



Maritsa Vegetable Crops Research Institute, Plovdiv

REPORT

Subject: Effect of the application of foliar fertilizer Panamin Agro on the yield and quality of vegetable crops



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Purpose of the test

MATERIALS AND METHODS

The experimental work was carried out during the period April-September 2017 in MVCRI-Plovdiv with onion (variety Melnik), cucumber (variety Gergana), tomato (variety Pink Heart) and pepper (variety Ivailovska kapia).

The onion was cultivated from seed onions – for spring (green) onion and for ripe onion. The cucumbers, tomatoes and pepper were cultivated as a medium-early field crops from pre-produced seedlings. The data about the sowing and the production of seedlings are given in Tables 1 and 2.

Table 1. Sowing terms of tomato, pepper, cucumber and onion for assessment of the effect of application of foliar fertilizer Panamin Agro on the yield and quality of the production.

Activity	Crop			
	Tomato	Pepper	Cucumber	Onion
Sowing / Thinning	10.03 / 01.04	28.03	11.04	-
Planting	05.05	11.05	11.05	6.04
End of the growth	15.09	02.10	28.08	6.06 for spring onion 24.07 for ripe onion

Table 2. Conditions of the seedling production of tomato, pepper, cucumber and onions for assessment of the effect of application of foliar fertilizer Panamin Agro on the yield and quality of the production.

Crop	Substrate	Growing conditions
Tomato – dense seedlings	Peat: perlite 1:1 v/v	Trays without beds, with dimensions 51,5 cm x 33,0 cm Steel-glass conservatory with floor heating.
Tomato – thinned seedlings	Peat: perlite 1:1 v/v	Trays with dimensions: 51,5 cm x 33,0 cm, with 28 beds with diameter 6 cm and depth 7 cm. Non-heated steel-glass conservatory.
Cucumber	Peat: perlite 1:1 v/v	Trays with dimensions: 51,5 cm x 33,0 cm, with 28 beds with diameter 6 cm and depth 7 cm. Non-heated steel-glass conservatory.
Pepper	Peat: perlite 1:1 v/v	High bed, with sowing norm 8-10 g/m ² . The seedlings are not thinned. Non-heated steel-glass conservatory.

The trial is based on the long plots method in 4 repetitions. The growing schemes of the 4 crops are given in Table 3.

Table 3. Growing schemes of tomato, pepper, cucumber and onion for assessment of the effect of application of foliar fertilizer Panamin Agro on the yield and quality of the production.

Crop	Sowing scheme
Onion	20/10 cm x 50 plants, repeatedly
Pepper	80/15 cm x 32 plants, repeatedly

Cucumber	80/40 cm x 12 plants, repeatedly
Tomato	80/30 cm x 16 plants, repeatedly

Trial groups:

1. Control group - without fertilizers and plant protection products (PPP). The plants of this group are cultivated in naturally fertile soil, without incorporation of additional fertilizers and without application of plant protection products.

2. Conventionally treated (Conventional) group - with fertilizers and plant protection products (PPP) according to a conventional technology. The plants were fertilized with ammonium nitrate, potassium sulphate and triple superphosphate, incorporated before the planting and as growth fertilizers. Their quantity expressed as active substance for the whole growth period of the respective crop is presented in Table 4. The plant protection products were applied depending on the occurrence and the extent of diseases and pests attacks. The following plant protection products were used: Syneis 480 SC, Confidor Energy, Mospilan 20 SP, Aktara 25 SG, Eforia 045 ZC, Quadris 25 Sc, Danitron 5 Sc, Affirm 095 SG, Bayfidan 250 EC, Ridomil Gold SL 68 SG, Nisoran 5 EC.

Table 4. Conventional fertilizing scheme for onion, cucumber, tomato and pepper

Crop	Active substance, kg/dca		
	N	P ₂ O ₅	K ₂ O
Onion	10	10	20
Cucumber	15	10	25
Pepper	20	12	30
Tomato	25	18	50

3. Panamin Agro - independent application. The plants are cultivated in naturally fertile soil, without application of plant protection products, only with application of Panamin Agro. The application scheme of Panamin Agro is according to the recommendations of the manufacturer (Table 5).

Table 5. Application scheme of Panamin Agro

Crop	First application	Further applications
Onion	5 - 10 cm height	II to V at 14-day intervals
Cucumber, tomato, pepper	5 - 10 cm height	II - before flowering, III after flowering, IV and V during the fruit growth at 10 - 14 day intervals

4. Panamin Agro at 70% reduced fertilization and pesticide spraying. Panamin Agro is applied according to the scheme for trial 3. The fertilizers are applied according to scheme 2 but reduced by 70%. The plant protection products are the same as for trial 2 but reduced by 70%.

The plants were cultivated in accordance with the standard agro-technical practices for medium-early field production, the same for all trials. Agrochemical soil analysis was carried out before the transplantation. The type and quantity of fertilizers for

basic fertilization and nutrition are consistent with the nutrient supply of the soil and the demands of the crop (Table 6).

Table 6. Nutrient supply of the soil according to the trials

Trial	pH	EC mS/cm	Nutrients, ppm				
			N-NO ₃	P	K	Ca	Mg
Control group	6,61	0,10	20	19,1	33,2	20,1	4,8
Conventional	6,65	0,09	20	16,6	24,9	16,2	7,2
Panamin Agro	6,58	0,11	25	17,7	33,2	16,2	4,8
Panamin Agro with reduced fertilizers and PPP	6,56	0,10	20	18,1	33,2	12,4	9,6

Observations, measurement and analysis:

- Agrochemical soil analysis - before the transplantation and 2 times during the growth of each crop, for average sample of the trial pH, EC, N, P, K, Ca, Mg in aqueous extraction were measured to determine the type and quantity of the fertilizers.
- Phenological observations - beginning of flowering and length of the growth period.
- Phytopathological observations - periodically during the growth, observation was carried out for diseases and pests attacks to determine the need for plant protection measures (prophylactic and treatment) in two of the trials.
- - Biometrics - periodically, the most important biometric indicators were measured for each crop per repetition. For the spring onion, the weight and the length of the plant, the number of leaves and the diameter of the stem were measured. For ripe onion - average bulb weight, total yield, percentage of large:small fraction. for tomato, pepper and cucumber - average mass of fruits, of which standard and non-standard (of poor commercial appearance, irregular form and size, infested by diseases and pests) and total yield (formed by all fruits harvested until the date set for the end of the growth). for cucumber, the length of the fruit was also determined and for tomatoes and pepper - the early yield.
- Biochemical analysis of fruits - tomato, pepper and cucumber. For average samples of 2 kg during the mass yield, for each trial the dry matter and vitamin C content were determined.

RESULTS

Spring onion

Under the experimental conditions, in all trials the plants were healthy and plant protection products were not applied.

For mass of the plant, number of leaves and stem diameter, the lowest values were measured for soil with natural fertility and no plant protection products (control group). When Panamin Agro is applied, the values of most of the tested indicators

increased. The plants are higher, with thicker stems. The average mass of the individual plants is 13% higher.

When cultivated under conventional production conditions, i.e. with incorporation of synthetic fertilizers, the tested indicators increase considerably relative to the non-fertilized trial, while the mass and the height of the plants is by approx. 30% higher and the diameter of the stem is by 5% higher.

The spring onion responds best to combined fertilization with Panamin Agro and reduced mineral fertilization (Table 7). The measured indicators: plant mass (49.3 g), plant length (60.7 cm), stem diameter (23.1 mm) and number of leaves (5.9) are highest, exceeding even the conventional trial. As opposed to the previous three trials, increase of the number of leaves by 0.2 pc/plant was also reported here.

The application of Panamin Agro at natural fertility of the soil stimulates the growth of the onion, increasing the mass of the plants by 13%. When only 30% of the mineral fertilizer dose is applied, Panamin Agro increases the mass of the plants by 60%, the length by 40% and the thickness by 20%. Compared to the conventional trial where synthetic fertilizers are used at doses of 10-10-20 of the active substance, Panamin Agro combined with fertilizers at doses 3-3-7 of the active substance results in a greater mass and plant length and thicker stems. The observed better development of the plants when Panamin Agro is applied, will lead to an earlier market realization of the production. It can be applied successfully, while in the synthetic fertilizers quantities are reduced significantly (70%).

Table 7. Morphological indicators for spring onion

Trial	Plant mass, g	Length, cm	Leaves, number	Stem diameter, mm
Control group	31,2	43,8	5,7	19,4
Conventional	40,5	57,9	5,7	21,6
Panamin Agro	35,2	57,8	5,7	20,4
Panamin Agro with reduced fertilizers and PPP	49,3	60,7	5,9	23,1

Ripe onion

The phytopathological observations during the trials showed that when no PPP were used, the prevention of mildew caused by the fungus *Peronospora destructor* was problematic. In the conventional trial and the trial with Panamin Agro, at reduced doses of pesticides (trials 2 and 4) the prevalence of the disease was limited.

The ripe onion yield in the control group was the lowest - 1.4 t/dca. The application of Panamin Agro resulted in 43% increased yield and for the conventional cultivation of the crop by 92% (Table 8). For the specific trial, the highest yield was obtained by combined fertilizing with the foliar fertilizer Panamin Agro and reduced quantity of mineral soil fertilizers and PPP. The yield for this trial exceeds even the conventional one by 16.5%. The same is the tendency for the average mass of the bulb - the smallest are the bulbs in the control group (mass 57 g) and the largest - in

the combined trial with Panamin Agro + reduced doses of fertilizers and PPP(mass 102 g). The latter has the best coarse ratio large:small fraction, namely 93:7.

Panamin Agro can replace the conventional scheme for cultivation of ripe onion.

Table 8. Quality of the production and yield of onion

Trial	Large fraction*, %	Small fraction*, %	Average mass of the bulb, g	Total yield, kg/dca
Control group	65	35	57 c	1396 c
Conventional	85	15	85 b	2676 b
Panamin Agro	77	23	80 bc	1996 bc
Panamin Agro with reduced fertilizers and PPP	93	7	102 a	3121 a

*large fraction - bulbs with weight above 50 g, small fraction - bulbs with weight below 50 g

Cucumber

The phenological observations showed flowering of 3 to 5 days earlier for the trials treated with Panamin Agro.

The lowest yield was for the control group cultivated in naturally fertile soil, without application of plant protection products (Table 9). If Panamin Agro is applied under these conditions, the yield of cucumbers slightly increases (by about 200 kg/dca). The conventional cultivation for this crop (fertilizers and pesticides at optimal doses) leads to a significant increase of the yield and reaches 8 t/dca. When the fertilizers and pesticides doses are reduced by 70% of the optimum doses and Panamin Agro is applied, the yield is comparable to the obtained with the full dose of fertilizers and preparations. Panamin Agro also has a positive impact on the quality of the cucumbers because due to its application the plants form larger number of standard fruits. In the combined trial with Panamin Agro and reduced fertilizers and pesticides doses, the yield ratio of standard to non-standard production is the best (62%:38%).

Table 9. Structure of the yield for cucumber

Trial	Standard production, kg/dca	Non-standard production, kg/dca	Total yield, kg/dca
Control group	4177	3119	7296 b
Conventional	4471	3514	7985 a
Panamin Agro	4270	3193	7463 ab
Panamin Agro with reduced fertilizers and PPP	4712	2888	7600 a

Standard production - the shape of the fruits is regular, non-standard production - the crops are deformed and distorted

Positive effect of Panamin Agro was also reported about the quality of the cucumber fruits (Table 10). When Panamin Agro is used without fertilizers and pesticides, the fruits are with proven greater mass and length compared to the control group. When

Panamin Agro is used and the fertilizers and pesticides doses are reduced by 30% of the recommended, the mass and length of the cucumber are comparable to the conventional cultivation, i.e. with the full recommended dose of fertilizers and PPP. The increase in vitamin C content as a consequence of the use of Panamin Agro is insignificant. There is slight increase in the dry matter content when Panamin Agro is sprayed.

Table 10. Quality of the cucumber fruits

Trial	Mass, g	Fruit length, mm	Content of vitamin C, mg/100g fresh mass	Dry matter content, %
Control group	0.20 b	21.02 b	2,79	3,0
Conventional	0,26 a	25,96 a	2,88	3,3
Panamin Agro	0,25 a	25,25 a	2,83	3,5
Panamin Agro with reduced fertilizers and PPP	0,26 a	25,96 a	2,84	3,9

Tomato

During the cultivation, the pests were problematic for all trials - the tobacco thrips (*Thrips tabaci*), the cotton bollworm (*Helicoverpa armigera*) and the tomato mining moth (*Tuta absoluta*). Regardless of the treatment with plant protection products, for trials 2 and 4 there were plants attacked by viral diseases caused by tobacco thrips. Although the climatic conditions during the cultivation period did not allow severe development of fungal diseases, only in the control group attack, albeit slight was reported of alternaria and potato late blight fungus.

The phenological observations showed that the flowering of tomatoes treated with Panamin Agro begins about a week earlier, which increases the early yield by 16% compared to the control group (Table 11). The total yield obtained in the control group is 6933 kg/ha, and in the conventional cultivation group - by 1350 kg/dca higher. The independent application of Panamin increased the yield by 19.4% compared to the control group and does not differ from the conventional cultivation. The highest yield was reported in the trial combined treatment with Panamin Agro and reduced mineral fertilization and PPP, where the yield is 5% higher even compared to the conventional cultivation.

Table 11. Economic early ripening and total yield of tomato

Trial	Economic early ripening, kg/dca	Total yield, kg/dca
Control group	1280	6933 c
Conventional	1490	8283 b
Panamin Agro	1440	8276 b
Panamin Agro with reduced fertilizers and PPP	1450	8723 ab

The smallest fruits (330 g) were obtained in the control group, and the largest (445 g) - in the conventional (Table 12). Although the difference was not statistically proven in the trial with independent application of Panamin Agro, the average fruit weight was 68 g/fruit higher than that in the control group. In the combined trial with Panamin Agro and fertilizers and pesticides doses reduced by 70%, the average fruit weight is slightly lower than that in the conventional cultivation.

Table 12. Quality of the tomato fruits

Trial	Average mass of the fruit, g	Content of vitamin C, mg/100g fresh mass	Dry matter content, %
Control group	330 b	24,1	4,7
Conventional	445 a	21,8	4,7
Panamin Agro	398 ab	25,5	4,7
Panamin Agro with reduced fertilizers and PPP	439 ab	26,4	5,0

The application of Panamin Agro, alone or combined with reduced fertilizers and PPP doses influences positively some biochemical indicators of fruit quality. This indicates that Panamin Agro can serve as an approach to increase the content of

antioxidant substances, such as vitamin C. The content of vitamin C is increased in the trials with Panamin Agro compared to the control and the conventional group. There is an increase in the dry matter content for the combined trial.

Pepper

It has been observed that Panamin Agro promotes less attack of fungal diseases but does not prevent damage by pests.

The phenological observations showed flowering of 5-7 days earlier for the trials treated with Panamin Agro. The first harvest of red fruits was carried out at the end of August and the highest yield was reported for the trial with Panamin Agro and 30% mineral fertilization, followed by the trial treated only with Panamin Agro. The results show that the treatment with Panamin Agro accelerates the formation and the ripening of the fruits, which can be marketed at the end of August. Compared to this, in the conventional cultivation the fruits form and ripen later, and the realization of the production on the market is delayed by 2-3 weeks, since the mass ripening of the fruits is at the end of September, the beginning of October.

Regarding the early yield, the groups Control and Panamin Agro do not differ statistically, but for the latter the yield is higher by 20 kg/dca (Table 13). Similarly, for the trial with Panamin Agro combined with reduced fertilizers and pesticides doses, the yield is by 40 kg/dca higher compared to the conventional cultivation. The total yield is lowest in the control group and highest in the conventional group. The standard yield is highest in the conventional cultivation due to fewer attacks of viral diseases and pests. The two trials with Panamin occupy an intermediate position. For this indicator, the independent application of Panamin increases the yield by 33% compared to the control group, and when the doses of fertilizers and PPPs are reduced by 70%, the yields with Panamin Agro is comparable to that for the conventional cultivation.

Table 13. Early and total yield of pepper

Trial	Early yield, kg/dca	Total yield, kg/dca
Control group	1230 b	3045 c
Conventional	1440 a	4255 a
Panamin Agro	1250 b	4071 b
Panamin Agro with reduced fertilizers and PPP	1480 a	4211 a

The average fruit weight is highest for trial 4 (Panamin Agro and 30% mineral fertilizers and PPP), which exceeds even the conventional trial by 28%. Statistically indistinguishable by average weight of the fruit are trial 3 (Panamin Agro alone) and trial 2 (conventional). The thickness of the pericarp in the treated groups is greater than the control group and the differences are statistically proven. The highest vitamin C content was recorded in the trial with Panamin Agro alone. This indicator is lower for the two trials with fertilizers and pesticides, but in combination with Panamin it is slightly increased. The lowest content of dry matter is reported in the conventional trial, and highest - in the control group. This is in line with many scientific data for the backward correlation found between yield and fruit quality indicators. The two trials with Panamin Agro do not differ from each other and occupy an intermediate position between the control group and the conventional group.

Trial	Average mass of the fruit, g	Thickness of the pericarp, mm	Content of vitamin C, mg/100g fresh mass	Dry matter content, %
Control group	79.9 c	4.48 b	130,2	10,7
Conventional	86.0 b	5,39 a	122,8	9,9
Panamin Agro	86.4 b	5,38 a	152,5	10,0
Panamin Agro with reduced fertilizers and PPP	110,4 a	5,44 a	128,3	10,0

Summary of the phytopathological observations

As a result of the treatment of the plants with Panamin, less attack by powdery mildew (*Podosphaera xanthii*) on cucurbits and less effect against the vectors of viruses and the common spider mite (*Tetranychus urticae* Koch.) is observed. In onions, the attack of mildew (*Peronospora destructor*) is less but there is no influence on the degree of attack of tobacco thrips (*Thrips tabaci* Lindeman). The tomatoes are less attacked by alternaria and TSWV and Panamin Agro has little effect on the attack by the common spider mite (*Tetranychus urticae* Koch.), the tomato mining moth (*Tuta absoluta* Povolny) and the cotton bollworms. Pepper treated with Panamin has less signs of black leaf spots (*Alternaria solani*) and TSWV, but only for the reduced treatment with plant protection products.

CONCLUSIONS

Based on the test, the following more important conclusions can be made&

I. For cultivation of vegetable crops in naturally fertile soil and without application of plant protection products, the foliar application of Panamin Agro:

- stimulates the growth of spring onion, increasing the mass of the plants by 13%, increases the average mass of the bulbs and the yield of ripe onion by 43%;
- insignificantly (by about 200 kg/dca) increases the yield of cucumbers because the plants form larger number of standard fruits;
- in tomato and pepper accelerates the formation and the ripening of fruits;
- increases the total yield of tomato by 19.4% and for pepper - by 33%;
- influences positively the vitamin C content and the dry matter content in cucumber, tomato and pepper.

II. When the vegetable crops are cultivated with incorporation of fertilizers and plant protection products, the foliar application of Panamin Agro can replace up to 70% of the mineral fertilizers and pesticides doses. When only 30% of the recommended doses of fertilizers and PPP are used together with Panamin Agro:

- the mass of the onion plants increases by 60%, the length - by 40% and the thickness - by 20%, the average mass of the bulb increases resulting in a higher yield of ripe onion - large fraction. The yield of onion exceeds even the conventional one by 16.5%.
- results in higher yields of cucumber, tomato and pepper comparable to that obtained from the conventional cultivation, i.e. with the full recommended dose of fertilizers and PPP.