The influence of foliar fertilization on the productivity of *Cyamopsis tetragonoloba (L.) Taub.* cultivated on ordinary chernozem

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Abstract. At present, work is underway in Russia to expand the species diversity of plants, to provide processing enterprises of the light and food industries with domestic raw materials. The purpose of the research is to study the effect of complex mineral fertilizers containing trace elements on the yield of guar grain. The studies were carried out in the soil and climatic conditions of the Lower Don on ordinary chernozem. On average for 3 years the highest yield of 156.0 g / m² was obtained when applied fractionally, in three terms (in the phases: steming, budding, fruit formation) of complex fertilizer Ecogrinvit legumes in an amount of 6 l / ha (2 l / ha for one feeding) with a consumption rate working solution of 200 l / ha (for one treatment). The effect of fertilizers was 183.6%. Trace elements copper, boron and molybdenum contained in the studied complex fertilizers and applied fractionally to vegetating guar plants act not only as nutrients and as elements protecting plants from pathogens.

1. Introduction

One of the crops included in the introduction in the South of Russia is guar, the grain of which is the source of guar gum production. Guar (*Cyamopsis tetragonoloba L. Taub.*) is an annual leguminous plant from the legume family (Fabaceae) [1]. According to S.V. Bulyntseva (2017) Guar gum is a vegetable polysaccharide, it consists of galactose and mannose (galactomannan). The appearance is a milled white or light gray odorless powder. The chemical composition of guar gum: contains 80% galactomannan, 12% water, 5% protein, 2% acid-insoluble sludge or crude fiber, 0.7 % ash, 0.7 % fat [2].

Since 2010, in the soil and climatic conditions of the South of Russia, work has been underway to develop a technology for growing *Cyamopsis tetragonoloba L.* Research carried out to study the biological characteristics of guar is described in scientific papers published by employees: Federal Research Center "All-Russian Institute of Plant Genetic Resources named after N.I. Vavilov" and the Branch of KOS (VIR), JSC "Agrosvedenienie "Kuban", FGBUN "Scientific Research Institute of Agriculture of Crimea", FGBOU VO "Donskoy GAU" [3-7]. According to K.I. Pimonov (2018), surveys and observations of the growth and development of guar, carried out in the Rostov region, made it possible to establish that in ontogeny the culture goes through the following phases of vegetation: germination, shoots, stemming and branching, budding, flowering, seed formation (fruit formation) ripening. Under the conditions of the Lower Don, *Cyamopsis tetragonoloba (L.) Taub.* behaves like a short day plant [8]. E.A. Dzyubenko, N.I. Dzyubenko (2017), identified the primary
goal of breeding guar for cultivation in high latitudes and substantiated the search for early maturing forms. Plants with terminal inflorescences, which were distinguished by early maturity and high productivity, were isolated from the collection samples of guar stored in VIR [9]. El.A.A. Elsheikh, K. Ibrahim (1999), studying the role of biological nitrogen in guar plants growing in Sudan when seeds are inoculated with Bradyrhizobium spp. noted a noticeable positive effect on plant development in the form of an increase in dry mass of plants and seed yield [10]. N. Wadhwa (2016) argues that contaminated soils with fungi, including Rhizoctonia, pose a serious threat to guar cultivation worldwide. It has been found that trace elements play an important role in the fight against this disease. It was experimentally found that soil treatment with Zn$^{2+}$ 20 mg kg$^{-1}$ could be used as a soil nutrient agent to ensure the resistance of guar plants against fungal diseases [11]. Studying the timing of sowing *Cyamopsis tetragonoloba* in a subtropical climate (agroclimatic conditions of Assam), scientists came to the conclusion that the best sowing time is July 1, and the optimal plant placement pattern is 45×30 cm. This combination has a positive effect on the increase in the number of beans on the plant and leaves, and reduced the incidence of ant rot. This variant yielded a maximum grain yield of 12.46 t / ha [12].

The purpose of these studies was to determine the effect of complex fertilizers containing trace elements on the productivity of *Cyamopsis tetragonoloba* L. harvested for grain.

2. Materials and methods
The research was carried out at the FSBEI VO "Donskoy GAU" on the basis of the OP "Sarmat", which is located in the Azov soil and climatic zone of the Rostov region, in 2017-2019. Field experiments were carried out on ordinary chernozem. The climate of the Lower Don is characterized as a zone of insufficient, unstable moisture (GTC = 0.7–0.8). The average annual precipitation is 465 mm, the average annual air temperature in the region is 9.8 °C. Agrochemical parameters of the soil of the experimental site: humus content in the soil 3.6 %; nitrifying capacity is 17-19 mg / kg; content of mobile phosphorus 39.3 mg / kg (high), exchangeable potassium 424 mg / kg (high); the supply of microelements is low - zinc, boron, molybdenum and cobalt, medium - with copper, high - with manganese. The predecessor for guar was winter wheat. The Vavilovskiy 130 variety was sown in wide rows with a row spacing of 0.45 m with a seeding rate of 250 thousand germinating seeds per hectare. The heat-loving culture was sown in the third decade of May. In the maturation phase, typical plants were selected from four plots of 0.5 m$^2$ each. Structural analysis and biological yield of grain *Cyamopsis tetragonoloba* (L.) Taub. determined by the method of parsing sheaves. For this, 80 typical guar plants were selected for each variant. The experiment was repeated eight times, the placement of the plots on the field was randomized. The area of the experimental plot was 4 m$^2$. The experiment scheme is presented in table 1.

Agricultural technology in experience. After harvesting the predecessor, plowing was carried out (Lemken Eurodiamant 7 + 1 plow) to a depth of 0.25–0.27 m, the plowing was leveled in November (cultivator WilRich) to a depth of 0.1 m. In early April, the first cultivation (WilRich) was carried out to a depth of 6–8 cm. In the third decade of May, before sowing, the experimental plot was cultivated to a depth of seeding (4–5 cm). Guar seeds were pickled 20 days before sowing (TMTD 10 l / t). Guar was sown with a Seniора single-coulter vegetable seeder. A soil herbicide (Pivot VK 0.5 l / ha) was applied before germination. The sowing was treated against pests with an insecticide (Ampligo 0.2 l / ha). A sprayer (Apache 710) was used to control weeds and pests. To optimize the nutrition of guar with microelements for vegetative plants, mineral fertilizers containing microelements in a chelated form were applied. The application of fertilizers was carried out in three terms, tied to the phases of plant development. The first feeding was carried out in the stalking phase, the second - in the budding phase, and the third - in the guar fruiting phase.
Table 1. Doses, timing of application and consumption rate of the working fluid of mineral fertilizers applied when growing guar, 2017-2019.

| No | Option                  | Deadline for entering | Top dressing dose (disposable / total), l / ha | Consumption rate of working solution, l / ha |
|----|-------------------------|-----------------------|-----------------------------------------------|---------------------------------------------|
| 1  | Control 1 (water)       | f. stalking           | water                                         | 200×1 = 200                                 |
| 2  | Ecogreenwit legumes     | f. stalking           | 2 / 2                                         | 200                                         |
| 3  | Fe₃₀                    | f. stalking           | 1 / 1                                         | 200                                         |
| 4  | Cu₄₀                    | f. stalking           | 1 / 1                                         | 200                                         |
| 5  | Zn₃₀                    | f. stalking           | 0.5/0.5                                       | 200                                         |
| 6  | B₁₃₅                    | f. stalking           | 1 / 1                                         | 200                                         |
| 7  | Mn₄₀                    | f. stalking           | 1 / 1                                         | 200                                         |
| 8  | Mo₂₅                    | f. stalking           | 1 / 1                                         | 200                                         |
| 9  | Fe₃₀ B₁₃₅               | f. stalking           | 1+1/2                                         | 200                                         |
| 10 | Cu₄₀ Mo₂₅               | f. stalking           | 1+1/2                                         | 200                                         |
| 11 | Cu₄₀ B₁₃₅               | f. stalking           | 1+1/2                                         | 200                                         |
| 12 | B₁₃₅ Mo₂₅               | f. stalking           | 1+1/2                                         | 200                                         |
| 13 | Cu₄₀ Mo₂₅ B₁₃₅          | f. stalking           | 1+1+1/3                                       | 200                                         |
| 14 | Control 2 (water)       | f. budding            | water                                         | 200×2=400                                   |
| 15 | Ecogreenwit legumes     | f. budding            | 2 / 4                                         | 200                                         |
| 16 | Fe₆₀                    | f. budding            | 1 / 2                                         | 200                                         |
| 17 | Cu₆₀                    | f. budding            | 1 / 2                                         | 200                                         |
| 18 | Zn₆₀                    | f. budding            | 0,5 / 1                                       | 200                                         |
| 19 | B₂₇₀                    | f. budding            | 1 / 2                                         | 200                                         |
| 20 | Mn₄₀                    | f. budding            | 1 / 2                                         | 200                                         |
| 21 | Mo₅₀                    | f. budding            | 1 / 2                                         | 200                                         |
| 22 | Fe₆₀ B₂₇₀               | f. budding            | 1+1/4                                         | 200                                         |
| 23 | Cu₆₀ Mo₅₀               | f. budding            | 1+1/4                                         | 200                                         |
| 24 | Cu₆₀ B₂₇₀               | f. budding            | 1+1/4                                         | 200                                         |
| 25 | B₂₇₀ Mo₅₀               | f. budding            | 1+1/4                                         | 200                                         |
| 26 | Cu₆₀ Mo₅₀ B₂₇₀          | f. budding            | 1+1+1/6                                       | 200                                         |
| 27 | Control 1 (water)       | f. fruiting           | water                                         | 200×3=600                                   |
| 28 | Ecogreenwit legumes     | f. fruiting           | 2 / 6                                         | 200                                         |
| 29 | Fe₉₀                    | f. fruiting           | 1 / 3                                         | 200                                         |
| 30 | Cu₁₂₀                   | f. fruiting           | 1 / 3                                         | 200                                         |
| 31 | Zn₉₀                    | f. fruiting           | 0,5 / 1,5                                     | 200                                         |
| 32 | B₄₀₅                    | f. fruiting           | 1 / 3                                         | 200                                         |
| 33 | Mn₁₂₀                   | f. fruiting           | 1 / 3                                         | 200                                         |
| 34 | Mo₂₅                    | f. fruiting           | 1 / 3                                         | 200                                         |
| 35 | Fe₉₀ B₄₀₅               | f. fruiting           | 1+1/6                                         | 200                                         |
| 36 | Cu₁₂₀ Mo₇₅              | f. fruiting           | 1+1/6                                         | 200                                         |
| 37 | Cu₁₂₀ B₄₀₅              | f. fruiting           | 1+1/6                                         | 200                                         |
| 38 | B₄₀₅ Mo₇₅               | f. fruiting           | 1+1/6                                         | 200                                         |
| 39 | Cu₁₂₀ Mo₇₅ B₄₀₅         | f. fruiting           | 1+1+1/9                                       | 200                                         |

3. Results and Discussion
Trace elements that make up complex fertilizers had a positive effect on increasing the number of clusters, the number of formed beans, grains in a pod, the mass of grain formed per plant, as well as the grain size (weight 1000). The largest number of beans from 30.4 to 34.0 pcs / plant was taken into account when using foliar feeding with complex fertilizer EcoGreenVit legumes. The number of grains per plant was from 201.7 to 231.2 pieces, with a weight of 1000 equal to 36.0–36.6 gram. The
introduction of mono-chelate fertilizers Ecogrinvit zinc (180.2–183.9 units / plant) and Ecogrinvit had positive effect boron (168.6 - 196.4 pcs.). Most of the grain, 7.1 gram per plant, was collected on average in the variant with the introduction of boron in a dose of B

The highest yield was on the variant with foliar processing in three terms with the fertilizer Ecogrinvit legumes 156.0 g / m$^2$, the effect of agricultural intake was 183.6 (tables 2, 3 and 4). In second place in terms of yield was the option with the introduction of complex fertilizer at a dose of Cu$_{120}$Mo$_{75}$B$_{405}$, the effect was 156.0%.

Table 2. Efficiency of foliar dressing of guar with mineral fertilizers containing trace elements, one dressing, (average for 2017-2019), g / m$^2$.

| No  | Option                  | Grain yield, g / m$^2$ | Average yield over 3 years g / m$^2$ | ± to control, g / m$^2$ | Effect from fertilizers,% |
|-----|-------------------------|------------------------|---------------------------------------|-------------------------|---------------------------|
|     |                         | 2017  | 2018  | 2019  |                             |                          |                          |
| 1   | Control 1 (water)       | 42.3  | 53.1  | 57.6  | 51.0                       | –                        | –                        |
| 2   | Ecogreenwit legumes     | 90.5  | 117.2 | 181.4 | 129.7                      | 78.7                     | 154.6                    |
| 3   | Fe$_{30}$               | 45.2  | 56.8  | 65.1  | 55.7                       | 4.7                      | 9.2                      |
| 4   | Cu$_{40}$               | 59.7  | 71.9  | 96.4  | 76.0                       | 25.0                     | 49.0                     |
| 5   | Zn$_{30}$               | 84.8  | 83.5  | 141.6 | 103.3                      | 52.3                     | 102.5                    |
| 6   | B$_{35}$                | 65.1  | 93.7  | 105.2 | 88.0                       | 37.0                     | 72.5                     |
| 7   | Mn$_{40}$               | 54.7  | 81.0  | 114.2 | 83.3                       | 32.3                     | 63.3                     |
| 8   | Mo$_{25}$               | 52.5  | 74.6  | 83.8  | 70.3                       | 19.3                     | 37.8                     |
| 9   | Fe$_{30}$B$_{135}$      | 58.5  | 85.8  | 68.6  | 71.0                       | 20.0                     | 39.3                     |
| 10  | Cu$_{40}$ Mo$_{25}$     | 64.6  | 74.2  | 106.3 | 81.7                       | 30.7                     | 60.2                     |
| 11  | Cu$_{40}$B$_{135}$      | 79.4  | 91.5  | 113.2 | 94.7                       | 43.7                     | 85.7                     |
| 12  | B$_{35}$ Mo$_{25}$      | 84.3  | 97.2  | 94.5  | 92.0                       | 41.0                     | 80.4                     |
| 13  | Cu$_{40}$Mo$_{25}$B$_{135}$ | 86.7 | 114.4 | 125.8 | 109.0                      | 58.0                     | 113.7                    |
|     | HCP 05                  | 18.7  | 22.8  | 24.3  | -                          | -                        | -                        |

HCP 05

Table 3. Efficiency of foliar dressing of guar with mineral fertilizers containing microelements, two dressings (average for 2017-2019), g / m$^2$.

| No  | Option                  | Grain yield, g / m$^2$ | Average yield over 3 years g / m$^2$ | ± to control, g / m$^2$ | Effect from fertilizers,% |
|-----|-------------------------|------------------------|---------------------------------------|-------------------------|---------------------------|
|     |                         | 2017  | 2018  | 2019  |                             |                          |                          |
| 14  | Control 2 (water)       | 44.3  | 51.6  | 56.2  | 50.7                       | –                        | –                        |
| 15  | Ecogreenwit legumes     | 116.2 | 122.4 | 191.3 | 143.3                      | 92.6                     | 182.6                    |
| 16  | Fe$_{60}$               | 47.1  | 55.4  | 71.5  | 58.0                       | 7.3                      | 14.4                     |
| 17  | Cu$_{80}$               | 88.9  | 76.7  | 114.3 | 93.3                       | 43.1                     | 85.0                     |
| 18  | Zn$_{60}$               | 91.3  | 87.2  | 143.4 | 107.3                      | 56.6                     | 111.6                    |
| 19  | B$_{270}$               | 86.5  | 102.7 | 106.9 | 98.7                       | 48.0                     | 94.7                     |
| 20  | Mn$_{80}$               | 58.4  | 80.5  | 127.2 | 88.7                       | 38.0                     | 75.0                     |
| 21  | Mo$_{50}$               | 61.3  | 76.8  | 95.0  | 77.7                       | 27.0                     | 53.3                     |
| 22  | Fe$_{60}$B$_{270}$      | 77.5  | 97.2  | 78.5  | 84.4                       | 33.7                     | 66.5                     |
| 23  | Cu$_{80}$Mo$_{50}$      | 93.4  | 80.7  | 120.8 | 98.3                       | 47.6                     | 93.9                     |
| 24  | Cu$_{80}$B$_{270}$      | 91.6  | 108.6 | 124.1 | 108.1                      | 57.4                     | 113.2                    |
| 25  | B$_{270}$ Mo$_{50}$     | 104.5 | 110.3 | 101.4 | 105.4                      | 54.7                     | 107.9                    |
| 26  | Cu$_{80}$ Mo$_{50}$B$_{270}$ | 112.4 | 118.3 | 153.6 | 128.1                      | 77.4                     | 152.7                    |
|     | HCP 05                  | 19.1  | 19.4  | 23.5  | -                          | -                        | -                        |
Table 4. Efficiency of foliar dressing of guar with mineral fertilizers containing microelements, three dressings (average for 2017-2019), g / m$^2$.

| No | Option | Grain yield, g / m$^2$ | Average yield over 3 years ± to control, g / m$^2$ | Effect from fertilizers, % |
|----|--------|------------------------|-----------------------------------------------|--------------------------|
|    |         | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 |
| 27 | Control 2 (water) | 46.8 | 57.1 | 61.1 | 55.0 | – | – | – | – | – | – | – | – |
| 28 | Ecogreenwit legumes | 122.9 | 142.6 | 202.5 | 156.0 | 101.0 | 183.6 |
| 29 | Fe$_{50}$ | 48.4 | 58.1 | 63.6 | 56.7 | 1.7 | 3.1 |
| 30 | Cu$_{120}$ | 96.8 | 83.2 | 126.9 | 102.3 | 47.3 | 86.0 |
| 31 | Zn$_{90}$ | 96.7 | 92.0 | 149.4 | 112.7 | 57.7 | 104.9 |
| 32 | B$_{405}$ | 90.6 | 105.2 | 117.1 | 104.3 | 49.3 | 89.6 |
| 33 | Mn$_{120}$ | 60.5 | 89.1 | 127.3 | 92.3 | 37.3 | 67.8 |
| 34 | Mo$_{75}$ | 62.4 | 77.3 | 105.4 | 81.7 | 26.7 | 48.5 |
| 35 | Fe$_{50}$B$_{405}$ | 82.8 | 80.3 | 76.0 | 79.7 | 24.7 | 44.9 |
| 36 | Cu$_{120}$Mo$_{75}$ | 98.2 | 89.4 | 129.5 | 105.7 | 50.7 | 92.2 |
| 37 | Cu$_{120}$B$_{405}$ | 103.3 | 111.6 | 133.1 | 116.0 | 61.0 | 110.9 |
| 38 | B$_{405}$Mo$_{75}$ | 108.1 | 114.7 | 109.3 | 110.7 | 55.7 | 101.3 |
| 39 | Cu$_{120}$Mo$_{75}$B$_{205}$ | 117.9 | 141.2 | 163.3 | 140.8 | 85.8 | 156.0 |

Of the mono-chelated fertilizers used, the most effective was the variant with the introduction of Zn$_{90}$ with Ecogrinvit in three terms, the increase to the control was 57.7 g / m$^2$, or 104.9 %. Apparently, the zinc used worked not only as a trace element, but also as a fungicide, which reduced the load of pathogenic microflora. In the control variant, the plants experienced a significant zinc deficiency because its low content was noted in the soil.

The effect of copper introduced in a dose of Cu$_{120}$ was also positive, the grain yield was 102.3 g / m$^2$, and the effect from the microelement was 86.0 %. In this case, when optimizing the nutrition of guar plants with copper in the leaves, the process of photosynthesis proceeded intensively, and the number of plants infected with Fusarium, Alternaria and bacteriosis also decreased, despite the fact that the soil of the experimental plot is moderately provided with this element.

Foliar application on guar in the phases of steming and budding of the fertilizer Ecogrinvit legumes made it possible to increase the grain yield in comparison with the control by 92.6 g / m$^2$, and the effect of fertilization was 182.6 %. Treatment of guar plants with complex fertilizer applied in a dose of Cu$_{80}$Mo$_{50}$B$_{270}$ increased grain yield by 77.4 g / m$^2$, the effect of foliar feeding was 152.7 %. Other studied options were less effective (depending on the added microelement, the effect ranged from 14.4 to 113.2 %).

The introduction of complex fertilizers on vegetative plants on guar plants in the stalking phase made it possible to increase the grain yield in relation to the control variant. However, the increase in grain yield and the effect of foliar dressing were much less than with double and triple application. Over the years of research, the regularities identified by the effect of complex fertilizers on guar plants remain 2019 was the most favorable year, 2017 the driest. In 2018, there was a reduction in the growing season of guar, due to late germination and early cooling.

4. Conclusion
When guar was grown in the Lower Don conditions on ordinary chernozem, foliar dressing had a positive effect on the growth, development and productivity of plants. On average, over three years, the combination turned out to be the best: foliar feeding in phases: stalking, budding, fruit formation with complex fertilizer EcoGreenVit legumes in an amount of 6 l / ha (2 l / ha per feeding) with a
working solution consumption rate of 200 l / ha (in one treatment). On this option, the grain yield was 156.0 g / m$^2$, more than the control by 101.0 g / m$^2$, with an effect of 183.6 %.

An increase in the resistance of guar plants to diseases and the optimization of mineral nutrition was facilitated by feeding with a complex fertilizer containing copper, boron and molybdenum, applied in a dose of Cu$_{80}$Mo$_{50}$B$_{270}$ in three periods, which corresponds to the use of 3 l / ha at a time with a consumption rate of 200 l / ha at a time.

This combination made it possible to obtain 140 g / m$^2$ of guar grain, more control by 85.8 pcs / m$^2$ with an effect of 156.0 % fertilization.

The microelements contained in the studied complex fertilizers and applied fractionally for vegetative guar plants act not only as nutrients, but also have a fungicidal effect, protect plants from damage by Fusarium, Alternaria and bacteriosis.

References

[1] Kopot E I, Pimonov K I and Molchanova N P 2020 The use of fertilizers in the sowing of Cyamopsis tetragonoloba (L.) on ordinary chernozem in the Lower Don conditions. Agrarian scientific journal 7 26-32

[2] Bulyn'tsev S V, Valyanikova T I, Silaeva O I, Kopot E I and Pimonov K I 2017 Guar is a new legume crop for Russia. In the collection: Innovations in crop cultivation technologies. Materials of the All-Russian scientific-practical conference 167-172

[3] Voloshin M I, Lebed D V and Brusentsov A S 2016 Results of the introduction of a new legume plant - guar (Cyamopsis tetragonoloba (L.) Taub.). Proceedings of the Kuban State Agrarian University 1(58) 84-91

[4] Dzyubenko N I, Dzyubenko E A, Potokina E K and Bulyn'tsev S V 2017 Guar Cyamopsis tetragonoloba (L.) Taub.: characteristics, application, genetic resources and the possibility of introduction in Russia. Agricultural biology 52(6) 1116-1128

[5] Kostenkova E V, Reinstein L N and Ostapchuk P S 2015 Application of Cyamopsis Tetragonoloba (L.) in feeding farm animals, poultry and fish: problems and prospects. Tavricheskiy Bulletin of Agrarian Science 2(4) 108–117

[6] Lebed D V, Kostenkova E V and Voloshin M I 2017 Agronomic rationale for the placement of Cyamopsis tetragonoloba L. crops in the South of the European part of Russia. Tavricheskiy Bulletin of Agrarian Science 1(9) 53-64

[7] Pimonov K I, Evtushenko E V, Kopot E I and Tokareva S P 2017 Diseases and yield of guar grain during cultivation in the soil and climatic conditions of the Lower Don. In the collection: Innovations in technologies for the cultivation of agricultural crops. Materials of the All-Russian scientific-practical conference 117-122

[8] Pimonov K I 2018 Botanical characteristics and biological characteristics of Cyamopsis tetragonoloba (L.) Taub., Grown in the conditions of the Lower Don. Resource saving and adaptability in the technologies of cultivation of agricultural crops and processing of crop products: materials of the Intern. scientific-practical conf. 267–271

[9] Dzyubenko E A and Dzyubenko N I 2017 A new characteristic of guar stem determinancy Cyamopsis tetragonoloba (L.) Traub. Ideas N.I. Vavilov in the modern world: abstracts. report IV int. scientific. Conf. 118

[10] Elsheikh El A Al and Ibrahim K 1999 The effect of Bradyrhizobium inoculation on yield and seed quality of guar (Cyamopsis tetragonoloba L.). Food Chem. 65(2) 183–187

[11] Wadhwa N and Joshi U N 2016 Zinc supplementation induces resistance against root-rot in guar (Cyamopsis tetragonoloba (L.). Taub seedlings. Australasian Plant Pathology 45(5) 465-471

[12] Effect of sowing dates and spacing on growth and yield of cluster bean (Cyamopsis tetragonoloba) in subtropical climate of Assam 2015 (Moscow) 343

[13] Yudin F A 2018 Agrochemical research technique (Moscow: Kolos) 366

[14] Dospekhov B A 1985 Field experiment technique (Moscow: Agropromizdat) 351