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MODERN TRENDS IN AGRICULTURE SCIENCE: PROBLEMS AND SOLUTIONS

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The monograph is a collection of the results of actual achievements of domestic agricultural scientists, obtained directly in real conditions. The authors are recognized experts in their fields, as well as young scientists and postgraduate students of Ukraine. Research is conceptually grouped at 7 sections: Plants protection and quarantine; vegetable growing in open and closed ground; horticulture, fruit growing, viticulture; breeding and seed production; agrochemistry and soil science; agriculture and modern agricultural technologies; management and strategies for future development. The monograph will be interesting for experts in plant breeding, economics, plant protection, selection, agrochemistry, soil science, scientific workers, teachers, graduate students and students of agricultural specialties of higher education institutions, and for all those who are interested in increasing the quantity and quality of agricultural products.

Keywords: agriculture, modern technologies, plants protection, quarantine, vegetable growing, horticulture, fruit growing, viticulture, breeding and seed production, agrochemistry, soil, management, strategies, development.

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CULTIVATION OF GRAFTED WATERMELON ON DIFFERENT ROOTSTOCKS IN THE CONDITIONS OF THE LEFT-BANK FOREST-STEPPE OF UKRAINE

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The study investigated the effect of commercial rootstock hybrids Pelops F1 (Lagenaria siceraria) and Cobalt F1 (C.maxima x C.moschata) on diploid watermelon Yukon F1 and triploid watermelon Kidman F1 in the open field, with ungrafted watermelons as controls. The influence of rootstocks on the growth vigour and yield of grafted watermelon plants was studied. The rootstock Cobalt F1 showed the best results both in comparison with the control and in comparison, with the rootstock Pelops F1.

Key words: *watermelon, grafted plants, rootstocks, yield.*

Watermelon (*Citrullus lanatus*) is one of the most widely grown and consumed vegetable crops worldwide, with a total area of over 3 million hectares and production of over 100 million tonnes (FAO, 2021). The use of grafting for watermelons is a common practice in many countries around the world, including Japan, China, Korea, Spain, Italy and Israel (Sakata et al., 2007). Watermelons are typically grafted onto rootstocks of Cucurbita maxima x Cucurbita moschata, Cucurbita moschata and Lagenaria siceraria hybrids. Rootstocks influence plant vigour, yield, fruit quality and resistance to abiotic factors (Turhan et al., 2012), and thus may cause variation in yield and fruit quality associated with scion-rootstock combinations (Alan et al., 2007).

The study was conducted in 2019-2021 in the Kharkiv region on the fields of Krasnohrad Vegetable Factory LLC. The object of the research was plants of commercial watermelon hybrids: diploid Yukon F1 and triploid Kidman F1 grafted onto different rootstocks. Commercial rootstock hybrids were studied as rootstocks: Pelops F1 (*Lagenaria siceraria*) and Cobalt F1 *(C.maxima x C.moschata).* Ungrafted watermelons were used as controls: Yukon F1 and Kidman F1. The research is aimed at studying the influence of different rootstocks on the development and yield of Yukon F1 and Kidman F1 watermelon plants.

The grafted seedlings were grown by removing one cotyledon (Japanese method), at an angle of 45 ^{0}. The first step was sowing watermelons in cassettes with a mesh size of 25 x 25 x 55 mm, using peat as a substrate. Seed germination took place in a germination chamber, where the substrate temperature was maintained at 24-26 ^{0}C, relative humidity 90-95 %, and after receiving about 20 % of the "loops", the cassettes were taken to a greenhouse for permanent cultivation with a temperature regime of 20-22 ^{0}C during the day and 18 ^{0}C at night. After the first sprouts of watermelon were obtained, rootstocks were sown in cassettes 25x25x55 mm, the substrate was peat. The microclimate regime in the germination chamber was maintained at 24-26 ^{0}C, relative humidity 90-95 %, after the first shoots were obtained, the cassettes were transferred to the greenhouse where the temperature was maintained at 20-22 ^{0}C during the day and 18 ^{0}C at night, where they were grown until grafting. When the phase of the first true leaf with a diameter of about 20 mm in watermelon and expanded cotyledons with a clearly visible growth point in pumpkin was reached, inoculation was carried out. In pumpkin plants, one cotyledon and the growth point were removed at an angle of 45 ^{0}, and the watermelon was cut at a distance of 1-1,5 cm below the cotyledons, at the same angle. Using a PS 1 silicone clip (Royal Brinkman), the plants were connected at the cut points and transplanted into a peat cassette with a cell size of 50x50x60 mm.

An important condition for high-quality growth is the same stem diameter of the rootstock and scion. Immediately after grafting, the plants were transferred to the growing chamber where the microclimate was maintained at the following levels: air temperature 24-26 ^{0}C, relative humidity > 95 %. After the first 3 days, the air humidity was gradually reduced to 85 % over the next 5 days. After rootstock and scion splicing, the plants were moved to a conventional greenhouse with a temperature of 20-22 ^{0}C during the day and 17-18 ^{0}C at night. A week before the seedlings were planted in the field, they were hardened. The age of the planted seedlings was 30-35 days, and the plant had 3-4 true leaves.

The area of the accounting plot was 84 m^2, the experiment was repeated three times. Seedlings of Yukon F1 watermelon grafted on rootstocks and ungrafted were planted at a density of 4 thousand/ha. Seedlings of triploid watermelon Kidman F1 were planted with a pollinator - a diploid hybrid of watermelon of Suga Baby - Baroness F1 variety in a ratio of 4 to 1, where 4 plants of triploid and 1 plant of diploid watermelon. The total number of plants is 5 thousand per hectare. Seedlings of grafted and ungrafted watermelons were planted in one strip on a mulching film, with a distance of 2,1 metres between rows, and 1,19 metres for Yukon F1 watermelon and 0,95 metres for Kidman F1 watermelon with the pollinator Baroness F1. Plants were watered using a drip irrigation tape with fertilisation with complex and simple water-soluble mineral fertilisers depending on the stages of plant development. Experiments were carried out to determine the effect of grafting on the onset of plant development, biometric parameters and yield of diploid and triploid watermelons. Fruit harvesting was carried out twice with a difference of 7-10 days between the first and second harvest. Accounting was carried out in three replications with the average yield for each year of the trial. The data was statistically processed.

According to the results of three years of research, it was determined that both rootstocks influenced the passage of interphase phases of plant development of diploid watermelon Yukon F1 and triploid watermelon Kidman F1 (Table 1).

Over the years of research, it has been established that the best rootstock in terms of early maturity for the diploid watermelon Yukon F1 and triploid watermelon Kidman F1 was the bottle gourd hybrid Pelops F1. Thus, the duration of the period from planting seedlings to the ripening of the first fruit in watermelon Yukon F1 was on average 3 days shorter than in the control and amounted to 70 days. In watermelon Kidman F1 on rootstock Pelops F1, the time from planting to harvesting the first fruit was 65 days, which is 5 days less than in ungrafted watermelon. Analysing the data on phenological observations, we can conclude that the plants grafted onto the rootstock of the Pelops F1 hybrid went through all the phases of growth and development 3-5 days earlier than the control in both the diploid Yukon F1 and triploid Kidman F1 watermelons. On plants grafted on the rootstock Cobalt F1, there was no significant difference in the timing of all phenological stages of development compared to the control in both diploid watermelon Yukon F1 and triploid Kidman F1.

In terms of biometric parameters, a significant difference between grafted and ungrafted watermelon plants was observed over the years of research, regardless of the combination of rootstock and scion, the average data are summarised in the table. Measurements were carried out a week before the first harvest (Table 2).

Table 1

Duration of the phenophases of growth and development of diploid watermelon Yukon F1 and triploid watermelon Kidman F1 grafted onto different rootstocks, on average for 2019-2021, days

Options	Duration of interphase periods, days			
	Planting-flowering of male flowers	Planting - flowering of female flowers	Flowering of female flowers - ripening of fruits	Planting - fruit ripening
Yukon F1 (control)	20	25	39	73
Yukon F1 + Pelops F1	17	22	36	70
Yukon F1 + Cobalt F1	20	25	38	72
Kidman F1 (control)	19	22	35	70
Kidman F1 + Pelops F1	16	19	31	65
Kidman F1 + Cobalt F1	18	21	33	69

Analysing the biometric parameters of diploid and triploid watermelons, there was a significant difference in plant weight over the years of research. The highest plant weight was observed on the rootstock Cobalt F1, both in diploid and triploid watermelons. Thus, in watermelon Yukon F1 it was 3303 g, and in watermelon Kidman F1 – 2473 g, which is 160,3 % and 144,8 % more than in control plants and ungrafted plants. The weight of the plants grafted on Pelops F1 rootstock also differed, so in watermelon Yukon F1 - 2738 g, and in watermelon Kidman F1 - 2235 g, which is 115,8 % and 121,3 % more than in ungrafted plants. Our findings are in line with researchers who reported that grafted plants produced more fresh plant weight (Oda et al., 1993). The greatest length of the main stem during the years of research was observed on the rootstock Cobalt F1, which was 358 cm on diploid watermelon Yukon F1 and 335 cm on triploid watermelon Kidman F1, which is 28,3 % and 70,9 % more than on control plants, respectively. On the Pelops F1 rootstock, a longer main stem was also observed in both Yukon F1 watermelon by 24,7 % and Kidman F1 watermelon by 60,7 % more than in the control plants.

Table 2

Biometric parameters of plants of diploid watermelon Yukon F1 and triploid watermelon Kidman F1 grafted onto different rootstocks, in the phase of fruit ripening, on average for 2019-2021.

Options	Plant weight, g	Length of the main stem, cm	Number of shoots of the first and second order, pieces	Number of leaves, pcs.	Leaf surface area, m^2/plant.
Yukon F1 (control)	1269	279	12	228	1,95
Yukon F1 + Pelops F1	2738	348	25	375	3,16
Yukon F1 + Cobalt F1	3303	358	29	396	3,40
Kidman F1 (control)	1010	196	10	181	1,31
Kidman F1 + Pelops F1	2235	315	22	270	2,07
Kidman F1 + Cobalt F1	2473	335	26	365	2,76

Our findings are in line with other studies, as researchers have reported that grafted watermelon plants had a longer main stem length than ungrafted plants (Salam et al., 2002; Mohamed et al., 2012; Shahidul et al., 2013). There was also a difference in the number of first and second order shoots in both diploid and triploid watermelons. The largest number of shoots was observed on the rootstock Cobalt F1. Thus, in watermelon Yukon F1 there were 29 pieces, and in watermelon Kidman F1 - 26 pieces, which is 17 and 16 pieces more than in ungrafted plants. On Pelops F1 rootstock, there was also a significant difference in the number of lateral shoots, both in Yukon F1 watermelon - 25 pieces and Kidman F1 - 22 pieces, which is 13 and 12 pieces more than in the control, respectively. Our findings are in line with the results of researchers who reported that grafted watermelon plants produced more shoots than ungrafted ones (Alan et al., 2007). The largest number of leaves over the years of research was observed on the rootstock Cobalt F1, both in diploid and triploid watermelons. Thus, on average, Yukon F1 watermelon had 396 leaves, and Kidman F1 watermelon had 365 leaves, which is 168 and 184 leaves more than on control plants. In watermelons grafted onto Pelops F1 rootstock, a higher number of leaves was also observed in two watermelons. The average number of leaves on Yukon F1 watermelon during the years of research was 375 pieces, and on Kidman F1 watermelon - 270 pieces, which is 147 and 184 pieces more than in ungrafted plants. The largest leaf surface area was observed on the grafted plants of diploid and triploid watermelons on the rootstock Cobalt F1. Thus, on average, over the years of research on watermelon Yukon F1 it was 3,40 m^2, and on watermelon Kidman F1 – 2,76 m^2, which is 74,4 % and 110,7 % more than on control plants. On the rootstock of the Pelops F1 hybrid, a difference in leaf area was also observed, on watermelon Yukon F1 – 3,16 m^2, and on watermelon Kidman F1 – 2,07 m^2, which is 62,1 % and 58,1 % more than on ungrafted plants. The results of our studies are similar to those of other studies in which researchers found that grafting increases the vigour of watermelon plants (Davis et al., 2008; Petropoulos et al., 2012; Huang et al., 2013). The study showed that both rootstocks significantly affect the growth vigour of diploid watermelon Yukon F1 and triploid watermelon Kidman F1, which leads to higher yields. Yield data for the years of testing are shown below (Table 3-4).

Table 3. Yields of grafted and ungrafted diploid watermelon Yukon F1, on average for 2019-2021.

Options		Yield, t/ha	Regarding control	
Method of cultivation (factor A)	Number of fruit harvests (factor B)		t/ha ±	% ±
Yukon F1 (control)	1 harvest	39,4	-	-
	2 harvest	22,8	-	-
	In total of two harvests	62,2	-	-
Yukon F1 + Pelops F1	1 harvest	46,5	7,1	18,0
	2 harvest	28,2	5,4	23,7
	In total of two harvests	74,7	12,5	20,0
Yukon F1 + Cobalt F1	1 harvest	49,5	10,1	25,6
	2 harvest	29,5	6,7	29,4
	In total of two harvests	79,0	16,8	27,0
LSD_{05} for factor A LSD_{05} for factor B		3,5 2,8		

LSD_{05} for factor AB	4,9	

Over the years of research, the highest yield of diploid watermelon Yukon F1 was obtained on grafted plants on the rootstock Cobalt F1, which averaged 79,0 t/ha over three years, which exceeded ungrafted plants by 27,0 %. On the Pelops F1 rootstock, a 20,0 % higher yield was observed than on the control.

Table 4

Yields of grafted and ungrafted triploid watermelon Kidman F1, on average for 2019-2021

Options		Yield, t/ha	Regarding control	
Method of cultivation (factor A)	Number of fruit harvests (factor B)		t/ha ±	% ±
Kidman F_1 (контроль)	1 harvest	25,7	-	-
	2 harvest	12,7	-	-
	In total of two harvests	38,4	-	-
Kidman F_1+ Pelops F_1	1 harvest	32,9	7,2	28,0
	2 harvest	20,6	7,9	62,2
	In total of two harvests	53,5	15,1	39,3
Kidman F_1 + Cobalt F_1	1 harvest	37,4	11,7	45,6
	2 harvest	25,1	12,4	97,6
	In total of two harvests	62,5	24,1	62,8
LSD_{05} for factor A LSD_{05} for factor B LSD_{05} for factor AB		3,2 2,6 4,5		

Over the three years of research, the highest yield of triploid watermelon Kidman F1 was obtained on the rootstock Cobalt F1, which was 62,5 t/ha, which exceeded the control by 24,1 t/ha. The Pelops F1 rootstock also showed a 15,1 t/ha higher yield than the uninoculated plants.

Conclusions

1. The best rootstock for early maturity for diploid watermelon Yukon F1 and triploid watermelon Kidman F1 was the rootstock of bottle pumpkin Pelops F1. In Yukon F1 watermelon, the duration of the period from

planting seedlings to fruit ripening was 3 days shorter than in uninoculated plants, and in Kidman F1 watermelon by 5 days, respectively. In the combinations of grafting on interspecific hybrid pumpkin Cobalt F1 with watermelons Yukon F1 and Kidman F1, there was no significant difference in the timing of fruit ripening compared to the control.

2. The grafted watermelon plants, regardless of the combination of rootstock and scion, formed a larger plant weight, the length of the main stem, the number of shoots, leaves, and leaf surface area. The largest plant weight of 3304 g was observed in watermelon Yukon F1 grafted onto rootstock Cobalt F1, which is 160,3 % more than in rootstock plants. The largest length of the main stem - 358 cm was observed in the combination of rootstock Cobalt F1 and watermelon Yukon F1, which is 28,3 % more than in the control plants, a greater number of lateral shoots - 29 pieces, which is 17 pieces more than in the control, as well as a greater number of leaves - 396 pieces, which is 168 leaves more than in the control, and the largest leaf surface area – 3,40 m^2, which is 74,4 % more than the area on ungrafted plants of watermelon Yukon F1.

3. Over the years of research, the highest yield was provided by grafting on the rootstock Cobalt F1, both in diploid watermelon Yukon F1, which was 79,0 t/ha, and triploid watermelon Kidman F1 – 62,5 t/ha, which exceeds the control by 16,9 t/ha and 24,1 t/ha, respectively. On the Pelops F1 rootstock, higher yields were also observed for both Yukon F1 watermelon – 74,7 t/ha and Kidman F1 watermelon – 53,5 t/ha, which is 12,5 t/ha and 15,1 t/ha higher than the yield on control plants.

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