Application of ecologically balanced technologies of rice cultivation in the Krasnodar Territory

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Abstract. The domestic and foreign research in the field of rice cultivation carried out over the past 10-15 years has identified four main promising technologies that can reduce the cost of rice produced: 1 - intermittent flooding; 2 - periodic moistening without creating a layer of water; 3 - sprinkling, including surface irrigation; 4 - drip irrigation. Drip irrigation of rice is the most priority area of research, since it can significantly reduce the irrigation rate, labor costs, the cost of rice production and anthropogenic load. The purpose of our research was to develop a new technology of rice cultivation with drip irrigation adapted for the climatic and soil conditions of the Krasnodar Territory. As a result of the research carried out, a drip irrigation technological scheme was developed and implemented for LLC "Chernoerkovskoye" of the Slavyansky District of the Krasnodar Territory. The developed scheme of rice cultivation on drip irrigation has proven its effectiveness, which was expressed in improving the reclamation state of soils, increasing the profitability of production by 22% and increasing the yield by 20%, reducing the irrigation rate by an average of 5.3 times, the cost of rice grain by 15% and labor intensity by 34%.

1 Introduction

It is known from the world practice of rice production [1-6] that rice is a moisture-loving crop that requires large volumes of irrigation water and labor costs for its production. Therefore, scientific research to find new solutions to reduce the cost of rice production has always been relevant, including in the historical aspect of rice cultivation [7-9]. However, in the last decade, due to the stable positive dynamics of demographic growth of the population, a decrease in irrigation water volumes and, in connection with this, the limited irrigation fund of land, as well as an increase in prices for all components of rice production: seed material, fertilizers, fuel and lubricants, payment for water supply to rice irrigation systems [10-13], the problem of the transition of rice producers to less costly cultivation technologies has reached its apogee, and ways to solve it have become a priority at the state level.

In connection with the above, the purpose of our research is to develop new

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technological solutions for the cultivation of rice with a significant reduction in direct costs of its production.

The modern level of scientific and technological progress allows minimizing the use of resources to obtain consistently high yields of high-quality rice grain without prejudice to the reclamation state of soils and the ecosystem of the region [14]. The most promising technology is the cultivation of rice using drip irrigation. This is confirmed by more than ten years of successful experience in the cultivation of rice with drip irrigation in China [15], as well as domestic developments of technologies for cultivation of rice with drip irrigation, which have been successfully tested in the farms of the Volgograd and Rostov regions [16-19], and have proven the effectiveness and feasibility further research in this direction. The effectiveness of drip irrigation is due to a number of factors [20]: a reduction in the irrigation rate, the possibility of rice cultivation on the lands of non-irrigation fund, the development of fundamentally new rice crop rotations with the inclusion of melons and vegetables in them. It should be noted that the areas of the irrigation fund of the Krasnodar Territory available for planting rice annually decrease as a result of partial and sometimes complete non-compliance with crop rotations and rice cultivation technologies, which leads to a decrease in soil fertility up to partial and / or complete withdrawal of lands from agricultural purposes [21]. In such cases, the rice irrigation systems require major repairs that are not economically viable. All of the above confirms the relevance of our research, and the research results can be used to develop mathematical models that help workers in the agro-industrial complex make timely management decisions to develop optimally adapted flow charts for rice production using drip irrigation in order to obtain guaranteed high yields of rice without reducing reclamation state of soils.

2 Materials and methods

Tests of the method of rice cultivation were carried out in the Krasnodar Territory at LLC "Chernoerkovskoe" of the Slavyansky District (2nd department) on a rice check (hereinafter "experimental field") with an area of 4.5 hectares each.

The farm uses a diagram of an engineering rice plot of the Krasnodar type.

The cultivated rice crop was the Rapan variety.

The predecessor in the first year of the implementation of the method is rice.

On the experimental field from 2016 to 2019, the following crop rotation was applied:

- 2016: rice (seedling) + tomato (seedling);
- 2017: rice (seedling) + peas (seminal);
- 2018: rice (seedling) + sweet pepper (seedling);
- 2019: rice (seedling) + lupine (seminal).

The method of cultivating rice on the checks of the rice irrigation system with drip irrigation under polyethylene and/or biodegradable mulching perforated film included a list of technological operations presented in Table 1.

Table 1. The list of technological operations for the cultivation of rice on drip irrigation under perforated plastic and / or mulch film.

| №  | Name of technological operations                                      | Unit composition |  |
|----|-----------------------------------------------------------------------|------------------|--|
| 1  | Cutting and restoration of peripheral grooves (depth 0.4-0.6 m, along the perimeter of the check) | DT-75B           | MK-23 |
| 2  | Aligning checks                                                      | DT-75B           | D-569 |
| 3  | Basic tillage (depth 0.22-0.25 m)                                    | T-150 (DT-75B)   | PLN-5-35 (PCN-3,2) |
|   |   |   |
|---|---|---|
| 4 | Cleaning of irrigation and waste canals | EO-2621 – |
| 5 | Backfilling of check rollers up to design marks | DT-75B D-569 |
| 6 | Deep loosening (chiseling, depth 0.16-0.18 m) | DT-75B KZU-0,3V |
| 7 | Loading organic fertilizer into an organic fertilizer spreader | JCB 3CX – |
| 8 | Organic fertilization | MTZ-1221 ROUM-14 |
| 9 | Deep loosening (chiseling, depth 0.10-0.12 m) and application rate of 50 t/ha | DT-75B BDT-3,0 |
|   | Spring-Autumn 2016 (first year of implementation of the method) |   |
| 10 | Harrowing with tooth harrows in two tracks to a depth of 0.08 m | DT-75B MVTZ-1,2 |
| 11 | Formation of technological driveways and passages to a depth of 0.2 m | DT-75B MK-17 |
| 12 | Delivery of non-woven geosynthetic material | MTZ-1221 2 PTS-4 |
| 13 | Disking with incorporation of organic fertilizers (depth 0.10-0.12 m) and application rate of 50 t/ha | DT-75B BDT-3,0 |
| 14 | Loading organic fertilizer into an organic fertilizer spreader | JCB 3CX – |
| 15 | Organic fertilization | MTZ-1221 ROUM-14 |
| 16 | Delivery of drip irrigation and fertigation system elements (pumps, filters for fine and coarse water purification, water meter, liflet hose, drip tape, taps, valves, tees, splitters, plugs, injector, fertilizer tank, etc.) | MTZ-1221 2 PTS-4 |
| 17 | Drip irrigation system assembly including fertigation system (no drip tape laying) | Manually |
| 18 | Drip irrigation system assembly including fertigation system (no drip tape laying) | Manually |
| 19 | Laying of Netafim drip tapes, water consumption of each dropper 1.8 l/h, diameter and wall thickness of the drip tape - 16 mm and 0.2 mm, respectively, distance between droppers 0.2 m, distance between drip lines - 0.24 m | MTZ-1221 Drip irrigation tube unwinder tm "GreenBull" |
| 20 | Single pre-sowing treatment of seeds with a growth regulator "Albit" at a dose of 50-100 ml/t | Manually |
| 21 | Planting rice seedlings (Rapan variety) in nutrient pots in a phytotron, a mixture of various components is used as a substrate: highly fertile field land, sod land, humus, high peat, coarse sand with the addition of microelements to the substrate before planting rice seeds with a norm of N80P120K60 in kg a.d./ha, the humus content in the substrate is not less than 40%, the substrate density is less than one, the porosity is 60-90%, the air content is not less than 10%. Maintaining the temperature regime: in the daytime 20-24 °C, in cloudy weather - 16-18 °C, at night - 15-16 °C, optimal pre-irrigation humidity - at the level of 55-65% of HB, relative humidity - 60-70%. To maintain a stable regime when these parameters were increased, ventilation was switched on. During the period of seedling growing, the lighting was controlled using fluorescent lamps and turned off at night. Seedlings in the phase of 2–3 leaves were fed with nitrogen fertilizers in dissolved form at the rate of N40 in kg a.d./ha. Before planting in the ground, the seedlings corresponded to the standard, had 6–7 leaves with a green color, with a well-developed root system and not infected with pests and diseases. | Manually |
| 22 | Pre-planting irrigation with an irrigation rate providing soil moisture of 90% of HB in a layer of 0.6 m | Drip irrigation system |
| 23 | Spraying the soil surface with soil herbicides: "Ordram" 720 EC (5.0 l / ha, treatment rate 1) + Gezagard with a rate of 60-80 ml/10 l of water to combat annual dicotyledonous and cereal weeds | Self-propelled sprayer IBIS-2500-18P |
| 24 | Shelter of ridges with perforated polyethylene mulch film | MTZ-1221 Film stacker |
| 25 | Spraying BAS "Epin Extra" in the norm of 5-6 drops per 0.5 l of water two days before planting seedlings to increase survival rate and increase stress resistance | Cordless sprayer Clever OE-12,5L-N |
| 26 | Planting rice seedlings | MTZ-1221 Transplanter FTM 2 |
| No. | Task Description                                                                                                                                                                                                                                                                                                                                 | Equipment/Method                                                                 |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 23  | Drip irrigation of rice through a drip irrigation system during the growing season of rice with the frequency and rate of irrigation depending on compliance with the condition for ensuring constant soil moisture 80% of HB in a layer of 0.4 m                                                                                   | Drip irrigation system                                                         |
| 24  | The introduction of microelements after complete survival of rice seedlings (in the phase of 8-9 leaves) by fertigation through a drip irrigation system by the norm N\textsubscript{30}P\textsubscript{30}K\textsubscript{30} at kg a.d./ha                                                                                           | Drip irrigation system                                                         |
| 25  | Treatment with herbicides Bazagran, v.r., (bentazone, 480 g/l), "BASF AG" of rice crops in the tillering phase, with a consumption rate of 2.0-4.0 l/ha and a working fluid consumption of 200-300 l/ha                                                                                     | Self-propelled sprayer IBIS-2500-18P                                             |
| 26  | Spraying of seedlings of young seedlings of BAS "Albid" at the end of tillering before the start of emergence into the tube at a dose of 30 mg/ha to prevent lodging                                                                                                                                     | Self-propelled sprayer IBIS-2500-18P                                             |
| 27  | Introduction of microelements into the tillering phase of rice by the method of fertigation through a drip irrigation system with the norm N\textsubscript{30} kg a.d./ha                                                                                                          | Drip irrigation system                                                         |
| 28  | Treatment with fungicides in the phase of entering the tube for prophylaxis (blast, fusarium, septoria), Kolosal, EC (250 g/l) rate 0.75 l / ha                                                                                                                                                   | Self-propelled sprayer IBIS-2500-18P                                             |
| 29  | Rice harvesting                                                                                                                                                                                                                                                                                                                                     | Harvester Don 1500                                                             |
| 30  | Transfer of rice seeds                                                                                                                                                                                                                                                                                                                               | Kamaz grain carrier 6360                                                        |
| 31  | Presowing soaking of tomato seeds in Fitosporin-M universal (paste) for 1-2 hours at a rate of 1 drop per 100 g                                                                                                                                                                                | Manually                                                                       |
| 32  | Planting tomato seeds (variety Zagadka) 55-60 days before planting in open ground, planting is carried out in containers with a depth of 8-10 cm filled with soil consisting of fine-grained sand, peat and humus with soddy soil in a ratio of 1:1:1:1, respectively, after which grooves 2-3 cm deep are made at a distance of 4 cm each, into which the seeds are laid out and sprinkled with a thin layer of earth with light compaction and watering, then the containers are covered with transparent polyethylene, while the following air temperature regime is maintained in the room: the first seven days after the emergence of seedlings during the day 17°C (± 2°C) at night 14°C (± 2°C), then to the phase of 2-3 true leaves during the day 22°C (± 2°C) at night 18°C (± 2°C), soil temperature day and night and 15°C (± 2 0C) in the first week after germination, while when the first sprouts appear, the film is removed from the containers, at the same time, during the cultivation of seedlings, two fertilizing with mineral fertilizers "Intermag vegetable garden" are performed: the first at the phase of the 2nd present sheet, the second at the phase of the 3rd present sheet with the norm of 1 tbsp. spoon for 3 liters of water, at the same time, during the cultivation of seedlings, two fertilizing with mineral fertilizers "Intermag vegetable garden" are performed: the first at the phase of the 2nd true leaf, the second at the phase of the 3rd true leaf with a rate of 1 tbsp. spoon for 3 liters of water, while throughout the cultivation of seedlings, soil moisture is maintained within 70-75% of the PPV, the recommended water temperature is 20°C (± 2°C). | Manually |
|   |   |
|---|---|
| 33 | After the appearance of 2-3 true leaves, tomato seedlings are picketed into peat cups, while it is necessary to maintain a distance between seedlings of at least 15 cm from each other, while the following temperature regime is maintained in the room: during the first three days after the emergence of seedlings in the daytime 21 °C (± 1° C) at night 17 °C (± 1° C), then in the daytime 19 °C (± 1° C) at night 15° C (± 1° C), at the same time, during the cultivation of seedlings, three additional fertilizing with mineral fertilizers "Intermag Ogorod" is carried out: the first after 12 days after picking the norm of 2 tbsp. tablespoons per 10 liters of water, the second 10-12 days after the first feeding with the rate of 1 tbsp. spoon for 10 liters of water, the third 10 days before planting in the ground while throughout the cultivation of seedlings, soil moisture is maintained within 65-70% of the PPV. |
|   | Manually |
| 34 | Cutting 2-3 lower true leaves 2-3 days before planting tomato seedlings, to improve the development of the first flower cluster and reduce the likelihood of diseases, while the leaf cut is made so that stumps remain 1.5-2.0 cm long and disappear by themselves after drying |
| 35 | Pre-planting irrigation with the introduction of mineral fertilizers by fertigation through a drip irrigation system with a rate of 0.5 kg of potassium sulfate with superphosphate and 250-300 g of ammonium nitrate per area of 10 m² with an irrigation rate providing soil moisture of 90% of HB in a layer of 0.4 m |
|   | Drip irrigation system |
| 36 | Planting seedlings in open ground (before planting in open ground, the seedling bush should be at least 20 cm high, have 10 (± 2) well-developed leaves and one or two inflorescences, while the rice stubble is removed and a peat pot is placed in the formed hole with seedlings with powder to the first fox and light compaction of the soil, while a peg 40–50 cm high is placed near each tomato plant, to which the tomato seedlings are tied |
|   | MTZ-1221 |
|   | Platform for harvesting and planting seedlings of vegetables PUO-1A |
| 37 | Drip irrigation of tomatoes through a drip irrigation system during the growing season with the frequency and rate of irrigation, depending on compliance with the condition for ensuring constant moisture in the soil layer of 1 m: 65-70% of the PPV from planting to the beginning of flowering, 75-80% of the PPV in the flowering phase, 80–85% of PPV in the fruiting phase |
|   | Drip irrigation system |
| 38 | 3-4 times spraying tomato plants with the fungicide "Ridomilgold" in the form of a working solution of standard concentration (0.5%) - 5 g per 1 l of water with an interval of 1-2 weeks, regardless of the causative agent and the affected crop during the growing season to combat with fungal diseases from the consumption rate of working fluid 1 liter per 20 m² to combat fungal diseases, while the waiting period from the last treatment to harvesting the fruits is 14 days |
|   | Self-propelled sprayer IBIS-2500-18P |
| 39 | Spraying of crops in the phase of 2–4 leaves in weeds, regardless of the phase of development of the tomato culture with pesticides Panther, EC (40 g / l) or Bagheera, EC (40 g/l) with a rate of 0.75–1.0 l (kg) / ha for the control of annual cereals (chicken millet, field sorghum, bristle grass) weeds |
|   | Self-propelled sprayer IBIS-2500-18P |
| 40 | Spraying of crops at a weed height of 10-15 cm, regardless of the phase of culture development with pesticides Panther, EC (40 g / l) or Bagira, EC (40 g / l) with a rate of 1.0-1.5 l (kg) / ha for control with perennial cereal (wheatgrass creeping) weeds |
|   | Self-propelled sprayer IBIS-2500-18P |
| No. | Description                                                                                                                                                                                                 | Equipment/Tools                                                                 | Notes                  |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|------------------------|
| 41  | Spraying the soil before planting seedlings. Working fluid consumption - 200-300 l/ha with pesticides Zino, SP (700 g/kg) with a rate of 1.1-1.4 l(kg)/ha to combat annual dicotyledonous and cereal weeds | Self-propelled sprayer IBIS-2500-18P                                           |                        |
| 42  | Spraying weeds with pesticides 15–20 days after planting seedlings in the ground. Working fluid consumption - 200-300 l/ha with pesticides Zino, SP (700 g/kg) at a rate of 1.0 l(kg)/ha to combat annual dicotyledonous and cereal weeds | Self-propelled sprayer IBIS-2500-18P                                           |                        |
| 43  | Protection of crops from pests with the insecticide Aktara, VDG in two ways: under the root by the method of fertigation through a drip irrigation system with a consumption rate of 0.4 kg/ha and a working fluid consumption of 2500-5000 l/ha; spraying during the growing season with the rate of consumption of the drug 0.08-0.12 kg/ha and the consumption of working fluid 200-400 l/ha | Under the root – drip irrigation system Spraying – Self-propelled sprayer IBIS-2500-18P |                        |
| 44  | Tomato harvest                                                                                                                                                                                             | MTZ-1221                                                                      | Platform for harvesting and planting seedlings of vegetables PUO-1A |
| 45  | Cleaning of plastic mulch film and drip tape                                                                                                                                                                | MTZ-1221                                                                      | GDM EzyLift Plastic Mulch Lifter                                  |
| 46  | Preservation and dismantling of the drip irrigation system, including the fertigation system (without removing the drip tape)                                                                             | Manually                                                                      |                        |
| 47  | Removal of elements of the drip irrigation and fertigation system                                                                                                                                            | MTZ-1221                                                                      | 2 PTS-4               |
| 48  | Peeling in two tracks to a depth of 0.06-0.08 m                                                                                                                                                            | MTZ-1221                                                                      | LDS-2,5               |
|     | **Spring-Autumn 2017**                                                                                                                                                                                    |                                                                               |                        |
| 49  | Restoring the geometry of ridges                                                                                                                                                                           | DT-75M                                                                      | MK-17                 |
| 50  | Rolling the soil of the ridges                                                                                                                                                                             | MTZ-1221                                                                      | KVG-1,4               |
| 51  | Delivery of drip irrigation and fertigation system elements (pumps, filters for fine and coarse water purification, water meter, liflet hose, drip tape, taps, valves, tees, splitters, plugs, injector, fertilizer tank, etc.) | MTZ-1221                                                                      | 2 PTS-4               |
| 52  | Drip irrigation system assembly including fertigation system (no drip tape laying)                                                                                                                                 | Manually                                                                      |                        |
| 53  | Laying of Netafim drip tapes, water consumption of each dropper 1.8 l/h, diameter and wall thickness of the drip tape - 16 mm and 0.2 mm, respectively, distance between droppers 0.2 m, distance between drip lines - 0.24 m | MTZ-1221                                                                      | Drip irrigation tube unwinder TM "GreenBull"              |
| 54 | Single pre-sowing treatment of seeds with a growth regulator "Albit" at a dose of 50-100 ml/t | Manually |
| 55 | Planting rice seedlings (Rapan variety) in nutrient pots in a phytotron, a mixture of various components is used as a substrate: highly fertile field land, sod land, humus, high peat, coarse sand with the addition of microelements to the substrate before planting rice seeds with a norm of N80P120K60 in kg a.d./ha, the humus content in the substrate is not less than 40%, the substrate density is less than one, the porosity is 60–90%, the air content is not less than 10%. Maintaining the temperature regime: in the daytime 20-24°C, in cloudy weather - 16-18°C, at night - 15-16°C, optimal pre-irrigation humidity - at the level of 55-65% of HB, relative humidity - 60-70%. To maintain a stable regime when these parameters were increased, ventilation was switched on. During the period of growing seedlings, the lighting was controlled using fluorescent lamps and turned off at night. Seedlings in the phase of 2–3 leaves were fed with nitrogen fertilizers in dissolved form at the rate of N40 in kg a.i./ha. Before planting in the ground, the seedlings corresponded to the standard, had 6–7 leaves with a green color, with a well-developed root system and not infected with pests and diseases. | Manually |
| 56 | Pre-planting irrigation with an irrigation rate providing soil moisture of 90% of HB in a layer of 0.6 m | Drip irrigation system |
| 57 | Spraying the soil surface with soil herbicides: "Ordram" 720 EC (5.0 l/ha, treatment rate 1) + Gezagard with a rate of 60–80 ml/10 l of water to combat annual dicotyledonous and cereal weeds | Self-propelled sprayer IBIS-2500-18P – |
| 58 | Shelter of ridges with perforated polyethylene mulch film | MTZ-1221 – |
| 59 | Spraying BAS "Epin Extra" in the norm of 5-6 drops per 0.5 l of water two days before planting seedlings to increase survival rate and increase stress resistance | Cordless sprayer Clever OE-12.5L-N – |
| 60 | Planting rice seedlings | MTZ-1221 – |
| 61 | Drip irrigation of rice through a drip irrigation system during the growing season of rice with the frequency and rate of irrigation depending on compliance with the condition for ensuring constant soil moisture 80% of HB in a layer of 0.4 m | Drip irrigation system |
| 62 | Introduction of microelements after complete survival of rice seedlings (in the phase of 8–9 leaves) by fertigation through a drip irrigation system with a rate of N80P120K60 in kg a.d./ha | Drip irrigation system |
| 63 | Treatment with herbicides Bazagran, v.r., (bentazone, 480 g/l), "BASF AG" of rice crops in the tillering phase, with a consumption rate of 2.0-4.0 l/ha and a working fluid consumption of 200-300 l/ha | Self-propelled sprayer IBIS-2500-18P – |
| 64 | Spraying of seedlings of young seedlings of BAS "Albid" at the end of tillering before the start of emergence into the tube at a dose of 30 mg/ha to prevent lodging | Self-propelled sprayer IBIS-2500-18P – |
| 65 | Introduction of microelements into the tillering phase of rice by the method of fertigation through a drip irrigation system with the norm N30 in kg a.d./ha | Drip irrigation system |
| 66 | Treatment with fungicides in the phase of entering the tube for prophylaxis (blast, fusarium, septoria), Kolosal, EC (250 g/l) rate 0.75 l/ha | Self-propelled sprayer IBIS-2500-18P – |
| 67 | Rice harvesting | Harvester Don 1500 – |
| 68 | Transfer of rice seeds | Kamaz grain carrier 6360 – |
| 69 | Unloading pea seeds from the storage (Prizer variety) | Electric motor + PShP 4A – |
| Table Entry | Description |
|-------------|-------------|
| 70          | Pea seed dressing 2 weeks before planting with Fundazol, 50% c. p. - 2 kg/t, with the addition of microelements to the dressing solution: boric acid - 300 g / t, ammonium molybdate - 250 g / t, with obligatory humidification at a water consumption of 5-10 l/t and the use of adhesives (NaKMC-200 g/t). |
| 71          | Pre-planting irrigation with an irrigation rate providing soil moisture of 80% of HB in a layer of 0.8 m |
| 72          | Spraying with herbicides on vegetative weeds after harvesting the predecessor (rice) to combat perennial cereals: creeping wheatgrass, sow thistle and thistle and dicotyledonous plants. Roundup, 360 g / l f.t.h.; dominator, BP, glyphophan, BP; glialka, 360 g / l f.t.h. and others - 4-6 l/ha or roundup, 360 g / l f.t.h. + 2.4-D - 2 + 1.5-2 l, kg/ha |
| 73          | Treatment of pea seeds on the day of sowing with rhizotorphin at a rate of 1 l/kg per 1 ton or sapronite-1 at a rate of 200 ml per hectare seed rate with the addition of 2 liters of water |
| 74          | Transporting seeds with loading seeders GAZ-SAZ-53B |
| 75          | Planting seed peas to a depth of 4-5 cm MTZ-1221 seeder ForigoModula |
| 76          | Drip irrigation of peas through a drip irrigation system during the growing season with the frequency and rate of irrigation depending on compliance with the condition of ensuring constant soil moisture of 70-80% of HB in a layer of 0.6 m |
| 77          | The introduction of trace elements on the next day after planting peas by fertigation through a drip irrigation system by the norm NaPnPKn |
| 78          | Spraying with herbicide gesagard of the soil before pea shoots. Consumption rate of the drug, 2.5-3.0 l, kg/ha. Working fluid consumption - 200-300 l/ha. For the control of annual dicotyledonous and cereal weeds |
| 79          | Spraying with herbicide of pea crops in the phase of 1-3 leaves by Pulsar, BP (40 g/l) (imazamox) with a consumption rate of 0.75-1.0 kg(l)/ha to combat annual cereals and dicotyledons |
| 80          | Spraying with herbicide of pea crops in the phase of 3-5 leaves Herbitox, VRK (500 g /l MCPP) or Agritox, VK (500 g/l MCPA) with a consumption rate of the drug 0.5-0.8 kg(l)/ha for the control of annual cereals and dicotyledons |
| 81          | Herbicide spraying of pea crops in the phase of 5-6 leaves of Bazagran, BP (480 g/l) (bentazone) or Korsar, VRK (480 g/l) (bentazop) with a consumption rate of 2.0-3.0 kg(l)/ha for the control of annual dicotyledons |
| 82          | Herbicide spraying of crops irrespective of the phase of peas in the phase of 2-4 leaves of annual cereal weeds: Fuzilad Super, EC (125 g/l) (fluazifop-P-butyl) with a consumption rate of 1.0-2.0 kg(l)/ha, Miura, EC (125 g/l) (quizalofop-P-ethyl) with a drug consumption rate of 0.4-0.8 kg(l)/ha, Fuzilad Forte, EC (150 g/l) (fluazifop-P-butyl) with a drug consumption rate of 0.75-1.0 kg(l)/ha |
| 83          | Herbicide spraying of crops regardless of the culture phase at 10-15 cm in wheatgrass: Panther 4% ae. - 1.0-1.5 kg(l)/ha; Targasuper, 5% k.e. - 2.0; fuselade new, 15% k.e. - 1.5-2.0 kg(l)/ha; zellek super, 10.6% ae. - 1.0 kg(l)/ha |
| 84          | Spraying of pea plants in the presence of 13 or more beetles (root weevils) in crops is performed at the phase of the first pair of true leaves with the insecticide Bulldok, EC - 0.3; decis, EC - 0.2; extra decis, EC - 0.04; vismethyl, 25% ae. - 0.3 kg(l)/ha |
| Page | Description |
|------|-------------|
| 85   | Marginal spraying of the strips with insecticides in the budding-flowering phase, at the beginning of settlement, with the number of aphids (pea, vetch, alfalfa, bean) at 30-50 individuals per 10 sweeps of the net: Aktara, VDG-0.1; actellic, CE-1.0; Bi-58 new, 400 g/1 EC - 0.5-1.0 kg(l)/ha; bulldok, EC - 0.3 kg(l)/ha; decis, EC - 0.2 kg(l)/ha; extra decis, EC - 0.04 kg(l)/ha; zolon, EC - 1.4 kg(l)/ha; mospilan, 20% R.p. - 0.2-0.25 kg(l)/ha; rogor S, EC - 1.0-1.5 kg(l)/ha; Sumialfa, 5% ae. - 0.15-0.3 kg(l)/ha; sumicidin, 20% ae. - 0.3 kg(l)/ha; fufanon, 570 g/l EC - 0.5-1.2 kg(l)/ha. Self-propelled sprayer IBIS-2500-18P. |
| 86   | Spraying of pea crops during the growing season when pea thrips is detected with Aktara insecticide, WDG - 0.1 kg(l)/ha. Self-propelled sprayer IBIS-2500-18P. |
| 87   | Spraying of pea crops with an insecticide in the absence of aphids in the crops during the mass summer and egg laying of the pea moth in the budding-flowering phase: Trichogramma twice, 50 thousand individuals per 1 ha. Self-propelled sprayer IBIS-2500-18P. |
| 88   | Spraying pea crops with an insecticide when more than 6 males are caught on a pheromone trap per week during the mass summer and egg laying of the pea moth in the budding-flowering phase: Bi-58 new, 400 g/l aq. - 0.5-1.0 kg(l)/ha; danadim, 400 g/l ae. - 0.8-1.0 kg(l)/ha; rogor S, EC - 0.5-1.0 kg(l)/ha; fufanon, 570 g/l EC - 0.5-1.2 kg(l)/ha. Self-propelled sprayer IBIS-2500-18P. |
| 89   | Spraying pea crops with an insecticide when the first signs of disease appear (gray rot, peronosporosis, ascochitosis) in the budding-flowering phase: Rex, 49.7% c.w. - 0.6 kg(l)/ha + trace elements: copper sulfate, 300 g/ha + zinc sulfate, 350 g/ha; agate-25K - 0.04 kg(l)/ha; sumilex 50% s.p. - 2-3 kg(l)/ha. Self-propelled sprayer IBIS-2500-18P. |
| 90   | Spraying pea crops with an insecticide when the first signs of disease appear (powdery mildew) in the budding-flowering phase: PSK, 25% bw. - 2-4 kg(l)/ha. Self-propelled sprayer IBIS-2500-18P. |
| 91   | Desiccation of pea crops 7-10 days before harvesting is performed at the yellowing phase of 2/3 of the beans on the plant for pre-harvest drying of the harvested mass and reducing the moisture content of pea seeds by 20–25%, super raglon, BP - 2 l/ha; basta, VR - 1-2 l/ha; roundup, 360 g/l f.th. - 3-4 l/ha. Working fluid consumption - 200 l/ha. Self-propelled sprayer IBIS-2500-18P. |
| 92   | Peas harvest. Harvester Don 1500. |
| 93   | Removal of pea seeds. Kamaz grain carrier 6360. |
| 94   | Cleaning of plastic mulch film and drip tape. MTZ-1221, GDM EzyLift Plastic Mulch Lifter. |
| 95   | Preservation and disassembly of the drip irrigation system, including the fertigation system (without removing the drip tape). Manually. |
| 96   | Removal of elements of the drip irrigation and fertigation system. MTZ-1221, 2 PTS-4. |
| 97   | Peeling in two tracks to a depth of 0.06-0.08 m. MTZ-1221, LDS-2,5. |
| 98   | Restoring the geometry of ridges. DT-75M, MK-17. |
| 99   | Rolling the soil of the ridges. MTZ-1221, KVG-1,4. |
| 100  | Delivery of drip irrigation and fertigation system elements (pumps, filters for fine and coarse water purification, water meter, liflet hose, drip tape, taps, valves,tees, splitters, plugs, injector, fertilizer tank, etc.). MTZ-1221, 2 PTS-4. |
|   | Description                                                                                       | Method          | Equipment/Method          |
|---|--------------------------------------------------------------------------------------------------|-----------------|----------------------------|
| 101| Drip irrigation system assembly including fertigation system (no drip tape laying)              | Manually        |                            |
| 102| Laying of Netafim drip tapes, water consumption of each dropper 1.8 l/h, diameter and wall thickness of the drip tape - 16 mm and 0.2 mm, respectively, distance between droppers 0.2 m, distance between drip lines - 0.24 m | MTZ-1221        | Drip irrigation tube unwinder TM “GreenBull” |
| 103| Single pre-sowing treatment of seeds with a growth regulator “Albit” at a dose of 50-100 ml/t   | Manually        |                            |
| 104| Planting rice seedlings (Rapan variety) in nutrient pots in a phytotron, a mixture of various components is used as a substrate: highly fertile field land, sod land, humus, high peat, coarse sand with the addition of microelements to the substrate before planting rice seeds with a norm of N80P120K60 in kg a.d./ha, the humus content in the substrate is not less than 40%, the substrate density is less than one, the porosity is 60–90%, the air content is not less than 10%. Maintaining the temperature regime: in the daytime 20-24° C, in cloudy weather - 16-18° C, at night - 15-16° C, optimal pre-irrigation humidity - at the level of 55-65% of HB, relative humidity - 60-70%. To maintain a stable regime when these parameters were increased, ventilation was switched on. During the period of growing seedlings, the lighting was controlled using fluorescent lamps and turned off at night. Seedlings in the phase of 2–3 leaves were fed with nitrogen fertilizers in dissolved form at the rate of N40 in kg a.i./ha. Before planting in the ground, the seedlings corresponded to the standard, had 6–7 leaves with a green color, with a well-developed root system and not infected with pests and diseases. | Manually        |                            |
| 105| Pre-planting irrigation with an irrigation rate providing soil moisture of 90% of HB in a layer of 0.6 m | Drip irrigation system |                            |
| 106| Spraying the soil surface with soil herbicides: "Ordram" 720 EC (5.0 l/ha, treatment rate 1) + Gezagard with a rate of 60–80 ml/ 10 l of water to combat annual dicotyledonous and cereal weeds | Self-propelled sprayer IBIS-2500-18P |                            |
| 107| Shelter of ridges with perforated polyethylene mulch film                                         | MTZ-1221        |                            |
| 108| Spraying BAS "Epin Extra" in the norm of 5-6 drops per 0.5 l of water two days before planting seedlings to increase survival rate and increase stress resistance | Cordless sprayer Clever OE-12.5L-N |                            |
| 109| Planting rice seedlings                                                                          | MTZ-1221        |                            |
| 110| Drip irrigation of rice through a drip irrigation system during the growing season of rice with the frequency and rate of irrigation depending on compliance with the condition for ensuring constant soil moisture 80% of HB in a layer of 0.4 m | Drip irrigation system |                            |
| 111| The introduction of microelements after complete survival of rice seedlings (in the phase of 8-9 leaves) by fertigation through a drip irrigation system is normal N10P10K10 in a.d./ha | Drip irrigation system |                            |
| 112| Treatment with herbicides Bazagran, v.r., (bentazone, 480 g/l), "BASF AG" of rice crops in the tillering phase, with a consumption rate of 2.0-4.0 l/ha and a working fluid consumption of 200-300 l/ha | Self-propelled sprayer IBIS-2500-18P |                            |
| 113| Spraying of seedlings of young seedlings of BAS "Albid" at the end of tillering before the start of emergence into the tube at a dose of 30 mg / ha to prevent lodging | Self-propelled sprayer IBIS-2500-18P |                            |
| 114| Introduction of microelements into the tillering phase of rice by the method of fertigation through a drip irrigation system with the norm N10 in kg a.d./ha | Drip irrigation system |                            |
| 115| Treatment with fungicides in the phase of coming out into the tube for prophylaxis (blast, fusarium, septoria), Kolosal, EC (250 g/l) rate 0.75 l/ha | Self-propelled sprayer IBIS-2500-18P |                            |
| Page | Description | Equipment/Method | Notes |
|------|-------------|------------------|-------|
| 116  | Rice harvesting | Harvester Don 1500 | – |
| 117  | Transfer of rice seeds | Kamaz grain carrier 6360 | – |
| 118  | Presowing soaking of pepper seeds of the "Red Bison" variety for 2-3 days, while at the last hour the pepper seeds are soaked in a solution of the biological product Fitosporin-M with a rate of 1.5 g per 1 l of water | Manually |
| 119  | Planting pepper seeds 50–65 days before planting in open ground, planting is carried out in peat cups with a cross section of at least 100 mm to a depth of 0.5–1.0 cm in "BIO Soil Ecoflora for Vegetables" from "Hera" and then covered with foil at the same time, it is necessary to observe the distance between the seedlings at least 15 cm from each other, while the temperature in the soil is maintained at 27° C (± 20° C), the air temperature before the emergence of shoots is 28 ° C around the clock, then after the emergence of shoots until the formation of the 1st leaf 17° C (± 1° C) around the clock, in the next plant phases during the day 23-28° C, at night 16-17° C, the temperature of irrigation water is 25-30° C; at the same time, during the growing of seedlings, fertilizing is performed, while for the first time fertilizers are applied at the emergence phase 1– 2 real sheets with the following composition: dilute 5 grams in 10 liters of water ammonium nitrate, 10 g potassium-based dressings, 30 g superphosphate fertilizers. The next feeding is in two weeks according to the same scheme, but with a doubling of the dosage. The third feeding is performed a couple of days before planting the seedlings, in which the dosage of potassium in the solution is increased to 80 g per 10 l of water, while during the growth of seedlings, soil moisture is maintained at 70% of HB, and before planting in the ground, 75% of HB. | Manually |
| 120  | Treatment with a pesticide (systemic fungicide) propamocarb hydrochloride 3-4 days before planting seedlings at a concentration of 607 g/l and a consumption rate of 15 ml per 10 l of water to combat soil, root and leaf diseases | Drip irrigation system |
| 121  | Application of herbicide Treflan, 24% (3.6-4.8 l/ha) 12-14 days before planting seedlings to combat annual cereals and a number of dicotyledonous weeds | Drip irrigation system |
| 122  | Pre-planting irrigation with the introduction of mineral fertilizers based on potassium, nitrogen and phosphates at the rate of 30 grams per 1 m² by fertigation through a drip irrigation system and an irrigation rate providing soil moisture of 90% of HB in a layer of 0.8 m | Drip irrigation system |
| 123  | Planting seedlings in open ground (a bush of seedlings before planting in open ground should be at least 20 cm high, have up to 12 well-developed leaves and developing inflorescences, and the crown bud should be removed), while the rice stubble is removed and a peat bush is placed in the formed hole a pot of pepper seedlings with a light compaction of the soil | MTZ-1221 Platform for harvesting and planting seedlings of vegetables PUO-1A |
| 124  | Introduction of biostimulants for the development of the root system 10-12 days after transplanting pepper seedlings at the rate of 30 ml / 10 l of water with an interval of 10-12 days | Drip irrigation system |
| 125  | Introduction of biopreparations and growth stimulants 10-12 days after transplanting pepper seedlings at the rate of 30 ml / 10 l of water and then at the same rate every 5-10 days to protect plants from stress | Drip irrigation system |
| No. | Description                                                                 | Equipment/Method                                                                 |
|-----|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| 126 | Foliar application on the Omex 3X leaf (50 ml/10 l of water) at intervals of 3-7 days | Self-propelled sprayer IBIS-2500-18P                                               |
| 127 | Top dressing with ammonium nitrate 75 g/10 l of water at intervals of 3-7 days | Drip irrigation system                                                            |
| 128 | Two-time spraying with Fitoverma insecticide (thrips, mealybug and spider mite), consumption of 10 ml per 1 liter of water | Self-propelled sprayer IBIS-2500-18P                                               |
| 129 | Single spraying with an insecticide (aphid), the consumption of the product is 8 ml per 1 liter of water. | Self-propelled sprayer IBIS-2500-18P                                               |
| 130 | Drip irrigation of sweet pepper through a drip irrigation system during the growing season with the frequency and rate of irrigation depending on compliance with the condition for ensuring constant moisture in the soil layer 0.8-0.9 m: 80% of HB during the growing season | Drip irrigation system                                                            |
| 140 | Mineral fertilization during planting N80P160K240 (ratio NPK 1:2:3) then a week further after the first cleaning and then every week N25P25K25 | Drip irrigation system                                                            |
| 141 | Boron introduction at the rate of 25-30 ml / 10 l of water in the flowering phase | Drip irrigation system                                                            |
| 142 | Application of mineral fertilizers on a leaf - leaf microfertilizers 5:15:45 (25 g / 10 l of water) with an interval of 4-10 days | Self-propelled sprayer IBIS-2500-18P                                               |
| 143 | Harvesting sweet peppers                                                     | MTZ-1221                                                                          |
| 144 | Cleaning of polyethylene mulching film and / or drip tape                    | MTZ-1221                                                                          |
| 145 | Preservation and dismantling of the drip irrigation system, including the fertigation system (without cleaning from the drip tape ridges) | Manually                                                                          |
| 146 | Removal of elements of the drip irrigation and fertigation system            | MTZ-1221                                                                          |
| 147 | Peeling in two tracks to a depth of 0.06-0.08 m                              | MTZ-1221                                                                          |
|     |                                                                              | LDS-2,5                                                                          |
|     |                                                                              | Spring-Autumn 2019                                                                |
| 148 | Restoring the geometry of ridges                                             | DT-75M                                                                            |
| 149 | Rolling the soil of the ridges                                               | MTZ-1221                                                                          |
| 150 | Delivery of elements of the drip irrigation and fertigation system (pumps, filters for fine and coarse water purification, water meter, lifelet hose, drip tape, taps, valves, tees, splitters, plugs, injector, fertigation container) | MTZ-1221                                                                          |
| 151 | Drip irrigation system assembly including fertigation system (no drip tape laying) | Manually                                                                          |
| 152 | Laying of Netafim drip tapes, water consumption of each dropper 1.8 l/h, diameter and wall thickness of the drip tape - 16 mm and 0.2 mm, respectively, distance between droppers 0.2 m, distance between drip lines - 0.24 m | MTZ-1221                                                                          |
| 153 | Single pre-sowing treatment of seeds with a growth regulator "Albit" at a dose of 50-100 ml/t | Manually                                                                          |
Planting rice seedlings (Rapan variety) in nutrient pots in a phytotron, a mixture of various components is used as a substrate: highly fertile field land, sod land, humus, high peat, coarse sand with the addition of microelements to the substrate before planting rice seeds by the norm N₈₀P₁₂₀K₆₀ in kg a.d./ha, humus content in the substrate is not lower 40%, the density of the substrate is less than one, the porosity is 60–90%, the air content is not less than 10%.

Maintaining the temperature regime: during the day 20-24°C, in cloudy weather - 16-18°C, at night - 15-16°C, optimal pre-irrigation humidity - at the level of 55-65% of HB, relative air humidity - 60-70%. To maintain a stable regime when these parameters were increased, ventilation was switched on. During the period of seedling growing, the lighting was controlled using fluorescent lamps and turned off at night. Seedlings in the phase of 2–3 leaves were fed with nitrogen fertilizers in dissolved form at the rate of N₄₀ in kg a.d./ha. Before planting in the ground, the seedlings corresponded to the standard, had 6–7 leaves with a green color, with a well-developed root system and not infected with pests and diseases.

| Step | Description | Equipment/Procedure |
|------|-------------|---------------------|
| 154  | Pre-planting irrigation with an irrigation rate providing soil moisture of 90% of HB in a layer of 0.6 m | Drip irrigation system |
| 155  | Spraying the soil surface with soil herbicides: "Ordram" 720 EC (5.0 l/ha, treatment rate 1) + Gezagard with a rate of 60–80 ml / 10 l of water to combat annual dicotyledonous and cereal weeds | Self-propelled sprayer IBIS-2500-18P |
| 156  | Shelter of ridges with perforated polyethylene mulch film | MTZ-1221 |
| 157  | Spraying BAS "Epin Extra" in the norm of 5-6 drops per 0.5 l of water two days before planting seedlings to increase survival rate and increase stress resistance | Cordless sprayer Clever OE-12.5L-N |
| 158  | Drip irrigation of rice through a drip irrigation system during the growing season of rice with the frequency and rate of irrigation depending on compliance with the condition for ensuring constant soil moisture 80% of HB in a layer of 0.4 m | Drip irrigation system |
| 159  | Drip irrigation of rice through a drip irrigation system during the growing season of rice with the frequency and rate of irrigation depending on compliance with the condition for ensuring constant soil moisture 80% of HB in a layer of 0.4 m | Drip irrigation system |
| 160  | The introduction of microelements after complete survival of rice seedlings (in the phase of 8-9 leaves) by fertigation through a drip irrigation system by the norm N₃₀P₃₀K₃₀ in kg a.d./ha | Drip irrigation system |
| 161  | Treatment with herbicides Bazagran, v.r., (bentazone, 480 g/l), "BASF AG" of rice crops in the tillering phase, with a consumption rate of 2.0-4.0 l/ha and a working fluid consumption of 200-300 l/ha | Self-propelled sprayer IBIS-2500-18P |
| 162  | Spraying of seedlings of young seedlings of BAS "Albid" at the end of tillering before the start of emergence into the tube at a dose of 30 mg/ha to prevent lodging | Self-propelled sprayer IBIS-2500-18P |
| 163  | Introduction of microelements into the tillering phase of rice by the method of fertigation through a drip irrigation system with the norm N₁₀ in kg a.d./ha | Drip irrigation system |
| 164  | Treatment with fungicides in the phase of entering the tube for prophylaxis (blast, fusarium, septoria), Kolosal, EC (250 g/l) rate 0.75 l/ha | Self-propelled sprayer IBIS-2500-18P |
| 166  | Rice harvesting | Harvester Don 1500 |
| 167  | Transfer of rice seeds | Kamaz grain carrier 6360 |
| 168  | Unloading soybean seeds from storage (Irbis variety) | Electric motor + PShP 4A |
Treating soybean seeds with a fungicide on the day of sowing with Fundazol, SP (Agro-Kemi Kft.) (500 g/kg), application rate 3 kg/t or MAXIM, KS (Syngenta LLC) (25 g/l) with consumption working fluid 7–8 l/t with obligatory moistening at a water consumption of 5–10 l/t and the use of adhesives (NaKMTs-200 g/l).

Presowing treatment of soybean seeds with Agropon C growth regulators, HRV (1 g/l), working fluid consumption 10 l/t to enhance growth and development processes, increase seed yield, increase fat and protein content and/or Mival Agro, KRP (760 + 190 g/kg) at a rate of 15 g/t to increase the number of beans per plant and increase yields.

Pre-planting irrigation with an irrigation rate providing soil moisture of 80% of HB in a layer of 0.8 m.

Spraying with herbicides Trophy 90, EC (900 g/l) before sowing (with incorporation with a lack of moisture) or before crop sprouting with a rate of application of 1.5-2.0 l/ha with a working fluid flow rate of 200-300 l/ha to combat with annual cereals and some dicotyledonous weeds.

Transportation of soybean seeds with loading seeders GAZ-SAZ-53B.

Planting seed soybeans to a depth of 2-3 cm MTZ-1221 seeder ForigoModula.

Drip irrigation of soybeans through a drip irrigation system during the growing season with the frequency and rate of irrigation depending on compliance with the condition of ensuring constant soil moisture of 70-80% of HB in a layer of 0.6 m.

Application of mineral fertilizers on the next day after planting soybeans by the method of fertigation through a drip irrigation system as normal N20P30K60.

Spraying with herbicides Bazagran, BP (480 g/l) starting from the phase of the 1st true leaf of the culture in the early phases of weed growth (2–6 leaves), the application rate is 1.5–3.0 l/ha with a flow rate of the working fluid - 200–300 l/ha for control of annual dicotyledonous weeds, incl. cocklebur.

Spraying with herbicides Zellek-super, EC (104 g/l) during the period of their active growth in the phase from 2 leaves to tillering (regardless of the phase of crop development) with a rate of application of 0.5 l/ha with a working fluid consumption of 200-300 l/ha for the control of annual dicotyledonous weeds, incl. cocklebur.

Spraying with herbicides Fusilad Forte, EC (150 g/l) in the phase of 2–4 leaves (regardless of the phase of crop development) with a rate of application of 0.75–2.0 l/ha with a working fluid consumption of 200–300 l/ha to combat with annual and perennial cereal weeds.

Spraying with herbicides Galaktion, EC (104 g/l) during the period of their active growth (in the phase from 2-6 leaves to tillering) with a rate of application of 0.5 l/ha with a working fluid consumption of 200-300 l/ha for fight against annual millet (chicken millet, weed-field millet, types of bristles).

The introduction of microelements "Meristem NPK 20:20:20" at the budding phase by fertigation through a drip irrigation system at a rate of 1.0–2.0 kg/ha.

Drip irrigation system.

Self-propelled sprayer IBIS-2500-18P.
3 Results and its discussion

As a result of approbation of the method of rice cultivation on checks of the rice irrigation system with drip irrigation under polyethylene and biodegradable mulching perforated film, it was possible to prove the effectiveness of not only rice cultivation (Table 2), but also rice crop rotation crops (Table 3).
Table 2. Quantitative, qualitative and biological characteristics of the Rapan rice variety.

| № | Name                                      | 2016  | 2017  | 2018  | 2019  |
|---|-------------------------------------------|-------|-------|-------|-------|
| 1 | Vegetation period                         | 117   | 119   | 118   | 120   |
| 2 | Panicle height, cm                        | 90,4  | 90,8  | 91,4  | 91,2  |
| 3 | Panicle length, cm                        | 17,6  | 18,3  | 18,8  | 18,9  |
| 4 | The number of spikelets in a panicle, pcs. | 204   | 208   | 210   | 215   |
| 5 | Number of grains, pcs.:                   |       |       |       |       |
|   | – general                                 | 75    | 77    | 79    | 82    |
|   | – empty                                   | 2     | 2     | 1     | 1     |
| 6 | Emptyness, %                              | 2,6   | 2,2   | 1,8   | 1,5   |
| 7 | Caryopsis length to width ratio (l/b)     | 1,9   | 2,0   | 2,1   | 2,2   |
| 8 | Weight g/plant:                           |       |       |       |       |
|   | – grain                                   | 2,5   | 2,6   | 2,6   | 2,6   |
|   | – straw                                   | 2,3   | 2,3   | 2,3   | 2,4   |
| 9 | Straw to grain ratio                      | 0,92  | 0,88  | 0,88  | 0,92  |
| 10| Weight of 1000 grains, g                  | 28    | 27    | 29    | 30    |
| 11| Productivity, t/ha                       | 11,3  | 11,6  | 12,1  | 13,4  |
| 12| Yield control, t/ha                       | 10,5  | 10,7  | 10,8  | 10,5  |
| 13| Increase in yield                         |       |       |       |       |
|   | – t/ha                                    | 0,8   | 0,9   | 1,3   | 2,9   |
|   | – %                                       | 7,1   | 7,8   | 10,7  | 21,6  |

Table 3. Characteristics of the accompanying crop – peas.

|                          | Tomato - variety Riddle, kg/m² | Peas – variety Prizer, c/ha | Sweet pepper - variety Bison, kg/m² | Lupine - variety Irbis, c/ha |
|--------------------------|---------------------------------|-----------------------------|-------------------------------------|-----------------------------|
|                          | 22                              | 45,6                        | 7,5                                 | 26,8                        |

The use of the claimed method of rice cultivation made it possible to improve the reclamation state of soils (Table 4).

Table 4. The dynamics of the reclamation state of soils in the experimental field in LLC "Chernoerkovskoe" of the Slavyansky district of the Krasnodar Territory, with an area of 4.5 hectares for 2016–2019 when cultivating rice on drip irrigation under mulching perforated film.

| № indicator | Name                                      | Indicator unit   | Year research | Indicator value | Assessment of the reclamation state of soils |
|-------------|-------------------------------------------|------------------|---------------|-----------------|---------------------------------------------|
| 1           | Groundwater level / Groundwater salinity  | m/(g/l)          | 2016          | 1,5             | 1                                           |
|             |                                            |                  | 2017          | 1,6             | 1                                           |
|             |                                            |                  | 2018          | 1,7             | 1                                           |
|             |                                            |                  | 2019          | 1,8             | 1                                           |
| 2           | Soil pH                                   | -                | 2016          | 6,7             | 1                                           |
|             |                                            |                  | 2017          | 6,8             | 1                                           |
|             |                                            |                  | 2018          | 7,0             | 1                                           |
|             |                                            |                  | 2019          | 7,0             | 1                                           |
| 3           | Humus content                             | %                | 2016          | 3,9             | 4                                           |
|             |                                            |                  | 2017          | 3,9             | 4                                           |
|             |                                            |                  | 2018          | 4,0             | 3                                           |
|             |                                            |                  | 2019          | 4,2             | 3                                           |
|   | Description                                                                 | Unit         | 2016   | 2017   | 2018   | 2019   |
|---|-----------------------------------------------------------------------------|--------------|--------|--------|--------|--------|
| 4 | Humus reserves in the layer 0-100 cm                                        | t/ha         | 184    | 189    | 194    | 202    |
| 5 | Hydrolysable nitrogen supply (according to Tyunin - Kononova)               | mg/100 g     | 4.9    | 5.3    | 5.4    | 5.7    |
| 6 | Availability of mobile phosphorus (according to Chirikov)                   | mg/100 g     | 4.2    | 4.6    | 5.0    | 5.2    |
| 7 | Availability of mobile potassium (according to Chirikov)                    | mg/100 g     | 3.5    | 3.8    | 4.1    | 4.8    |
| 8 | Enrichment with nitrogen C:N                                               | -            | 11.2   | 10.3   | 9.7    | 9.1    |
| 9 | The content of exchangeable magnesium in the soil (MgO)                     | mg/kg of soil| 57     | 62     | 68     | 74     |
| 10| Sulphate (mobile) sulfur content, S                                          | mg/kg of soil| 9.4    | 9.9    | 10.4   | 10.8   |
| 11| Saturation with bases, V                                                    | %            | 29     | 32     | 38     | 46     |
| 12| Structure factor, K_{str}                                                   | -            | 0.76   | 0.84   | 0.91   | 0.99   |
| 13| Total porosity                                                              | %            | 40     | 47     | 53     | 61     |
| 14| Soil density (according to N.A.Kachinsky)                                   | g/sm³        | 1.30   | 1.26   | 1.21   | 1.17   |
| 15| Soil nitrification capacity                                                 | mg N03/kg    | 19.0   | 24.0   | 29.0   | 34.0   |
| 16| Content of water-resistant aggregates in a layer of 0-30 cm                 | %            | 22     | 28     | 35     | 41     |
### 17 Salt content / Salinity type

|       | 2016 | 2017 | 2018 | 2019 |
|-------|------|------|------|------|
| % / - | 1,4  | 1,3  | 1,1  | 0,8  |

### 18 The "cumulative effect" of toxic CO$_3^{2-}$, HCO$_3^{-}$, Cl$^-$, SO$_4^{2-}$ (N. I. Bazilevich, E. I. Pankova)

|       | 2016 | 2017 | 2018 | 2019 |
|-------|------|------|------|------|
| mg Cl$^-$ | 1,94 | 1,76 | 1,43 | 1,08 |

### 19 Issue rate of CO$_2$ in soil

|       | 2016 | 2017 | 2018 | 2019 |
|-------|------|------|------|------|
| mg CO$_2$/ (10 g/day) | 9,8  | 11,4 | 13,9 | 15,6 |

### Trace element content:

| Tracy element | 2016 | 2017 | 2018 | 2019 |
|---------------|------|------|------|------|
| Manganese (Mn) (in 0,1 n. H$_2$O$_4$) | 19   | 21   | 24   | 26   |
| Cuprum (Cu) (in 0,1 n. KCl) | 1,80 | 2,10 | 2,40 | 2,50 |
| Zinc (Zn) (in 0,1 n. KCl) | 0,40 | 0,60 | 0,80 | 1,10 |
| Cobalt (Co) (in 0,1 n. HNO$_3$) | 1,10 | 1,40 | 1,80 | 2,10 |
| Molybdenum (Mo) (in the extract of oxalate) | 0,18 | 0,21 | 0,25 | 0,28 |

### The sum of the points of the indicators of the reclamation state of the soil / Assessment of the reclamation state of the soil

|       | 2016 | 2017 | 2018 | 2019 |
|-------|------|------|------|------|
|       | 71   | 64   | 59   | 48   |

**4 Output**

The efficiency of the developed technology of cultivation of rice on drip irrigation under polyethylene and mulching perforated film on the lands of the irrigation fund has been proved.
The main performance indicators are:
- reduction of the irrigation rate by 5.3 times relative to the traditional technology of rice cultivation by flooding;
- improvement of the reclamation state of soils;
- reduction of labor intensity on average by 34 %;
- increasing the yield by an average of 20% and the quality of the resulting grain;
- reducing the cost of rice production on average by 15 %;
- decrease in the amount of introduced macro and microelements on average by 30 %;
- increasing profitability by 22%.

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