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FORMATION CHARACTERISTICS OF WATERMELON SEED PRODUCTIVITY UNDER INTERCROPPING.

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Characteristics of watermelon seed formation in intercropping were studied. Different growing methods of watermelon seeds depending on its interaction with intercrops (sweet maize and common bean) and their sowing schemes on area under melons were investigated. The developed elements for growing technology of the watermelon seed reduced the impact of high temperatures on this crop (the number of fruits with sunburn decreased by 7.1 % compared to control).

The results of phenological observations and analysis of yield components, seed productivity and quality of Favoryt watermelon variety in the intercropping with sweet maize and common bean were presented.

It was established that the developed technology elements of the growing watermelon in intercropping under high temperatures and low relative air humidity in the Northern Steppe of Ukraine increased of watermelon yield and the full-fledged seed formation.

It was found that intercropping of watermelon with sweet maize under proper cultivation gave positive results (watermelon seed yield gain by 12.4 % and 0.7 t/ha ears of sweet maize in milky-dough ripeness were additionally received), and with common bean (watermelon seed yield gain by 8.9 % and additional 75 kg/ha of beans). Methods and sowing schemes of watermelon and intercrops were established: sweet maize between rows of watermelon according to scheme 2.8 x 1 m, common bean between rows of watermelon according to scheme 1.4 x 0.5 m.

It was found that the full- fledged seed yield per one fruit of watermelon under intercropping with sweet maize increased up to 88.5 %, and with common bean – to 84.9 %.

Key words: *watermelon, sweet maize, common beans, intercropping, seed yield.*

Recently, significant climate change can be observed towards warming. Fluctuations and variability have always been characteristic of the climate. Considering the bioclimatic potential of the Northern Steppe zone of Ukraine, these phenomena occur in this region. Thus, the air temperature in June – August rises to 32–38 °C, and it reaches even higher levels on the soil surface. High temperatures during the flowering stage of watermelon (*Citrullus vulgaris* Schrad) are especially dangerous, because its pollen loses viability under such conditions; some flowers remain unfertilized, which leads to reduced fruit yield and failure to obtain full seeds. Significant damage to the fruits is caused by sunburn, seed yield is reduced by 50 % or more and its quality deteriorates. Therefore, it is especially important to establish the reasonability of intercropping watermelon with other field crops on the basis of their interaction. This will increase the yield and condition of melon seeds and reduce the negative effects of high temperatures.

One of the protection methods of the melon seeds during flowering and fruiting stages from the harmful effects of high temperatures and dry winds is the cultivation of maize in between rows of the main crop [1–2]. A general review of the literature indicates a limited

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number of publications on this issue.

Aim. To improve agricultural technological measures for growing watermelon seeds by intercropping with sweet maize (*Zea mays* L. Saccharate Sturt.) and common beans (*Phaseolus vulgaris* L.) for fuller use of the biological potential of melons in the Northern Steppe of Ukraine.

Materials and Methods. The research was conducted at the Dnipropetrovsk Research Station of the Institute of Vegetables and Melons Growing of NAAS in 2018–2020.

The soil of the experimental plots was ordinary leached low humus chernozem on loamy loess. Humus layer was uniform color on 0–45 cm depth, transitional layer – 45–80 cm, depth of carbonate effervescence from hydrochloric acid (HCl) – 63–75 cm.

The thickness of the arable layer was 30 cm. The arable layer was silt and lumpy with a humus content of about 3.2 % (according to Tiurin). Hydrolytic acidity was 0.84–1.40 mg-eq. /100 g of soil (according to Gedroits). The groundwater level was 8–9 m.

The sown area of watermelon was 80 m^2, area under sweet maize and common beans was 22.4 m^2, record plots – 63 and 14 m^2, respectively. Favorit early-ripening watermelon variety selected by the Dnipropetrovsk Research Station of the Institute of Vegetables and Melons Growing of NAAS, Delikatesna sweet maize variety selected by the Synelnykove Breeding and Research Station of the SE Institute of Grain Crops of NAAS of Ukraine, and Hotika common beans were grown. Replication is 4 times during the field trial.

Plant density was 10 thousand plants/ha for watermelon, for intercrops: sweet maize – 7.0 and 3.5 thousand plants/ha, common beans – 15.0 and 7.5 thousand plants/ha.

Researches were performed in accordance with the "Research methodology in vegetable and melon growing" [3], "Methods of field experience" [4]. Agricultural techniques for growing and harvesting watermelon seeds were in accordance to DSTU 5046:2008 [5]. Sowing qualities of seeds was determined in accordance to current standards [6–7].

Harvesting watermelon was one-time, when most fruits had signs of ripening.

Sweet maize ears were harvested at the end of milk and the beginning of the dough stage; common beans for grain – when 70–80 % of the fruits matured.

Weather conditions during the watermelon growing season varied from year to year, which made it possible to comprehensively assess the effectiveness of the studied measures.

In 2018, the first ten-day of May was arid, and heavy rains fell in the second one (150.8 mm), which accelerated the emergence of sprouts. The average air temperature ranged from 15.3–21.2 °C, the maximum was 29.6 °C, and the relative humidity was quite low – 27–30 %. On some days, the temperature on the soil surface reached 58.5–60.5 °C, which led to the rapid evaporation of moisture from the arable layer. In 2019–2020, dry and hot weather was observed in the second half of the watermelon growing season, which led to an increase in the number of fruits with sunburn. The growth and development of watermelon plants took place without infectious load.

In the years of research, phenological observations of plant growth and development showed that watermelon sprouts in all variants of the field trial emerged simultaneously regardless of the intercrop and sowing scheme. The first sprouts of melon emerged in the second ten-days of May (20 days after sowing), mass sprouts – in the third ten-days of May (31 days after sowing seeds). The beginning of flowering male flowers in the control and under intercropping of watermelon with sweet maize (scheme of 2.8 x 1 m) and common beans (scheme of 1.4 x 0.5 m and 2.8 x 0.5 m) was observed June 24 (36 days after sprout emergence), mass flowering – July 5 (47 days after sprout emergence). The beginning of the flowering female flowers was June 28, the flowering female flowers was delayed by 3–4 days (40 days after sprout emergence), mass flowering – July 8 (50 days after sprout emergence). The flowering melon plants were delayed for 2–3 days compared to control when growing intercrops in rows of watermelon (distance between them 1.4 m). The time interval between the appearance of male and female flowers was 4–5 days, which indicated that there was almost no difference in the term of flowering, i.e. the negative impact of intercrops on flowering and pollination of watermelon plants was not found. The tendency to delay the subsequent stages of growth and development of watermelon plants compared to the control

took place before the fruit ripening.

The sprouts of intercrops (sweet maize and common beans) emerged in the second tendays of May. The calculation of the plant density of watermelon before harvesting fruits indicated that the inhibition of watermelon plants (8.9–9.3 thousand plants/ha) was not observed in intercropping, the thinning of crops during the growing season was within normal limits – 3.5–4.2 %. The plant density of intercrops according to the schemes was: sweet maize and common beans 6.5–3.2 and 12.9–7.2 thousand plants/ha, respectively.

The analysis of biometric indicators showed that the length of the main stem during fruit formation in the case of intercropping watermelon with maize (scheme of 1.4 x 1 m per row) decreased by 4.3 % compared to control, this indicator was within control (159–163 cm) in other variants of the field trial.

In the intercropping of watermelon with beans (scheme of 1.4 x 0.5 and 2.8 x 0.5 m in rows) there was also inhibition of the growth of the main stem by 5.5 and 4.7 %, respectively. This was due to the shape of the bean bush. The growth inhibition of the main stem of watermelon was not observed when the intercrop was grown between rows (Table 1).

1. The biometric parameters of watermelon on intercropping (average for 2018–2020)

Variant	Length of main stem, cm	Quantity of fruits with sunburn, %	Intercrop	
			Height of plants, cm	Quantity of ears, pods per plant
Without intercrop (control)	162–165	20,5	–	–
Watermelon + sweet maize 1.4 x 1.0 m in row	156–159	9.8	113	1.2
Watermelon + sweet maize 2.8 x 1.0 m in row	157–161	9.1	116	1.3
Watermelon + sweet maize 1.4 x 1.0 m between rows	158–162	8.4	121	1.4
Watermelon + sweet maize 2.8 x 1.0 m between rows	160–164	6.8	126	1.5
Watermelon + common beans 1.4 x 0.5 m in row	154–157	15.7	31	4.2
Watermelon + common beans 2.8 x 0.5 m in row	156–160	14.8	33	4.5
Watermelon + common beans 1.4 x 0.5 m between rows	159–162	13.5	35	5.2
Watermelon + common beans 2.8 x 0.5 m between rows	167–160	14.3	38	5.5
LSD_{05}, %		3.9		

Analysis of biometric indicators of intercrop showed a certain inhibition of growth processes when placing them in rows of watermelon: the height of sweet maize was 113–116 cm, common beans – 31–33 cm, and between rows – 121–126 and 35–38 cm, respectively. The individual productivity of intercrops was 1.2–1.3 and 1.4–1.5 ears per plant and 4.8–5.5 pods per plant, respectively. Despite the decrease in biometric indicators of watermelon plants, full-fledged fruits formed and were less damaged by sunlight due to their shading by intercrops; as a result, fruits without sunburns were more by 10.7–20.5 % in the case of intercropping with maize and 13.5–15.7 % – with beans than in single-species sowing of melons. The least sunburned fruits of watermelon (6.8 %) were in the growing maize between rows of melons (2.8 x 1.0 m). The highest yield of full-fledged seeds from one fruit (21.7 g) was also noted here, and the yield increase to control was 14.2 % (Table 2).

The highest yield of watermelon seeds was obtained when growing sweet maize between rows of melons – 190 kg/ha (increase in watermelon seed yield compared to the control was 12.4 %). At the same time, an additional yield of sweet maize ears was obtained (end of milk - the beginning of dough ripeness of grain) at the level of 0.7 t/ha.

2. The watermelon seed productivity on intercropping (average for 2018–2020)

Variant	Average weight seed fruit, kg	Seed yield per 1 fruit	
		g	%
Without intercrop (control)	2.32	19.0	0.82
Watermelon + sweet maize 1.4 x 1.0 m in row	2.45	20.5	0.84
Watermelon + sweet maize 2.8 x 1.0 m in row	2.47	20.9	0.85
Watermelon + sweet maize 1.4 x 1.0 m between rows	2.50	21.3	0.88
Watermelon + sweet maize 2.8 x 1.0 m between rows	2.53	21.7	0.86
Watermelon + common beans 1.4 x 0.5 m in row	2.41	20.2	0.84
Watermelon + common beans 2.8 x 0.5 m in row	2.44	20.5	0.84
Watermelon + common beans 1.4 x 0.5 m between rows	2.47	20.9	0.85
Watermelon + common beans 2.8 x 0.5 m between rows	2.45	20.6	0.84

The highest yield of melon seeds (184 kg/ha) with an additional yield of beans (75 kg/ha) was obtained when growing beans between rows of watermelon according to the scheme 1.4 x 0.5 m (Table 3). Bean plants were not high enough for shading watermelons.

The calculation of the economic efficiency of growing watermelon seeds under intercropping showed that its indicators depended on the yield of melons and the impact of intercrops.

3. The seed yield of watermelon, sweet maize and common beans on intercropping (average for 2018–2020)

Intercrop (A factor)	Scheme of intercrops (B factor)	Yield			Increase in watermelon seed yield	
		watermelon		intercrops: maize, t/ha, beans, kg/ha		
		fruits, t/ha	seeds, kg/ha		kg	%
Without intercrops (control)		20.6	169	–	–	–
Sweet maize	1.4 x 1.0 m in row of watermelon	21.3	179	0.9	10	5.9
	2.8 x 1.0 m in row of watermelon	21.7	184	0.5	15	8.8
	1.4 x 1.0 m between rows of watermelon	22.0	187	1.1	18	10.6
	2.8 x 1.0 m between rows of watermelon	22.2	190	0.7	21	12.4
Common beans	1.4 x 0.5 m in row of watermelon	21.0	176	63	7	4.1
	2.8 x 0.5 m in row of watermelon	21.4	180	34	11	6.5
	1.4 x 0.5 m between rows of watermelon	21.7	184	75	15	8.9
	2.8 x 0.5 m between rows of watermelon	21.5	181	41	12	7.1
LSD_{05}, kg/ha for: A factor		0.9	4.8			
B factor		0.4	3.5			
Interaction of AB		3.6	7.4			

The highest total profit of 70.4 thousand UAH/ha and profitability of production of 250 % was obtained when intercropping watermelon with sweet maize (scheme of 2.8 x 1 m between rows), exceeding control indicators was 15.1 thousand UAH/ha and 35,

3 % respectively (Fig. 1).

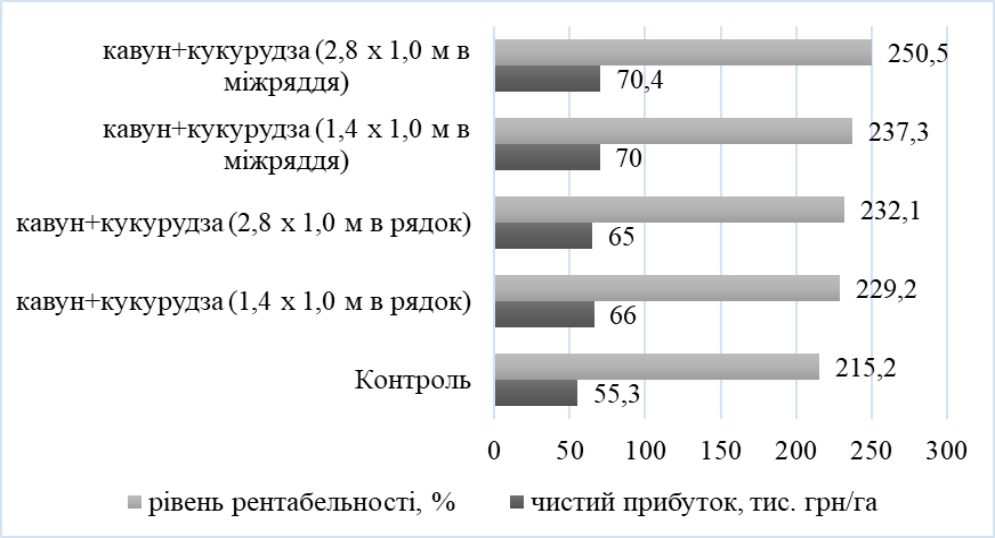

Fig. 1. Economic efficiency of growing watermelon seeds with sweet maize on intercropping (average for 2018–2020).

The highest total profit of 65.6 thousand UAH/ha and the level of profitability of 227 % was obtained when growing beans between rows of watermelon according to the scheme 1.4 x 0.5 m; in this case, the indicators were higher than in the control by 10.3 thousand UAH/ha and 12.6 %, respectively (Fig. 2).

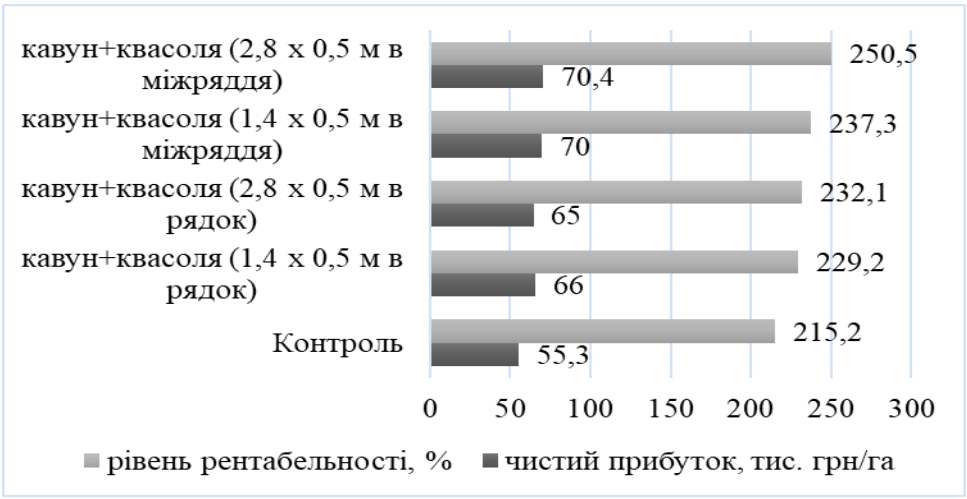

Fig. 2. Economic efficiency of growing watermelon seeds with common beans on intercropping(average for 2018–2020).

Conclusions. Based on the research, it was found that:

1. The yield of full-fledged watermelon seeds increases by 12.4 % at intercropping with sweet maize.

2. The increase in the yield of full-fledged melon seeds was 9.5–14.5 % at intercropping of watermelon with common beans.

3. The best results were obtained when growing watermelon with sweet maize (between rows) under the scheme of 2.8 x 1 m; due to this net profit increased by 27 % or more, and the level of profitability – by 16.4 %.

4. At growing watermelon with beans under scheme of 1,4 x 0,5 m when intercrop is placed between rows of a melons, the net profit increased by 18,6 %, and the level of profitability of production – by 5,8 %.

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