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Study of the effect of using electrical stimulation on the increase of potato yield

A Mukhammadiev[1], A T Sanbetova[2*], N Toshpulatov[2], A Babayev[2], and M Abdukadirova[2]

[1]Institute of Energy Problems, Academy of Science of the Republic of Uzbekistan, Tashkent, Uzbekistan
[2]"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, 100000 Tashkent, Uzbekistan

[*]Email: uzaman72.sa@mail.ru

Abstract. Several studies have shown that electric stimulation improves germination, root growth, and disease resistance. Nonetheless, there is a scarcity of research on the effect of electric treatment on plant growth characteristics and quality. We investigated the effect of electric fields on three potato varieties (Santé, Quvonch-1650M, and Bahro-30), and also to confirm the results, seeds of the same variety were planted with and without electrical stimulation in the second experiment. Seed tubers were electrically stimulated during this study using hand-held equipment equipped with two ultraviolet emitters and an antenna (low-frequency radio impulse bio-stimulation). Studies have shown that pre-planting electrical stimulation of plants accelerates emergence of shoots of plants for 3-4 days depending on a grade. In addition, use of electrical stimulation had a positive effect on the growth of the plant. All studied varieties were taller by 4-5 cm and multi-stemmed, and 12-20 flowers were formed on one stem, which is 2-2.5 times more than in the control. In the second study stimulated each bush (one seed) gave an average of 813 grams, while 398 grams was observed in the control group. Conducted visual counts and serological analyzes showed that electrical stimulation of plants contributes not only to the reduction of infestation plants with viral diseases, but also the manifestation of symptoms of damage. The Kuvonch-1656M, in the studied variant, were affected by diseases 12%, while in the control variant this figure was 16%. Hidden virus infection of plants was 26% and 31%, respectively.

1. Introduction

Crop productivity is one of the most important indicators of agricultural production efficiency. Modern varieties of cultivated plants have a high genetic potential for productivity, showing excellent yields in variety trials [1], but under production conditions, this potential is only partially realized. This issue happens due to external (cultivation conditions) and internal (quality of seed material and its adaptive potential) factors. These factors are exacerbated in Uzbekistan's territory, where the salinity of irrigated lands and soil erosion are increasing. This feature is associated with the aridity of the climate and the geological and hydro-geological conditions of irrigated territories. Soil protection from corrosion is especially relevant for the Republic of Uzbekistan since the area of lands subject to erosion is 1772.3 thousand hectares, or 41.2% of the total area of arable land, of which 721.9 thousand hectares are subject to irrigation erosion. Agriculture annually loses up to 20–30% of the gross crop production, and the total damage is several billion sums per year [1]. Taking into account all these circumstances and the significant crop losses from irrigation erosion in typical gray soils, it became necessary to find

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measures to combat it and ways to restore the fertility of eroded lands and increase the yield of each irrigated hectare [2-5].

These measures are carried out by developing a complex of agro-technical and reclamation measures, including:

• Correct selection of crops, varieties, and their alternation
• Applying rational methods of soil cultivation based on soil properties and characteristics
• Use of mineral fertilizers, taking into account the reserves of nutrients in the soil, their dynamics over time, and the nutritional requirements of crops
• Application of organic fertilizers to increase the content of humus in the soil
• Regulation of soil moisture regime, improvement of moisture permeability, moisture capacity, reduction of water losses due to evaporation and discharges
• Soil salinization control, including leaching, drainage, special agricultural techniques, and chemical reclamation
• Comprehensive introduction of crop rotation with the use of crops of alfalfa and other grasses.

In addition to these measures, numerous methods have been developed for stimulating the physical processing of seed material using laser [6-8], ultrasonic, magnetic, and electromagnetic radiation [9, 10]. Such methods include electrical stimulation of sowing seeds, soil, and plants. Because of a reduction in electrical conductivity, this approach increases the resistance of seeds to stress conditions.

The stimulating effect of the electric field on the seeds includes regulatory changes at all levels of the organization of the plant organism []. The consequence of these changes is the formation of plant resistance to a complex of harmful factors, including economically dangerous pests and infectious diseases. Our team conducted a study to determine the effect of electrical stimulation of seed potatoes on the growth, development, yield, and seed quality of various potato varieties.

2. Materials and Methods

Electro-stimulation of plants is a complex and stepwise electrical impact on a system consisting of seeds, soil, and plants. Electric impact on seeds is carried out before sowing and during sowing. Electric impact on soil is carried out before sowing seeds, during the growing season, during row spacing, and also to protect plants from diseases and pests. In our studies, potato seed tubers were treated with a two-lamp field irradiator equipped with 220-volt lamps emitting ultraviolet light as part of a stationary electric irradiator. It can be used by connecting to a 220 volt AC power source, as well as to a 12-volt generator or tractor battery (see Figure 1). Seed tubers of varieties Santé, Kuvonch-1656m, and Bahro-30 were subjected to electrical stimulation before planting, and the treatment was also carried out 15 days after emergence and during the flowering of plants**.**

Figure 1. Electro-stimulation using manual equipment equipped with two ultraviolet emitters

In addition, for data comparison, we planted seeds of the same variety of spring potatoes. During the experiment, 7 rows of potatoes were stimulated, and 1 row was not. The planting area was 58 meters long and had seven rows of eight meters each (220pcs). The control variant was planted in 1 row (20pcs) without being irradiated.
The seeds were irradiated with R=60 W UBN = 254, t= 10 minutes before sowing (March 18). At a plant height of 10-15 cm R=30 W UBN = 254, the second irradiation was performed. During the period of plant entry into the soil, electrical treatment was carried out at the same parameters. On June 15, harvesting was completed.

3. Results and Discussion

According to research, pre-planting electrical stimulation of plants speeds up the emergence of seedlings by 3-4 days, depending on the variety. For example, in the studied variant of the potato variety Kuvonch-1656M, the planting-shooting period is 20, whereas the control figure is 24 days. The Sante and Bahro-30 varieties yielded comparable results, which were 21, 24, and 22-25 days, respectively (see Table 1). It should be noted that when compared to the control variant, the plants of all studied varieties were 4-5 cm taller and multi-stemmed by an average of 0.3-05 pcs/plant in the variant with electrical stimulation. It is well known that crop yield is affected to some extent by the size of the assimilation surface. For example, in the potato variety Sante, the leaf surface of plants averaged 42 thousand m2 in the electrical stimulation variant, while this figure was 40 thousand m2 in the control variant. Similar figures of 36 m 2 and 35 m 2 were obtained for the potato variety Kuvonch- 1656 M, respectively.

Table1. The effect of electrical stimulation on the growth, development and yield of different varieties of potatoes

№	Indicators	VARIETIES AND VARIANTS					
		Santé		Kuvonch-165M		Bahro-30	
		With electrical stimulation	Control	With electrical stimulation	Control	With electrical stimulation	Control
1	Duration Planting period-shoots, days	21	24	20	24	22	25
2	Plant height, cm	86	81	78	74	84	80
3	number of stems pcs/plant	4.3	4.0	3.8	3.3	4.0	3.7
4	number of leaves pcs/plant	135	128	115	108	124	117
5	Number of axillaries shoots, pcs/plant	24	19	18	14	20	15
6	Assimilation surface thous. m2 / ha	42	40	36	35	38	37
7	Infection of plants with viruses,% A) in an explicit form B) in a latent form	12 26	16 31	10 20	13 25	11 18	14 21
8	Productivity gr/plant	630	550	570	510	640	576
9	Productivity, t/ha	38.5	34	33.4	31	39.7	35.3
10	Yield structure, % up to 30 grams 30 - 80 grams over 80 grams	5.4 74.0 20.6	7 76 17	7 77 16	8 78 14	6 72 23	7 72 21

The data in Table 1 show that the germination energy of potato seeds of all varieties and laboratory and field germination, on average for the observation season, was quite high and fully met the requirements for original seeds. Also, the infection of plants with viruses was relatively lower than in the control variant.
To analyze the data of the second experiment, we examined 10 bushes with and 10 without electrical stimulation (Table 2).

Table 2. Comparison of potato yields productivity with electrical stimulation (2) and without (1)

№	Variants	Productivity		Yield Fraction					
		g/ tuber	Quantity pcs/tuber	up to 30g(small)		30-80 g		Above 80 gr.	
				number	gram	number	gram	number	gram
1	1	377	7	3	77	2	80	2	220
2	1	460	10	5	100	3	180	2	180
3	1	315	6	3	85	2	140	1	90
4	1	280	7	4	95	2	85	1	100
5	1	541	10	4	80	2	181	4	280
6	1	327	8	5	112	2	100	1	115
7	1	354	9	3	62	4	142	2	150
8	1	397	9	5	127	2	120	2	150
9	1	428	10	3	71	5	195	2	162
10	1	411	10	5	140	3	101	2	170
	average	398	8.6	4	94.9	2.7	132.4	1.9	161.7
1	2	920	13	1	25	5	330	7	565
2	2	900	11	2	45	6	385	3	470
3	2	815	9	2	55	3	260	4	500
4	2	685	10	2	45	6	385	2	255
5	2	840	9	1	25	2	150	6	665
6	2	770	10	1	20	5	315	4	435
7	2	700	11	4	105	3	165	4	430
8	2	810	8	2	55	3	255	3	500
9	2	905	9	2	40	4	305	3	560
10	2	790	12	3	50	4	225	5	515
	average	813.5	10.2	2.	46.5	4.1	277.5	4.1	489.5

Figure 2. Effect of electrical stimulation of seed material on the development of spring potato tubers (1-control; 2-electrostimulation)

According to the table, it can be seen that in tubers without electrical stimulation, on average, there were 8.6 pieces of potatoes in each bush. Almost half were small types of potatoes (4 pieces) and they weighed an average of 95 grams, there were fewer medium potatoes (2.7 pieces) weighing 132.4 grams, large sizes amounted to 1.9 pieces with an average weight of 161.7grams.While in treated one the average number of potatoes was 10.2, where 4pcs in a large size and smaller ones 2pcs, it means that 2 times more than in control.The yield increase was mainly due to an increase in the yield of large tubers and a decrease in the yield of small tubers. Potato viral diseases are widespread in Uzbekistan, causing a decline in seed quality and crop yields. Given these circumstances, we investigated the effect of electrical stimulation on plant susceptibility to viral diseases in our research. Visual counts and serological analyses revealed that electrical stimulation of plants contributes not only to the reduction of viral disease infestation of plants but also to the manifestation of damage symptoms. For example, in the studied variant of Quvonch-1656M, the explicit infection of plants with viral diseases was 12%, while in the control variant it was 16%. Hidden virus infection of plants was 26% and 31%, respectively As a result, the offered integrated potato protection system, which includes the use of pre-planting treatment of seed tubers with electrical stimulation, significantly reduces the development of the studied potato diseases while increasing both total yield and marketable fraction of tubers, making it very promising for the potato-growing industry.

4. Conclusions

In conclusion, we can say that the electrical stimulation of seeds and plants (for example, cotton, potatoes, wheat, tomatoes, etc.) enhances nucleic and protein metabolism, the intensity of photosynthesis, the activity of enzymes, etc. Electric exposure does not disturb the formation of pollen and does not reduce its viability, and the fertilization process has a positive effect on the microflora of the rhizosphere, increasing the content of beneficial and reducing the number of harmful microorganisms in the soil, improving the phytosanitary state of the soil by reducing microscopic mold fungi and increasing the number of actinomycetes. It has been experimentally proven that the electrical stimulation of soil, seeds, and plants contributes to a significant increase in the content of digestible nitrogen, phosphorus, and potassium [2]. The selective reaction of the studied cotton genotypes to the early maturity and setting of bolls and seeds during electrical stimulation was revealed. [3] These electrical technologies make it possible to increase the yield of crop production at a low cost. Studies have established that electrical stimulation of potato plants helps to improve seed quality and obtain 2.4-4.5 t/ha of additional yield. The increase occurs mainly due to rise in the number of large tubers and a decrease of small tubers in the yield. Thus, the development of the use of electrical technologies in crop production is necessary to reduce the labor intensity of production and reduce costs.

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