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Harmfulness of Weed Plants in Crops of Vegetables and Melons

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Weeds pose the greatest danger to vegetables and melons in the second half of May, when their number reaches a maximum. The purpose of the research is to assess the degree of harmfulness of weed plants in crops of vegetables and melons in irrigated plots in the Lower Volga region. The studies were conducted in accordance with the "Guidelines for the study of economic thresholds and critical periods of harmfulness of weeds in agricultural crops". Assessment of harmfulness of weed plants was performed by the method of the model plots, where was created a weed infestation of soil of varying degrees by one type of weed by removing excess plants as they appear within the whole period of vegetation. As the result of the research were studied the dynamics of germination, intraspecific and interspecific competitive abilities. Were identified critical periods of weed infestation for non-seedlings of cucumber and tomato – 20 days after germination, seedlings of watermelon and tomato – 50 days from germination of watermelon or transplanting. Were determined the economic thresholds of harmfulness in the planting of tomato: barnyard grass – 4±2; amaranth upturned – 3±1; nightshade black – 5±2,5 PCs./m². In watermelon crops: barnyard grass – 3,5 pieces/m²; amaranth upturned - 3.8 pieces/m²; black nightshade – 4,2 PCs./m².

Key words. Weed, pest damage, infestation, critical period, tomato, non-seedlings, seedlings, cucumber, watermelon, yield.

Weeds possess high competitive ability and represent the greatest risk to vegetable and melon crops. Different types of weeds differ significantly from each other by the damage to agricultural crops[1, 2, 3]. This is primarily due to the biology of the weed (the time of germination, the habitus of the plant, the duration of its growing season, seed production, competitive ability, etc.). The vegetables and melons are more sensitive to the weed infestation than the grains or even technical. So, at the same level of infestation of crops, loss of wheat is 25%, of potatoes - 25%, of soybeans - 36%, of beetroot – 71%, of sugar beet -77%, of garlic – 88%, of onions and carrots – 100%[4].

Using the moisture and depleting the soil, the weeds choke crops, weakening their damage resistance. Some types of weeds create favorable conditions for development of pests and diseases of agricultural crops. Thus, the infestation of wheat grass promotes the growth of wireworms. Flowering weeds are a food source for webworm, grain scoops, scoops-scales[5].

Many weeds have high fertility. Under favorable conditions, the weed forms from 100,000 to 150,000 seeds, while cultivated plants are 1000-15000. The abundant fruiting have the so-called junk weeds, such as plantain gives up to 390 thousand seeds, sisymbrium – 730 thousand, pigweed seeded – 3 million. Seeds have a long germination period. This gives them a great

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advantage in the sense that under adverse conditions (cold + drought, etc.) are dying only the part of the plants, the rest will grow and produce offspring. Many weed seeds can remain viable for many years, for example thlaspi field up to 9 years, melilot – up to 70 years. In order to effectively combat weeds, you must know the extent and nature of the debris field[6].

Weeds cause significant damage to agriculture. They usually have a higher competitive ability, even in comparison with such cultures of continuous sowing as crops. For example, wild radish consumes from the soil in two times more nitrogen and phosphorus than oats; pigweed white (with the number of 158 PCs/m^2) in 30 days after sowing of oats has a raw weight equal to 33.6 t/ha, and consumes 104 kg of nitrogen, 78 kg of phosphorus, 124 kg of potassium[7]. According to the data of Siberian Institute of agriculture, with the number of nettle 38 pieces/m2 the yield of wheat decreased by 2.6%, with 70 pieces/m^2 - by 8%, with 102 PCs/m^2 – by 12%; and 27 plants of a sow-thistle field reduced the yield by 18.5%, 58 pieces/m^2 – by 44.6% [8].

Many works are devoted to the development of research techniques and data processing[9-12, 3]. On the basis of generalisation of data on the weed infestation of crops in various regions of the former USSR were compiled guidelines for the assessment of harmfulness of weed plants in grain crops[13-15]; Economic thresholds of harmfulness of weeds in crops of major crops[16, 17]. Were estimated the approximate economic threshold of certain types of weeds in grain crops and in some technical cultures[1, 18].

Generally, is considering the total weed infestation of the fields of annual or perennial weeds and almost never is evaluating the harmfulness of each weed species of agrophytocenosis association. And their competitive ability is wide-ranging, as well as of the cultural plants.

So, studying the harmfulness of barnyard grass in tomato crops Bhowmik P C., Reddy K. N. found that when the number of weed is 16 pieces on 1 m of row, the yield of tomato was reduced by 25%, while the number is 64 pieces on 1m – by 84%. At the same time it was noted a decrease in dry weight of plants and a marketable fruit quality[19].

Depending on the level of weed infestation of species of the nightshade non-seedlings tomatoes have lost more crops than seedlings. Tomatoes sown at high plant density of twin rows provided a higher yield than the low plant density in single rows. With increasing of plant density of the weed, its weight and number of seeds decreased per 1 plant, but increased per area unit regardless of the technology of tomato cultivation[20].

According to the West Siberian vegetable-potato breeding research station, the number of weeds of 17-21 PCs/m^2 is critical for the tomato. At this level of infestation the applying of herbicides is not economically feasible [8]. These results are consistent with data obtained by Dagestan research Institute of agriculture, which also showed that the critical threshold of harmfulness of weeds for non-seedlings tomato is 20 pieces/m^2 (mass of 864 g/m^2), for the seedling – 50 PCs./m^2 (weight -1729 g/m^2)[18].

As can be seen from the presented data, the detailed studies of the dependence of yield of vegetable and especially of melons from the level of weed infestation with different types of weeds are very rare or none at all, for example among the melons.

On the irrigated lands of the Lower Volga were identified 115 species of annual and perennial and 51 species of weeds belonging to 34 families.

Among the widest spread number of species the most representative families are: Compositae (24 species), Gramineae (20 species), Chenopodiaceae (20 species), Cruciferae (14 species), Leguminosae (12 species), Polygonaceae (9 species), Boraginaceae (8 species), Orabanchaceae (8 species).

Among them the most common and harmful for vegetable and melon crops are: barnyard grass, black nightshade, amaranth upturned, mountain bluet and the field bindweed. The main part of the crops at 90-95% has a weed infestation with annual weeds. The quantity of its seeds in the soil layer of 0.00-0.15 m is about 2 billion pieces/ha[6, 9].

In this regard, we carried out field studies to assess the degree of harmfulness of weed plants, the study of critical periods of harmfulness of weeds and assessment of harmfulness of weed plants in crops of vegetables, melons and gourds.

METHODS

To assess the degree of harmfulness of weed plants, was studied the dynamics of germination, intraspecific and interspecific competitive ability. The assessment was carried out as follows: part of the plots in the field on the 30-th of March was closed with black tape, the other part – with the transparent film, and the third part of the plots was left open. Plots were located under the film during 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 days. After the appropriate time the film was removed, were determined the species composition and a number of weeds and then they were pulled up. Then every 10 days was conducted an accounting of the number of newly emerged weeds by species, but they were not removed from the experimental plots until the end of observations. On the plots without films weeds were removed after the first consideration, as in the previous plots with the films, and then was conducted the accounting of germinated weeds.

Were studied the critical periods of harmfulness of weeds in seedling and non-seedlings tomato, in crops of cucumber and melon on the natural background of weed infestation in the irrigated plots of the Lower Volga region. The studies were conducted in accordance with the "Guidelines for the study of economic thresholds and critical periods of harmfulness of weeds in agricultural crops". In the experiment there were two controls: the first – with weed infestation throughout the growing season, the second – clean. In the experimental cases, the weed infestation was determined at the end of the growing season on the record plots (11,2 m^2).

Assessment of harmfulness of weed plants was performed by the method of the model sites, where was created a weed infestation with varying degrees by one type of weed by removing excess plants, as they appear in the course of the whole period of vegetation. Gradation in the number of weeds is: 0; 5; 10; 20; 40; 80; 160; 320 pieces/m^2 of the protective zone of the row (1 m^2 of the protective area of the row corresponds to 4 running meters of row or 5.6 m^2 area of the crop). The repetition of experiments – three replications.

Area of the record plot is 5.6 m^2 (1,4x4.0m). An agricultural cultivation of crops is common. The experimental crops were covered immediately after the emergence of seedlings or transplanting, before the start of the critical period of weed infestation. The density of cultivated plants in all variants was the same: seedlings tomato – 48 thousand/ha, non-seedlings tomato – 72-78 thousand/ha, the watermelon – 9 thousand/ha.

The weight of weeds was determined at the end of the vegetation period (the first half of September). A collection of tomatoes (seedlings) was conducted for 3-4 times, non-seedlings tomatoes and watermelon – only once. At the end of the vegetation period were removed all the fruits to determine the biological yield of the crop and also was measured the aboveground mass of tomato.

RESULTS AND DISCUSSION

Observations have shown that in open plots weeds appeared in mid-April: the first were the germinations of frost blite, barnyard grass, amaranth upturned and much later – the black nightshade. Seedlings of many species of annual weeds appeared in the period from 10th May to 10th June. The peak of seedlings number was noted at the end of May. Further, the number of germinating weeds declined sharply, which appears to be associated with intraspecific and interspecific competition of plants as well as with a decrease in supply of seeds in the upper soil layer. So, at the end of May the number was 570 PCs/m^2, at the end of June – 80 PCs/m^2, in mid-July – 30 PCs./m^2.

Consequently, weeds pose the greatest danger to vegetables, melons and gourds planted at the open ground, in the second half of May, when their number reaches a maximum. When planting tomato seedlings in late April, it manages not only to naturalize well, but it begins to grow rapidly. Then by the end of May tomatoes already have a significant vegetative mass and in the moment of peak germination of weeds are quite effectively compete with them. In non-seedlings crops in the early stages a plant development is slowed down, therefore, competitiveness is much lower and therefore the crops suffer more from the weed.

In plots covered with transparent or black plastic film the seedlings of weed plants appeared on 10-15 days earlier than in the open plots. The exposition under the film in April for 10 and 20

days at the time of germination and a number of seedlings of annual weeds in subsequent periods did not provide a significant impact. If the black film was removed in May, June or July, the plots were clean of weeds, or there were some single absolutely etiolated threadlike sprouts.

Table 1. The duration effect of competition of weeds in crops on the yield of vegetable and melon crops

Culture	Yield, t/ha		The loss of productivity, gross and standard, %													
	gross	standart	10 days		20 days		30 days		40 days		50 days		60 days		70 days	
Tomato seedlings	50,3	45,5	14	15	17	18	27	28	38	39	51	52	–	–	–	–
Tomato non-seedlings	48,8	41,4	0	0	8	11	19	29	45	53	64	70	80	83	77	77
Cucumber	11,9	9,1	0	0	22	32	52	57	83	86	90	91	–	-	–	–
Watermelon	32,5	30,5	6	9	23	30	41	45	63	68	76	78	–	–	–	–

$HCP_{,05}$ in terms of total and standard yield:
Tomato seedlings 10 and 12% Tomato non-seedlings 22 and 27%
Cucumber 33 and 32% Watermelon 16 and16%

Table 2. The effect of plant density of barnyard grass in a critical period of development on yield of tomato seedling

Option (the number of weeds, PCs./m^2)	Weight, kg/m2 of weed	of culture	The yield of tomato gross		of a standard fruit	
			t/ha	%	t/ha	%
Control (without weed)	0	6,9	53,1	100,0	43,8	82,5
5	0,8	6,6	51,1	96,2	42,8	83,7
10	1,6	6,2	48,9	92,1	41,5	84,9
20	2,3	5,8	45,1	84,9	37,6	83,4
40	3,6	5,8	40,2	75,7	33,6	83,6
80	4,1	5,6	39,2	73,8	32,6	83,2
160	5,4	5,0	34,2	64,4	28,3	82,7
320	6,7	4,7	32,5	61,2	27,4	84,3
Natural background of weed infestation	9,1	2,9	25,3	47,6	20,8	82,2
$HCP_{0,05}$	1,8	0,7	6,7	–	5,5	–

Table 3. The level of fouling, a species composition and yield of tomato seedling

Species of a weed plant	Quantity, PCs./m^2	The level of clogging	Harmfulness	Reduction in yield, % of control
Barnyard grass	5-10	low	average (moderate)	4-8
Amaranth upturned	5			10
Nightshade black	5			4
Barnyard grass	20	average	strong	15
Amaranth upturned	10-40			15-19
Nightshade black	10-40			9-16
Barnyard grass	40-80	high	very strong	24-26
Amaranth upturned	80			31
Nightshade black	80			28
Barnyard grass	160-320	very high	super strong	36-39
Amaranth upturned	160-320			51-57
Nightshade black	160-320			57

Under the transparent film the weeds were severely deformed, and their number was in many times less than in the open plots. Moreover, in the control the weeds were strongly developed. If the film was removed in May, then in June was observed an increase in the number of sprouting weeds. However, their numbers were much lower than in May.

Thus, to prevent large yield losses because of the oppression of the culture of annual

Table 4. The effect of plant density on barnyard grass on yields of non-seedlings tomato in the critical period of weed culture

Option (the number of weeds, PCs./m^2)	Weight, kg/m2		The yield of tomato			
	of weed	of culture	gross		of a standard fruit	
			t/ha	%	t/ha	%
Control (without weeds)	0	5,7	47,6	100,0	33,8	71,0
5	1,4	5,6	48,8	102,5	31,6	64,7
10	3,3	3,6	36,8	77,3	25,9	70,4
20	4,1	3,5	36,4	76,5	21,0	57,7
40	8,4	2,4	30,9	64,9	15,0	48,5
80	10,0	2,1	22,2	46,6	12,8	57,7
160	10,5	0,9	19,0	39,9	11,2	58,9
320	15,7	0,5	18,3	38,4	11,3	61,7
$HCP_{0,05}$	3,6	1,2	8,6	-	6,0	-

Table 5. The effect of plant density of amaranth upturned on the productivity of non-seedlings tomato in the critical period of weed culture

Option (the number of weeds, PCs./m^2)	Weight, kg/m2		The yield of tomato			
	of weed	of culture	gross		of a standard fruit	
			t/ha	%	t/ha	%
Control (without weeds)	0	7,0	54,0	100,0	24,8	64,4
5	4,7	4,4	42,8	79,3	26,7	62,4
10	5,5	2,1	36,0	66,7	21,8	60,5
20	8,5	1,9	25,7	47,6	15,7	61,1
40	12,3	2,0	23,5	43,5	15,0	63,8
80	15,0	1,7	16,6	30,7	10,6	63,9
160	12,6	1,6	17,9	33,1	10,1	56,4
$HCP_{0,05}$	3,3	0,9	6,0	-	3,7	-

Table 6. The influence of plant density of S. nigrum on the yield of non-seedlings tomato in the critical period of weed culture

Option (the number of weeds, PCs./m^2)	Weight, kg/m2		The yield of tomato			
	of weed	of culture	gross		of a standard fruit	
			t/ha	%	t/ha	%
Control (without weeds)	0,1	5,8	44,2	100,0	26,4	59,7
5	4,4	2,9	35,1	79,4	23,3	66,4
10	6,0	3,0	32,5	73,5	18,0	55,4
20	9,6	2,9	26,1	59,0	16,7	64,0
40	15,6	2,4	18,5	41,9	10,1	54,6
80	19,4	2,2	10,1	22,9	5,0	49,5
$HCP_{0,05}$	3,1	1,1	5,6	-	2,7	-

Table 7. The level of fouling, species composition and yield of non-seedlings tomato

Species of a weed plant	Quantity, PCs./m^2	The level of clogging	Harmfulness	Reduction in yield, % of control
Barnyard grass	5-10	low	average (moderate)	21-26
Amaranth upturned	10-20			23-24
Nightshade black	5			21
Barnyard grass	20	average	strong	41
Amaranth upturned	40			35
Nightshade black	10			33
Barnyard grass	40	high	very strong	58
Amaranth upturned	80			53
Nightshade black	20-40			52-56
Barnyard grass	80	very high	super strong	77
Amaranth upturned	160-320			60-62
Nightshade black	80-160			69-67

Table 8. Figures based on yields of seedling of tomato from the debris of planting with different types of weed

Species of a weed plant	The correlation coefficient between yield and		The determination coefficient between yield and		The coefficient of harmfulness of weed	
	a number of weed	a mass of weed	a number of weed	a mass of weed	t/ha per 1 weed/m^2	t/ha per 1 kg/m^2 of weed
gross yield						
Barnyard grass	-0,86	-0,99	0,74	0,98	-0,059	-3,32
Amaranth upturned	-0,83	-0,96	0,68	0,92	-0,073	-2,90
Nightshade black	-0,77	-0,96	0,59	0,92	-0,054	-2,60
the yield of standard fruits						
Barnyard grass	-(0,61±0,35)	-(0,59±0,36)	0,38±0,12	0,35±0,13	-(0,049±0,027)	-(2,04±1,23)
Amaranth upturned	-(0,82±0,25)	-(0,72±0,31)	0,68±0,06	0,52±0,10	-(0,065±0,02)	-(1,98±0,85)
Nightshade black	-(0,63±0,34)	-(0,72±0,31)	3,39±0,11	0,52±0,10	-(0,042±0,023)	-(1,82±0,77)

Table 9. The dependence of the yield of non-seedlings tomato from the species composition and abundance of weeds

Species of a weed plant	The correlation coefficient between yield and		The determination coefficient between yield and		The coefficient of harmfulness of weed	
	a number of weed	a mass of weed	a number of weed	a mass of weed	t/ha per 1 weed/m^2	t/ha per 1 kg/m^2 of weed
gross yield						
Barnyard grass	-0,83	-0,95	0,68	0,90	-0,09	-2,11
Amaranth upturned	-0,70	-0,98	0,49	0,96	-0,17	-2,58
Nightshade black	-0,93	-0,99	0,86	0,98	-0,38	-1,68
the yield of standard fruits						
Barnyard grass	-(0,49±0,39)	-(0,88±0,21)	0,24±0,15	0,77±0,04	-(0,058±0,046)	-(1,51±0,36)
Amaranth upturned	-(0,63±0,39)	-(0,88±0,24)	0,39±0,15	0,77±0,06	-(0,134±0,82)	-(1,37±0,37)
Nightshade black	-(0,77±0,34)	-(0,89±0,24)	0,59±0,11	0,80±0,06	-(0,252±0,112)	-(1,098±0,295)

weeds the seedling tomatoes should be planted in late April– early May, with a later planting it is necessary that at the end of May – beginning of June the field was clean of weeds. On non-seedlings cultures it is important to destroy the weeds as much earlier as possible, that the field would be clean during the period from the 10th of May. When preparing the soil for late crops (cabbage, potato, cucumber, tomato, carrot) it is advisable in April – early May the soil surface to be closed with the transparent or black plastic film. This will let not to conduct one preseeding cultivation.

For successful protection of plants from weeds is of a great importance the determination of critical period of weed infestation of crops, in which a culture is particularly sensitive to weeds. The weed infestation of the site in this time will result in the greatest crop losses[8, 21].

Vegetable crops are the most sensitive to the weed infestation of crops in the first 4 weeks after emergence of sprouts. According to Friesen G., a productivity of tomato seedlings did not differ significantly from the potential, if the crops were kept clean from the weeds during the first 12-36 days after transplanting[22].

At the same time, the yield of non-seedlings tomato was significantly lower compared to the pure control, if the weeds remained in the

Table 10. The effect of plant density of barnyard grass in a critical period of development of culture on the yield of watermelon

Option (density of the weedPCs/m^2)	Mass of weed, kg/m^2	The yield of tomato			
		gross		of a standard fruit	
		t/ha	%	t/ha	%
Control (without weed)	0	40,6	100,0	38,3	94,3
5	2,6	29,2	71,9	26,0	89,0
10	4,1	26,6	65,5	23,4	88,0
20	6,2	27,5	67,7	19,9	72,4
40	8,5	19,8	48,8	12,1	61,1
80	9,4	14,9	36,7	8,6	57,7
160	11,6	9,6	23,6	1,6	16,7
320	12,3	7,1	17,5	0,9	12,7
Control (natural background contamination)	14,0	10,0	24,6	0,1	1,0
$HCP_{0,05}$	2,3	6,7	–	9,3	–

Table 11. The effect of plant density of amaranth upturned at a critical period of the development of culture on the yield of watermelon

Option (density of the weedPCs/m^2)	Mass of weed, kg/m^2	The yield of tomato			
		gross		of a standard fruit	
		t/ha	%	t/ha	%
Control (without weed)	0	39,2	100,0	37,1	94,6
5	8,2	26,5	67,6	23,3	87,9
10	9,7	22,7	57,9	20,6	90,7
20	9,7	18,3	46,7	13,9	76,6
40	12,5	13,5	34,4	9,2	68,1
80	12,8	11,9	30,3	5,9	49,6
160	9,6	5,0	12,7	0,1	2,0
320	11,5	5,5	14,0	0,1	1,8
Control (natural background contamination)	14,1	10,0	25,5	0,1	1,0
$HCP_{0,05}$	4,5	8,5	-	8,0	-

field for more than 5 weeks after sowing.

For non-seedlings culture of tomato it is very important that after the emergence of sprouts within 20 - 70 days, the crop was free from weeds, and for seedling – within 20-50 days after planting it in the field. These periods are the most critical for growing tomato.

The results of studies of critical periods of harmfulness of weeds have shown that the efficiency of weeding depended on time (table 1). If they were held on the 10-th day, the yield of tomato (non-seedlings), cucumber and watermelon were practically on the level of pure control and the seedling of tomato is below 15%. If weeds have remained longer, then the crop losses in all cultures

Table 12. The influence of plant density of *S. nigrum* at a critical period of development of culture on the yield of watermelon

Option (density of the weedPCs/m^2)	Mass of weed, kg/m^2	The yield of tomato			
		gross		of a standard fruit	
		t/ha	%	t/ha	%
Control (without weed)	0	42,5	100,0	38,8	91,3
5	7,4	24,2	56,9	20,9	86,4
10	10,5	20,8	48,9	17,1	82,2
20	13,5	15,5	36,5	10,4	67,1
40	11,6	9,6	22,6	2,8	29,2
80	14,6	9,2	21,6	3,3	35,9
160	19,7	8,0	18,8	0,1	1,2
320	19,9	8,3	19,5	0,1	1,2
Control (natural background contamination)	14,1	10,0	23,5	0,1	1,2
$HCP_{0,05}$	5,2	8,5	-	6,6	-

Table 13. The decline in the yield of watermelon, depending on the level of weed infestation of crops (quantity, PCs./m^2)

Species of a weed plant	Reduction in yield, % of control		
	25-50average	51-75high	76-100very high
Barnyard grass	5-20	40-80	160-320
Amaranth upturned	5-10	20-80	160-320
Nightshade black	5	10-20	40-320

Table 14. The dependence of the yield of watermelon from the species composition and abundance of weeds

Species of a weed plant	The correlation coefficient (r) between		The coefficient of determination (d_{yx}) between		The coefficient of harmfulness of weeds - loss of productivity			
					gross		standard	
	a number of weeds and yield	the weight of the weed, and harvest ness	a number of weeds and yield	the weight of the weed, and harvest ness	t/ha per 1 pieces/m^2	t/ha per 1 kg/m^2	t/ha per 1 pieces/m^2 of weeds	t/ha per 1 kg/m^2 of weeds
Barnyard grass	-(0,67±0,33)	-(0,88±0,21)	0,45±0,11	0,77±0,44	-0,083	-2,50	-(0,092± 0,045)	-(2,92± 0,694)
Amaranth upturned	-(0666±0,33)	-(0,47±0,39)	0,44±0,11	0,23±0,15	-0,076	-2,35	-(0,085±0.043)	-(1,22±1,0)
Nightshade black	-(0,59±0,35)	-(0,80±0,26)	0,35±0,12	0,64±0,07	-0,061	-1,68	-(0,076±0,045)	-(1,59± 0,524)

have increased directly proportional to the duration of weed infestation of crops. A cucumber is especially sensitive for the weed infestation. The presence of weeds for 40 days reduced the harvest of cucumbers on 86%. According to the sensitivity of the culture for the weed infestation we can place them in the following descending order: cucumber > melon > tomato non-seedlings > tomato seedling. Hence, to avoid crop losses, weeds should be destroyed in the first 10 days after emergence of seedlings, with a maximum in the first 20 days. Tardy of weeding has a negative impact on crop yields. And the later it is, the lower is the yield.

The great value has not only the time of the first weeding, but the frequency of weeding as a one-time removal of weeds creates favourable conditions for the development of culture in a relatively short period of time, then the weeds appear again on the plot, especially after watering. In this context, crop yields will not only depend on the time of the weeding, but also from their multiplicity.

The results showed that a single weeding, even in the optimum time, reduced the yield of tomato seedling by 54%, non-seedlings by 23%, cucumber – by 17% and watermelon by 68%, compared to the control. The two weeding (10-th and 20-th days) almost negated the yield losses of non-seedlings of cucumber and tomato, but they were not enough to obtain maximum yields of watermelon and tomato seedlings. Only 5-fold weeding the fields allowed to eliminate a competition from weeds and to receive the same fees of watermelon and tomato, as in the net control.

Thus, if for non-seedlings of cucumber and tomato the first 20 days are critical, then the watermelon and tomato seedlings are need to preserve the purity of the plot until almost till the end of the growing season of crops. This means that for the last two crops, the critical period lasts up to 50 days after transplanting of tomato or emergence of watermelon germination.

Our results about the critical periods of weed infestation does not fully coincide with the data of Pankova, V. I.[18] and S. E. Weaver[21]. It is possible that this is due to differences in soil and climatic conditions and with a species composition of weeds. Besides Pankova V.I. gives too large interval, for example, for non-seedlings tomato - 20-70 days. To use these results in the production, the interval of the critical impact of weeds on crop yields should be much narrower.

Varying of the critical period of weed infestation in different vegetable and melon crops is primarily associated with the biological characteristics of plants. Cultivated plants are especially sensitive to weed competition prior to the phase of fruit formation. So, in cucumber female flowers usually appear in 30-35 days after germination, in watermelon – after 45 - 50 days, in tomato - after 40-45 days. After flowering, plants usually become more resistant to the weed infestation.

We conducted a field study where in crops of tomato and watermelon was evaluated the harmfulness of the three most common types of weeds: barnyard grass, amaranth upturned, and black nightshade.

Tomato. The results of field studies showed that barnyard grass with the number of 5 and 10 PCs./m^2 (ratio of cultural and weed plants, respectively 6:1 and 3:1) had no significant effect on growth, cultural development and yield formation (Table 2). The total harvest was in control of 53.1 t/ha and in trial versions – 51,1 and 48,9 t/ha, i.e. a decrease in the yield was within the error of the experiment. Similar data were obtained for the collection of standard fruit.

The increase in weed infestation up to 20, 40 and 80 pieces/m^2 caused a significant decrease in aboveground mass culture and yield of fruit, respectively, on 15, 24 and 26%. The fall in gross yields, of course, was accompanied by a decrease in the yield of standard products. When the number of weed is 160 and 320 pieces/m^2 the aboveground mass at the end of the growing season exceeded the biomass of the culture, respectively, by 8 and 30%. The yield of tomato fell on 36% and 39%, with the decreased harvest of standard fruit. However, it should be noted that at all levels of weediness of crops of tomato, a ratio between gross collection of fruits and the standard was practically the same and accounted for 82-84%.

Amaranth upturned did not reduce the yield of tomato seedling only when the number was 5 PCs./m^2. Increase in its number to 10, 20 and 40 pieces/m^2 had a distinct impact on the development of culture that was reflected in the decrease of its biomass from 5.6 kg/m^2 to 4.6 kg/m^2,

and in reduced yields, respectively, on 15; 19; and 19%.

A further increase in its numbers up to 80 pieces/m^2 was accompanied by a sharp increase in the mass of weed that had prevailed on the biomass of tomato (6.5 and 4.1 kg/m2). The oppression of culture affected the harvest, which decreased by 31%. In the amount of 160 and 320 pieces/m^2 amaranth upturned so strongly suppressed the development of a culture that the elevated mass of tomato was in 3 times less than the weight of the weed. The yield of tomato in these cases was practically the same (of 21.8 and 19.4 t/ha), as well as the collection of standard fruit (15.6 and 14.2 t/ha). In comparison with the control a collection of tomatoes fell in more than 2 times. As in the previous experience, in the presence of the reduction of crop capacity the ratio between the gross yield of tomato and a mass of standard fruits remained virtually unchanged. And the output of standard products was almost equal in the range of 79 - 82%, with the exception of two variants, where the ratio was lower - 71.6 and 78% (respectively when the number of weed was 160 and 320 pieces/m^2).

Tomato seedlings quite successfully competed with nightshade black. This is because after transplanting, seedlings of the weed, due to its biological features appear somewhat later than the barnyard grass or amaranth upturned. Therefore, during the critical period of weed infestation for tomato, the nightshade black does not have time to cause significant damage to the crop yield.

In our experiments when the number of black nightshade is 5 pieces/m^2 the aboveground mass culture was practically the same as in the control, i.e., the weed did not affect the development of the tomato. This is confirmed by the yield of a tomato – it was at the control level. With increasing of a number of nightshade up to 10-40 PCs/m^2 there was a significant inhibition of the growth and development of culture, which led to a decrease in yield of fruit, respectively on 9, 10 and 16% and the output of standard products. The competition of black nightshade with the plant density of 80, 160 and 320 pieces/m^2 increased sharply– at the end of the growing season in above-ground weight of weeds exceeded the mass of cultivated plants by 14; 45 and 78%, respectively. In turn, mass of culture decreased compared with the control by in average on 36%. And of course, the yield of tomato decreased on 28-37%.

Thus, the conducted research revealed a clear dependence of the yield of tomato from the level of weed infestation in a critical period of cultural development. For each type of weed we can clearly distinguish 4 levels of weed infestation, which differ in their impact on the development of culture and harvesting (table 3).

Therefore, only at a low level of weed infestation with these types of weeds it is possible to obtain yields of tomato, close to the control (without weed). Along with this, it should be noted that the output of standard products is not dependent on the degree of weed infestation of the crops, in spite of a noticeable effect.

So, in the control options the standard cropping of fruit was 80-84%. Therefore, was reduced a gross yields and consequently the yield of standard fruits, and the percentage ratio between them remained. Also the level of the weed infestation had no effect on fruit quality (dry matter content, sugar content, amount of nitrates, ascorbic acid).

For non-seedlings tomato the studied species of weeds were more competitive than for the seedling culture. In our experiments only barnyard grass with the number of 5 PCs/m^2 did not significantly affect the growth and development of seedlings of tomato. This variant practically did not differ from the control on the above-ground mass of culture and on the yield of tomato (table 4). When the number is of 10-20 pieces/m^2 the barnyard grass already significantly influenced the development of tomato - was observed a decrease in mass of the plants (from 5.7 to 3.6-3.5 kg/m^2) and in yield of tomato on 33-34%. If the number is 40 pieces/m^2 the weight of weed increased to 8 kg/m^2, at the same time with the increasing of the number of weeds up to 80 and 160 pieces/m^2 their above-ground biomass was at 10 kg/m^2. In these embodiments, the yield of tomato was reduced in comparison with the control, respectively, on 35%; 53% and 60%. When the plant density of the weed is 320 PCs./m^2, its biomass was 15.7 kg/m^2, but the yield of tomato was practically the same as when the number of weed was 160 pieces/m^2.

In the experiment with Amaranth upturned weeds in the amount of 5 pieces/m^2 resulted in a

significant reduction in the yield of tomato by 21%, and its standard products – by 23% (table 5). When the plant density is 10 PCs/m^2, the damage to the crop was, respectively, 33% and 37%. Further increase in the population of weed to 20 and 40 pieces/m^2 contributed to the reduction in the gross harvest on 52 - 57%, and a standard on 55-57%, compared with the control. When the weed infestation is 80 and 160 pieces/m^2, the productivity of non-seedlings tomato decreased by 67 - 70%.

In tomato crops of the most competing ability possessed the black nightshade (table 6). When the number is 5 PCs/m^2 it grew so intense that at the end of the vegetation period its biomass was 4 kg/m^2. Naturally, such an active development of the weed inhibited the growth of tomato and as a result, its yield was lower than in the control by 21%, and the standard fruit – by 12%. When the plant density is 10 and 20 PCs /m^2 the above-ground weight of weeds, respectively, was equal to 6 and 10 kg/m^2, the yield of standard fruits decreased by 32-37%.

The increase in the number of black nightshade up to 80 PCs/m^2 led to such an active suppression of culture that its above-ground mass was in 2.6 times lower ,than in the control, and in 8.8 times lower than the mass of weed. According to such weed infestation the yield of tomato decreased by 77%, respectively, and the collection of standard fruit was also decreased.

In non-seedlings sowing of tomato, as well as in the seedling culture, depending on the plant density of the studied species of weeds in the critical period of the development of culture, it is possible to allocate some levels of weed infestation, which were significantly different according to the damage to the tomato.

The results of correlation and regression analysis of the obtained data indicate that between the number of weeds and their mass at a critical period of development of culture and the yield of tomato there is a strong inverse correlation, which is described by the two equations ó = à + âõ (equation of a straight line) and ó = à + â 1ïõ (logarithmic equation).

In the vast majority of cases the coefficient of correlation of tomato yield with the number and weight of weeds was highest in the approximation by the linear dependence.

The obtained results clearly indicate that non-seedlings tomato is much sensitive to the weed infestation compared to seedlings. And even the low abundance of weeds of 5-20 pieces/m^2 causes a decrease in yield from 20 - 26% to 41%. For sowing of tomato black nightshade and amaranth thrown back were more dangerous than the barnyard grass. The black nightshade and amaranth already at number of 80 pieces/m^2 are so strongly inhibiting the development of a culture that the harvesting is reduced by 69-77%, that is, at this level of weed infestation the costs are not recouped with the resulting harvest (table 7).

Judging by the size of coefficients of determination, the yield of standard seedlings of tomato fruits depends on the plant density of barnyard grass on 38%, amaranth upturned on 68%, black nightshade – on 39%, by weight of these weeds, respectively, by 35%, 52% and 52% (table 8).

At the non-seedlings method of cultivation of tomato the yield depended on the number of barnyard grass by 24% and by the weight of this weed by 77%, on the number of amaranth upturned by 39 and 77%, and by a black nightshade – by 59 and 80% (table 9). Consequently, the yield of tomato was more correlated with weight of weeds, and less with the density of their plant density. However, in production, in the first place, we have to solve the question of carrying out of certain actions for weed control, based on the number of sprouts.

The coefficients of harmfulness of weeds were calculated depending on their number and mass. For example, with the increasing of plant density per 1 m^2 of the barnyard grass, amaranth upturned, and black nightshade per 1 plant the yield of standard seedlings of tomato fruits decreased, respectively by 0,049±0,027; 0,065± 0.02 and 0,042±0,023 t/ha. Each kilogram of mass of weeds grown on 1 m^2, reduced the standard products by 2.04±1,23; 1,98±0,85 and 1.82±0,77 t/ha respectively (table 8).

In non-seedlings sowing of tomato were obtained the following coefficients of harmfulness: for barnyard grass (-) 0,058±0,046, for amaranth upturned (-) 0,134 ± 0,082; for black nightshade (-) 0,252±0,112 t/ha on 1 plant of weed per 1 m_2 (table 9). The coefficients of harmfulness allow determining economic thresholds of harmfulness of weeds (ETH) and selecting the optimum

measures against them while growing tomatoes.

For example, if the real costs for carrying out activities for the protection of row zone of tomato seedlings from weeds (transient zone) will be 200 thousand rubles/ha, the realizable value of the tomato (RV) – 1 million RUB/ton, the additional yield, covering the cost of expenses of weed control (AY) would be equal to 0.2 t/ha (AY = TZ/ RV). The coefficient of harmfulness of barnyard grass (h) is (-) 0.049±0.027 t/ha. Therefore, the ETH of barnyard grass is 4±2 plants/m^2 (ETH = AY/h).

So, on the basis of the conducted studies with seedlings and non-seedlings tomato, where was studied the harmfulness of black nightshade, barnyard grass and amaranth upturned. It was established a sufficiently close inverse correlation between the number of weeds and yield of tomato, which obeys the equation of a line ó = à - âõ. For seedling of tomato is relatively safe the presence in crops of barnyard grass in a number of 5-10 pieces/m^2 (a protective area of the row), of amaranth upturned, and nightshade black – 5 PCs/m^2. The decline in the yield of tomato by 20-25% was observed in the number of barnyard grass 20-80 PCs/m^2, amaranth upturned, and black nightshade – 10-40 PCs/m^2. The increase of barnyard grass up to 160-320 pieces/m^2, of amaranth upturned – up to 80 PCs/m^2 and black nightshade – up to 80-320 pieces/m^2 greatly influenced to the development of culture and caused the decline in the yield of tomato by 30 - 35%, while if the number of amaranth thrown back was 160-320 pieces/m^2 in this way yields decreased by 50-60%.

The non-seedlings tomato is much more sensitive to the weed infestation. Reduced yields by 20% or more are observed with an abundance of black nightshade of 5-10 pieces/m^2, amaranth – 5 pieces/m^2, barnyard grass – 10-20 pieces/m^2. The growth of weed infestation (nightshade black - 40 PCs/m^2, amaranth thrown back – 20-40 pieces/m^2, barnyard grass – 80 PCs./m^2) caused the fall of harvest by 52-58%; a further increase in the number: of black nightshade up to 80 PCs/m^2 led to such significant losses (77%), that the cultivation culture has become unprofitable. Similar data were obtained when the number of amaranth thrown back was 80-160 PCs/m^2 (losses 69-67%), of barnyard grass 160-320 units/m^2 (losses 60-62%). For seedlings of tomato, the coefficient of harmfulness of barnyard grass is (-) 0,049±0.027 t/ha, for amaranth thrown back is (-) 0.065±0.02 t/ha, for nightshade black is (-) 0,042±0,023 t/ha of a standard yield per 1 plant of weed per 1 m^2 of the protective zone of the row. As the difference between them is insignificant (at the 95% level of significance), it is possible to operate with the same for all three weeds coefficient of weediness, which is equal to (-) 0,052±0,023 t/ha. For non-seedlings tomato, the coefficient of harmfulness of barnyard grass is equal to (-) 0,058±0,046 t/ha, for amaranth thrown back is (-) 0,134±0,082 t/ha, for nightshade black is (-) 0,252±0,112 t/ha of a standard yield per 1 plant/m of the protective area of the row. For barnyard grass and amaranth thrown back, you can use a single ratio (-) 0,096±0,064 t/ha 1 plant/m^2 of a protective area of the row.

Watermelon. The results confirm the very high sensitivity of watermelon to weed infestation. In a critical period of cultural development, which lasts 50 days after emergence of watermelon sprouts, the growing in the sowing of even 5 weeds per 1 m^2 of the protective zone of the row significantly inhibited the growth and development of culture and reduced productivity.

The relationship between weed infestation and yield is not functional, but the correlational, since each value of the number of weeds meets not one, but several variables of yields. With the increase in the number of weeds from 5 to 320 pieces/m^2 there are several levels of contamination, differing on the extent of damage.

Based on this, we proposed the following gradation assessment of weed infestation: the decrease in yield by 25% – low, 25 - 50% – medium, 51-75%, and 75% –very high.

Barnyard grass with the plant density of 5; 10 and 20 PCs./m^2 caused a reduction of gross yield of watermelon on 28-32%, including the standard fruits on 32 - 48%, with the number of 40 and 80 pieces/m^2, respectively, on 51-63% and on 68-77%. In embodiments, where at a critical period of the development of the culture density reached 160 and 320 pieces/m^2, at the end of the vegetation period, the biomass of weeds was 12 kg/m^2. When such weed infestation the biological productivity of watermelon was decreased compared with the control on 76 - 83%, and standard fruits were virtually absent (table 10).

Thus, in the experiment with the barnyard grass, were clearly demonstrated three levels of

weed infestation, which can be characterized as medium (5-20 pieces/m^2), high (40-80 pieces/m^2) and very high (160-320 PCs/m^2).

Amaranth upturned already at the density of 5, 10 PCs./m^2 by the end of the vegetation period had a biomass of 8-10 kg/m^2 and contributed to the reduction of gross crop yield by 32-42%, including a standard crop – 37-45%. Twenty and forty plants of weed per 1 m^2 reduced yields of standard watermelon on 63-75% (table 11).

If the number is 40, 80 PCs./m^2 weight of amaranth upturned was the same – 12,5-12,8 kg/m^2. With such weed infestation, the gross yield was reduced by 66-70%, and the increase in the number of weeds up to 160 and 320 pieces/m^2 resulted in a complete loss of the standard product. Therefore, a change in the number of amaranth upturned from 5 PCs/m^2 up to 320 PCs./m^2 was accompanied by the uneven decline of productivity. In the presence of 5-10 pieces/m^2 were reduced by 32-42%, of 20-80 PCs/m^2– by 53% to 70% and if 160 - 320 PCs/m – by 87-86%, which corresponds, according to the proposed gradation, to the three levels of weed infestation: medium, high and very high.

Black nightshade had the same impact in the damage. When the number is 5 PCs/m^2 it had a rather powerful vegetative mass and blocked the development of watermelon, resulting in reduction of productivity by 43% (table 12). Therefore, the presence of even 5 pieces/m^2 corresponds to the average level of productivity.

The further growth of the number weed from 10 to 20 pieces/m^2 was accompanied by a decrease in yield by 51% and 64%. This is consistent with the high level of the weed infestation of crops. And the decrease of yields on 77-81% was observed when the number of black nightshade was from 80 to 320 pieces/m^2, which corresponded to a very high degree of the weed infestation of the watermelon crops.

Of course, the decrease of the total yield was accompanied by a significant decrease in the yield of standard products from 38.8 t/ha in the control to 21 t/ha - with an average weed infestation, and of up to 17-10,4 t/ha – with a high weed infestation, and of up to 3.3-0.1 t/ha with a very high weed infestation. It should be noted that the natural background levels of weed infestation in all three experiments, represented by different types of weeds were very high (lots of weeds have reached 14,1 kg/m^2) and yield losses amounted to 76.5%, and the collection of standard fruits was almost absent (0.1 t/ha). Thus, the watermelon was more sensitive to the weed infestation compare to tomato (seedling and non-seedlings). This is reflected in the summary table 13, where the yield loss depending on the level of the weed infestation of crops is presented.

It should also be noted that watermelon is the percentage between the gross output and the standard depended to a much greater extent, on the level of weed infestation than in the experiments with tomato. So, if in the control the collection of standard watermelon was 91%, then if the number of weeds was of 160-320 pieces/m^2, the collection was only – 1,2-2,0%.

Correlation and regression analysis of the data showed that between the number of weeds in the critical period of cultural development, as well as between the mass of weeds in the end of vegetation period and yield there is a close inverse correlation that obeys the equation $y = a + BX$. The coefficients of correlation and determination are presented in table 14.

The coefficients of harmfulness of weed plants were calculated based on the number and weight of weeds. With increasing of plant density of barnyard grass, amaranth thrown back, and black nightshade on one plant for every m^2, a standard yield of watermelon decreased accordingly: on 0,092; of 0.085; 0,076 t/ha. And every kilogram of mass of these weeds have caused the loss of a standard watermelons on 2.92; 1.22 and 1.59 t/ha.

The given coefficients of harmfulness allow us to calculate the economic threshold of weeds (ETH) and the economic threshold of feasibility of control (EHPC), to choose the best methods of suppression of weeds in crops of watermelon. For example, if the real costs of suppression of weeds in the protective zone of the rows in crops of watermelon made up of 19,000 rubles/ha (TZ). With the cost of sales of watermelons in average 60000 RUB/t (RV) the additional crop, pay off the cost of weed control was 0.32 t/ha (AY= TZ/ RV). The coefficient of harmfulness (H) of barnyard grass (-0,092). Therefore, the ETH of barnyard grass was equal to 3.5 pieces/m^2 (ETH= AY/H). And EHPC, in which the cost of control of weeds are compensated with

a preset efficiency, when the profitability of production, for example, 140%, and the biological effectiveness of protective measures 80%, it is 6.2 pieces/m^2 of barnyard grass. For amaranth and black nightshade the ETH was equal respectively 3,8 and 4,2 PCs./m^2, and EHPC 6.7 and 7.4 pieces/m^2.

CONCLUSION

The research resulted in identification of critical periods of weed infestation: for non-seedlings of cucumber and tomato – 20 days after germination, seedlings of watermelon and tomato – 50 days from germination of watermelon or transplanting. Differences in the duration of the critical period were caused by the biological peculiarities of the cultures. The sensitivity to weed infestation of culture is presented in the following descending order: cucumber > melon > tomato non-seedlings > tomato seedling.

Harmfulness of weed plants depends not only on their quantity but also on the species composition. In non-seedlings culture of tomato the most competing ability has the black nightshade, in seedling – a significant danger have barnyard grass and amaranth upturned. Calculation of coefficients of determination showed that the yield of tomato seedling was dependent on the plant density of barnyard grass by 38%, of amaranth thrown back by 68%, of black nightshade by 39%, and from the crude masses of these weeds, respectively, by 35%; 52% and 52%. The yield of non-seedlings tomato depended on the number of these weeds by 24%, 39% and 59%, and from their mass respectively by 77%, 77% and 80%. Consequently, the productivity is more correlated with the mass of weed than with their number.

Were calculated the coefficients of harmfulness, characterizing the decrease in yield (t/ha) per 1 kg wet weight of weeds, as follows: for tomato seedlings – barnyard grass - 2.04±1,23; for amaranth upturned – 1.98±0.85, for the black nightshade - 1.82±0,77 and for tomato non-seedlings, respectively, - 1.57±0,36; 1,37±0.37 and 1.1±0.3.

In accordance with the coefficients of harmfulness were determined economic thresholds of harmfulness (ETH) in the planting of tomato: barnyard grass – 4±2; amaranth upturned – 3±1; nightshade black – 5±2,5 PCs./m^2.

In crops of watermelon ETH were the following: barnyard grass – 3,5 pieces/m^2; amaranth upturned - 3.8 pieces/m^2; black nightshade – 4,2 PCs./m^2.

The economic threshold of feasibility control (EHPC) of these types of weeds, respectively, was 6,2; 6,7 and 7,4 PCs/m^2.

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