Comparison of Rootstocks Geneva 16, M9 and CG11 under organic cultivation at the LVWO Weinsberg – actualized results 2009-2019

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Abstract

The rootstocks Geneva CG16 (weaker than M9), M9 (as standard) and Geneva CG11 (stronger than M9) have been tested in the combination with the cultivar 'GoldRush' in the organically cultivated part at the fruit research station of the LVWO Weinsberg since February 2008. Data were evaluated about growth of the stem, flower setting, fruit-setting, yield and sorting of colour and size. If necessary a light thinning by hand was done. Effects on level of infections by apple scab, sooty blotch, which was only in a few years a problem, and on russeting of the fruits were proofed. Only in single years (like 2013 and 2019) differences in russeting could be seen. Breakdown of scab-resistance has been watched in the organic orchard of the LVWO Weinsberg since 2008, 2013 and 2016 were years with an extreme infection level of Venturia inaequalis. Over eleven years the rootstock CG11 showed large advantages regarding the yield, size and colour of the fruits, the yield was slightly more balanced due to a better relation between growth and yield. 2015 and 2018 were years with extreme dry and hot weather periods during summer, so the ability of the rootstocks from apple trees to root deeper will be important in future considering changing climate conditions.

Keywords: Rootstocks CG 11, CG16, organic apple growing, yield, scab, climate change

Introduction

In 2001 a European exact trial started on several research institutes in middle Europe about the comparison of rootstocks, which should be less susceptible against fire blight, in combination with the variety 'Golden 'Delicious' under conventional conditions (Ruess, 2006). Based on good results for the rootstocks CG 16 and CG11 one of three new trials, which were planted at research institute in Weinsberg, ('Pinova' and 'Gala' in the conventional trial), started in the organically grown orchard of Obstversuchsgut Heuchlingen with the variety 'GoldRush', which was chosen as a variety, which is only low susceptible for fire blight and which shows changes in average fruit weight and in alternate bearing depending from adjusted crop load either by thinning strategies or by using adequate rootstocks. The actualized results of this trial over eleven vegetation periods will be shown and discussed in this article.

Material and Methods

The unifactorial trial was planted in February 2008 with distance of 3.5 m x 1.2 m in the organic research plot of Obstversuchsgut Heuchlingen. Because of varying grafting success in the nursery only two replications were planted for three rootstocks: 2 x 12 trees on CG16, 2 x 10 trees on M9 and 2 x 8 trees on CG11 (at time of grafting the availability of the rootstock CG11 was not so good). In the tables and figures parcel 1 and parcel 2 are signed with the abbreviations P1 and P2. In 2008 flower clusters were removed to encourage the growing in the first year after planting. In nearly all following years only thinning by hand was done

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one or two times depending from each crop load, at high crop loading first time at end of May.

The following evaluations were done every year from 2009 to 2019 **per tree**: During each winter the diameter of the trunk has been measured. Intensity of flowering was estimated at phenological stage full blossom (1-9, 1 = no flowers at all, 9 = white blossom), bearing index (1-9, 1 = no fruits at all), yield (kg/tree) at harvest.

Table 1: Characteristic weather-conditions at the experimental orchard Heuchlingen of the LVWO Weinsberg, comparison of the long-time means (of the evaluation period of the trial (2008-2019), data from weather station of LTZ Augustenberg (2020,

mm rainfall [1)]	**Aver.** [2]	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Jan.	**67**	36	37	22	99	77	35	38	93	88	18	99	64
Febr.	**58**	51	37	63	22	10	43	44	12	94	26	28	10
March	**63**	124	89	47	12	7	40	7	47	46	59	36	67
Apr.	**58**	84	66	24	12	32	51	24	26	61	18	42	36
May	**71**	66	106	96	12	15	82	75	24	216	93	38	61
June	**81**	91	57	36	84	48	59	43	55	87	66	31	57
July	**67**	40	210	44	94	70	46	77	16	87	118	22	29
Aug.	**70**	72	39	121	78	27	69	78	49	59	69	19	54
Sept.	**53**	87	19	48	26	52	80	56	13	31	60	25	61
Okt.	**58**	93	51	47	49	45	84	27	35	54	53	10	103
Nov.	**67**	14	79	92	1	83	56	36	92	53	74	15	60
Dec.	**74**	56	99	111	97	110	41	45	25	6	70	110	85
Sum	**785**[1]	814	892	750	586	570	683	547	486	883	725	473	686
days with frost in April+ May		1	0	3	1	4	5	1	6	4	4	0	3
Difference temperature [3)].		+0.7	+0.6	-0.5	+1.3	+0.8	+0.2	+1.9	+1.7	+1.0	+1.1	+2.2	+1.5
dry March-Oct.					X	X		X	X			X	X
Too warm months [4)]		3	2	1	5	4	2	7	5	4	3	8	6

1) rainfall: rounded values, grey shading of colour = less rain than average

2) average: long-term means of the years 1961-1990 (site Neudenau)

3) difference of average temperature of the single year to long-term average

4) Months with average temperature >=1.8°C more than long time average

During the period of evaluations the climate changes became noticeable in decreasing amounts of rainfall and in higher temperatures in the vegetation months. Between March and October it was too dry in the years 2011 (-57 mm), **2012** (-221 mm), 2014 (-132 mm), especially **2015** (-253 mm), **2018** (-296 mm) and 2019 (-52 mm). On the opposite in May 2016 there has been a heavy rain event (nearly 167 mm within two days), so the sum of rain in this month was higher than in normal year. In six of eleven winter seasons rainfall was clearly lower than the long-time average. Meanwhile in four cases a dry winter preceded a very hot summer.

The yield of each parcel of the rootstocks was sorted by a GREEFA-sorting machine. In order to make visible the influence of the rootstock in the data, which was clearly observed at harvest in the orchard, special classes were defined to distinguish the single shades of yellow or green: dark green, green-yellow, light yellow and golden, all with/without red cheek.

Size was divided into 8 classes (< 60 mm, 60-65 mm etc. up to 85-90 mm, > 90 mm). Altogether from combination of colour and size 64 classes of quality were sorted, so that either only the colour or only the size could be estimated or either four groups of quality could be cumulated as clue for marketing value: “bad, only for juice” (dark green or < 65 mm), middle (> 65 mm, green-yellow), good (> 65 mm, light yellow) or excellent (> 65 mm, golden colour). The content of acid, sugar and vitamin C was determined of an average sample per rootstock in many years. 2013 and 2016 were important years concerning the infection level for *Venturia inaequalis*, differences were seen between the rootstocks about infection on the leaves of the young shoots and later on the fruits at harvest. The methods for the evaluations of scab on the leaves and on the fruits and of russeting were described in an earlier publication (Pfeiffer, 2014 and Pfeiffer, 2016). In this current publication the focus will be set on the interactions between weather influences and yield, average fruit weight and flower setting in the following year.

Results

In 2009 the trees started with a uniform level of flowering setting of 5.6 to 7.5 and were adjusted to approximately 30-40 apples per tree by thinning by hand. In two previous articles the most important data from the years 2009-2012 were described and discussed (Pfeiffer 2014, Pfeiffer 2016). During the complete period of the trial there had been some nights with frost during blossom or a few days after the end of the blossom: 2011 strong frost after blossom, 2012 light frost, 2016 middle frost at the beginning of blossom, 2017 severe frost, only flowers on one-year-old branches had a few apples, 2019 light frost after end of blossom, which caused some more russeting. Under these conditions concerning frost the relation between flowering intensity and yield has to be interpreted.

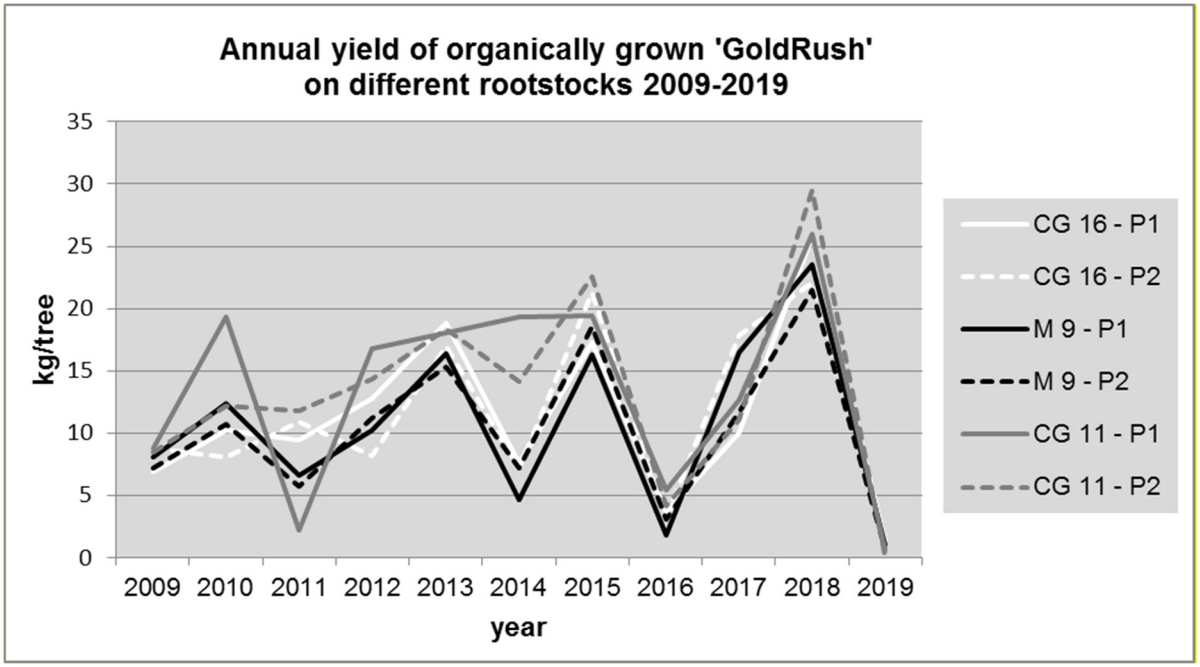

Figure 1: Development of annual yield kg/tree (total, unsorted) of organically grown ‘GoldRush’ on different rootstocks (CG 16, M9, CG 11), 2009-2019

In figure 1 the yield per tree over eleven years is presented. Within the first five years only moderate alternating bearing has been observed, not as heavy as it was seen in the older trial with ‘Golden Delicious’. CG 16 showed the same alternating tendencies like M9. On the other side especially in the years 2012 to 2015 the yield on CG 11 was on a higher level and

seemed to be more balanced (except for the first 3 years of parcel 1, here the yield in 2010 was too high for the young trees).

In table 2 data about flowering intensity, yield and fruit-weight from 2013-2019 are described, additional data about russeting from 2013 and 2014. The last two lines show the summarized yield from 2009-2019 and the part > 65 mm as kg/tree.

Table 2: Flowering intensity(notes 1-9), yield (kg/tree), average fruit weight (g) of organically grown 'GoldRush' on the rootstocks CG16, M9 and CG11 (P1 =parcel 1, P2 = parcel 2) in the years 2009-2019, additional % of fruits with middle + heavy russeting in 2013, 2014 and 2015

year	characteristic	G 16 P1	G 16 P2	M 9 P1	M9 P2	CG11 P1	CG11 P2
2013	flowering intensity	6.9	6.8	6.5	6.6	4.8	6.0
	kg/tree	18.81	17.02	16.42	15.29	18.06	18.40
	fruit weight (g)	132	122	120	115	146	116
	russeting % B3+B4	19.1	14.2	4.0	3.8	4.2	3.7
2014	flowering intensity	3.7	3.7	3.3	3.8	6.5	5.1
	kg/tree	7.61	7.23	4.67	7.20	19.31	14.15
	fruit weight (g)	164	151	165	164	158	153
	russeting % B3+B4	7.9	5.2	25.0	5.1	0	2.9
2015	flowering intensity	7.0	7.7	7.0	6.7	6.5	5.8
	kg/tree	17.28	21.31	16.35	18.58	19.45	22.57
	fruit weight (g)	112	113	106	115	103	119
	russeting % B3+B4	7.7	8.7	3.3	2.4	5.5	5.4
2016	flowering intensity	3.9	4.3	2.8	4.4	5.1	4.1
	kg/tree	3.84	3.05	1.71	3.18	5.26	3.91
	fruit weight (g)	125	126	139	135	136	130
2017	flowering intensity	7.8	7.9	7.4	7.8	8.1	7.8
	kg/tree	9.01	16.45	15.01	10.68	11.23	10.17
	fruit weight (g)	120	121	140	141	138	149
2018	flowering intensity	8.0	7.4	7.4	7.8	8.1	7.8
	kg/tree	25.27	21.86	24.44	21.05	24.61	28.33
	fruit weight (g)	123	111	118	111	110	131
2019	flowering intensity	2.5	2.4	2.1	2.1	2.1	1.4
	kg/tree	1.14	1.38	0.95	0.60	0.65	0.16
	fruit weight (g)	156	209	141	181	173	207
2009 -2019	kg/tree total	119.32	121.95	114.88	108.51	142.65	141.12
	kg > 65 mm	85.86	83.57	81.41	75.76	105.36	107.52

The single years should not be seen separately, but as a continuous development for each rootstock, where the level of yield and the number of apples/tree (data not included in table 2) influences the flowering setting of the following year. For example at rootstock CG 11 the flowering intensity in 2014 was higher than at M9, in spite of more yield than on M9 in 2013.

In 2015 the flower setting was slightly lower at CG 11, but yield was clearly higher. This year was one of the striking years with very hot temperatures and too less rain, so that the trees began to suffer. Nevertheless the flowering intensity in 2016 was comparable or higher than on CG 16 or M9. In combination with the frost close to blossom the yield in 2016 has been not as high as it could be expected by the evaluation of flower setting.

2017 the heavy frost during blossom reduced the yield over all rootstocks. In comparison to other varieties in the organically grown plot of Heuchlingen, the level of yield of 'GoldRush' was good. The parcel CG 16 P1 at the edge of the trial was affected more, because the trees have a little bit smaller canopy and are more open for cold air and cold wind. In 2018 the flowering setting was strong on all rootstocks and resulted in a very high yield, but in combination with the lack of water again

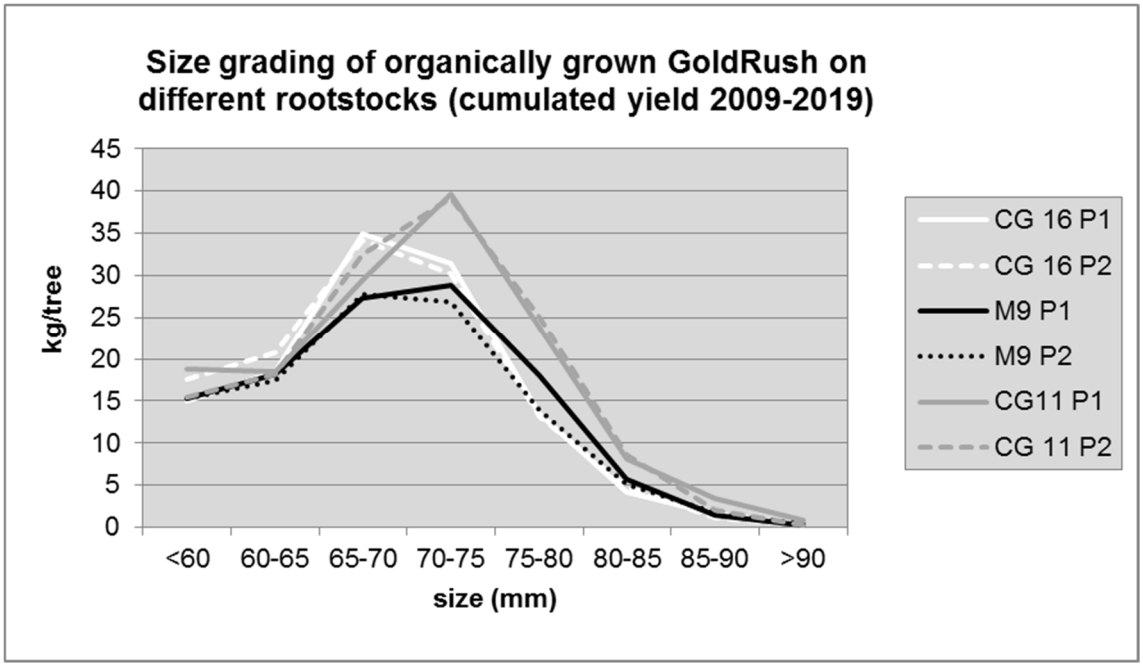

Figure 2: Size grading of organically grown 'GoldRush' on rootstocks CG16, M9 and CG11, cumulated yield (kg/tree) 2009-2019

In figure 2 the yield per tree in the single parcels is shown divided in the 8 classes of size.

As result of the former years results 2009-2015 (see Pfeiffer, 2014 and Pfeiffer, 2016) rootstock CG11 held a promising position: Up to the evaluations of year 2015 CG 11 had a significantly higher total yield and a significantly higher cumulated yield >65 mm than M9 (see Pfeiffer, 2016, ANOVA oneway, tukey-test, α=5%). In the single years no significant differences could be seen except for the years 2014 and 2019 due to the big variances within the rootstocks. Adding the years 2016-2019 CG 11 had nearly every year the lowest variance, followed by CG 16 and at least M 9, where the variance was tremendous (SAS, version 9.4).

CG11 influenced sorting of size (figure 2) and colour of the apples (figure 3) in an advantageous way. The higher proportion of golden and yellow apples is still a convincing detail, so that the increased percentage of the apples with excellent quality for the market was the most important benefit of this rootstock, it was often combined with an increased

content of sugar, too. Respecting the part of light yellow apples the rootstock CG 16 developed in a good way, even in 2018 these parcels had the most attractive apples.

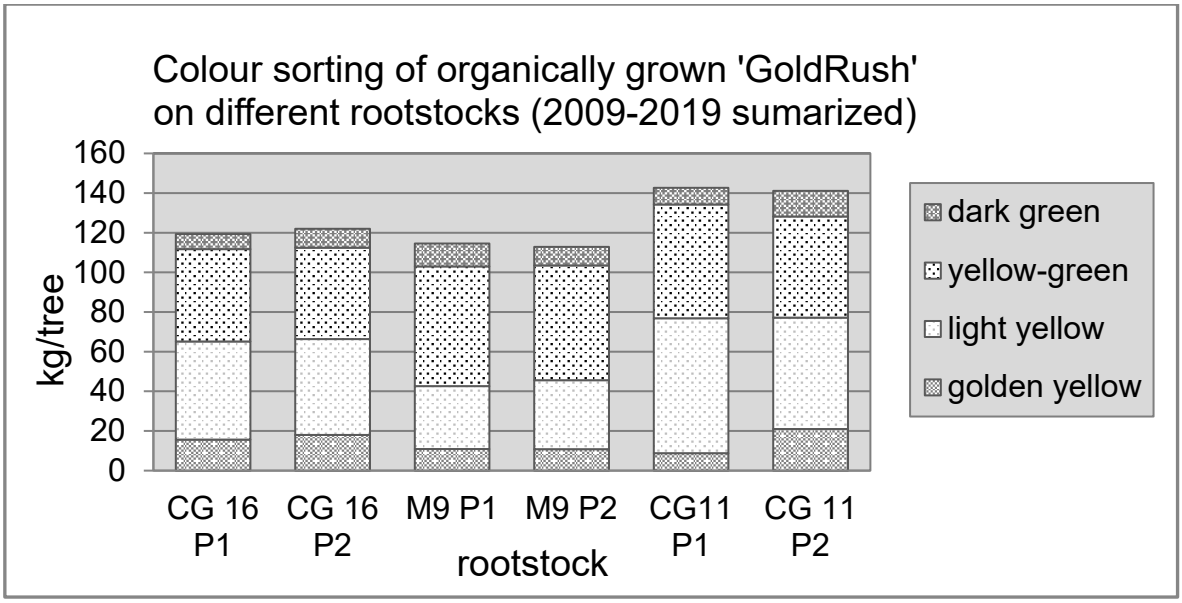

Figure 3: Results of colour sorting (four classes of base colour) of organically grown ‘GoldRush’ on rootstocks CG16, M9 and CG11, cumulated 2009-2019 (kg/tree).

From 2008 to 2019 the average of growing of the trunk per year was 3.7 mm for CG16, 2.8 mm for M9 and 3.2 mm for CG 11, caused by hot summers the mean per tree decreased slightly in comparison to the first few years. The lowest cross-section area of the trunks was observed for rootstock M9 (ø 20.89 cm^2), followed by CG 11 (ø 25.36 cm^2, equal to M9) and CG 16 (ø 30.79 cm^2, significant higher, tukey-test, α=0.05), which had a little bit stronger growth in the last few years. Considering the specific yield, calculated as kg (sum 2009-2019)/cm^2 in January 2020, the rootstock CG 16 had the lowest specific yield (3.87 kg/cm^2 = 72 % of M9, significant lower, tukey-test, α=0.05) and did not fill the distance between the trees completely. M 9 had a specific yield of 5.35 kg/cm^2, while CG 11 had 5.69 kg/cm^2 (= 106 % of M9, no significant difference between these rootstocks).

Discussion

Over all trial years evaluations were done about the infections of the fruits by apple scab and about russeting. These observations left their marks indirectly in the sorting process, here the proportions of not marketable fruits (too much scab, too much russeting or sooty blotch, too small or too green) were assessed in all years. The economic estimation of the rootstocks depends in a critical way on the prices, which could be realised for dessert apples or for juice apples or for purée apples. Some organic fruit-growers can produce dried fruits and sell parts of the harvest, which have smaller skin defects, as apple-chips. Even under aspects of marketable part of the yield the rootstock CG 11 achieved the best results.

Especially for cultivars with smaller fruits like ‘Gala’ or weaker growing cultivars and for soils, which offer not so good growing conditions, or for regions with dry weather periods in summer this rootstock should be respected. It can be recommended, to test new varieties of the breeding work, where a broad source of genes for resistance against important fungal diseases was combined, with trees grafted on CG 11, but the characteristic growth of the variety should be reflected, so that the height of grafting should be adapted. During the scab

season the growth should be watched carefully to avoid infections in the months May and June, when trees on this rootstock can grow a little bit stronger than trees on M9. 2015 another trial with 'Natyra' on four rootstocks, partly with interstem 'Summerred' was planted in Heuchlingen, here after the dry and hot year 2018 the rootstock CG11 showed clear advantages at the fruit size, while the apples on M9 stayed smaller.

Under the climate conditions, which will be expected in future, the rootstock for planned orchards under organic cultivation should be chosen carefully, even if water resources for irrigation in the summer could be limited. Considering the results of other trials with rootstocks under organic conditions (like Spornberger, 2020), CG 11 has advantages for the organic fruit-grower. Walch, Schöneberg and Perren (2017) reported about positive results of trials, where in Switzerland under conventional conditions the combinations CG 11 with cultivars Diwa or Mairac (site Güttingen) or with Gala Galaxy or Braeburn (site Wädenswil) had positive effects on the specific yield, too, only at Braeburn the average fruit weight was a little bit lower. Other advantages there had been the low susceptibility of the rootstock CG 11 for fireblight and the very small number of shoots out of the rootstock. Rühmer (2016) described positive results for the site Haidegg/Austria for the combinations with cultivars Gala and Golden Delicious, too. The availability of this rootstock increased in the last few years, there are possibilities to adapt the height of the grafting to the growth potential of a variety and to the rainfall of the region, where the trees shall be planted.

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