) 41 4479
e-mail: dinashokaeva@rekom.ru

(Received August 4, 2004/Accepted March 17, 2005)

ABSTRACT

In 2001 and 2002, twenty short-day strawberry genotypes were evaluated in terms of their capacity to produce abundant and reliable yields of marketable fruit. The genotypes evaluated were ‘Dukat’, ‘Elista’, ‘Elsanta’, ‘Gariguette’, ‘Senga Sengana’, ‘Senga Tigaiga’, ‘Sudarushka’, ‘Tago’, ‘Tantallon’, ‘Tenira’, ‘Toro’, ‘Yuzhanka’, ‘Zenith’, ‘Zolushka of Kuban’, Or 171-15-5, Or 913-7-140, Or 965-7-1, Or 967-5-29, Or 967-7-49 and Or 968-9-58. Data recorded included flower count per square meter of row, marketable fruit set percentage, mean marketable berry weight, truss count per plant, branch crown count per plant, and total marketable yield per hectare for the first and second fruit bearing years. The truss to branch count ratio and the berry weight to flower count per truss ratio were calculated, and the correlations between these ratios and total yield were also calculated for each year. Genotypes with higher truss to branch crown ratios and berry weight to flower count ratios tended to have high yields in the first fruit bearing year. Genotypes with lower ratios did not have as high yields in the first year, but had higher yields in the second year. A marketable berry count of 8.5 to 11.0 berries per branch crown weighing 70 to 100 g in the first year signified that the genotype produced high yields of high quality, marketable fruit. In both years, the genotypes with the highest flower counts had the lowest yield losses due to late spring frosts. Genotypes with intermediate flower counts had the lowest reductions in cumulative yield.

Key words: strawberries, yield components, total marketable yield, commercial fruit percentage, coefficient of relationship, central Russia

INTRODUCTION

One of the main requirements of strawberry producers is cultivars, which reliably bear high yields. Many researchers have studied how different factors interact to directly or indirectly influence yield in the first and second fruit bearing years (Rogers and Modlibowska, 1951; Hondelmann, 1965; Craig and Aalders, 1966; Baumann et al., 1993). However, they usually treated each year separately and only studied a few cultivars. The inheritance of traits that influence yield have been studied in various genotypes (Strik and Proctor, 1988; Morishita, 1994). However, the combination of these factors varies from genotype to genotype. In the same genotype, the interaction of these factors is also dependent on soil and weather conditions, growing system, time of planting, and many other factors (Popenoe and Swartz, 1985). In short-day cultivars, the interactions among factors, which affect yield in the first fruit bearing year, are different from those in the second fruit bearing year (Baumann et al., 1993).

In this study, the influence of various factors on yield in the first and second fruit bearing years was studied in central Russia. These factors included flower count per square meter of row, marketable fruit set percentage, mean marketable berry weight, truss count per plant, branch crown count per plant, and total marketable yield per hectare. The aim of this study was to identify which factors were most closely correlated with two-year cumulative yield and to determine the relationship between first and second year yields in twenty strawberry genotypes.

MATERIAL AND METHODS

In 2001 and 2002, twenty short-day strawberry genotypes were evaluated in terms of their capacity to produce abundant and reliable yields of marketable fruit. The genotypes evaluated were ‘Dukat’, ‘Elista’, ‘Elsanta’, ‘Gariguette’, ‘Senga Sengana’, ‘Senga Tigaiga’, ‘Sudarushka’, ‘Tago’, ‘Tantallon’, ‘Tenira’, ‘Toro’, ‘Yuzhanka’, ‘Zenith’, ‘Zolushka of Kuban’, Or 171-15-5, Or 913-7-140, Or 965-7-1, Or 967-5-29, Or 967-7-49 and Or 968-9-58.

In the spring of 2000, thirty plants of each genotype were planted 25 cm apart in loamy soil in spaced beds in a random block design with three replicates. The beds were spaced 80 cm apart, for a planting density of 50,000 plants per hectare.

In 2000, all blossoms and runners were removed. In 2000 and 2001, all runners were also removed. The number of flowers, trusses and branch crowns per plant was determined for ten representative plants of each genotype. The number of flowers, trusses and branch crowns per square meter was also determined for each genotype. Marketable fruit set percentage and mean berry weight were recorded for each replicate. Berries were harvested twice a week during the fruiting period. Marketable berries were counted and weighed for each plot. Marketable berries were those, which were at least 18 mm in maximum diameter. Marketable fruit set percentage, mean berry weight, marketable berry count per branch crown, and marketable berry weight per branch crown were also recorded for each replicate of each variety.

Data were statistically analyzed in accordance with the methods recommended by the SAS Institute in the United States (1989), in accordance with CORR and REG procedures. The significance of differences between means was calculated using Duncan's multiple-range t-test. The inter-relationships among the various factors and marketable yield were analyzed with the Axum software package (MathSoft, Inc., USA).

RESULTS AND DISCUSSION

Results are presented in Table 1 and Figure 1.

Table 1. Some yield components and indices of the most productive varieties and selections established in the first year of fruiting and the cumulative marketable yields of their better replicates obtained over two years of fruiting (2001+2002)

Replicate*		Flower count per square meter of row	Marketable fruit set percentage	Mean marketable berry weight [g]	Ratio		Total marketable yield [tons per hectare]
					truss to branch crown	berry weight to flower count per	
Dukat	1	181	79.8	8.4	1.22	1.29	31.0
	2	233	73.4	7.2	1.45	1.43	28.9
	3	180	68.6	8.3	1.15	1.19	26.6
Elsanta	1	128	87.4	10.7	1.08	1.04	30.2
	2	95	95.5	11.0	1.04	1.09	29.6
Senga Tigaiga	1	204	69.6	8.9	1.33	1.31	30.6
		228	53.5	9.3	1.35	1.29	32.0
Tantallon	1	130	76.4	11.4	1.59	1.56	31.0
	2	110	82.3	11.2	1.57	1.87	27.9
	3	119	81.0	11.2	1.56	1.72	27.1
Zolushka	2	168	76.2	10.4	1.00	1.01	28.0
of Kuban	3	174	69.6	10.2	0.96	1.00	26.3
Or 171-15-5	1	81	94.4	10.1	1.26	1.53	31.2
	3	84	99.4	10.6	1.31	1.63	30.9
Or 965-7-1	1	186	75.6	9.4	1.25	1.36	33.5
	2	190	81.1	9.0	1.23	1.34	33.0
	3	175	73.9	9.3	1.26	1.33	30.9
$LSD_{0.05}$		-	-	-	-	-	6.1

*Only varieties cumulative commercial yields of which differed from the highest mean value by not more than $LSD_{0.05}$ are included

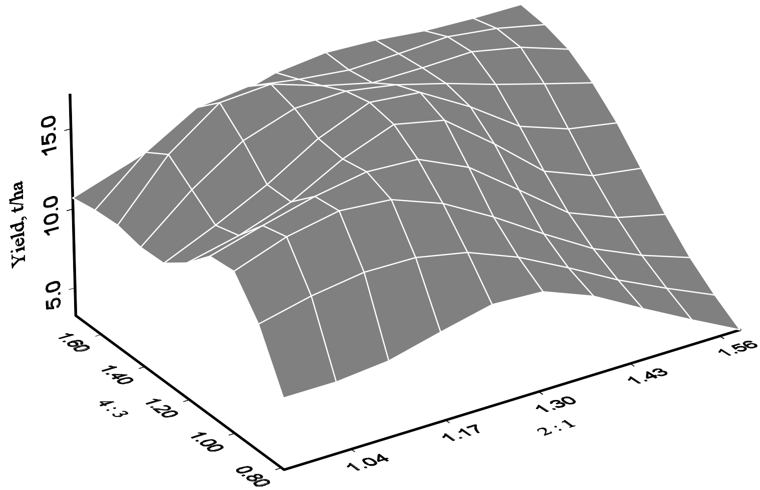

Figure 1. Maximum commercial yield (mean of two years) response to the first and second ratios between components in the first year of fruiting. The following yield components are shown: 1 – branch crown number per plant, 2 – truss count per plant, 3 – average flower count per truss, 4 – mean berry weight. The highest yield values used for the plot construction were adjusted using computation of consecutive means

For both years, the correlations were calculated between marketable yield and various factors including flower count, truss count and branch crown count per square meter, mean berry weight, marketable fruit set percentage, berry count per branch crown, and berry weight per branch crown. Each replicate was treated separately because there were often significant differences between replicates.

In the first year, yield was most closely correlated with berry count per square meter (r = 0.96), marketable yield per branch crown (r = 0.95), and marketable fruit set percentage (r = 0.92). The correlations between yield and the remaining factors were weaker or absent. Yield was negatively correlated with flower count per square meter (r = -0.68).

In the second year, yield was also most closely correlated with berry count per square meter (r = 0.90), marketable yield per branch crown (r = 0.82), marketable fruit set percentage (r = 0.92), and, in contrast to the first year, with flower count per square meter (r = 0.92).

In both years, marketable fruit set percentage was negatively correlated with flower count per square meter. In the first year, the relationship was curvilinear and could be expressed as:

$$y = 0.0008x^2 – 0.4434x + 117.8, R^2 = 0.88$$

where x represents flower count per square meter and y represents marketable fruit set percentage. In the second year, the highest recorded marketable fruit set percentage was lower, but this was offset by an even higher difference in flower count. The relation for the second year could be expressed as:

$$y = – 0.2781x + 104.4, R^2 = 0.90.$$

However, it is more important to calculate the relationship between the maximum marketable fruit set percentage and flower count per square meter because this relationship was correlated in most cases with high two-year cumulative yield. This relationship for the first year can be expressed as:

$$y = – 0.00102x^2 + 0.1416x + 95.98, R^2 = 0.99.$$

Very high cumulative yields were possible, if the flower count per square meter in the first year lay within the range from 80 to 230 and the marketable fruit set percentage was very high. On the other hand, if the flower count was under 80 per square meter, yield was low even if the marketable fruit set percentage was high. Genotypes, which produced from 80 to 160 flowers per square meter, could have high two-year cumulative yields, large berries, and higher fruit set percentages than expected from the equations. Most of the genotypes which had a high flower count per square meter, such as ‘Dukat’, Or 965-7-1 and ‘Senga Tigaiga’, also had high yields. However, genotypes, which had more than 230 flowers per square meter, had less high cumulative yields, low marketable fruit set percentages, and low berry weights.

In the second year, marketable yield was strongly correlated with high flower count, but negatively with yield in the first year.

Analysis of the data revealed that high two-year cumulative yields were very high in three circumstances:

1. If in the first year, flower count per square meter was between 80 and 130, marketable fruit set percentage was over 80%, and marketable berry weight was between 10.0 and 11.5 grams. Although yields in the first year were comparatively low, yields in the second year were outstanding for some of the genotypes. These genotypes also had the lowest proportion of culls.

2. If flower count in the first year was between 130 and 180, fruit set was between 75 and 85%, and berry weight was between 9.0 and 10.5 grams. Yields could exceed 10 tons per hectare in the first year, but were not as high in the second year as in the first group.

3. If flower count was over 180, fruit set was under 80%, and berry weight was between 8.0 and 9.0 grams. Some genotypes in this group were the highest producers in the first year, but had much lower yields in the second year than in the groups above. Other genotypes had higher yields in the second year. These genotypes had the highest proportion of culls.

‘Elsanta’ and Or 171-15-5 belonged to the first group. Yield in these genotypes did not exceed 9.0 tons per hectare in the first year, but was two or even more times higher in the second year.

'Tantallon' had a slightly higher yield in the first year, up to 11.3 tons per hectare, because it had larger berries and a somewhat higher flower count, although the fruit set percentage was lower. However, in the second year, yield was not high.

For a given flower count, larger berry size resulted in a lower yield. Conversely, for a given berry weight, a higher flower count resulted in a lower yield. If both flower count and berry size were high in the first year, marketable yield was low in the second year.

'Zolushka of Kuban' and Or 965-7-1 could be assigned to the second group, with some reservations. 'Zolushka of Kuban' had a lower fruit set percentage, and consequently, a lower yield. Or 965-7-1 sometimes had a slightly higher flower count, but large berries and a comparatively low marketable fruit set percentage in the first year. In both of these genotypes, yield in the second year was higher than in the first year, but not as much as in genotypes of the first group.

Genotypes in the third group had high branch crown counts and high flower counts even in the first year. 'Dukat' had a rather high marketable fruit set percentage, relatively small berries, and the highest yield in the first year. 'Senga Tigaiga' had slightly larger berries, a significantly lower fruit set percentage, and, consequently, a lower yield in the first year. 'Dukat' produced fewer flowers in the second year, which resulted in a higher marketable fruit set percentage, and its yield in the second year was only slightly higher than that in the first year. 'Senga Tigaiga' had slightly more flowers and a significantly higher yield in the second year.

Some varieties have been reported to have high yields in the first year and low yields in the second year, or low yields in the first year and high yields in the second year (Baumann et al., 1993). In our study, none of the genotypes belonged to the top yielding groups for both years. Those genotypes that had high yields in one of the years had only moderate yields in the other year. Our results agree well with an earlier study, in which earlier flower bud differentiation resulted in a high yield in the first year, and later flower bud differentiation resulted in a lower yield in the first year, but much higher yield in the next year (Pustovalova, 2001).

Cumulative and mean of two years marketable yields were higher in genotypes which had a truss to branch crown ratio between 1.0 and 1.6 and a mean berry weight to flower count per truss ratio of 1.0 and 1.6 in the first year. This was especially the case with the truss to branch crown ratio. None of the genotypes with either ratio outside of this range were among those having the highest yields. For the genotypes with both of these ratios inside this range, genotypes with higher ratios had higher yields in this first year. Genotypes with lower ratios had moderate yields in the first but much higher yields in the second year. Genotypes in which the sum of the absolute values of these four components was between 23.5 and 30.5 could have cumulative yields over 20 tons per hectare. Genotypes in which the sum of the absolute values of these four components ranged from 24.4 to 29.1 could have yields over 30 tons per hectare. Almost all of the genotypes that had high yields in the second year also had larger berries in the second year as well. With ‘Dukat’, berry weight was about the same in both years. As a rule, cultivars with low cumulative yields had smaller berries in the second year.

The factors, which affected yield in the first year, were different from the factors that affected yield in the second year and cumulative yield. A marketable berry count of 8.5 to 11.0 berries per branch crown weighing 70 to 100 g in the first year signified that the genotype produced high yields of high quality marketable fruit. Genotypes with fewer marketable berries per branch crown did not have high yields, especially in the first year. Genotypes with more marketable berries per branch crown had a lower yield in the second year and a higher proportion of culls. ‘Tantallon’ had a marketable yield of 136 grams per branch crown in the first year, and 124 grams per branch crown in the second year. However, branch crown count and yield only slightly increased in the second year.

Berry weights per branch crown were higher in genotypes, which had higher truss to branch crown ratios and higher mean berry weight to flower count per truss ratios.

In our study, there were no late spring frosts in either year. In a previous unpublished study with almost the same set of genotypes, early spring frosts significantly reduced yields in both years. Analysis of the results of both studies indicates that genotypes belonging to the first group are particularly susceptible to spring frost damage, especially in the first year. Genotypes belonging to the second group are far less susceptible to early spring frost damage and had about the same yields regardless of whether early spring frosts occurred. Some genotypes of the third group had higher yields in the first year in years when late spring frosts occurred. However, they were susceptible to early spring frost damage in the second year.

REFERENCES

Baumann T.E., Eaton G.W., Spaner D. 1993. Yield components of day-neutral and short-day strawberry varieties on raised beds in British Columbia. HORTSCIENCE 28: 891-894.

Craig D.L., Aalders L.E. 1966. Influence of cultural systems on strawberry fruit yield and berry size. PROC. AM. SOC. HORT. SCI. 89: 318-321.

Hondelmann W. 1965. Untersuchungen zur Ertragszüchtung bei der Gartenerdbeere (*Fragaria ananassa* Duch.) PFLANZENZÜCHTUNG 54: 46-60.

Morishita M. 1994. Studies on genetic variation and inheritance of quality and yield characters for advanced strawberry breeding. BULL. NAT. RES. INST. VEGET. ORNAM. PLANTS TEA Ser. A 8: 1-53.

Popenoe J., Swartz H.J. 1985. Yield component comparison of strawberry plants grown in various cultural systems. ADV. STRAWBERRY PROD. 4: 10-14.

Pustovalova S.V. 2001. Criteria of selection of strawberry cultivars for different growing systems. In: Basic results and perspectives of scientific

investigations in I.V. MICHURIN RES. INST. HORT. (1931-2001) vol. 1. Tambov: 191-196 (In Russian).
Rogers W.S., Modlibowska I. 1951. Strawberry cultivation studies, III: spaced and matted systems. J. HORT. SCI. 26: 47-59.
Strik B.C.; Proctor J.T.A. 1988. Yield component analysis of strawberry genotypes differing in productivity. J. AM. SOC. HORTIC. SCI. 113: 124-129.

CZYNNIKI WPŁYWAJĄCE NA PLONOWANIE I WIELKOŚĆ OWOCÓW RÓŻNYCH ODMIAN TRUSKAWKI KRÓTKIEGO DNIA W OKRESIE DWÓCH LAT ZBIORÓW

Dina Shokaeva

STRESZCZENIE

W latach 2001-2002 oceniano plonowanie dwudziestu odmian i mieszańców truskawki dnia krótkiego. Badaniami objęto odmiany ‘Dukat’, ‘Elista’, ‘Elsanta’, ‘Gariguette’, ‘Senga Sengana’, ‘Senga Tigaiga’, ‘Sudarushka’, ‘Tago’, ‘Tantallon’, ‘Tenira’, ‘Toro’, ‘Yuzhanka’, ‘Zenith’ i ‘Zolushka of Kuban’ oraz mieszańce oznaczone symbolami Or 171-15-5, Or 913-7-140, Or 965-7-1, Or 967-5-29, Or 967-7-49 i Or 968-9-58. W doświadczeniu określano: liczbę kwiatów przypadającą na 1 m^2 rzędu, procent zawiązanych owoców, średnią masę owoców, liczbę kwiatostanów i koron na roślinie oraz plon handlowy z hektara w pierwszym i drugim roku owocowania. Ponadto określano stosunek liczby kwiatostanów do liczby koron oraz stosunek masy owoców do liczby kwiatów w kwiatostanie i wzajemną korelację między nimi. Genotypy zwiększą liczbą kwiatostanów przypadających na jedną koronę i wyższym stosunkiem masy owoców do liczby kwiatów w pierwszym roku owocowania miały wysokie plony. Genotypy, dla których obliczony stosunek był niższy plonowały słabiej w pierwszym roku, ale zkolei miały wyższe plony w drugim roku owocowania. Liczba owoców od 8,5 do 11,0 o masie 70-100 g z jednej korony w pierwszym roku zbiorów oznaczała wysoki plon i wysoką jakość truskawek. W obydwu latach badań genotypy z dużą liczbą kwiatów miały najmniejszą stratę plonu spowodowaną przymrozkami wiosennymi. Genotypy ze średnią liczbą kwiatów charakteryzowały się wysokim plonem sumarycznym.

Słowa kluczowe: truskawki, składniki plonu, plon handlowy, jakość owoców, korelacja, centralna Rosja