ACTA
Acta Sci. Pol. Hortorum Cultus, 17(4) 2018, 117–127
www.acta.media.pl ISSN 1644-0692 e-ISSN 2545-1405 DOI: 10.24326/asphc.2018.4.11

ORIGINAL PAPER

Accepted: 22.01.2018

EFFECT OF ROOTSTOCK ON YIELD QUANTITY AND QUALITY OF GRAPEVINE 'REGENT' IN SOUTH-EASTERN POLAND

Magdalena Kapłan[1], Kamila Klimek[2]✉, Andrzej Borowy[1], Agnieszka Najda[3]

[1] Department of Nursery and Pomology, University of Life Science, Leszczyńskiego 58, 20-068 Lublin, Poland

[2] Department of Applied Mathematics and Informatics, University of Life Science in Lublin, Głęboka 28, 20-612 Lublin, Poland

[3] Department of Vegetable Crops and Medicinal Plants, University of Life Science in Lublin, Leszczyńskiego 58, 20-068 Lublin, Poland

ABSTRACT

Globally, the application of rootstocks for grapevine cultivation has been a standard, while in the northern regions, like in Poland where the viticulture tradition is relatively short, the selection of the most suitable rootstock types requires multi-year observation and research. The objective of the present study was to assess the effect of six following rootstock types: '101-14 Mgt', '161-49C', '125AA', '5BB', 'SO4', 'SORI', and own-rooted vines on yield quantity and quality of 'Regent' grapevine in south-eastern Poland. The three-year research period indicates that the vines on '125AA' tended to produce not only the highest yields but had positive influence on the number and weight of clusters and berry weight as well. Whereas the vines grafted onto '161-49C' gave the lowest yields and had the smallest number of clusters per vine. The fruit extract content in 'Regent' grapes on '101-14 Mgt' rootstock was found to be significantly lowest among those under study. The extract content and yield of grapevines evaluated in the own-rooted vines and those grafted to the rootstocks which formed one group, did not differ.

Key words: own root, rootstock, number of berries per cluster, berry weight, extract

INTRODUCTION

Viticulture has been gaining in popularity in Poland and hence, the increasing number of vineyards, especially those with the processing grape cultivars. Grapevine worldwide is considered to have really great economic importance but in Poland it is hindered by numerous agrotechnical problems arising from limited knowledge of this exothermic species [Myśliwiec 2009].

Currently, commercial vineyards have been planted using the scions grafted to rootstocks imported from Europe. However, lack of local traditional knowledge and thereby no, practical experience makes the best suited rootstock-cultivar match very challenging as it merely requires many-year cultivation and observation. Besides, the selection of most suitable rootstocks is hampered because of a high number of new types that have been marketed lately [Loreti and Massai 2006].

Grafting practice of grapevines dates back to 2nd century BC but this propagation technique became very popular in the 1880s to overcome a serious threat of root louse phylloxera (*Phylloxera vitifoliae*, Fitch.) that severely devastated most of viticultural areas [Coombe 1999]. At present, cultivation of this plant species relies mainly on grafted vines.

According to Reynolds and Wardle [2001], Satisha et al. [2010] appropriate selection of a rootstock can affect vine resistance to phylloxera, nematodes,

✉ kamila.klimek@up.lublin.pl

soil pH, salinity, soil nutrient availability and drought. Numerous reports point out that rootstocks have influence on vine vigour, yield, quality of fruit and wine [Sivilotti et al. 2007, Sabir et al. 2010]. However, these effects of rootstocks on growth characteristics and development of grapevines are noticeable to a greater or lesser extent because they are the consequences of interactions between a cultivar and environmental, physiological and agrotechnical factors, which have still remained unclear [Rizk-Alla et al. 2011]. A vast body of scientific papers highlighted positive influence of rootstocks on growth, size and quality of grapevine yield as compared to own-rooted vines [Hedberg et al. 1986, Miller et al. 1988a, b, Palliotti et al. 1991, Ferre et al. 1996, Wunderer et al. 1999, Sommer et al. 2001]. Interestingly, negative or indifferent impact of vine grafting management on grapevine performance was also noted [Boselli et al. 1992, Ferroni and Scalabrelli 1995, Reynolds and Wardle 1995, 2001].

Globally, there have been many researches related to rootstock effects on cold hardiness and this knowlegde seems to be of primary importance as regards the location of the Polish vineyards. The studies of Miller et al. [1988a] demonstrated considerable responsiveness of cane and bud hardiness to a type of rootstock used; rootstock '3309C' vines were hardier and recovered better after cold damage as against '5BB' and 'SO4'. Miller et al. [1998b] pointed out that grafted 'White Riesling' was hardier than the own-rooted vines. Substantial influence of a rootstock on the studied frost sensitivity was determined for grapevines 'Cabernet Sauvignon' and 'Chardonnay', which when grafted on '5BB' and '1103P' had less cold damage than on 'SO4' and '420A Mgt' [Palliotti et al. 1991].

The objective of the study was to assess the effect of rootstocks on yield quantity and quality of 'Regent' grapevine in south-eastern Poland.

MATERIALS AND METHODS

The studies were carried out in the 'Nobilis Vineyard', the Sandomierz Upland' (50°39'N; 21°34'E) south-eastern Poland, during the years 2012–2014. The research material comprised the 'Regent' grapevines planted at the 2.0 × 1.0 m spacing (5000 units × ha^{-1}) in spring 2009 in loess soil of pH 7.5 (I bonitation class). The plants were trained according to the Single Guyot system with the trunk of the vine kept at 40 cm, one cane of about 0.9 m length and one two-bud spur. The test evaluated the influence of a rootstock type on yield size and quality of 'Regent' vines. The grapevines of the investigated cultivars grew on six following rootstocks: *V. riparia* × *V. rupestris* crosses – Millardet et de Grasset 101-14 ('101-14 Mgt'); *V. berlandieri* × *V. riparia* crosses – Couderc 161-49 ('161-49C'); Kober 125AA ('125 AA'); Kober 5BB ('5BB'); Selection Oppenheim No.4 ('SO4'); *V. solonis* × *V. riparia* – SORI ('SORI'). The ungrafted own-rooted vines made the control.

The test aimed to assess the yield size and quality analyzing the parameters: number and weight of clusters, number and weight of berries and finally, total extract content. The fruit harvest date, irrespective of a rootstock type applied, was the same, i.e. 28.09.2012; 30.09.2013; 26.09.2014. The yield and number of clusters per vine from each plot were estimated through counting and weighing of fruits from each vine with an accuracy of 0.001 kg. Average weight of berries was determined by weighing and counting of fruits from five average-sized clusters, from each replication. A fruit extract content was measured using an Abbe refractometer, its percentage was established while squeezing the juice from 20 representative berries from each plant.

The trial was set up in a randomized block design and included 7 treatments with 5 replications. The replicates were the plots in which 3 plants were grown.

The results obtained in this test were analyzed statistically using the one-way analysis of variance and Tukey's confidence intervals. Besides, the results were depicted graphically by means of a box-plot. The inference was based on the significance level $p < 0.05$. The correlations between the grape qualitative parameters were estimated through the counting of Pearson's correlation coefficients. There were applied the experimental data multidimensional analysis techniques conducting the cluster analysis in order to group the objects (types of rootstocks) in relatively homogeneous groups in such a way that the objects in the same cluster were more similar to each other than to those in other clusters. The results of the cluster analysis are summarized using a dendrogram. All the statistical analyses were performer using SAS Enterprise Guide 5.1. software.

RESULTS AND DISCUSSION

Table 1 presents the average monthly air temperatures and precipitation totals in the years 2012–2014. It was observed that the weather conditions at particular study years were conducive to grape production. The mean annual air temperature in each research year was slightly higher compared to the multi-year average. The average air temperatures in January, February and December 2012 were found lower as against the multi-year average. A similar relationship was noted in January, February and March 2013.The annual precipitation totals in 2013 and 2014 were higher than the multi-year average and the differences were 38.6 mm and 30.5 mm, respectively. In 2012, total precipitation was lower as compared to the muli-year average. The analysis of precipitation distribution at particular vegetation periods showed that in 2012 high precipitation totals were recorded in October, while in 2013 in June and finally, in May 2014. The weather conditions throughout the research time did not affect negatively the grapevine growth or yielding.

Table 1. Mean air temperatures and total precipitation according to weather station in Sandomierz, Poland 2012–2014

Month	Mean air temperature (°C)				Amount of precipitation (mm)			
	2012	2013	2014	mean for years 1988–2008	2012	2013	2014	mean for year 1988–2008
January	–1.8	–3.4	–2.0	–1.6	34.2	48.1	31.2	22.4
February	–7.2	–0.8	2.0	–0.4	11.3	25.2	14.4	21.8
March	4.9	–1.5	6.0	3.0	23.0	56.6	29.2	28.8
April	9.9	9.0	10.12	8.8	29.2	31.8	40.6	45.7
May	15.2	15.1	13.37	14.2	41.2	88.6	143.4	57.0
June	17.9	18.3	16.12	16.9	76.5	111.2	59	68.7
July	21.2	19.5	19.88	19.1	53.6	33.4	60.8	82.4
August	19.1	19.5	17.34	18.4	38.8	14.9	73.6	58.7
September	14.9	12.2	14.06	13.4	39.6	73.6	40.2	57.0
October	8.2	10.3	8.8	8.6	124.0	5.4	26.8	37.9
November	5.4	5.3	4.0	2.8	21.7	73.7	17.0	30.5
December	–3.3	1.4	0.0	–1.2	24.0	11.0	29.2	24.0
Mean annual air temperature (°C)	8.7	8.7	9.1	8.5	–	–	–	–
Amount of precipitation (mm)	–	–	–	–	517.1	573.5	565.4	534.9

The three-year observation period highlighted significant effect of a rootstock type on yield size and quality of the grapevine of the 'Regent' variety (tab. 2). The statistical analysis showed that a rootstock type affects significantly the cluster numbers on a vine that ranged between 13.53 and 23.23 units. It was found that the vines grafted onto '125AA' and 'SO4' produced significantly more clusters than onto '161-49C' and '5BB'. In 2013, the vines had the significantly highest number of clusters, while significantly the least in 2012. Reynolds and Wardle [2001] investigated eight grapevine cultivars and did not determine any significant differences in the number of clusters per vine between the varieties grafted on 'SO4' and '5BB'. The studies of Satisha et al. [2010] demonstrated the influence of a type of a rootstock on cluster numbers of 'Thompson Seedless' grapevines which when grafted onto the '110R' rootstock produced the highest mean number of clusters over the four-year research period. It was found that the own-rooted vines generated more clusters than those grafted to the '99R', 'Dog Ridge', '1103P' and 'St. George'. Similar dependences were observed in this work: the own-rooted vines produced more clusters than those grafted onto '101-14 Mgt', 'SORI', '161-49C', and '5BB' rootstocks, however these differences were insignificant. Different viticultural results were reported by Ferre et al. [1996] who investigated the 'Cabernet Franc' variety which was shown to produce a lower number of clusters by the own-rooted plants versus those on the rootstocks '3309C', '101-14 Mgt', '5C', '1616E', SO4', '18-815C' and '5BB'.

The cluster weight depended significantly on a rootstock type and ranged from 85.11 up to 127.8 g. Significant differences were seen between the vines grafted to '125AA' and '101-14Mgt', '161-49C', '5BB' and the own-rooted plants. The statistical analysis did not demonstrate any significant effect of the study year on the investigated parameter. The researches of Satisha et al. [2010] indicated that most of the grafted grapevines produced bigger clusters than those grown on their own roots, except for the plants grafted onto the 'St. George'. Reynolds and Wardle [2001] who worked on the vines of 'Chardonnay', 'Gewürztraminer', 'Ortega', 'Riesling',

Table 2. Effect of rootstock on yield quantity and quality of grapevine 'Regent'

	Rootstock	Average number of cluster (pcs)	Cluster weight (g)	Number of berries per cluster (pcs)	Berry weight (g)	Extract, °Brix	Yield (kg·vine^{-1})	Yield (t·ha^{-1})
Rootstock	101-14 Mgt	19.16 ab	96.67 b	78.00 ab	1.34 b	18.6 b	1.86 bcd	9.32 bcd
	SORI	18.06 ab	103.93 ab	98.06 ab	1.18 b	20.09 a	1.98 bc	9.88 bc
	161-49C	13.53 b	87.25 b	69.46 bc	1.23 b	20.51 a	1.16 d	5.78 d
	5BB	15.60 b	85.11 b	56.40 c	1.48 b	20.20 a	1.58 cd	7.88 cd
	SO4	22.80 a	107.08 ab	86.40 ab	1.27 b	20.66 a	2.36 ab	11.80 ab
	125AA	23.23 a	127.8 a	75.00 bc	1.96 a	20.55 a	2.92 a	14.58 a
	Own root	22.03 ab	96.53 b	86.20 ab	1.16 b	20.64 a	2.08 ab	10.40 ab
Year	2012	12.27 c	95.00 a	90.63 a	1.11 b	18.42 b	1.26 b	6.28 b
	2013	24.91 a	100.51 a	72.43 b	1.53 a	21.17 a	2.53 a	12.65 a
	2014	20.32 b	106.36 a	71.46 b	1.49 a	20.94 a	2.18 a	10.90 a
P-value	Rootstock	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Year	<0.0001	0.1304	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Rootstock × Year	0.0095	0.0098	0.0002	0.5792	<0.0001	0.0066	0.0063

Mean values marked with the same letters do not differ significantly at $P = 0.05$

'DeChaunac', 'Marechal Foch', 'Okanagan Riesling', 'Seyval Blanc', 'Verdelet' grafted on '3309C', '5BB', '5C' and 'SO4' did not note any considerable influence of a rootstock type on yield size, cluster numbers and weight or berry weight. They suggested that the rootstocks did not provide significant advantage over the own-rooted plants under the conditions of Pacific north-western U.S. and British Columbia. However, the studies of Kamiloglu [2012] proved significant effect of a type of a rootstock on cluster weight and qualitative parameters of berries of the 'Round Seedless' grapevine variety. Significant average higher cluster weight was obtained from the vines grafted on '110R' than on 'Rup. Du Lot' and '1616C'. Significantly larger berries had the plants grafted onto '110R' as compared to others. Similar influence of a rootstock type on grapevine yield size and quality was reported by Celik and Kismali [2003], Ilhan et al. [1998] and Satisha et al. [2010].

The present studies have shown that the vines grafted on '5BB' produced significantly less berries than the plants on '101-14 Mgt', 'SORI', SO4' and own-rooted. There was found significant effect of the study year on the investigated characteristic as on average significantly more berries were reported in the first study year than in others. Reynolds and Wardle [2001] found significant impact of a rootstock type on berry number per cluster and stated that vines of the 'Gewürztraminer' variety grafted on 'SO4' rootstock generated significantly higher number of berries than the plants on '5BB'. The present research results have confirmed this finding. The opposite effect was reported by Reynolds and Wardle [2001] for 'Marechal Foch' grapevines. The authors observed that the number of berries in clusters in the own-rooted vines and those grafted on 'SO4' did not differ significantly in the case of 'Seyval Blanc', 'Verdelet', 'Ortega'. While in the 'Marechal Foch' and 'Gewürztraminer' the vines grown on their own roots produced clusters with significantly higher berry numbers as against those on 'SO4'. No significant impact of a type of rootstock on the parameter investigated was found for the vines of 'De Chaunac', 'Okanagan Riesling', 'Chardonnay', Riesling' variety. Ferre et al. [1996] worked on 'Cabarnet Franc' grapevines and indicated that the 'SO4', '5C' and '18-815C' rootstocks tend to generate big clusters containing many berries, whereas the own-rooted plants produce smaller clusters and less berries. This finding does not fully agree with this paper.

Average berry weight ranged between 1.16 and 1.96 g and it differed significantly between the combinations under study (tab. 2). The vines grafted on '125AA' had significantly heavier fruits than those from other combinations. It was observed that throughout the growing cycle, the plants on their own roots yielded the smallest berries. Significant impact of the study year on the studied characteristic was shown, significantly smaller berries were obtained in the first study year as compared to other years. Satisha et al. [2010] investigated 'Thompson Seedless' grapevine variety and highlighted significant effect of a rootstock type on berry weight as on average in the four-year research period, the berries from the own-rooted vines were found to be significantly smaller than from the plants grafted on 'Dog Ridge', '1103P', '110R' and '99R'. Reynold and Wardle [2001] working on vines of 'De Chaunac', 'Marechal Foch', 'Chardonnay' grafted onto 'SO4' rootstock showed that these plants produced significantly larger berries than those on '5BB' ,which has not been confirmed in the present paper.

On average, during the three-year study period, the vines grafted on '101-14 Mgt' produced fruits of a significantly lower extract content as against others. Main et al. [2002] evaluated the impact of rootstocks on yield quality of 'Chardonel' grapevines and concluded that the plants grown on their own roots displayed significantly higher extract content compared to those grafted on 'Cynthiana' and '5BB'. The present researches have shown that the studied parameter was significantly dependent on the study year; in the first year the extract content in 'Regent' fruits was found significantly lower than in other years.

Fruit yield oscillated from 1.16 up to 2.92 kg· vine^{-1}, i.e. from 5.78 up to 14.58 t·ha^{-1} and differed significantly between the combinations assessed. The best-yielding vines throughout the research period were those grafted on '125AA', while the poorest on '161-49C'. It was reported that the plants grafted onto 'SORI' and 'SO4' rootstocks yielded higher than the own-rooted, but the differences were not significant.

As for the vines on the other rootstocks, the opposite relationship was noted. The vines grafted on '161-49C' and '5BB' had significantly lower yield than the own-rooted. In the first study year, the vines of the tested variety yielded significantly lower as compared to the second and third study year.

The rootstock influence on yield size was widely documented in the literature around the world. As early as in 1937, Vaile confirmed that a rootstock can exert definite influence on the behavior of the scion cultivars, predominantly growth vigour and performance. Snyder and Harmon [1958] observed that highly vigorous rootstocks generate much wood, especially in the first growth stage. Inverse relationship was noted in the case of less vigorous rootstocks with lower growth rate but positive impact on fruit quality. According to Wolf and Pool [1988] and Parejo et al. [1995], yield quality is negatively correlated with vine vigour.

Loomis [1952] assessing 14 rootstocks and 12 grape varieties found that nearly all the rootstocks have beneficial influence on yield, vigour and longevity of grapevines as compared to the own-rooted, which has not been fully confirmed in the present work. Special attention was paid to 'Dog Ridge' that considerably affected profitability of the crop. Nithya D. Menora et al. [2015] who worked on the impact of '1103P', 'SO4', 'Dog Ridge' and the vines grown on their own roots on the size yield of 'Thompson Seedless', 'Flame Seedless', 'Kishmish Chorni' grape showed that regardless of a variety, the own-rooted vines yielded higher than those grafted on 'SO4'. Among the grafted vines, the plants on 'SO4' had the lowest yield while the highest on 'Dog Ridge'. Hedberg [1980] established that performance of all grafted grape cultivars evaluated in his studies was substantially higher as compared to those grown on their own roots, the attention was focused on 'Ramsey' and 'Dog Ridge'. Similarly, Ferre et al. [1996] confirmed higher performance of the grafted 'Cabernet Franc' and 'White Riesling' than the own-rooted .

Wunderer et al. [1999] demonstrated that 'Gruner Veltliner' grape varieties grafted onto 'SO4', '5BB' and '5C' rootstocks were characterized by greater growth vigour and wood production (green matter) than the vines grown on their own roots.

There are numerous reports available in literature that indicate negative or indifferent impact of rootstocks on vigour, productivity and profitability of grapevines. Boselli et al. [1992] reported that application of '5C', '5BB', 'G13', '8B', 'SO4', '1103 P', '41B' rootstocks in 'Chardonnay' grape did not have any considerable impact on performance as compared to the own-rooted plants. Whereas in the Ferroni and Scalabrelli [1995] studies, the 'Chardonnay' grapevines on '5BB' and '1103P' were observed to have poorer growth as against those own-rooted. Reynolds and Wardle [1995] showed no differences in yield size, fruit composition or removed green matter between the 'Gewürztraminer' own-rooted vines and grafted ones. Novello et al. [1996] in their rootstock trials demonstrated that 'Erbaluce' grape grafted on '101-14 Mgt', '420A', '*Rupestris* du Lot', '5BB', 'SO4' had lower vigour than the own root. Sommer et al. [2001] found that grafted 'Sultana' vines always produced smaller fruit as compared to own-rooted vines.

Table 3. Correlation coefficients between measured parameters of grapevine 'Regent'

	Number of berries per cluster (pcs)	Berry weight (g)	Extract, °Brix	Average number of cluster (pcs)	Cluster weight (g)	Yield (kg·vine^{-1})
Number of berries per cluster (pcs)	1					
Berry weight (g)	**–0.5040**	1				
Extract, °Brix	–0.2720	0.3597	1			
Average number of cluster (pcs)	–0.0143	0.2537	0.3681	1		
Cluster weight (g)	0.2406	**0.5577**	0.1105	0.2482	1	
Yield (kg·vine^{-1})	0.0598	**0.4467**	0.3598	**0.8725**	**0.6195**	1

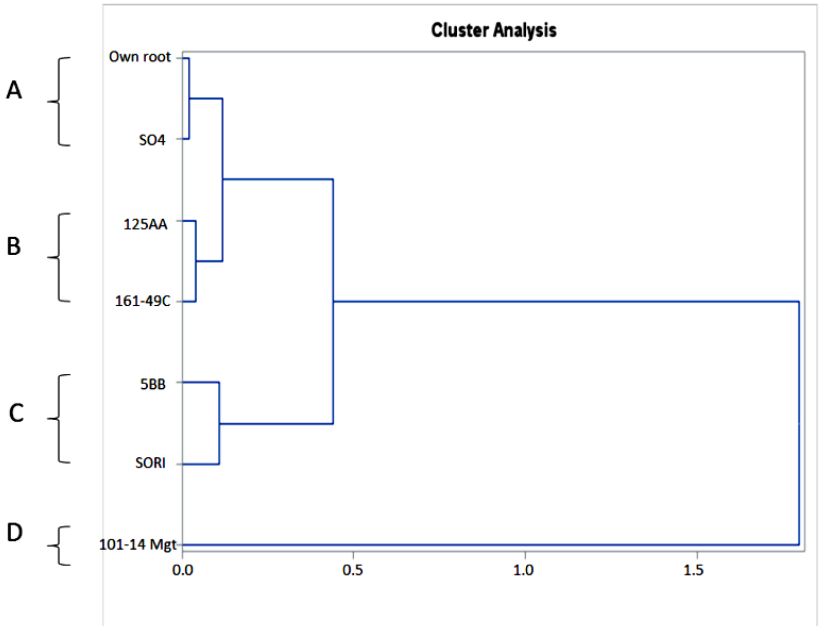

Fig. 1. Branching tree diagram for extract of grapevine 'Regent'

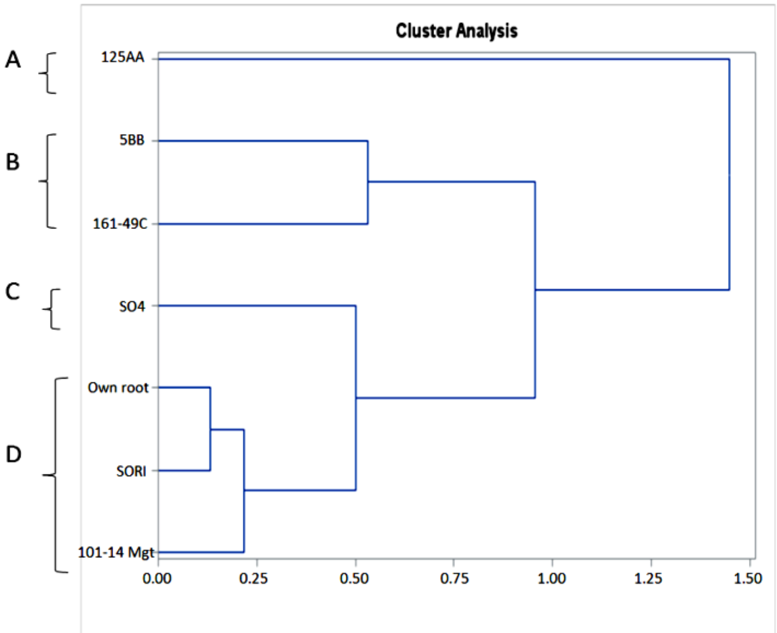

Fig. 2. Branching tree diagram for yield of grapevine 'Regent'

The calculated Pearson's coefficient (tab. 3) manifested a strong correlation between the number of clusters per vine and yield (R = 0.8725, $p < 0.05$). The correlation results confirmed the inverse relationship between berry weight and their number in cluster (R = 0.5040, $p < 0.05$).

The presented dendrogram (fig. 1) defined the similarity of the effect of rootstock types on fruit extract content in 'Regent' grape variety. On the basis of the obtained results distinct clusters were defined which allowed for the explicit interpretation of the results. There were specified three distinct clusters displaying some similarities and one separate cluster for '101-14 Mgt' rootstock. It was found that own-rooted vines and the rootstock 'SO4' had very similar influence on fruit extract concentration, similar relationships were established between the rootstocks: '123AA' and '161-49C' as well as '5BB' and 'SORI'. The A, B and C clusters join at some level and thus visualize some similarities of the effect on extract content. The presented results have unequivocally indicated the weakest impact of '101-14 Mgt' rootstock on the tested parameter.

The multidimensional analysis showed marked influence of a rootstock type on yield of 'Regent' grape variety (fig. 2). There were found clusters and similarities of the effect on the examined parameters reported between the rootstocks '5BB' and '161-49 C' that form cluster B and the own-rooted vines, 'SORI' and '101-14 Mgt' constituting cluster D. The separate clusters A and C visualize the rootstocks '125AA' and 'SO4' that had the highest yields.

The measurements of fruit extract content that were analyzed statistically and presented in a graphical form as box-plot (fig. 3) aimed at the comparison of the level of the tested parameter between the own-rooted vines and those grafted on the rootstocks recognized as one group. They did not show any substantial differences in the content of the investigated quality parameter. It does not agree with the results given by Reynolds and Wardle [2001] who demonstrated that the fruit content in grapes from the vines grown on their own roots was significantly lower compared to those grafted onto rootstocks.

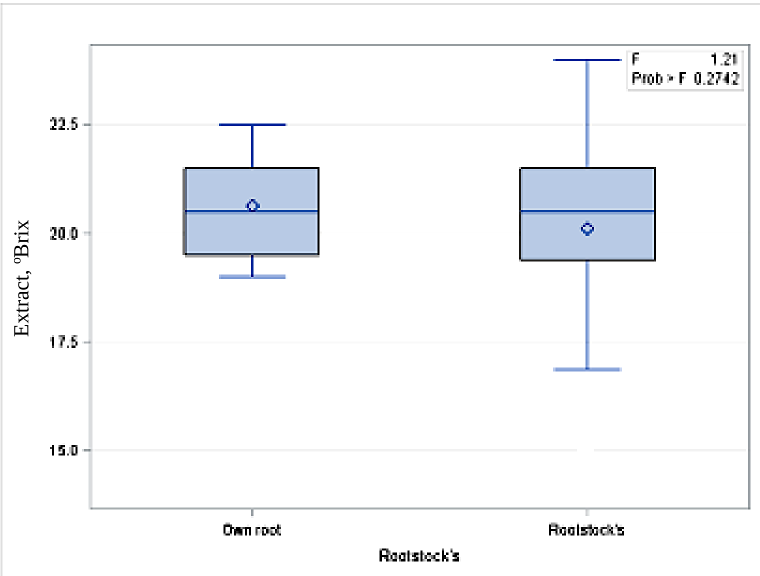

Fig. 3. Fruit extract between the own-rooted vines and those grafted on the rootstocks recognized as one group

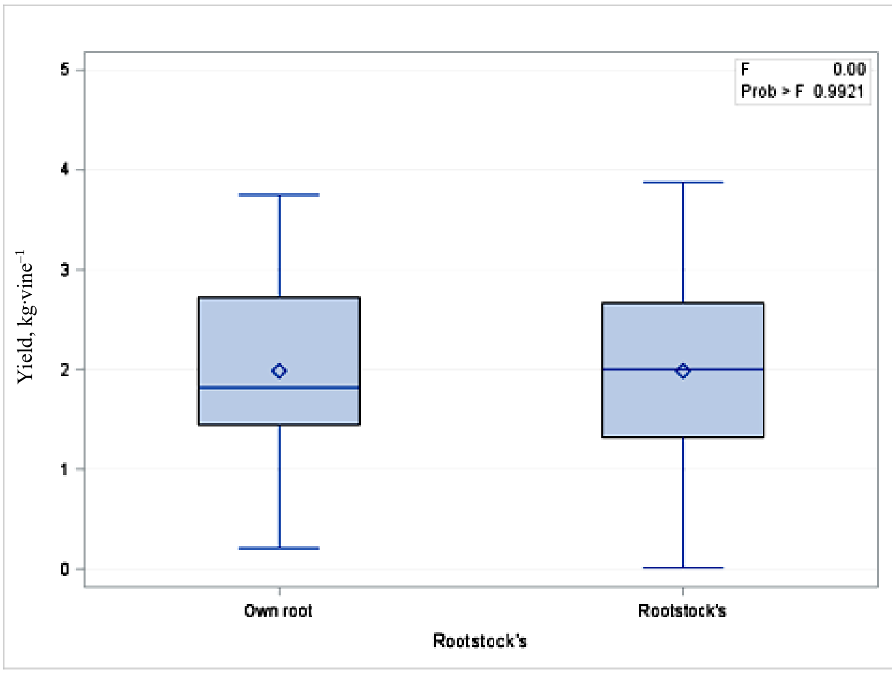

Fig. 4. Yield between the own-rooted vines and those grafted on the rootstocks recognized as one group

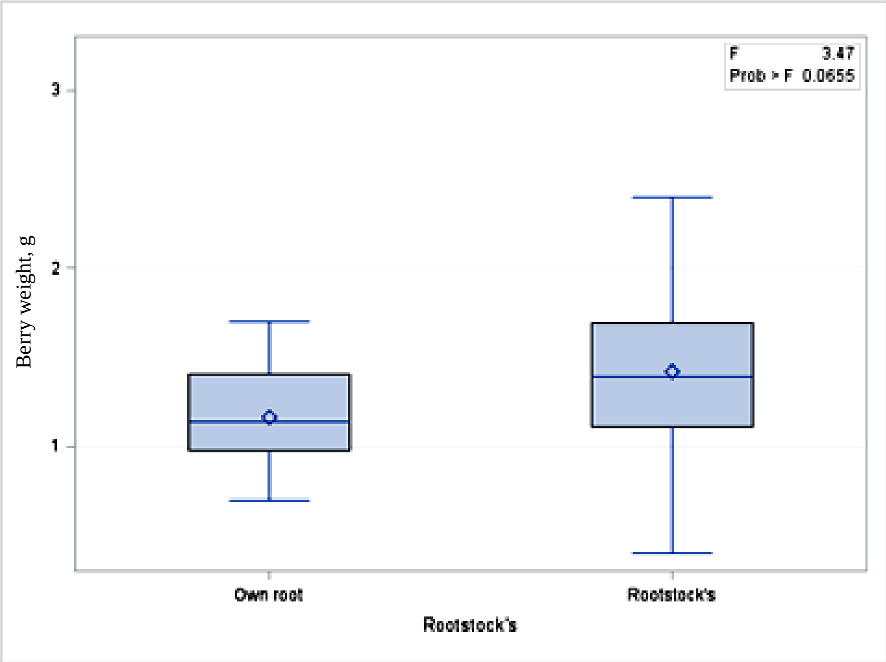

Fig. 5. Berry weight between the own-rooted vines and those grafted on the rootstocks recognized as one group

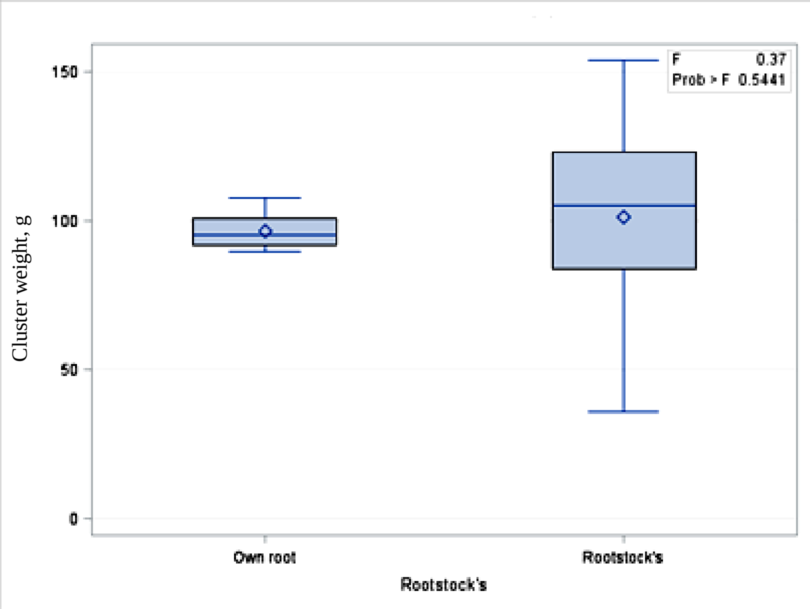

Fig. 6. Cluster weight between the own-rooted vines and those grafted on the rootstocks recognized as one group

Alike, fruit yield of grapevines of 'Regent' presented by means of the box-plot did not differ significantly between the own rooted versus grafted plants (fig. 4) and that is consistent with the results obtained by Reynolds and Wardle [2001].

Weight of berries developed in the first clusters on-own rooted 'Regent' vines was slightly smaller than those on grafted ones (figs 4 and 5).

CONCLUSION

The obtained research results show that the application of various types of rootstocks in grapevine cultivation under the conditions of south-eastern Poland can affect yield size and quality of 'Regent' grape. These results may be useful in further improvement of grapevine cultivation. The three-year observation period indicated that the vines grafted on '125AA' produced the highest yield among those evaluated, besides, they displayed very positive effect on cluster numbers and weight and berry weight. The vines on '161-49C' had the lowest yielding crops and produced the smallest cluster number per vine. The fruit extract content of 'Regent' grapevine variety grafted on the rootstock '101-14 Mgt' was the significantly lowest among those investigated. Fruit extract and yield of the own-rooted grapevines versus grafted onto rootstocks recognized as one group did not differ.

REFERENCES

Boselli, M., Fregoni, M., Vercesi, A., Volpe, B. (1992). Variation in mineral composition and effects on the growth and yield of Chardonnay grapes on various rootstocks. Agric. Ric., 14, 138–139.

Celik, M., Kismali, I. (2003). The researches on the effects of some rootstocks on yield, quality and vegetative growth of 'Round Seedless' cultivar. J. Ege Univ. Fac. Agric., 40(3), 1–8.

Coombe, B. (1999). Grafting. In: The Oxford companion to wine. 2nd ed. Robinson, J. (ed.). The Oxford University Press Inc., New York.

Ferre, D.C., Cahoon, G.A., Ellis, M.A., Scurlock, D.M., Johns, G.R. (1996). Influence of eight rootstocks on the performance of 'White Riesling' and 'Cabernet Franc' over five years. Fruit Var. J., 50, 124–130.

Ferroni, G., Scalabrelli, G. (1995). Effect of rootstock on vegetative activity and yield in grapevine. Acta Hortic., 388, 37–42.

Hedberg, P. (1980). Increased wine grape yields with rootstocks. Farmers' Newsl., 147, 22–24.

Hedberg, P.R., McLeod, R., Cullins, B., Freeman, B.M. (1986). Effect of rootstocks on production, grape and wine quality of Shiraz vines in Murrambidge irrigation area. Aust. J. Expt. Agric., 26, 511–516.

Ilhan, I., Yilmaz, N., Gokçay, E. (1998). Comparision of some rootstocks used for 'Round Seedless' grape variety from the point of yield and quality. 4th Viticulture Symposium, October 20–23, Yalova, 212–216.

Kamiloglu, Ö. (2012). The effect of rootstocks and trening system on the growth and fruit quality of the 'Round Seedless' grape. J. Food Agric. Environ., 10(1), 350–354.

Loomis, N.H. (1952). Effect of fourteen rootstocks on yield, vigor, and longevity of twelve varieties of grapes at Meridian, Mississippi. Proc. Amer. Soc. Hortic. Sci., 59, 125–132.

Loreti, F., Massai, R. (2006). State of the art on peach rootstocks and orchard systems. Acta Hortic., 713, 253–268.

Main, G., Morris, J., Striegler, K. (2002). Rootstock effect on Chardonel productivity, fruit and wine composition. Am. J. Enol. Viticult., 53, 37–40.

Menora, N.D., Joshi, V., Kumar, V., Vijaya, D., Debnath, M.K., Pattanashetty, S., Padmavathamma, A.S., Variath, M.T., Biradar, S., Khadakabhavi, S. (2015). Influence of rootstock on bud break, period of anthesis, fruit set, fruit ripening, heat unit requirement and berry yield of commercial grape varieties. Int. J. Plant Breed. Genet, 9, 126–135.

Miller, D.P., Howell, G.S., Striegler, R.K. (1988a). Cane and bud hardiness of selected grapevine rootstocks. Am. J. Enol. Viticult., 39, 55–59.

Miller, D.P., Howell, G.S., Striegler, R.K. (1988b). Cane and bud hardiness of own rooted white Riesling and scion of White Riesling and Chardonnay grafted to selected rootstocks. Am. J. Enol. Viticult., 39, 60–86.

Myśliwiec, R. (2009). Uprawa winorośli [Viticulture]. Plantpress, Kraków.

Novello, V., Bica, D., de Palma., L. (1996). Rootstock effects on vegetative productive indices in grapevine cv. Erbaluce trained to pergola system. Acta Hortic., 427, 233–240.

Palliotti, A., Cartechini A., Proietti, P. (1991). Influence of rootstock and height of training system on spring frost sensibility of Chardonnay and Cabernet Sauvignon grape cultivars in the Umbria region. Ann. Fac. Agrar., 45, 283–291.

Parejo, J., Minguez, S., Sella, J., Espinas, E. (1995). Sixteen years of monitoring the cultivar Xarello (*Vitis vinifera* L.) on several rootstocks. Acta Hortic., 388, 123–128.

Reynolds, A.G., Wardle, D.A. (1995). Performance of 'Gewurztraminer' (*Vitis vinifera* L.) on three root systems. Fruit Var. J., 49, 31–33.

Reynolds, A.G., Wardle, D.A. (2001). Rootstocks impact vine performance and fruit composition of grapes in British Columbia. HortTechnology, 11(3), 419–27.

Rizk-Alla, M.S., Sabry, G.H., Abd El-Wahab, M.A. (2011). Influence of some rootstocks on the performance of Red Globe grape cultivar. J. Am. Sci., 7(4), 71–81.

Sabir, A., Dogan, Y., Tangolar, S., Kafkas, S. (2010). Analysis of genetic relatedness among grapevine rootstocks by AFLP (Amplified Fragment Length Polymorphism) markers. J. Food Agric. Environ., 8(1), 210–213.

Satisha, J., Somkuwar, R.G., Sharma, J., Upadhyay, A.K., Adsule, P.G. (2010). Influence of rootstocks on growth yield and fruit composition of Thompson Seedless grapes grown in the Pune Region of India. S. Afr. J. Enol. Vitic., 31, 1–8.

Sivilotti, P., Zulini, L., Peterlunger, E., Petrussi, C. (2007). Sensory properties of 'Cabernet Sauvignon' wines as affected by rootstock and season. Acta Hortic., 754, 443–448.

Snyder, E., Harmoon, F.N. (1948). Comparative value of nine rootstocks for ten vinifera grape varieties. Proc. Amer. Soc. Hort. Sci. 51, 287–294.

Sommer, K.J., Islam, M.T., Clingeleffer, P.R. (2001). Sultana fruitfulness and yield as influenced by season, rootstock and trellis type. Aust. J. Grape Wine Res., 7, 19–26.

Wolf, T.K., Pool, R.M. (1988). Effects of rootstock and nitrogen fertilization on the growth and yield of Chardonnay grapevines in New York. Am. J. Enol. Viticult., 39, 29–33.

Wunderer, W., Fardossi, A., Schmuckenschlager, J. (1999). Influence of three different rootstock varieties and two training systems on the efficiency of the grape cultivar Gruner Veltliner in Klosterneuburg. Mitteilungen Klosterneuburg, Rebe und Wein, Obstbau und Fruchteverwertung, 49, 57–64.