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EFECTUL FERTILIZĂRII CU GUNOI DE PASĂRE ASUPRA CREȘTERII ȘI FRUCTIFICĂRII LA PRUN (*PRUNUS DOMESTICA* L.)

EFFECT OF CHICKEN MANURE FERTILIZATION ON VEGETATIVE AND REPRODUCTIVE PARAMETERS OF PLUM (*PRUNUS DOMESTICA* L.)

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Abstract

The investigation was conducted during the period 2018-2021 in an experimental plantation of the Institute of Agriculture – Kyustendil, Bulgaria with plum (*Prunus domestica* L.) cv. 'Stanley'. The planting was created in 2013. Planting distances were 5x5 m. The following fertilization variants were investigated: V1 – unfertilized – (control), V2 – chicken manure 2.5 kg/tree, V3 – chicken manure 5.0 kg/tree. The correlation between the fertilizer rate and the trunk growth rate of the plum cv. 'Stanley' was positive from the second year of chicken manure Vita organic application. The application of chicken manure at a rate of 2.5 kg/tree increased the canopy volume, and in the third year it was statistically significant at P<0.05 by 56.56%. On average for the period of the experiment, the fertilizer rate of 2.5 kg/tree increased the yield by 79.16%, and the average fruit weight by 5.93%. A higher content of dry matter and acids was found in the fruits at both fertilizer rates.

Cuvinte cheie: prun, gunoi de pasăre, producție, greutate medie fruct.
Key words: plum, chicken manure, yield, average fruit weight.

1. Introduction

One of the main fruit species grown in Bulgaria is the plum (*Prunus domestica* L.). For the period 2014-2021, the culture occupies the third place in terms of area, after the walnut and the cherry, and after 2016 there is a tendency to increase the harvested areas only for the cherry and the plum (xxx, 2021). The most widespread in the country is the American cv. 'Stanley', with a relative share of 73.4% found in the study of the structure of fruit species in 2017 (xxx, 2017). The cultivar is the subject of research in areas such as selection, plant protection, agrotechnics, food industry (Kamenova and Borisova, 2002; Lichev et al., 2004; Brashlyanova et al., 2014; Ivanova et al., 2015; Bozhkova and Savov, 2016; Minev et al., 2017; Stoev et al., 2017; Hristova and Georgiev, 2019; Pashev and Badjelova, 2019; Sotirov and Dimitrova, 2019; Pashev et al., 2020; Borisova and Sotirov, 2021).

The type, concentration and form of fertilizer applied at the appropriate stages of crop development are important for yield (Todorova and Boteva, 2015; Todorova, 2020). The fertilizer rate is one of the conditions on which the quantity and quality of fruit production depends. Inadequate fertilization leads to physiological disorders and fruit pollution (Milošević and Milošević, 2020). Organic production limits the use of artificial fertilizers and chemical treatments in order to protect the environment (Borovinova and Petrova, 2014; Staneva and Gospodinova, 2018; Milošević and Milošević, 2020; Chatzistathis et al., 2021). Organic fertilization is one of the main elements of the technology for biological plum production (Hassan et al., 2010; Singh et al., 2012; Marinova et al., 2014; Hristova et al., 2017a; Hristova et al., 2017b; Hristova and Georgiev, 2019; Pashev and Badjelova 2019; Butac and Chivu, 2020; Pešaković et al., 2020; Pešaković et al., 2021). It was found that the application of chicken manure at a rate of 0.5 kg/tree does not had a significant effect on the vegetative parameters of the cv. 'Elena', while the average fruit weight exceeds the non-fertilized control statistically proven at P<0.05 (Hristova and Georgiev, 2019).

Appearance and especially color are important indicators of food products. Color is the first indicator by which consumers evaluate the product (Petrova et al., 2009). With the highest sensory evaluation (appearance, color, texture, taste and aroma) were the fruits of the cv. 'Stanley' obtained from the variant with poultry manure, compared to the control, conventional and organic cultivation. With high quantitative values of the color indicators, determined with a colorimeter, they were found from the variant with poultry manure and the control (Hristova et al., 2021), and for dried fruits of the cv. 'Tegera' - from the variant with poultry manure (Hristova et al., 2018). The colour saturation had significantly been affected by the cv. 'Elena' fruits with applied chicken manure Vita organic, while the fruits of the conventional and organic variants had values close to the control (Hristova et al., 2022).

The aim of the present experiment is to determine the influence of chicken manure on the vegetative, reproductive and quality parameters of the cv. 'Stanley' plum.

2. Material and methods

The investigation was conducted during the period 2018-2021 in an experimental plantation of the Institute of Agriculture – Kyustendil, Bulgaria with plum (*Prunus domestica* L.) cv. 'Stanley'. The planting was created in 2013. Planting distances were 5x5 m. The following fertilization variants were investigated:
V1 – unfertilized – (control)
V2 – chicken manure 2.5 kg/tree
V3 – chicken manure 5.0 kg/tree

Chemical composition of chicken manure Vita organic (Eco Re EOOD): humus – 19.38%, C – 11.13%, N 1.2%, P – 1.99%, K – 2.5%, Ca 10.85%, Mg – 0.75%, Zn 350 mg /kg, Cu – 50 mg/kg, Mn – 443 mg/kg, Fe – 3450 mg/kg.

The following parameters were investigated: De Marton drought index - I=12.P/T+10, where P - the monthly amount of precipitation, mm, T - the average monthly air temperature, °C; Trunk cross-sectional area – $S = \pi.r^2$, cm^2; Canopy volume – $V = d^2.h.\pi/12$, m^3; Yield, kg/tree; Average fruit weight, g; Fruit chemical composition - dry matter, Re - refractometric; total sugars, % - according to Schoorl; acids, % - titrimetric (Stanchev et al., 1968); Pearson correlation coefficient (r) - (Daniel and Kostic, 2015).

Statistical method - one-factor analysis of variance LSD.

3. Results and discussions

During the period of the experiment, the values of meteorological indicators average daily, minimum and maximum air temperature and precipitation were recorded. In 2019, the monthly average daily temperature reached a maximum in August – 22.7°C. The amount of precipitation for the period April-August was 253.3 mm. In the second year of the experiment, the highest monthly values of the average daily temperature were in July 21.4°C and in August – 21.5°C. On April 16, a minimum air temperature of (-3.0°C) was recorded. The amount of precipitation for the growing season was 349.5 mm, of which 110.4 mm was in July. In the last year of the experiment, the average daily temperature reached a maximum of 23.7°C in July, and the amount of precipitation was 343.5 mm, with approximately 30% of the amount recorded in August – 109.1 mm. In 2019, the monthly De Marton drought index showed drought in May and July-September, with the vegetation index around the critical limit of 20 (Table 1). In 2020, the driest month was June, and next year were May, July and September.

In 2018, before applying the fertilization variants, biometric measurements were taken of the experimental trees, which were the basis for the indicators trunk cross-sectional area and canopy volume (Table 2 and Table 3). The trunk growth rate in 2019 compared to 2018 was the lowest in the 2.5 kg/tree variant – by 25.13%, where the highest yield was recorded (Table 2). The trend was maintained in the following years, with the increased in 2021 being 80.63% compared to 2018. In this variant, a strong negative correlation was found between the trunk growth rate and the yield - r = -0.999*, in variant 5.0 kg/tree r = -0.995, and in the control - r = -0.841. At the end of the experiment, the rate was the highest in the variant with a rate of 5.0 kg/tree - by 127.37%, in the control - by 109.52% compared to the base year, and in these variants a similar yield was obtained, and the fertilizer rate had a positive effect on trunk growth. In the first year of fertilizer application, no relationship was found between the fertilizer rate and the parameter, and in subsequent years it was strongly positive - for 2020 - r = 0.842 and for 2021 - r = 0.762.

After the fertilization variants application, the canopy volume was greatest in V2, and in the third year the increased over the control was 56.56% and was statistically proved at $P<0.05$ (Table 3). In V3, a weaker increase was found – by 34.75%. On average for the period, the influence of both variants on the indicator wasn't statistically proven, as in the study of Hristova and Georgiev, (2019) with cv. 'Elena plum.

The relationship of canopy volume with trunk cross-sectional area was strongly positive – at V1 r = 0.998*, at V2 r = 0.918 and at V3 r = 0.937. Such a relationship was also found by Kumar et al., (2019) where r = 0.995 in cv. 'Santa Rosa' plum. The correlation between the growth parameter and the yield was also positive - in the control - r = 0.559 and expressed to a stronger degree in the fertilization variants - in V2 r = 0.773 and in V3 r = 0.792, as in an experiment by Kumar et al., (2019) - r = 0.996. The correlation coefficient between the canopy volume and the trunk growth rate, as well as between the canopy volume and the average fruit weight was negative for the three variants.

The results of an experiment showed the highest average yield of 22.54 t/ha in cv. 'Stanley' (lowest of 7.98 t/ha in 'Malvazinka') (Ivanova et al., 2002). In a study in the Kyustendil region, Bulgaria with the 'Stanley', 'Topper', 'Top 2000', 'Topking', 'Topfit', 'Tophit plus' and 'Toptaste' cultivars, the highest yield was found at 'Stanley' (Sotirov et al., 2021). In a comparative investigation of introduced plum cultivars in the Dryanovo region, Bulgaria, cv. 'Stanley' was found to be suitable for organic production with a yield of 60.5 kg/tree, after cv. 'Anna Späth' with 60.8 kg/tree and cv. 'Renclod Hramovih' with 63.2 kg/tree (Vitanova et al., 2014). In an experiment with 10 cultivars, 'Stanley', 'Čačanska lepotica' and 'Čačanska najbolja' were the most productive in the fifth year of planting (Milošević and Milošević, 2011). The

highest productivity coefficient (kg/cm^2) was found with 'Topper', followed by 'Empress' and 'Stanley' in a comparative investigation of 25 cultivars (Milatović et al., 2020), and in a study by Blažek et al., (2018) the highest specific yield (kg/m^3) was registered at cv. 'Stáňa', followed by 'Stanley' from 8 studied cultivars.

In a study on the cold resistance of 10 plum varieties, conducted in Bulgaria under controlled conditions (-15, -20 and -25°C), it was found that 'Stanley', 'Top 2000', 'Topend Plus', 'Tophit Plus' and 'Torper' showed high resistance to low winter temperatures. Regarding sensitivity to late spring frosts, 'Stanley', 'Topking', 'Tophit Plus' and 'Top 2000' showed a low percentage of damaged pistils (between 14.3 and 38.5%), while for cv. 'Topper' it reached 75.8% at temperature (-3°C) (Dimitrova et al., 2021). The sensitivity of varieties to late spring frosts depends on the values of the minimum temperatures, combined with other adverse climatic factors, on the phenophases, the habitat, the varietal characteristics. In the phenophase of full flowering in the cv. 'Stanley', 23% frosting of flowers was found at a temperature (-4.0°C) in the Dryanovo region (Bozhkova and Ivanova, 2001), 1% at (-2.4°C) in Plovdiv (Bozhkova and Zhivondov, 2004), in 'Elena' and 'Tegera' cultivars 38% and 48% respectively at (-4.0°C) in the Troyan region (Hristova et al., 2019).

In 2020, the late spring frost (-3.0°C) during the full flowering phenophase led to a yield reduction (Table 4). In all years of the study, both variants increased yield compared to the control. On average for the period, the increase in V2 was by 79.16%, and in V3 by 5.30%.

Results of a study of 23 plum cultivars in the Czech Republic showed the highest dry matter content in cv. 'Stanley' fruit, and the vitamin C content ranged from 7.36 mg/100g in cv. 'Kometa' to 83.27 mg/100g in cv. 'Stanley' (Wolf et al., 2020). The amount of total sugars varied from 64.80 g/100g in cv. 'Stanley' to 68.44 g/100g in cv. 'Čačanska Lepotica' in a study in Serbia (Mitrović et al., 2019). When examining the content of antioxidants in 4 plum cultivars, the amounts of anthocyanins was found to vary from 4.25 mg/100g fresh weight in cv. 'Nevena' to 30.57 mg/100g fresh weight in cv. 'Stanley' (Dimkova et al., 2017). The amounts of anthocyanins in the fruits of the cv. 'Elena' reached 34.52 mg% in the variant with chicken manure, while in the control they were 18.23 mg% (Hristova et al., 2017a).

Fertilization variants had an impact on the average fruit weight, with variant 2.5 kg/tree being greater by 5.93% than the standard, and variant 5.0 kg/tree by 4.52%. The fertilizer rate of 2.5 kg/tree had a better effect on the reproductive manifestations of seven-year-old trees compared to the rate of 5.0 kg/tree.

In the three variants, a negative correlation was found between the yield and the average fruit weight - in the control r = -0.999*, in V2 r = -0.998* and in V3 r = -0.999*. Similar results were obtained by Kumar et al., (2019) - r = -0.754 for cv. 'Santa Rosa', as well as by Butac and Chivu, (2020) - r = -0.463**.

The correlation between average fruit weight and dry matter content in the control was negative r = -0.876, as in the experiments of Tripon et al., (2016) - r = -0.706*** and Kumar et al., (2019) - r = -0.799. For the fertilization options, the relationship was positive - V2 r = 0.913 and for V3 r = 0.987.

The correlation between the average fruit weight and the acids content was negative - for V1, V2 and V3 as follows r = -0.995, r = -0.927 and r = -0.984. Other authors also found a negative relationship - r = -0.652 (Tripon et al., 2016) and r = -0.50 (Mesa et al., 2021), but in in the experiment of Kumar et al., (2019) r = 0.477.

On average over the study period, the 2.5 kg/tree variant increased the dry matter content of the fruit by 2.19%, and the 5.0 kg/tree variant by 2.73% above the standard (Table 5), as in the study of Butac and Chivu, (2020), and the correlation of the fertilizer rate with the parameter was strong positive - r = 0.944. A trend of decrease was established for sugars. The acid content of both variants exceeded the control by 1.54%, in contrast to an organic fertilization experiment in Romania with 'Centenar', 'Tita' and 'Stanley' cultivars (Butac and Chivu, 2020).

The correlation between dry matter and total sugars was strongly positive only in the fertilization variants - r = 0.956 in V2 and r = 0.872 in V3. The present study confirms the results of an experiment with the cv. 'Santa Rosa' plum, where r = 0.900 (Kumar et al., 2019).

A negative correlation was found between dry matter and acids - for V2 r = -0.693, and for the variant with the higher fertilizer rate r = -0.999*, analogous results were obtained by Kumar et al., (2019), while in the control it was not such a relationship was established.

In both fertilization variants, the correlation between total sugars and acids was negative – of a medium degree at V2 (r = -0.451), as in the study by Kumar et al., (2019) and of a strong degree at V3 (r = -0.865). In the conditions of the unfertilized control, no correlation was found between the two parameters.

4. Conclusions

The correlation between the fertilizer rate and the trunk growth rate of the plum cv. 'Stanley' was positive from the second year of Vita organic application.

The application of chicken manure at a rate of 2.5 kg/tree increased the canopy volume, and in the third year it was statistically significant at P<0.05 by 56.56%.

On average for the period of the experiment, the fertilizer rate of 2.5 kg/tree increased the yield by 79.16%, and the average weight of the fruit by 5.93%.

A higher content of dry matter and acids was found in the fruits at both fertilizer rates.

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Tables

Table. 1. De Marton drought index

Year	Month						Mean IV-IX
	IV	V	VI	VII	VIII	IX	
2019	44.4	12.8	29.8	11.7	16.5	8.3	20.6
2020	33.8	37.3	21.0	42.2	31.9	10.4	29.4
2021	50.4	22.1	35.2	8.1	39.4	12.8	28.0

Table. 2. Trunk cross sectional area (cm^2) and trunk growth rate (%) of plum cv. 'Stanley'

Variant	Year							
	2018	2019	2019/ 2018	2020	2020/ 2019	2021	2021/ 2020	2021/ 2018
	cm^2	cm^2	%	cm^2	%	cm^2	%	%
V1	43.89	62.98	143.50	83.38	132.39	91.96	110.29	209.52
V2	62.56	78.28	125.13	103.11	131.72	113.00	109.59	180.63
V3	37.2	51.69	138.95	74.67	144.46	84.58	113.27	227.37
LSD 0.05	26.53	29.99		41.32		39.20		
LSD 0.01	43.91	49.63		68.38		64.84		
LSD 0.001	82.19	92.90		127.9		121.4		
sd	9.55	10.79		14.87		14.10		
f	3.79	3.06		1.92		2.17		

Table. 3. Canopy volume of plum cv. 'Stanley', m^3

Variant	Year									
	2018		2019		2020		2021		2019-2021	
	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%
V1	1.90	100.00	3.48	100.00	4.77	100.00	5.64	100.00	4.63	100.00
V2	1.80	94.74	4.16	119.54	5.82	122.01	8.83*	156.56	6.27	135.42
V3	1.42	74.74	3.49	100.29	5.08	106.50	7.61	134.75	5.39	116.41
LSD 0.05	0.725		1.520		1.613		2.139		1.672	
LSD 0.01	1.200		2.516		2.670		3.540		2.767	
LSD 0.001	2.247		4.709		4.997		6.626		5.179	
sd	0.26		0.55		0.58		0.77		0.60	
f	1.86		1.02		1.71		8.75		3.71	

* - P<0.05.

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Table 4. Reproductive parameters of plum cv. 'Stanley'

Variant	Yield, kg/tree				Average fruit weight, g			
	2019	2020	2021	2019-2021	2019	2020	2021	2019-2021
V1	5.40	1.49	17.44	8.11	37.9	40.8	27.6	35.4
V2	12.00*	4.70	26.90	14.53	38.6	43.6	30.4	37.5
V3	6.20	2.10	17.30	8.54	39.0	43.0	28.9	37.0
LSD 0.05	5.425	5.018	20.35	9.355	7.229	8.65	6.49	5.99
LSD 0.01	8.977	8.453	33.68	15.48	11.96	14.31	10.74	9.911
LSD 0.001	16.80	15.82	63.05	28.97	22.39	26.79	20.10	18.55
sd	1.95	1.84	7.32	3.36	2.60	3.11	2.33	2.15
f	6.81	1.71	1.13	2.27	9.29	0.45	0.69	0.52

* - P<0.05.

Table 5. Fruit chemical composition of plum cv. 'Stanley'

Variant	Dry matter, Re				Total sugars, %				Acids, %			
	2019	2020	2021	2019-2021	2019	2020	2021	2019-2021	2019	2020	2021	2019-2021
V1	18.4	18.0	18.6	18.3	8.60	10.6	9.64	9.61	0.61	0.59	0.75	0.65
V2	18.6	18.9	18.5	18.7	8.40	10.0	8.50	8.97	0.62	0.62	0.73	0.66
V3	19.0	19.1	18.3	18.8	9.58	10.7	8.80	9.69	0.64	0.63	0.72	0.66