ISSN 1313 - 8820
Volume 8, Number 2
June 2016

AGRICULTURAL SCIENCE AND TECHNOLOGY

2016

An International Journal Published by Faculty of Agriculture,
Trakia University, Stara Zagora, Bulgaria

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The journal is accepted to be indexed with the support of a project № BG051PO001-3.3.05-0001 “Science and business” financed by Operational Programme “Human Resources Development” of EU. The title has been suggested to be included in SCOPUS (Elsevier) and Electronic Journals Submission Form (Thomson Reuters).

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ISSN 1313 - 8820

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AGRICULTURAL SCIENCE AND TECHNOLOGY, VOL. 8, No 2, pp 136 - 139, 2016
DOI: 10.15547/ast.2016.02.024

Performance of eleven plum cultivars under agroclimatic conditions of Plovdiv region, Bulgaria

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(Manuscript received 13 May 2016; accepted for publication 8 June 2016)

Abstract. *Plum is a traditional fruit crop in Bulgaria. The South Central Region represents 22.2% of the total area occupied with plum trees. In this study the results of a four years' investigation on ten plum cultivars carried out at the Fruit Growing Institute in Plovdiv are presented. Stanley was used as a standard. The observed phenological characteristics included flowering and fruit ripening. The cultivars Tophit plus and Toptaste are the earliest flowering, whereas Topstar plus is the latest one. Fruits of Topfirst cultivar ripen at the beginning of July, those of Top and Tophit plus in September and all the rest in August. According to biometrical analyses, fruit weight of Topgigant plus and Tophit plus is over 60g. The total soluble solid content in the studied cultivars varies from 15.7% in Top cultivar to 24.75% in Toptaste. Yield was determined and expressed in kg per tree. Over 30 kg per tree was harvested from the cultivars Stanley, Jojo, Topgigant plus and Tophit plus. The lowest yield was obtained from the cultivars Top, Topfive and Toptaste. In 2012, the percentage of flower buds destroyed by frost was evaluated. The lowest degree of damages was reported in the cultivars Tophit plus, Topgigant plus and Mirabelle de Nancy (below 10%), and the greatest damages in Toptaste (51%). According to the obtained results, the most suitable plum cultivars recommended to be grown in Plovdiv region, are Jojo, Topgigant plus and Tophit plus, as well as the cultivar Bellamira from the group of Mirabelle plum.*

Keywords: *Prunus domestica* L., fruit characteristics, chemical composition

Introduction

Plum is a traditional fruit crop in Bulgaria. The South Central Region represents 22.2% of the total area occupied with plum trees. The main cultivar grown is still Stanley, because the limiting factor of plum growing in the country is plum pox (Djuvinov and Vitanova, 2002). During the second half of the 20th century extensive breeding programs on European plum were established to obtain cultivars resistant and/or tolerant to the disease. A lot of new cultivars were registered in Europe as tolerant to plum pox but few of them were accepted by producers and spread in the orchards. Till now only plum cultivar Jojo is known as resistant to plum pox (Neumeller et al., 2010). Some other new German plum cultivars tolerant to plum pox and with good economic properties were obtained in Geizenheim (Jacob, 2002; Blažek and Pištěková, 2009.). The cultivation of new plum cultivars improves the production characteristics of plums, which increases productivity and makes the fruit more attractive in size and nutritive composition (Markuszewski and Kopytowski, 2013).

Bulgarian producers are interested in new cultivars and possibilities to diversify the list of cultivars in their orchards. As an answer of this need, in 2008, ten new plum cultivars were introduced from Germany in the Fruit Growing Institute. In this study the results of four years' investigation on those cultivars are presented. The aim is to recommend the best one to the plum producers.

Material and methods

The study was carried out in the period 2011 – 2014 at the Fruit Growing Institute, Plovdiv. The trees of the studied cultivars Bellamira, Mirabelle de Nancy, Jojo, Top, Topfive, Topfirst, Topgiant plus, Tophit plus, Topstar plus and Toptaste were planted in a collection plantation in 2006 at a planting distance 4 × 4 m. Stanley cultivar, which is the major one in the plum orchards in Bulgaria, was used as a standard. The collection plantation is grown under non-irrigation conditions. The area is naturally grassed, the inter-row strips are maintained by mowing and the in-row strips are treated with herbicides. The observed phenological characteristics included flowering and fruit ripening.

Biometrical and chemical analyses of the fruits were performed. Total soluble solids (TSS) content was determined (Brix). Sugars were determined according to the method of Schoorl-Regenbogen, the acid contents were defined titrimetrically, active acidity (pH) was measured potentiometrically and the ascorbic acid (Vitamin C) was determined by the method of Tillmans. UPOV descriptor (2006) was used to allocate the cultivars into groups according to the fruit weight, using the following scale: very small 10 – 15 g, small 15 – 30 g, medium 30 – 40 g, large 40 – 60 g, very large > 60 g. Fertility of each cultivar was evaluated in kg per tree by weighing the fruits. In 2012, the percentage of flower buds destroyed by frost was evaluated by reporting the injuries caused on 100 buds of each cultivar. Data were statistically processed by Duncan's test (Steele and Torrie, 1980).

Results and discussion

It is known from literature that meteorological conditions influence the time and duration of flowering. In Plovdiv, which is located in the South Central Region of Bulgaria, the beginning of flowering of plum cultivars starts at the end of March or the beginning

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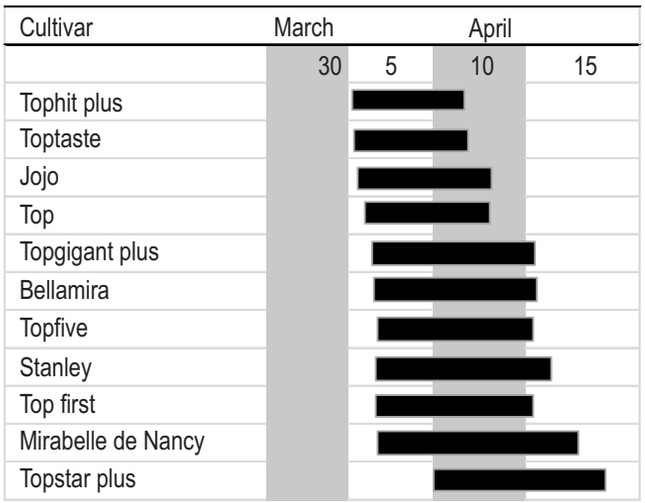

Figure 1. Phenogramme of flowering

Table 1. Frost damages in 2012

Cultivar	Damaged buds, (%)
Topfirst	17
Topfive	24
Topstar plus	16
Topgigant plus	9
Mirabelle de Nancy	9
Bellamira	20
Toptaste	51
Jojo	16
Stanley	11
Top	7
Tophit plus	5

of April but in some years even at the end of April. Of the studied cultivars, the earliest period of flowering is reported in Tophit plus and Toptaste and the latest in Topstar plus, the difference being only 4 days (Figure 1). During the period of study the flowering period continued 10 to 11 days and it was shorter only in Top cultivar – 9 days. In a study on plum cultivars Bozhkova and Butac (2009) established that in Plovdiv region flowering starts in the first decade of April and in Pitesti, Romania – in the second decade. In the Czech Republic, Blazek and Pistekova (2009) found out that the earliest to start flowering are the plum cultivars Topfirst and Topstar plus (on 14 April) and the latest ones – cultivars Katinka and Ruth Gerstetter (on 1 May). In Germany the period of flowering of cultivar Tophit plus is mid-early (Jacob, 2002). Obviously the flowering stage starts later in the more northern regions and countries.

Although rarely, provocative spring frosts cause damages on flower buds, flowers and young fruit sets of the plum cultivars. For example, on 6 March 2012 the temperature dropped down to -3.5°C, and on 3 April to -2.2°C and the frost injured the flower buds. Data about the caused damages are presented in Table 1. The percentage of frost damaged buds varied from 5% to 51% at the phenological stage dormant buds. The lowest degree of damages was reported in cultivars Tophit plus, Topgigant plus and Mirabelle de Nancy – below 10%, and the greatest damages – in Toptaste – 51%. For comparison, the degree of frost damages in the standard cultivar Stanley was 11%. In other studies we established a lower percentage of frost damages in the Stanley cultivar (1.0%) at the phenological phase white bud (Bozhkova and Zhivondov, 2004). Obviously, not only the absolute values of the negative air temperatures are responsible for frost damages, but also the duration of the low temperatures. That is why, a lower percentage of damages could be observed even at later phenological stages of the flower buds and vice versa.

Fruits of the 11 studied cultivars ripen within a period of 2 months – from the beginning of July to the beginning of September (Table 2). Fruits of Topfirst cultivar ripen at the beginning of July, those of Top and Tophit plus ripen in September and all the rest in August. Similar results about the period of ripening of those cultivars were also obtained by other authors in the Czech Republic and Poland (Blazek and Pistekova, 2009; Markuszewski and Kopytowski, 2013). The difference of the date of ripening of a given cultivar in the separate years varies from 2 to 13 days, depending on the climatic conditions. According to data of the biometric analysis, the fruits of Mirabelle de Nancy are very small in size, of Bellamira and Top – small, of Stanley, Topfirst, Topfive, Topstar plus and

Table 2. Average biometric and economic values (2011 – 2014)

Cultivar	Fruit							
	Mean harvest time	Lengh, mm	Width, mm	Thickness, mm	Fruit weight, g	Stone weight, g	Relative share, %	Yield, kg/tree
Topfirst	06.07.	43.18 ^{c*}	36.36 ^{c}	33.44 ^{c}	33.53 ^{cd}	1.39 ^{b}	4.14	19.8 ^{cd}
Topfive	29.08.	40.25 ^{d}	37.27 ^{bc}	35.9 ^{bc}	31.88 ^{d}	1.22 ^{bc}	3.82	12.4 ^{e}
Topstar plus	02.08.	44.7 ^{c}	37.22 ^{bc}	36.87 ^{b}	36.01 ^{c}	1.46 ^{b}	4.05	17.8 ^{d}
Topgigant plus	09.08.	52.69 ^{a}	45.30 ^{a}	44.86 ^{a}	61.74 ^{a}	1.81 ^{a}	2.93	31.0 ^{b}
Mirabelle de Nancy	17.08.	25.11 ^{f}	23.44 ^{e}	23.83 ^{d}	10.41 ^{g}	0.41 ^{d}	3.93	21.2 ^{c}
Bellamira	18.08.	33.52 ^{e}	32.16 ^{d}	31.96 ^{c}	21.19 ^{f}	0.84 ^{c}	3.96	22.4 ^{c}
Toptaste	14.08.	42.11 ^{c}	36.25 ^{b}	37.20 ^{b}	34.88 ^{cd}	1.65 ^{ab}	4.73	15.8 ^{d}
Jojo	28.08.	48.77 ^{b}	39.38 ^{b}	38.07 ^{b}	42.98 ^{b}	1.51 ^{b}	3.51	33.1 ^{a}
Stanley	31.08.	48.50 ^{b}	34.65 ^{c}	36.12 ^{b}	33.48 ^{cd}	1.61 ^{ab}	4.80	36.4 ^{a}
Top	06.09.	40.48 ^{d}	33.55 ^{d}	34.87 ^{c}	25.59 ^{e}	0.92 ^{c}	3.59	13.6 ^{d}
Tophit plus	03.09.	53.74 ^{a}	43.41 ^{a}	47.39 ^{a}	61.71 ^{a}	1.87 ^{a}	3.03	31.8 ^{b}

*Different letters in the same row/column indicated significant difference ($p<0.05$)

Toptaste – medium, of Jojo – large, of Topgigant plus and Tophit plus – very large. Most of the cultivars bear fruits medium in size. Fruit weight is a trait determined by the biological characteristics of the cultivar, however, it is also influenced by the growing conditions, tree loading and health status. That could explain the significant differences of the results obtained in the studies of different authors and sometimes of the same author. For example, in the Czech Republic Blazek and Pistekova (2009) obtained results similar to ours for the cultivars Topfirst, Toptaste and Jojo. Smaller fruits were reported for Topfive and Tophit plus and larger fruits for Topgigant plus. The differences in the same cultivar varied from 0.1g (for Jojo) to 14.2g (for Topgigant plus). In Poland Markuszewski and Kopytowski (2013) reported smaller fruits of the cultivar Top in comparison with our results. Plum fruits have short pedicels. Pedicel length varies within 10 – 12 mm in the studied cultivars. It is slightly bigger in the cultivars Stanley – 17.44 mm and Bellamira – 16.35 mm. The stones of the cultivars Mirabelle de Nancy, Bellamira and Top are below 1 g in weight and in the rest of the cultivars their weight varies from 1.22 g to 1.87 g. The cultivar Topgigant plus has the largest fruits and stones but the lowest relative stone to fruit ratio (2.93%). As a whole, that characteristic is below 5%, which shows that compared to the other stone fruit species, plums have comparatively small stones. Over 30 kg per tree were harvested from the cultivars Stanley, Jojo, Topgigant plus and Tophit plus. The lowest yield was obtained from the cultivars Top, Topfive and Toptaste.

Determining the total soluble solids is the quickest way to get information about the content of the major chemical components. That is why, the higher total soluble solids is the biological value of the fruits. The total soluble solids in the 11 studied plum cultivars vary from 15.7% in Top cultivar to 24.75% in Toptaste (Table 3). Lower values of that characteristic were reported in the cultivars Toptaste and Topfive (Blazek and Pistekova, 2009), the difference to the values reported in the present study being 4.7% and 3.65%, respectively. In the study of the authors mentioned above, the total soluble solids in Topstar plus cultivar were 2.41% higher and in the cultivars Topgigant plus, Topfirst and Tophit plus data were comparable to the results obtained in the present study. Our data show that the lowest sugar content was established in the cultivars Top (7.96%) and Tophit plus (9.20%). The values for the other cultivars varied from 10.16% in Topgigant plus to 12.39% in Toptaste. In Poland Markuszewski and Kopytowski **(**2013) reported higher content of total sugar for cultivar Top. The acid content is low and only in Topgigant plus it is 1.37%. It was established that plum fruits are not very rich in ascorbic acid. The highest value was reported for the fruits of Stanley (11.92%). pH in the studied cultivars varies within a small range – from 3.09 in Topgigant plus to 3.67 in Top.

Table 3. Chemical composition of plum fruits (2011 – 2014)

Cultivar	Total soluble solids (°Brix)	Sugar, %			Titratable acidity, %	pH	Ascorbic acid, %
		Total	Invert	Sucrose			
Topfirst	15.75 ^{c*}	10.73 ^{b}	7.97 ^{ab}	2.62 ^{bc}	0.79 ^{c}	3.46 ^{a}	7.40 ^{b}
Topfive	23.35 ^{a}	12.16 ^{a}	7.77 ^{ab}	4.18 ^{a}	0.86 ^{bc}	3.34 ^{ab}	5.54 ^{c}
Topstar plus	15.79 ^{c}	10.71 ^{b}	5.88 ^{c}	4.83 ^{a}	0.89 ^{bc}	3.30 ^{ab}	5.62 ^{c}
Topgigant plus	16.6 ^{c}	10.16 ^{bc}	6.45 ^{bc}	3.52 ^{b}	1.37 ^{a}	3.09 ^{b}	5.29 ^{c}
Mirabelle de Nancy	21.2 ^{b}	11.99 ^{a}	7.23 ^{b}	4.52 ^{a}	0.76 ^{c}	3.32 ^{ab}	3.36 ^{d}
Bellamira	20.2 ^{bc}	11.29 ^{a}	6.20 ^{bc}	4.83 ^{a}	0.63 ^{c}	3.39 ^{ab}	4.97 ^{cd}
Toptaste	24.75 ^{a}	12.39 ^{a}	8.10 ^{a}	4.07 ^{a}	0.81 ^{bc}	3.58 ^{a}	3.88 ^{d}
Jojo	20.06 ^{bc}	12.04 ^{a}	8.94 ^{a}	2.94 ^{bc}	0.81 ^{bc}	3.46 ^{a}	6.79 ^{bc}
Stanley	19.7 ^{b}	11.95 ^{a}	6.85 ^{bc}	4.84 ^{a}	0.61 ^{c}	3.64 ^{a}	11.92 ^{a}
Top	15.7 ^{c}	7.96 ^{d}	5.52 ^{c}	2.25 ^{c}	0.81 ^{bc}	3.67 ^{a}	3.62 ^{d}
Tophit plus	17.96 ^{c}	9.20 ^{c}	6.61 ^{bc}	2.47 ^{bc}	0.93 ^{b}	3.38 ^{ab}	4.91 ^{cd}

*Different letters in the same row/column indicated significant difference ($p<0.05$)

Until now Plum pox virus (PPV) was not detected in Jojo cultivar by ELISA and PCR test, but *Prunus necrotic ringspot virus* (PNRSV) was found (Milusheva et al., 2015).

Conclusion

The investigations carried out on a set of traits referring to fruit, yield and resistance of the cultivars to late winter temperatures showed that the most suitable plum cultivars recommended to be grown in Plovdiv region, are Jojo, Topgigant plus and Tophit plus, as well as the cultivar Bellamira from the group of Mirabelle plum.

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AGRICULTURAL SCIENCE AND TECHNOLOGY

Volume 8, Number 2
June 2016

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