Influence of biopreparation ‘Zamin-M’ on cotton plants (gossypium hirsutum) under soil salinization in Uzbekistan

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Abstract. In this article, a microbial inoculant acting as a biostimulant, consisting of three strains of local salt-tolerant strains of rhizobacteria Pseudomonas stutzeri SKB308, Bacillus subtilis SKB309, Bacillus megaterium SKB310. The authors have developed and introduced into agricultural practice an experimental sample of the biological product ‘Zamin-M’, which increases the resistance of cotton to stress conditions of soil salinity. It is proved that the biological product ‘Zamin-M’ increases soil fertility has a beneficial effect on the enzymatic activity of the soil and the development of a population of beneficial microorganisms. The bioproduct ‘Zamin-M’ is presented as a new stimulant in the practice of growing cotton in saline conditions. An agricultural technique for the use of a local biological product in agriculture has been developed. The ‘Zamin-M’ is included by the State Committee of the Republic of Uzbekistan in the list of agrochemicals and pesticides permitted for use in agriculture of the Republic of Uzbekistan (certificate No. 1A1005).

1. Introduction

The use of microbial inoculants in agriculture has expanded significantly over the past two decades, with both the public and private sectors of the agricultural research and development communities working to address the challenges posed by modern agriculture [1]. Microbial inoculants are commonly classified as biocontrol agents (also called biopesticides) or biofertilizers [2, 3].

Biofertilizers are biological products containing living microorganisms that, when applied to seeds, plant surfaces or soils, promote growth through several mechanisms, such as increasing nutrient storage, increasing root biomass or root area, and increasing plant nutrient absorption [4]. Among the biofertilizers that have been extensively studied are rhizobacteria that promote plant growth (PGPR) [5] and bacteria that promote plant growth (PGPB), which are free-living bacteria mainly isolated from the rhizosphere [6]. Several PGPR reviews have been published over the past few years [7, 8, 9]. Several factors need to be considered when developing effective microbial inoculants. For example, plant species and diversity can sometimes be a determining factor in benefiting from the use of biofertilizers [10, 11].

Crop losses due to drought and salinity stress are increasing mainly due to climate change and intensive agriculture, which leads to soil degradation. It has recently been found that some microbial inoculants known to have a positive effect on plant development can also help plants overcome or
tolerate abiotic stress conditions, thereby reducing potential yield losses. The increase in soil salinity in recent years has become a serious problem for crops. The use of some bacteria, such as Rhizobium spp and also Azospirillum SEU, increased plant tolerance to salinity [12, 13]. Application of the A. lipoferum strain to wheat plants reduced the negative effects of salt conditions [14]. Drought stress restricts crop growth and production, especially in arid and semi-arid areas [15].

Bacterial species such as Pseudomonas spp and Bacillus spp have also been reported to stimulate plant growth in dry conditions. Inoculation under drought conditions increased the biomass of shoots and roots as well as water content [16]. Increased root elongation and root biomass are characteristic of drought-resistant species [17]. Changes in root development allow improved water and nutrient uptake through deeper insight into roots in the soil [18].

The use of PGPR led to a significant increase in the uptake of N, P and K, as well as dry weight of roots and shoots in cotton plant (Gossypium hirsutum) [19]. Based on this, the goal of this work was to study the effect of the biological product ‘Zamin-M’ on cotton plants (Gossypium hirsutum) in the conditions of salinization of soils in the Syrdarya province of Uzbekistan.

2. Materials and Methods

The objects of the study were representatives of bacteria of the Bacillaceae and Pseudomonadaceae families isolated from the rhizosphere of cotton grown on the territory of the Republic of Uzbekistan with various types of salinity; weakly, moderately, strongly saline and non-saline meadow-sierozem, sierozem, meadow soils; mineral, organic, biological fertilizers; cotton varieties (Gossypium hirsutum L.): Ak-darya 6.

Table 1. Amount of water-soluble salts and the level and types of salinity in the irrigated soils of Sayhunabad district (Irrigated meadow soils in the farm named after T. Gulomov, Sirdarya province), %

| Cross-section | Depth, cm | Total Dissolved Solids | Cl     | SO4    | Salinity type and level |
|--------------|-----------|------------------------|--------|--------|-------------------------|
|              |           |                        |        |        | Type        | Level     |
| 13           | 0-29      | 0.345                  | 0.014  | 0.205  | Sulphur    | Weak      |
|              | 29-44     | 0.755                  | 0.021  | 0.491  | Sulphur    | Weak      |
|              | 44-79     | 0.555                  | 0.035  | 0.347  | Sulphur    | Weak      |
|              | 79-110    | 0.420                  | 0.035  | 0.236  | Sulphur    | Moderate  |
| 65           | 0-31      | 1.360                  | 0.087  | 0.839  | Sulphur    | Moderate  |
|              | 31-59     | 0.895                  | 0.063  | 0.520  | Sulphur    | Weak      |
|              | 59-85     | 0.335                  | 0.042  | 0.164  | Sulphur    | Moderate  |
|              | 85-117    | 0.300                  | 0.031  | 0.150  | Sulphur    | Weak      |
| 102          | 0-23      | 0.640                  | 0.154  | 0.261  | Ch. sulphur| Moderate  |
|              | 23-45     | 0.275                  | 0.059  | 0.119  | Ch. sulphur| Weak      |
|              | 45-88     | 0.200                  | 0.031  | 0.082  | Ch. sulphur| Weak      |
|              | 88-120    | 0.160                  | 0.024  | 0.061  | Ch. sulphur| Weak      |
| 21           | 0-28      | 0.695                  | 0.017  | 0.419  | Sulphur    | Weak      |
|              | 28-43     | 0.280                  | 0.010  | 0.152  | Sulphur    | Weak      |
| 107          | 0-30      | 0.165                  | 0.014  | 0.072  | Ch. sulphur| Weak      |
|              | 30-55     | 0.250                  | 0.014  | 0.127  | Ch. sulphur| Weak      |

Preparations used for the treatment of sowing seeds: biological product ‘Zamin-M’ with a complex action based on the strains B. subtilis SKB 309, B. megaterium SKB 310 and P. stutzeri SKB 308 and the reference biological product "Baikal-EM" - a microbiological fertilizer intended to improve soil
fertility of any structure and composition in the garden, and soil mixtures for indoor plants and seedlings. The active ingredient of the drug: lactic acid bacteria, nitrogen-fixing bacteria, photosynthetic bacteria, saccharomycetes (microscopic yeast), actinomycetes (radiant fungi), waste products of all these microorganisms.

The studies were carried out in laboratory and field conditions at the Department of Agrobiotechnology of the Tashkent State Agrarian University and in the farm of T. Gulyamov, Sayhunabad administrative district, Syrdarya province (Table 1).

During laboratory and field research, the current standards and methods were applied. Determination of the sowing and varietal qualities of seeds, and methods for determining quality is carried out on the basis of existing standards: ‘GOST 12036-2011’ - Agricultural seeds; ‘O’zDSt 663:2017’ - Sowing cotton seeds (Technical conditions); ‘O’zDSt 1080:2005’ - Raw cotton and seed cotton (Sampling methods); ‘O’zDSt 1128:2006’ - Sowing cotton seeds (Germination determination methods); and ‘O’zDSt 2823: 2014’ - Seeds of agricultural crops, varietal and sowing qualities (Technical conditions) [20-28]. Mathematical processing of the results obtained in the process of research was carried out according to B.P. Dospekho [29], the experimental scheme is given in Table 2.

| #  | Experiment options | Drug consumption rate, l/t | Presowing seed treatment, l/t | Processing during the growing season, l/ha |
|----|---------------------|-----------------------------|-------------------------------|--------------------------------------------|
| 1  | Control             | Unprocessed                 |                               |                                            |
| 2  | Baikal EM1 - standard | 3.0                         | 3.0                           | 3.0                                        |
| 3  | Zamin-M             | 2.5                         | 2.5                           | 2.5                                        |
| 4  | Zamin-M             | 2.5                         | 2.5                           | 2.5                                        |
| 5  | Zamin-M             | 3.0                         | 3.0                           | 3.0                                        |

Previously, the authors have created laboratory, semi-production, production regulations for obtaining a biological product with a complex action based on the strains B. subtilis SKB 309, B. megaterium SKB 310 and P. stutzeri SKB 308 on the basis of which the technology for the production of the biological product ‘Zamin-M’ competitive properties and adapted to living in conditions of soil salinization; experimental samples of biological products ‘Zamin-M’ have been developed and introduced into agricultural practice. A patent of Uzbekistan (No. IAP 05254 January 16, 2014) for the invention ‘Association of bacteria for obtaining a biological product that increases the fertility of saline soils’ was obtained [30]. As a result, the association of microorganisms makes it possible to produce a biological product ‘Zamin-M’ for the cultivation of crops in saline soils.

The bioproduct ‘Zamin-M’ is included in the list of pesticides and agrochemicals permitted for use in agriculture of Uzbekistan by the decision of the State Chemical Commission RUz (No. 1A1005; No. 5.11.155 January 23, 2015).

3. Results and Discussion

In the laboratory of the Department of Agrobiotechnology at TSAU, an experiment was laid to determine the length of seedlings of the aboveground and underground parts of cotton varieties "Akdarya - 6". Aboveground and underground parts of seedlings of cotton varieties were identified on the 7th day (Table 3).

When analyzing the influence of cultures of microorganisms on the growth and development of cotton varieties Akdarya-6, it was found that they have a positive effect on the height of the stems, the number of leaves, the number of fruit branches, the number of harvest elements, the number of open bolls.
Table 3. Influence of bacterization on cotton seeds of Akdarya-6 variety

| #  | Options       | Germination, % | Seedling length, cm | Dry weight of plants, gr |
|----|---------------|----------------|---------------------|--------------------------|
| 1  | Control       | 89±0.58        | 9±0.22              | 0.0722±0.016             |
| 2  | Baikal-M      | 91±0.89        | 10±0.20*            | 0.0765±0.001             |
| 3  | Zamin-M       | 93±0.59*       | 10±0.22             | 0.08±0.0016*             |

In particular, according to the results of the experiment carried out on June 1-2, the height of the controlled cotton plants was 18.3 cm, 19.1 and 19.7 cm, respectively, according to the variants of the experiment. When analyzing the number of leaves, the number of leaves was 8.7, 8.9, and 9.1, respectively; this was much higher than the control variant.

When observing biometric indicators on July 2-3, the height of controlled cotton plants was 55.7 cm and 56.31 and 57.1 cm, respectively. The number of fruit branches is 7.1, 7.5, 7.3, respectively, the number of harvesting elements is 10.5, 10.7, 11, 1 pieces.

As a result of a study conducted on August 1-2, the stem heights of the controlled cotton plant were 69.6 cm, 90.7 and 71.4 cm, respectively. The number of fruit branches was 10.9, 11.1 and 11.5, respectively, and the number of stems was 6.3, 7.6, and 6.7, respectively.

According to the results obtained on September 2-3, the height of the stems was 83.6, 105.3 and 86.1 cm, the number of branches - 11.2, 16.0, 13.9 pieces; the number of fruits on average was 8.9, 9.3 and 9.0 pieces, the number of open boxes was 2.0, 3.5 and 3.2 pieces, respectively, which indicates a positive effect of the biological product ‘Zamin-M’ on the biometric parameters of cotton (Table 4).

Table 4. Influence of biological products on the growth and development of cotton varieties Akdarya-6

| Experiment options | June 1-2 | July 2-3 | August 1-2 | September 2-3 |
|--------------------|----------|----------|------------|---------------|
| Shoot height, cm   | 18.5     | 55.7     | 7.3        | 10.5          |
| Number of growing leaves, pieces | 8.7 | 7.3 | 10.5 | 69.6 |
| Shoot height, cm   | 19.1     | 57.1     | 7.1        | 11.1          |
| Number of sympodial branches, pieces | 9.1 | 7.1 | 11.1 | 71.4 |
| Number of fruit elements | 8.7 | 8.2 | 6.7 | 86.1 |
| Number of membranes, pieces | 8.3 | 11.2 | 11.4 | 8.9 |
| Number of open membranes, piece | 2.2 | 3.0 | 3.2 | 9.5 |

Phenological observations showed that during the season, plants from seeds treated with biological products had advantages in terms of plant growth and development.

In the study, the yield of raw cotton in quintal per ha was determined for the variants treated with the preparations. The data are shown in Fig. 1. The data show that seed treatment with the biological product ‘Zamin-M’ has a positive effect on the yield of raw cotton.

Almost all indicators of plants whose seeds were treated with a biological product showed the result of an outstripping control variant and standard.

When studying the effect of biological products on cotton, the yield averaged 24 quintals per ha, 30.3 quintals per ha, and 28.3 quintals per ha, which showed an increase in yield up to 18%, respectively, compared with the control.
4. Conclusions

Based on 3-year studies conducted in laboratory and field conditions to study the effect of biological products on the growth, development, and productivity of agricultural crops, the following conclusions can be drawn:

It was revealed that cotton seeds showed laboratory germination of seeds treated with the biological product ‘Zamin-M’ above the control and the standard.

It is proved that the treatment of cotton seeds with the biological product ‘Zamin-M’ contributes to an increase in the length of seedlings of the underground and aboveground parts, increases the growth of development and contributes to an increase in plant productivity.

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