Agro ecological and technological assessment of new potato varieties based on in vitro in original seed production

S E Terentyev, Ir N Romanova, KV Martynova, S M Knyazeva and M I Perepichai
Smolensk State Agricultural Academy, 10/2, Bolshaya Sovetskaya street, Smolensk, 214000, Russia
E-mail: sgsha.nauka@mail.ru

Abstract. We found that by the duration of the growing season (102-129 days) the studied varieties corresponded to their morphobiological characteristics and belonged to the group of early maturing (Gulliver) and mid-ripening (Fritella and Grand) varieties. The analyzed fractional analysis of minitubers showed that under greenhouse conditions, potato varieties can form from 3.9 (Gulliver) to 5.0 tubers (Grand). According to the yield of the fine fraction, the variety Fritella was distinguished (1.4 pcs / clone, according to the yield of the middle fraction, the variety Grand (2 pcs / clone); according to the content in the clone of the large fraction, the variety Gulliver - 2.5 pcs / clone with tuber weight 149.1 g. The mass of tubers of one clone in the studied varieties ranged from 319.0 g to 427.7 g. In terms of biological yield, the potato variety Gulliver stood out - 42.8 t / ha, varieties Fritella and Grand were inferior by 10.9 t / ha and 6.5 t / ha, respectively. The presented calculated data showed that in order to create a seed fund in nurseries of original seed growing, it is necessary to obtain a yield of at least 20 t / ha annually, with a yield of seed fraction of at least 60% and the development of elements of varietal agricultural technology. The article presents the qualitative indicators of the assessment of tubers at the early stages of original seed production, which made it possible to characterize varieties by their use for food and technological purposes. The resulting yield of potato varieties and seed calculations showed that for the successful development of potato growing on an area of 20 thousand hectares and the creation of a seed fund in the amount of 70,000 tons, it is necessary to conduct seed production on a virus-free basis in the region, create 9 elite seed-growing enterprises and 3 research laboratories.

1. Introduction
Domestic breeding science is deservedly recognized throughout the world. She is successfully working on the creation of new varieties that are more environmentally friendly, yield and other economically valuable characteristics. Such varieties and their seeds are the most important factor in increasing yields and improving the quality of agricultural products and, in general, the efficiency of all crop production.

At the same time, even the most valuable variety from the point of view of breeding will not be able to show its potential if planting is carried out with seeds of low varietal and sowing conditions, if the scientifically grounded norms of variety change and varietal renewal are not observed, and if varietal agricultural techniques are violated [1-3].

The problem of the quality of seed potatoes continues to worsen more and more due to the strong spread of severe forms of viral diseases, bacterioses, spindle tuber viroid and other pathogens [3-4].
This jeopardizes the competitiveness of modern domestic varieties. Especially dangerous is the ubiquitous spread and increasing harmfulness of severe forms of viral diseases, which can reach 50% or more [3-5].

The situation is largely aggravated by insufficient production volumes of source material free of phytopathogenic viruses grown in favorable phytosanitary conditions, as well as the lack of technological regulations for the production of original, elite and reproductive seed potatoes based on modern legislation. The situation is aggravated by the fact that in many peasant and private farms, which are the main suppliers of potatoes, scientifically grounded crop rotations and, in general, crop cultivation technologies are not observed. Therefore, increasing the yield and efficiency of potato production by establishing elite and reproductive seed production based on accelerated reproduction (in vitro) both at the federal and regional levels is relevant [6-9].

2. Materials and methods

In connection with the above, we laid down experiments to evaluate varieties obtained on a virus-free basis (in vitro) in original nurseries of primary seed production.

We approached the choice of potato varieties based on the soil and climatic conditions of the region, processing directions at agricultural enterprises, saturation of the sales market and their responsiveness to biotic and abiotic conditions.

The greenhouse nursery for assessing mini tubers of the 1st year was founded on the basis of the FGBOU VO Smolensk State Agricultural Academy, the purpose of which was to create a base of original seeds (mini tubers), to give an agro ecological, technological assessment to new potato varieties Fritella, Grand, Gulliver, obtained on the basis of in vitro, as well as determine the yield of the seed fraction.

The starting material was micro tubers obtained from test-tube micro plants, as well as from micro tubers propagated in the autumn-winter period. Planting took place in greenhouse conditions at the end of the first - beginning of the second decade of May at the rate of 105 thousand pieces / ha.

During the growing season, each plant (clone) was visually assessed for resistance to diseases and pests. Only those plants that met the basic requirements were left for harvesting:

- Typicality and good expressiveness of the main varietal-distinctive features of a plant, stem, leaf, inflorescence;
- Absolutely healthy appearance of the plant according to external signs - leaf lobes are evenly colored, without signs of mottling, folding, twisting or twisting, smooth or with waviness characteristic of the variety;
- Normal development of plants with a characteristic number of main stems for the variety (all stems on the bush are uniformly developed in thickness and height).

During harvesting of each plant, micro tubers were dug out manually and each nest was individually assessed for productivity and varietal typicality. Low-productive nests were discarded. The yield of the mini tubers obtained was sorted into fractions, taking into account the dimensional characteristics.

Field and laboratory studies were carried out in accordance with existing methods, recommendations and GOSTs.

3. Results

The growing season of potato varieties determines the group of ripeness, growth and development of plants in different periods of the growing season and the duration of their passage. In our studies (tables 1 and 2), according to the duration of the growing season (88-99 days), the varieties corresponded to their morphobiological characteristics and belonged to the group of early ripening (Gulliver) and mid-ripening (Fritella and Grand) varieties.
By field (greenhouse) germination, the Fritella variety stood out - 99%. In terms of survival rate, this variety was inferior to the Grand and Gulliver varieties by 2%. We have carried out rejection during the period of their growth according to the atypical nature of the leaf and the shape of the stem and other indicators.

**Table 1.** Field germination and survival of plants of potato varieties.

| Varieties  | The number of emerged plants, thousand pieces / ha | Field germination, % | The number of preserved plants for harvesting, thousand pieces / ha | Survival, % | Rejection, % | Vegetation period, days |
|------------|-----------------------------------------------|---------------------|---------------------------------------------------------------|-------------|--------------|------------------------|
| Fritella   | 104                                           | 99                  | 100                                                           | 95          | 3            | 96                     |
| Grandee    | 103                                           | 98                  | 99                                                            | 97          | 2            | 99                     |
| Gulliver   | 103                                           | 98                  | 99                                                            | 97          | 4            | 88                     |

**Table 2.** Fractional analysis of mini-tubers in the nursery clone evaluation 1st year.

| Indicator | Number of tubers, pcs \ clone | Tuber mass, g | Fritella variety | Grand variety | Gulliver variety |
|-----------|-------------------------------|--------------|-----------------|---------------|-----------------|
|           | Fine fraction (<30 g)         | Middle fraction (30-80g) | Coarse fraction (> 80g) | Total | Fine fraction (<30 g) | Middle fraction (30-80g) | Coarse fraction (> 80g) | Total |
| Total for 1 clone, pcs | 1.4 | 1 | 1.9 | 4.3 | - | - | - | - |
| Weight from 1 tuber, g | - | - | - | - | 13.4 | 52.1 | 130.6 | 74.1 |
| Weight from 1 clone, g | 18.8 | 52.1 | 248.1 | 319.0 |
| Total for 1 clone, pcs | 1 | 2 | 2 | 5 | - | - | - | - |
| Weight from 1 tuber, g | - | - | - | - | 12.6 | 54.8 | 120.1 | 72.5 |
| Weight from 1 clone, g | 12.6 | 109.6 | 240.5 | 362.8 |
| Total for 1 clone, pcs | 0.5 | 0.9 | 2.5 | 3.9 | - | - | - | - |
| Weight from 1 tuber, g | 17.0 | 51.5 | 149.1 | 110 |
| Weight from 1 clone, g | 8.5 | 46.4 | 372.8 | 427.7 |

The data obtained (table 2) on the fractional analysis of minitubers show that under greenhouse conditions varieties form from 3.9 (Gulliver) to 5.0 tubers (Grand).

The yield of the fine fraction was the highest in the Fritella variety - 1.4 tubers, the smallest - in the Gulliver variety - 0.5 pieces.

According to the yield of the middle fraction, the variety Grand was distinguished - 2 tubers, with a tuber mass of 54.8 g. According to the content in the clone of a large fraction, the variety Gulliver was distinguished - 2.5 tubers with a tuber mass of 149.1 g.

These data clearly indicate that it is impossible to cultivate and multiply these varieties according to one agricultural technology. If for the Grand variety it was to some extent optimal, then for the Fritella and Gulliver varieties, it is necessary in the future to lay down experiments on the planting
schemes and norms, the timing and method of harvesting tops and tubers. These areas of research will increase the number of medium-sized tubers, delay the formation of large tubers and reduce the number of small tubers.

The mass of one minituber of the clone of the studied varieties ranged from 319.0 g to 427.7 g. It was the highest in the Gulliver potato variety, which is associated with the large presence of large tubers, which could not but affect the yield level.

The yield and yield of the seed fraction are the main assessment of the variety, the fraction of the fraction in the yield structure and the multiplication factor.

In terms of yield, the potato variety Gulliver stood out - 42.8 t / ha; the smallest value of this indicator was noted for the Fritella variety - 31.9 t / ha (table 3).

### Table 3. Yield and yield of seed fraction of new potato varieties in the nursery for assessing clones of the 1st year.

| Variety | Fraction yield, t / ha | Share of participation of fractions in the harvest, % | Productivity, t / ha | Seed fraction output, % | Market ability, % |
|---------|------------------------|------------------------------------------------------|----------------------|------------------------|------------------|
|         | fine fraction (<30 g)  | middle fraction (30-80 g) | coarse fraction (> 80 g) | fine fraction (<30 g)  | middle fraction (30-80 g) | coarse fraction (> 80 g) |
| Fritella| 1.9                    | 5.2                                    | 24.8                  | 6.0                    | 16.3                  | 77.7 |
| Grandee | 1.3                    | 11.0                                   | 24.0                  | 4.0                    | 30.0                  | 66.0 |
| Gulliver| 0.9                    | 4.6                                    | 37.3                  | 2.0                    | 11.0                  | 87.0 |

The yield of the seed fraction in the studied varieties ranged from 71 to 78% and was the highest in the Grand variety. It is possible to increase the yield of the seed fraction by varieties due to the development of elements of varietal agricultural technology at the early stages of seed production.

Hence, in order to create a seed fund for the next stage of seed production, it is necessary to annually obtain a yield of at least 20 t / ha, with a seed fraction yield of at least 60%.

Evaluation of tubers at the early stages of original seed production in terms of physicochemical and technological indicators will make it possible to characterize their purpose in terms of use (food and technological) and the share of the variety in total potato planting. These data will allow agricultural enterprises, according to their focus, to purchase potatoes of one sort or another.

All studied varieties had an overall assessment within the range of 4.3-4.7 points (table 4).

### Table 4. Physicochemical and technological indicators of potato tubers.

| Variety | dry matter | Content, % | Tasting score, point | Late blight, % | Scab, % | Viral diseases, % | Overall assessment of the variety, point |
|---------|------------|------------|----------------------|----------------|---------|------------------|----------------------------------------|
| Fritella| 18         | 14.4       | 6                    | 4.0            | 1.2     | -                | 4.6                                    |
| Grandee | 19         | 14.3       | 9                    | 3.9            | 1.3     | -                | 4.3                                    |
| Gulliver| 18         | 13.7       | 12                   | 4.6            | -       | -                | 4.7                                    |

The Gulliver variety for consumer qualities - table purpose (good taste, the pulp does not darken), can be used for cooking, mashed potatoes and processing into crispy potatoes. Fritella is ideal for fries. In terms of taste, the Gulliver variety stood out with a tasting rating of 4.8 points and is suitable for soups, salads, and frying.

### 4. Discussion

Using the example of a nursery for evaluating minitubers 1 year, the introduction of a modern scheme of the technological process of original seed production will make it possible to establish the production of healthy seed potatoes, calculate the seed growing areas and the need for seed material for an area of 20 thousand hectares.
Our scientific and practical calculations showed that it is necessary to grow elite potatoes annually on an area of at least 4500 hectares (table 5).

**Table 5.** Calculation of seed areas and the need for potato seeds, on an area of 20 thousand / hectare.

| Nurseries                                           | Sowing area, ha | The need for seeds, pcs. t. | Productivity, t / ha | Gross harvest, t total |
|-----------------------------------------------------|-----------------|------------------------------|----------------------|------------------------|
|                                                      | Raw material    |                              |                      |                        |
| Selection nursery from material sanitized by the     | 0,08            | 10000 pcs.                   | 4 pcs / plant (10-30 g) | 40000 pcs. 25%        |
| apical meristem method (BZSK)                        |                 |                              |                      |                        |
| Basic micro-tubers of                               | 0,3             | 30000 pcs.                   | 5 pcs / plant (10-80 g) | 180000 20% rejection  |
| BZSK plants (October-January; January-March)        |                 |                              |                      |                        |
| 1st year clone evaluation nursery (greenhouse       | 1,8             | 160000 pcs.                  | 20                   | 25                     |
| nursery for minitubers)                             |                 |                              |                      | 35                     |
| 1st field generation nursery (9 ha / 2%)            | 9,0             | 33000 pcs.                   | 20                   | 250, 180               |
|                                                    | 25              | 75                           | 20                   | 28                     |
| Original seed potatoes                              |                 |                              |                      | 500 700                |
| 1st field generation nursery (9 ha / 2%)            |                 |                              |                      |                        |
| 1st field generation nursery (9 ha / 2%)            | 1000            | 30000 pcs.                   | 20                   | 280                    |
| Super elite nursery (990-1000 ha / 22%)            |                 |                              |                      | 20000 28000            |
| Elite plot (3500 ha / 70%)                          | 3500            | 10500 pcs.                   | 20                   | 27                     |
| Elite plot (3500 ha / 70%)                          |                 |                              |                      | 70000 94500            |

However, given the large volumes of demand for seeds (70.0 thousand tons) and areas (4.5 thousand hectares), as well as the numerous varietal composition of potatoes (at least 15), the soil and climatic conditions of the seed-growing zones in the Smolensk region are necessary creation of at least 9-10 elite seed-growing enterprises and 3-4 research laboratories, including one based on the Academy for the production of source material, original and elite seeds in seed nurseries [11-16].

5. Conclusion

In the conditions of the Western part of the Russian Federation, the potato varieties Fritella, Grand and Gulliver were ecologically plastic and in the nursery, estimates of 1 year (greenhouse conditions) can form the yield of tubers of 31.9-42.8 t / ha.

During the cultivation period, the studied potato varieties based in vitro in the nurseries of the starting material were not affected by diseases, including viral ones.

In terms of yield, the potato variety Gulliver stood out - 42.8 t / ha; on the output of the seed fraction - the Grand variety - 78%.

According to the general (4.7 points) and tasting (4.8 points) assessments, the Gulliver variety stood out - for table purposes; Fritella and Grand are suitable for processing French fries and crisps.

Expansion of potato seed-growing areas, an increase in yield and the formation of a regional seed fund is possible with the creation of at least 9-10 seed-growing enterprises and at least 3 research laboratories.

References

[1] Shatalova M A and Nikolaeva S A 2009 Features of the development of potato stolons in vitro. *Potatoes and vegetables* 9 22

[2] Smolegovets D Ye 2008 Peculiarities of in vitro cultivation of microtubers and their use in original potato seed production (Moscow: All-Russian Scientific Research Institute of Potato Economy) 107
[3] Martynova K V, Romanova I N and Semchenkova S V 2019 The use of innovative technologies in potato seed production as a factor in ensuring food security in the region. *Vestnik Kursk State Agricultural Academy* 6 52-58

[4] Torikov V E, Kotikov M V and Bogomaz M A 2017 Potato varieties of intensive type (Bryansk: Publishing house of the Bryansk State Agrarian University) 76

[5] Torikov V E and Melnikova O V 2020 Production of crop production (St Petersburg: Lan Publishing House) 512

[6] Romanova I N, Karamulina I A and Terent'ev S E 2009 Optimization of agrotechnical processor in the production of potatoes on a virus-free basis (Smolensk: FGOU VPO "Smolensk State Agricultural Academy") 100

[7] Krupskiy I N and Karpukhin M Yu 2019 Improving the technology of cultivation of seed potatoes in the Middle Urals. *Agrarian Bulletin of the Urals* 5(184) 9-15

[8] Sazonov N V and Dorokhov A A 2019 Technological and technical support of potato production in Russia. *Potatoes and vegetables* 3 20-22

[9] Kolchin N N, Elizarov V P, Mikheev V V and Ponomarev A G 2014 Modern technologies and equipment for the preparation of seed potatoes. *Potatoes and vegetables* 5 27-29

[10] Demina G V and Safiullina G F 2016 Reproduction of virus-free potatoes. *Flora and vegetation of Siberia and the Far East Readings in memory of LM Cherepnin and materials of the Sixth All-Russian Conference with International Participation, dedicated to the 110th anniversary of the birth of LM Cherepnin and the 80th anniversary of the Herbarium named after LM Cherepnin (KRAS) Krasnoyarsk State Pedagogical University named after VP Astafieva; Responsible editor E M Antipova* 289-293

[11] Usanova Z I and Chernikova N S 2020 Formation of programmed yields of different varieties of potatoes. *Successes of modern natural science* 3 40-49

[12] Romanova Ju A, Morkovkin D E, Romanova Ir N, Artamonova K A and Gibadullin A A 2020 Formation of a digital agricultural development system. *IOP Conference Series: Earth and Environmental Science* 548 032014

[13] Morkovkin D, Hutarava I, Ogloblina E, Gibadullin A and Kharchenko S 2020 Assessment of the innovative potential of agriculture of the member states of the Eurasian Economic Union. *E3S Web of Conferences* 176 05002

[14] Khayrzoda S, Morkovkin D, Gibadullin A, Elina O and Elena K 2020 Assessment of the innovative development of agriculture in Russia. *E3S Web of Conferences* 176 05007

[15] Zhichkin K, Nosov V, Zhichkina L, Grigoryeva O, Kondak V and Lysova T 2020 The impact of variety on the effectiveness of crop insurance with state support. *IOP Conference Series: Earth and Environmental Science* 433 012004

[16] Zhichkin K, Nosov V, Zhichkina L, Tkachev S and Voloshchuk L 2020 Prediction methodology for potential damage from misuse of agricultural lands. *E3S Web of Conferences* 161 01060