EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology 2023, 24(5), 141–147
https://doi.org/10.12912/27197050/165791
ISSN 2719–7050, License CC-BY 4.0

Received: 2023.03.27
Accepted: 2023.05.20
Published: 2023.06.01

The Effect of Fertilisation and Plant Care Practices on the Yield Structure of Black Currant

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ABSTRACT

The article is focused on the influence of fertilisation and plant care on the productivity of the black currant variety 'Siuita Kyivska'. Black currant was planted on the Rodnikovka Experimental Farm of the Uman State Agrarian University. Better conditions for the development of such signs as the number of clusters per shrub and the length of a cluster were provided under the application of mineral fertilisation as a background and foliar application of fertiliser Riverm 5%, maintaining of interrow space as clean fallow and mulching plants in the row with straw. The best characteristics of clusters were obtained with $N_{60}P_{90}K_{90}$ as background fertilisation. Foliar application of fertiliser Riverm 5% resulted in an increased (by 251.2–299.8) number of clusters per plant and longer (by 0.60–0.80 cm) clusters. A combination of clean fallow and application of Riverm 5% against the background of mineral fertilisation resulted in lower indicators of the fruit weight in a cluster compared to the control. This means that the yield structure of black currant under the effect of fertilisation and plant care changes towards an increase in the number of clusters, thereby reducing the number of fruits and the weight of fruits from one cluster. It was also found that foliar application of fertiliser Riverm 5% against the background of mineral fertilisation contributed to an increase in the yield of black currant. In the treatment with clean fallow between rows and mulching plants in rows, application of fertiliser Riverm 3% or 5% against the background of mineral fertilisation $N_{60}P_{90}K_{90}$, the yield of fruits was 13.1 t/ha.

Keywords: number of clusters, length of a cluster, number of fruits in a cluster, number of fruits in a shrub, weight of fruits in a cluster, yield.

INTRODUCTION

Black currant (*Ribes nigrum*) is an extremely useful berry crop. Its fruits are rich in antioxidants and useful for consumption in a fresh and processed form. In Ukraine, black currant is grown on an area of 4.9 k hectares. Black currant is valuable as a food and disease-preventive product (Markovskyi, 2012; Davis et al., 2012). Black currant fruits contain vitamins C, P, B1, B2, PP, E, carotene, sugar, tannins and pectin, organic acids, essential oils, pigments (Haviuk, 2011), vitamins E and B (0.7–0.9 mg), sugars – mainly glucose and fructose (6–11%), citric, malic and succinic acids (1.5–3.6%), pectin, tannins, nitrogenous and coloring substances (Djordjevic et al., 2014; Gallagher et al., 2015). By the content of vitamin E, black currant overcomes almost all fruit and berry crops, after buckthorn, rosehips and aronia. It also contains vitamins B, A and P. Fruits and leaves of black currant have antibacterial properties. The phytoncides contained in them disinfect the surrounding air, and the juice of fruits can retain bactericidal properties for a month (Gommers et al., 2013; Kahu et al., 2009).

Among the biological features of black currant plants, rapid growth should be mentioned since it takes only from 3 to 5 years to obtain a high-yielding plantation, sufficient cold resistance and early fruiting (Hummer and Dale, 2010; Gopalan et al., 2012). At the same time, to obtain a high level of plantation productivity, effective agronomic practices should be applied to care for black currant plants (Heide and Sønsteby, 2012).

In the conditions of Ukraine, it is possible to obtain stable yields of black currant from 9 to 12 t/ha. However, a reason for the low profitability of black currant plantations in Ukraine is the low yield (about 4 t/ha), which leads to the impossibility of effective and environmentally-friendly cultivation of plantations (Markovskyi, 2012; Kopytko et al., 2019). Therefore, the search for ways of improving cultivation technology that could provide a high level of yield and quality of berries is an important task (Hummer and Barney, 2002; Kim et al., 2011).

Among the factors influencing the quality of the produce, fertilisation and plant care can be listed. Due to the lack of mineral components in plant nutrition, it is difficult to obtain highly productive black currant plantations, and in the case of excessive weeds infestation in a row and between the rows is not possible, because crop plants cannot compete with weeds for nutrients, which reduce crop productivity and the plantation becomes unprofitable (Lovell and Johnston, 2009; Malézieux et al., 2009; Opstad et al., 2007; Valladares et al., 2016).

Therefore, the development of efficient methods of fertilisation and plant care is the ground for the formation of high productivity and long-term exploitation of black currant plantations.

MATERIALS AND METHODS

The research was carried out on the Rodnikovka Experimental Farm of the Uman National University of Horticulture (Rodnikovka, Uman district, Cherkasy region).

The black currant variety 'Suita Kyivska' was used in the experiment. It is an industrial medium-early variety known as well-establishing, unpretentious, stable and high-yielding. The berries of this variety are quite large and reach 3.2−3.5 g, with an average weight of 1.7−1.8 g, round-oval in shape, uniform, black, shiny, with elastic strong skin, dry tear, soft greenish-brown flesh, sour-sweet and fragrant. The variety is characterized by the almost simultaneous ripening of fruits. The shrub is of medium height, slightly sprawling, and has elastic shoots and short internodes. Variety is resistant to powdery mildew and rust but can be affected by anthracnose. It is a self-fertile drought-resistant variety that has high processability of the shrub and high, stable yield.

The soil of the plantation was heavy loamy podzol forest chernozem with a humus content of 3.25%. The reaction of the soil solution was slightly acidic with a pH of 5.5, hydrolytic acidity of 2.1 mmol/kg, and a degree of alkali saturation of 92%. The soil of the experimental plantation contained movable compounds of alkaline hydrolysable nitrogen (determined by the Kornfield method) in the amount of 100–110 mg/kg, phosphorus and potassium (determined by the Chirikov method) of 100 mg/kg and 120 mg/kg, respectively.

The experiment was arranged for the study of such plant care options as the maintenance of the soil between rows as clean fallow or grassing with a garden mixture of grass species; maintenance of the soil in rows as clean fallow, mulched with straw or covered with a mulch film; foliar application of fertiliser Riverm at a concentration of 1, 3 and 5%.

Liquid organic bio-fertiliser Riverm contains NPK in a ratio of 10:1:1.5%, trace elements of calcium, magnesium, iron, manganese, copper, zinc, nickel, lead, cadmium, cobalt, microorganisms and nitrogen-fixing bacteria. The fertiliser has a plant-neutral pH of 7−7.4 and is used in the stage of opening leaf buds.

The placement of black currant shrubs in the experiment was 3 m × 0.5 m, with three replications. Ammonium nitrate, granulated superphosphate and potassium chloride were used for fertilisation. To reduce the loss of active components of fertilisers, nitrogen fertilisers were introduced before the beginning of vegetation, while phosphate and potassium fertilisers were applied in the autumn in the near-shrub area.

The methods of establishing and carrying out the experiment, determining crop yield and its structure are described by Prysiazhniuk et al. (2021). To establish patterns and determine the reliability of deviations in the experimental data, a dispersion multivariate analysis was performed using the ANOVA package.

RESULTS

Conditions for the growth and development of black currant differed in the years of research. Therefore, the influence of experimental factors on the formation of the number per branch and the length of a cluster will be analysed separately in the context of the influence of weather conditions during the vegetation season (Table 1).

Weather conditions during vegetation season were the most favourable for black currant in 2019, when, on average, the number of clusters per shrub reached the maximum of 337.7. The least favourable weather conditions were in 2020 when a minimum of 267.5 clusters per shrub was formed.

Clean fallow between rows significantly increases the amount of nutrients available to plants due to the mineralization of the organic component of the soil. Compared with grassing, we obtained 85.1−124.5 more clusters per shrub and 0.4−0.6 cm longer clusters.

If we analyse the options for maintaining the soil in the rows of shrubs, then we can see that clean fallow had the worst effect on the crop productivity indicators, compared to mulching with straw and mulch film. Thus, in the treatment with mulch film, plants had 60.0−84.3 more clusters per shrub and 0.41−0.51 cm longer clusters compared to the treatment with clean fallow. In the treatment with mulching, even higher indicators

Table 1. The number of clusters per shrub and the length of a cluster of black currant

Soil maintenance between rows	Fertilisation	Soil maintenance in rows	The number of clusters per shrub			Length of a cluster (cm)		
			2019	2020	2021	2019	2020	2021
Clean fallow	Control, without fertilisers	Clean fallow	104	80	94	3.6	3.3	3.4
		Mulching with straw	196	144	194	3.7	3.8	4.0
		Mulch film	155	118	150	4.0	3.9	3.9
	$N_{60}P_{90}K_{90}$	Clean fallow	248	161	169	5.8	5.3	6.0
		Mulching with straw	236	213	231	5.7	5.3	5.8
		Mulch film	316	258	296	5.0	4.8	5.0
	$N_{60}P_{90}K_{90}$ + Riverm 1%	Clean fallow	326	309	328	5.6	4.9	4.9
		Mulching with straw	505	340	502	5.6	4.9	4.9
		Mulch film	514	391	469	6.8	6.1	7.0
	$N_{60}P_{90}K_{90}$ + Riverm 3%	Clean fallow	479	396	373	4.7	4.3	4.5
		Mulching with straw	621	442	546	6.4	5.8	6.0
		Mulch film	593	403	573	5.6	4.3	4.5
	$N_{60}P_{90}K_{90}$ + Riverm 5%	Clean fallow	458	349	427	5.4	5.4	5.4
		Mulching with straw	670	553	569	6.3	5.7	6.1
		Mulch film	578	494	521	6.1	5.8	6.1
Grassing	Control, without fertilisers	Clean fallow	69	74	92	3.8	3.5	3.7
		Mulching with straw	106	94	105	4.0	3.8	3.9
		Mulch film	91	84	103	4.0	4.0	4.1
	$N_{60}P_{90}K_{90}$	Clean fallow	103	85	92	4.4	4.4	4.6
		Mulching with straw	207	127	200	4.1	3.9	4.6
		Mulch film	130	99	110	4.6	4.4	4.4
	$N_{60}P_{90}K_{90}$ + Riverm 1%	Clean fallow	220	207	223	4.7	4.4	4.4
		Mulching with straw	405	305	396	5.0	4.9	5.1
		Mulch film	328	294	306	4.5	3.8	3.9
	$N_{60}P_{90}K_{90}$ + Riverm 3%	Clean fallow	322	244	288	5.0	4.8	4.9
		Mulching with straw	464	408	451	5.2	4.8	4.9
		Mulch film	353	300	365	6.0	5.9	6.5
	$N_{60}P_{90}K_{90}$ + Riverm 5%	Clean fallow	365	318	379	4.8	4.1	4.2
		Mulching with straw	496	354	466	5.9	6.1	6.3
		Mulch film	472	382	415	6.0	5.5	5.7
$LSD_{0.05}$			23	20	18	0.3	0.3	0.2

were obtained: 75.7–121.2 more clusters per shrub and 0.41–0.56 cm longer clusters.

Fertilisation had a positive effect on the formation of black currant productivity indicators and the effectiveness of the $N_{60}P_{90}K_{90}$ application as a background fertiliser is undoubted. However, with the foliar application of Riverm 5% we obtained 251.2–299.8 more clusters per shrub and 0.60–0.80 cm longer clusters. It can be stated that better conditions for the formation of such yield structure components as the number of clusters per shrub and the length of a cluster ensured treatments with mineral fertilisation and foliar application of fertiliser Riverm 5%, and maintenance of the soil between rows in the state of clean fallow and plant rows mulched with straw.

We also determined the number of fruits per cluster and per shrub (Table 2).

When analysing the number of fruits per cluster, we observed a reverse trend in comparison with the number of clusters per shrub: in 2019, we obtained 3.1 fruit per cluster and in 2020 4.1 fruits per cluster. At the same time, grassed soil between rows ensured 8–1.1 more fruits in a cluster. On the contrary, the number of fruits per shrub was 70.5–181.8 higher under the maintaining of the soil between rows in the state of clean fallow compared to grassing.

Table 2. The number of fruits per cluster and shrub of black currant

Soil maintenance between rows	Fertilisation	Soil maintenance in rows	The number of fruits per cluster			The number of fruits per shrub		
			2019	2020	2021	2019	2020	2021
Clean fallow	Control, without fertilisers	Clean fallow	5.4	6.3	6.0	595	548	600
		Mulching with straw	3.1	4.3	3.4	636	653	700
		Mulch film	4.2	5.2	4.4	676	649	693
	$N_{60}P_{90}K_{90}$	Clean fallow	2.8	4.6	4.5	729	780	804
		Mulching with straw	3.6	4.9	4.5	887	1096	1089
		Mulch film	2.6	4.0	3.5	870	1085	1081
	$N_{60}P_{90}K_{90}$ + Riverm 1%	Clean fallow	2.2	2.8	2.6	751	897	907
		Mulching with straw	2.1	3.5	2.4	1110	1248	1251
		Mulch film	1.5	2.9	2.4	814	1174	1164
	$N_{60}P_{90}K_{90}$ + Riverm 3%	Clean fallow	1.5	2.6	2.7	777	1064	1060
		Mulching with straw	1.8	3.0	2.4	1183	1369	1378
		Mulch film	2.0	3.3	2.2	1239	1372	1322
	$N_{60}P_{90}K_{90}$ + Riverm 5%	Clean fallow	1.5	2.9	2.3	754	1045	1043
		Mulching with straw	1.7	2.3	2.3	1201	1351	1355
		Mulch film	1.6	2.5	2.4	969	1310	1310
Grassing	Control, without fertilisers	Clean fallow	6.8	6.3	5.9	512	504	582
		Mulching with straw	5.1	6.1	5.9	579	611	664
		Mulch film	6.2	6.4	5.7	603	580	629
	$N_{60}P_{90}K_{90}$	Clean fallow	5.9	7.5	7.5	651	687	743
		Mulching with straw	3.4	5.8	3.9	739	775	809
		Mulch film	5.5	7.3	7.1	750	773	827
	$N_{60}P_{90}K_{90}$ + Riverm 1%	Clean fallow	2.9	3.2	3.2	679	694	742
		Mulching with straw	2.4	3.2	2.5	1030	1005	1032
		Mulch film	3.1	3.7	3.6	1069	1130	1157
	$N_{60}P_{90}K_{90}$ + Riverm 3%	Clean fallow	2.2	2.9	2.6	744	750	791
		Mulching with straw	2.1	2.8	2.5	1041	1177	1195
		Mulch film	3.4	3.9	3.2	1250	1204	1209
	$N_{60}P_{90}K_{90}$ + Riverm 5%	Clean fallow	1.9	2.3	2.0	715	771	810
		Mulching with straw	1.5	2.9	2.3	779	1083	1113
		Mulch film	2.0	2.9	2.8	993	1170	1197
$LSD_{0.05}$			0.2	0.3	0.2	29	35	42

Options for soil maintenance in the rows worked similarly. Clean fallow, compared to clean fallow, provided better conditions for the formation of the number of fruits per cluster, while mulch film had a better effect on the number of fruits per shrub. Even better results were obtained for mulching with straw – 232.6–270.7 more fruits per shrub.

Data on the weight of fruits from a cluster under the effect of experimental treatments are shown in Table 3.

The highest weight of one fruit was formed in 2020 when a smaller number of fruits per shrub was obtained. It was also found that grassing of the space between rows ensures a 0.4−1.0 higher number of fruits per cluster. Clean fallow and foliar application of fertiliser Riverm 5% against the background of mineral fertilisation resulted in a lower weight of fruits per cluster compared to the control treatments of the experiment. This means that the yield structure of black currant under the effect of fertilisation and plant care changes towards an increase in the number of clusters, thereby reducing the number of fruits and the weight of fruits from one cluster

Let us analyse the yield of black currant under the effect of fertilisation and plant care (Fig. 1).

The highest yield of berries (9.0 t/ha) was obtained in 2019, the lowest (7.2 t/ha) in 2020 and average (8.2 t/ha) in 2022. Clean fallow between

Table 3. Weight of fruits per cluster of black currant

Soil maintenance between rows	Fertilisation	Soil maintenance in rows	Weight of fruits in a cluster (g)		
			2019	2020	2021
Clean fallow	Control, without fertilisers	Clean fallow	5.6	6.3	6.5
		Mulching with straw	3.7	4.9	4.2
		Mulch film	4.9	5.7	5.2
	$N_{60}P_{90}K_{90}$	Clean fallow	3.3	5.4	5.7
		Mulching with straw	4.6	6.7	6.6
		Mulch film	3.4	5.4	5.1
	$N_{60}P_{90}K_{90}$ + Riverm 1%	Clean fallow	2.6	3.6	3.7
		Mulching with straw	2.9	5.3	3.8
		Mulch film	1.9	4.1	3.6
	$N_{60}P_{90}K_{90}$ + Riverm 3%	Clean fallow	2.0	3.7	4.2
		Mulching with straw	2.6	4.6	3.9
		Mulch film	2.9	4.8	3.5
	$N_{60}P_{90}K_{90}$ + Riverm 5%	Clean fallow	1.9	4.0	3.5
		Mulching with straw	2.5	3.6	3.7
		Mulch film	2.2	3.8	3.8
Grassing	Control, without fertilisers	Clean fallow	6.4	5.9	5.8
		Mulching with straw	5.5	6.2	6.5
		Mulch film	6.5	6.4	6.2
	$N_{60}P_{90}K_{90}$	Clean fallow	6.4	7.9	8.4
		Mulching with straw	3.8	6.7	4.8
		Mulch film	6.3	8.6	8.6
	$N_{60}P_{90}K_{90}$ + Riverm 1%	Clean fallow	3.3	3.5	3.7
		Mulching with straw	3.0	4.0	3.3
		Mulch film	4.1	4.8	5.0
	$N_{60}P_{90}K_{90}$ + Riverm 3%	Clean fallow	2.5	3.4	3.2
		Mulching with straw	3.0	3.8	3.7
		Mulch film	4.7	5.3	4.6
	$N_{60}P_{90}K_{90}$ + Riverm 5%	Clean fallow	2.2	2.7	2.5
		Mulching with straw	1.8	3.9	3.2
		Mulch film	2.5	4.1	4.0
$LSD_{0.05}$			0.4	0.3	0.4

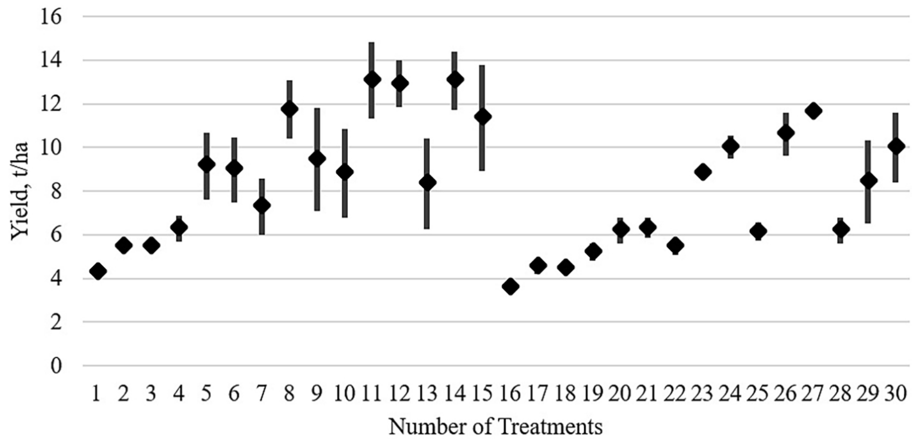

Fig. 1. Yield of black currant under the effect of fertilisation and plant care

rows contributed to obtaining a 1.2–2.5 t/ha higher yield compared to grassing. However, mulching rows with straw, similar to the application of mulch film, led to an increase in the fruit yield by 2.9–3.3 t/ha. That is, both mulching plants in rows with straw and mulch film are better options for plants than clean fallow.

It is quite natural that foliar application of fertiliser Riverm against the background of mineral fertilisation contributed to an increase in the fruit yield. Therefore, the treatment where clean fallow between rows, mulching plants in rows, mineral fertilisation $N_{60}P_{90}K_{90}$ and foliar application of fertiliser Riverm 3% or 5% were combined yielded in 13.1 tonnes of berries per hectare.

The patterns obtained by us are in agreement with the works of many scientists (Haviuk, 2011; Kucher, 2002; Markovskyi, 2012; Kopytko et al., 2019). They are a logical continuation of the study on the improvement of the cultivation technology of black currant in terms of adaptation to the conditions of the Forest Steppe of Ukraine.

CONCLUSIONS

It was found that better conditions for the formation of such yield structure components as the number of clusters per shrub and the length of a cluster are provided with mineral fertilisation and foliar application of fertiliser Riverm 5% along with maintenance of the soil between rows in the state of clean fallow and plant rows mulched with straw.

The best parameters of a cluster were obtained with the application of $N_{60}P_{90}K_{90}$ as background fertilisation. However, with the foliar application of Riverm 5%, on average in the experiment, we obtained 251.2–299.8 more clusters per shrub and 0.60–0.80 cm longer clusters.

Maintenance of the soil between rows in the state of clean fallow combined with foliar application of fertiliser Riverm 5% against the background of mineral fertilisation results in a lower weight of fruits per cluster, compared to the control. This means that the yield structure of black currant in the context of changes in nutrition and plant care is changing towards an increase in the number of clusters, thereby reducing the number of fruits and the weight of fruits per cluster.

Foliar application of fertiliser Riverm against the background of mineral fertilisation contributes to an increase in the yield of black currant. Clean fallow between rows, mulching plants in rows, mineral fertilisation $N_{60}P_{90}K_{90}$ and foliar application of fertiliser Riverm 3% or 5% yielded 13.1 tonnes of berries per hectare.

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