



# The Effectiveness of Meadow Improvement by Mechanical Processing of Sod in Combination with Other Agricultural Practices in the North-West of the Russian Federation

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## Introduction

For the Northwestern region of Russia, specializing in the production of dairy livestock products, the creation of highly productive meadow agrophytocenoses is of exceptional importance, since the natural conditions here are most consistent with the cultivation of perennial grasses for harvesting herbaceous fodder in a system of green and raw conveyor belts. The decisive role in this issue is played by perennial legumes, which surpass many fodder crops in terms of yield and protein productivity [1]. However, grasses, which are a source of carbohydrates in raw materials, are important in obtaining a balanced feed.

At the end of the twentieth century, its intensification based on the use of high doses of mineral nitrogen fertilizers and the multi-axis use of grass stands was relevant in meadow forage production [2]. Currently, in conditions of limited resource availability, including mineral nitrogen fertilizers, the solution to the feed problem should be based on biologization, due to a more complete use of the potential of the plants themselves [3].

The transformation of unproductive forage lands into high-yielding cultivated meadows by surface improvement techniques is currently one of the main tasks of the region's forage production. At the same time, the elimination of protein deficiency, mainly due to the lack of legumes in the herbage, remains an urgent problem in providing livestock with high-grade feed. The range of high-protein forage crops can complement the eastern goat, which is characterized by high environmental friendliness combined with high longevity, but it develops very slowly in the first years after sowing, and therefore it is difficult to create highly productive herb stands from the first years of use based on the eastern goat [4].

Among cereal grasses, meadow foxtail is a particular problem in creating highly productive meadows, which is also characterized by high longevity and high nutritional value, but due to the morphological characteristics of the seeds, it is practically not cultivated in the farms of the region.

In this regard, the use and improvement of long-lived legume stand with eastern goat and grass stands with meadow foxtail in the conditions of the North-West of the Russian Federation is currently a problematic and urgent issue and represents a scientific novelty.

## The purpose and objectives of the research

The purpose of the research is to scientifically substantiate the methods of surface improvement of old-seeded meadows created on the basis of eastern goatgrass and meadow foxtail to increase the content of valuable forage species in herb stands, ensuring an increase in their yield and nutritional value.

### To achieve this goal, the following tasks were solved:

- To study the process of transformation of old-age grass of meadow foxtail through mechanical processing of turf by disketing and the use of mineral fertilizers, and eastern goat grass by disketing in combination with sowing of grass seeds;
- Determine the impact of the studied improvement techniques on yield and species composition
- The studied herbage;

- To evaluate the forage value of improved experimental herbage;

### Conditions, objects and methods of research

The research was conducted on 2 experiments. The object of research in the 1<sup>st</sup> experiment was the seeded grass of the meadow foxtail of the 18<sup>th</sup> year of use. In the experiment, the effect of mechanical processing of the turf of the old-seeded grass of the meadow foxtail (*Alopecurus pratensis*) in combination with the use of different doses of mineral nitrogen was studied. The object of research in the 2<sup>nd</sup> experiment was the seeded herbage of the eastern goat (*Galega orientalis*) for 10 years of use. In the experiment, the effectiveness of surface improvement of the herbage by mechanical processing of turf and seeding of grasses was studied. The studied herbage was created by a graduate student of the department, G.E. Vysotsky, in 2003 by sowing seeds of the eastern goat variety Nadezhda in its pure form. By 2013, i.e. for the 10th year of use, this experimental herbage was heavily clogged, even with such a malicious species as Sosnovsky hogweed.

Experiments on the study of techniques for the surface improvement of old-seeded grass stands of meadow foxtail and Eastern goat grass were launched at the small experimental field of the Department of Agriculture and Meadow Breeding of St. Petersburg State Agrarian University in 2013.

### Scheme and methodology of research

The scheme of the experiment on the study of techniques for the superficial improvement of the old-seeded grass of the meadow foxtail included the following options:

1. Control – without treatment and fertilizers
2. Disking in 2 tracks (2013) – (without fertilizers)
3. Disking in 2 tracks (2013) + R60K60 (annually)
4. Disking in 2 tracks (2013) + N60P60K60 (annually)
5. Disking in 2 tracks (2013) + N90P60K60 (annually)
6. Disking in 2 tracks (2013) + N120P60K60 (annually)

The area of the experimental plot is 10m<sup>2</sup>, the repetition is fivefold. Mechanical processing of the sod of the studied herbage was carried out with a BDT-1.5 disc harrow in early May (May 5, 2013) in two tracks. After the disketing, the butchered turf was rolled up. It should be noted that due to the improvement of the soil air regime, there was a sharp outbreak of weeds due to invasion, therefore, a month after the treatment, the weeds were mowed down, after which the experiment was divided according to the scheme.

Scheme II of the experiment on the old-seeded herbage of the eastern goatgrass included the following options:

1. Disking in 2 tracks (2013) – control;
2. Disking in 2 tracks (2013) + sowing of meadow clover (5kg/ha);
3. Disking in 2 tracks (2013) + sowing of meadow clover and Timofeevka meadow (5+4 kg/ha)
4. Disking in 2 tracks (2013) + seeding of eastern goat (6 kg/ha);
5. Disking in 2 tracks (2013) + seeding of eastern goat and Timofeevka meadow (6+4 kg/ha)

The area of the experimental plot is 10 m<sup>2</sup>, the repeatability is 5 times. The processing of the turf of the old-seeded herbage of the

eastern goat was carried out on May 5, 2013 at the beginning of the spring regrowth of plants. After 2 times of disketing, the soil was rolled up and the grasses were sown according to the experimental scheme. Meadow clover from Volosovsky village was planted at a rate of 5 kg per hectare, and timofeevka meadow from Juno village – 4 kg/ha. Seeds of goatgrass of the eastern village of Nadezhda were used for sowing at a rate of 6 kg/ha, which were treated with rhizotorphin before embedding in the soil. During the research period, phenological observations, yield calculations, species composition analysis and economic assessment were carried out in accordance with the guidelines for conducting field experiments with forage crops developed by VNIIC named after V.R. Williams (1997). In the course of the work, the mathematical processing of the obtained experimental data was carried out using statistical analysis methods. All materials were processed on a personal computer using the Stat program.

### Results

The weather conditions during the research years differed in different periods, but generally approached optimal values. An analysis of the heat availability of the growing seasons during the research years showed that all growing seasons were characterized by warm weather. The sum of the air temperature during the growing season in 2013 – by 16.8°C, in 2014 – by 17.9°C and in 2015 – by 11.3°C exceeded the average annual values. The amount of precipitation varied by year and there was an uneven distribution during the growing season. The experiment was conducted on sod carbonate medium loamy soil with a humus content of 4.0%, pH of 5.7, mobile forms of phosphorus – 170.0 mg/1 kg of soil, exchangeable potassium-160 mg/1 kg of soil. The depth of the arable layer is 24cm. The underlying soil of the experimental site is moraine carbonate clay.

The effectiveness of the conducted surface improvement techniques on the old-seeded grass of the meadow foxtail was manifested primarily by a change in the species composition of the initial herbage. The original grass of the meadow foxtail of 18 years of use was heavily polluted, especially with such species as: dandelion officinale (*Taraxacum officinale*), pungent buttercup (*Ranunculus ácris*), comfrey officinalis. Of the legume species, creeping clover (*Trifolium repens*) and meadow chyna (*Láthyrus praténsis*) were found, and from the bluegrass family, creeping wheatgrass (*Elytrigia répens*). Meadow foxtail, being a rhizomatous cereal species, reacts positively to mechanical processing of sod by disketing. Cutting of underground plagiotropic shoots of the meadow foxtail provokes and stimulates the regrowth of new shoots from the renewal buds located on them. Therefore, in the first two years after this method, there is a sharp increase in the proportion of meadow foxtail, especially in the first mowing, when optimal soil moisture is observed (up to 62% in 2013 and up to 57% in 2014) (Table 1).

The studied method of surface improvement of the old-age grass of meadow foxtail by mechanical processing of sod in the form of disketing in 2 tracks allowed not only to increase the proportion of foxtail in the improved grass in the first 2 years, but also to increase yields (Table 2). In 2013, mechanical processing in the form of disketing provided an increase in the yield of old-age grasses by 0.5 t/ha, in total, 1.9 t/ha of dry weight was obtained in this variant for two mowing. In 2014 and 2015, mechanical processing was not carried out on this herbage, the aftereffect of this technique was studied.

Thus, the improvement of old-seeded grass based on meadow

**Table 1:** The content of meadow foxtail in the herbage, during the years of research, %.

| Experience options                                  | Type name          | The year 2013 |    | The year 2014 |    | The year 2015 |    |
|---|--------------------|---------------|----|---------------|----|---------------|----|
|   |                    | Mowing        |    |               |    |               |    |
|   |                    | I             | II | I             | II | I             | II |
| Control (without treatment and without fertilizers) | Meadow foxtail     | 37            | 21 | 33            | 21 | 45            | 26 |
|   | Non-seeded species | 63            | 79 | 67            | 79 | 55            | 74 |
| Disking (control) (2013r.) 2 tracks                 | Meadow foxtail     | 62            | 39 | 57            | 25 | 37            | 30 |
|   | Meadow foxtail     | 38            | 61 | 43            | 75 | 63            | 70 |

**Table 2:** Yield of meadow foxtail grass improved by disking in 2 tracks, t/ha dry weight.

| Experience options                   | The year 2013 |      |       | The year 2014 |      |       | The year 2015 |      |       | Average for 3 years t/ha | Increase in control |      |   |
|--------------------------------------|---------------|------|-------|---------------|------|-------|---------------|------|-------|--------------------------|---------------------|------|---|
|                                      | Mowing        |      | Total | Mowing        |      | Total | Mowing        |      | Total |                          | t/ha                | t/ha | % |
|                                      | 1             | 2    |       | 1             | 2    |       | 1             | 2    |       |                          |                     |      |   |
| Control without disking              | 1,0           | 0,4  | 1,4   | 1,0           | 0,5  | 1,5   | 0,8           | 0,3  | 1,1   | 1,2                      | -                   | -    |   |
| Disking in 2 tracks (2013) – control | 1.2           | 0,7  | 1.9   | 1,1           | 0,9  | 2,0   | 1,4           | 0,9  | 2,3   | 2,1                      | 0,9                 | 75   |   |
| HCP0,05                              | 0.09          | 0.03 | 0.21  | 0.06          | 0.04 | 0.12  | 0.05          | 0.03 | 0.18  |                          |                     |      |   |

**Table 3:** Soil density according to experimental variants in the years of research, g/cm<sup>3</sup>.

| An experience option                 | Soil layer, cm | The year 2013 |       | The year 2014 |      | The year 2015 |       |
|--------------------------------------|----------------|---------------|-------|---------------|------|---------------|-------|
|                                      |                | 12.07         | 25.10 | 16.05         | 3.11 | 14.05         | 24.09 |
| Control without disking              | 0-10           | 1,22          | 1,20  | 1,24          | 1,35 | 1,38          | 1,27  |
|                                      | 10-20          | 1,25          | 1,22  | 1,29          | 1,19 | 1,41          | 1,31  |
|                                      | 20-30          | 1,27          | 1,30  | 1,31          | 1,25 | 1,49          | 1,38  |
| Disking in 2 tracks (2013) – control | 0-10           | 1,21          | 1,19  | 1,26          | 1,29 | 1,25          | 1,30  |
|                                      | 10-20          | 1,27          | 1,21  | 1,31          | 1,21 | 1,33          | 1,26  |
|                                      | 20-30          | 1,29          | 1,24  | 1,37          | 1,35 | 1,26          | 1,34  |

foxtail by mechanical processing provided an increase in yield by an average of 75% over 3 years.

### Changing the agrophysical properties of the soil under the influence of mechanical treatment by disking

The density of the soil, being one of its important agrophysical properties, plays a significant role for the development of plants, creating a particular habitat for them and indirectly affecting the thermal, water and nutrient regime of the soil. Moisture absorption, air exchange in the soil, the vital activity of microorganisms and, naturally, the development of plant root systems depend on the density of the soil. In turn, the density of the soil depends mainly on the granulometric and mineralogical compositions, structure, humus content and processing [5]. Carrying out mechanical tillage by 2-fold disking had a noticeable effect on the agrophysical properties of the soil. So, if in the 1st year of tillage there was a slight decrease in density in spring only in the 0-10 cm layer, then in autumn a decrease in soil density occurs in all the studied layers (Table 3). In the years after mechanical treatment, there was no clear pattern of a decrease in soil density: for the 2<sup>nd</sup> year in 2014, in spring, there was an increase in this indicator in all layers except the surface.

A significant increase in yield was provided by mechanical processing of sod in combination with mineral fertilizers and especially with nitrogen fertilizers. In the variants with the use of fertilizers, the highest yield was noted in the 6<sup>th</sup> variant - 4.6 t/ha, where mineral fertilizers were applied at a dose of N120P60K60 against the background of mechanical treatment, the yield increase was 3.2 t/ha compared to the control without treatment and without fertilizers. The use of phosphorous-potash fertilizers alone at a dose of R60K60 on treated turf provided a yield increase of 1.3 t/ha. The use

of nitrogen fertilizer in the form of ammonium nitrate in all studied doses provided a significant increase in the studied herbage even in the first year after the violation of the turf and mechanical effects on plants. However, it should be noted that in both subsequent years, the yield of the experimental improved herbage decreased slightly, and for all variants (Table 4). It is known that the meadow foxtail belongs to the hydromezophytes, it requires increased moisture supply for growth, therefore, the lack of moisture in dry years has led to a decrease in yield. Thus, the improvement of old-seeded grass based on meadow foxtail by mechanical processing and the use of mineral fertilizers ensured an increase in yield to 4.4 t/ha of dry weight, which was 3.7 times higher than the yield of the initial herbage.

The use of mineral fertilizers not only ensured an increase in the proportion of the studied species, but also contributed to its preservation in the herbage throughout all the years of research. So, in the second variant, where only mechanical processing was carried out without the use of mineral fertilizers, already in the third year of research, the content of meadow foxtail in the herbage decreased to the initial state (30%), which indicates its low competitive capacity with a shortage of nutrition and low moisture supply, even under conditions of good aeration.

The use of mineral fertilizers against the background of improved air conditions by mechanical processing of sod contributed to the stability of the improved agrophytocenosis: even in the third year after disking, the content of meadow foxtail reached 74% in the first mowing and 58% in the second when N90P60K60 was applied. However, it should be noted that a further increase in the dose of mineral nitrogen to 120 kg/ha did not affect the content of the studied species, but the introduction of N120P60K60 hedgehog into the

**Table 4:** Yield of improved foxtail grass, t/ha dry weight.

| An experience option                 | The year 2013 |      |       | The year 2014 |      |       | The year 2015 |     |       | Average for 3 years | The increase t/ha |            |                      | Weight gain, kg per 1 kg N |
|--------------------------------------|---------------|------|-------|---------------|------|-------|---------------|-----|-------|---------------------|-------------------|------------|----------------------|----------------------------|
|                                      | Mowing        |      | Total | Mowing        |      | Total | Mowing        |     | Total |                     | t/ha              | To control | To the previous dose |                            |
|                                      | I             | II   |       | I             | II   |       | I             | II  |       |                     |                   |            |                      |                            |
|                                      |               |      |       |               |      |       |               |     |       |                     |                   |            |                      |                            |
| Disking in 2 tracks (2013) – control | 1.2           | 0,7  | 1.9   | 1,1           | 0,9  | 2,0   | 1,4           | 0,9 | 2,3   | 2,1                 | -                 | -          | -                    |                            |
| Disking + P60K60                     | 2,0           | 0,7  | 2,7   | 1,7           | 0,9  | 2,6   | 1,9           | 0,8 | 2,7   | 2,7                 | 0,6               |            | 100                  | -                          |
| Disking + N60P60 K60                 | 2,6           | 1,1  | 3,7   | 1,6           | 1,4  | 3,0   | 1,6           | 1,1 | 2,7   | 3,1                 | 1,0               | 0,4        | 114                  | 6,7                        |
| Disking + N90P60 K60                 | 2,8           | 1,4  | 4,2   | 1,8           | 1,1  | 2,9   | 2,5           | 1,7 | 4,2   | 3,7                 | 1,6               | 0,6        | 137                  | 11,1                       |
| Disking + N120P60 K60                | 2,9           | 1,7  | 4,6   | 2,3           | 1,4  | 3,7   | 3,0           | 1,8 | 4,8   | 4,4                 | 2,3               | 0,7        | 163                  | 14,1                       |
| HCP <sub>0,05</sub>                  | 0,32          | 0,23 | 0,38  | 0,29          | 0,29 | 0,33  | 0,5           | 0,4 | 0,65  |                     |                   |            |                      |                            |

**Table 5:** Yield of the studied herbage of the eastern goat during the years of research, tons/ha per year.

| An experience option                                     | The year 2013 |      |       | The year 2014 |      |       | The year 2015 |      |       | Average for 3 years |       |
|--|---------------|------|-------|---------------|------|-------|---------------|------|-------|---------------------|-------|
|  | Mowing        |      | total | Mowing        |      | total | Mowing        |      | total | t/ha                | %     |
|  | I             | II   |       | I             | II   |       | I             | II   |       |                     |       |
| Disking in 2 tracks (2013) – control                     | 2,0           | 3,0  | 5,0   | 7,0           | 3,0  | 10,0  | 5,6           | 2,0  | 7,6   | 7,5                 | 100   |
| Disking + planting of meadow clover                      | 3,4           | 3,4  | 6,8   | 3,9           | 3,1  | 7,0   | 5,6           | 1,9  | 7,5   | 7,1                 | 95    |
| Disking + planting of meadow clover + Timofeevka meadow  | 2,4           | 3,1  | 5,5   | 4,9           | 2,5  | 7,4   | 6,3           | 2,3  | 8,6   | 7,2                 | 96    |
| Disking + planting eastern goatgrass                     | 3,1           | 4,0  | 7,1   | 5,3           | 2,4  | 7,7   | 5,1           | 4,0  | 9,1   | 8,0                 | 106,7 |
| Disking + planting eastern goatgrass + Timofeevka meadow | 2,6           | 3,2  | 5,8   | 4,7           | 2,7  | 7,4   | 4,7           | 3,1  | 7,8   | 7,0                 | 93,3  |
| HCP <sub>0,05</sub>                                      | 0,32          | 0,35 | 3,04  | 0,44          | 0,17 | 2,70  | 0,37          | 0,18 | 1,23  |                     |       |

herbage, a species more sensitive to nitrogen nutrition, was noted.

Thus, the studied methods of surface improvement of the old-growth grass of the meadow foxtail allowed not only to dramatically increase its yield, but most importantly, to significantly improve the qualitative composition.

Mechanical processing of sod by 2-fold disking should be considered as a resource-saving element that allows for a significant improvement in the qualitative composition of degraded herb stands, especially with the presence of rhizomatous species in them. The application of mineral nitrogen fertilizers provides not only a significant increase in yield levels, but also the stability of the improved herbage.

### The effectiveness of sowing grass seeds in combination with mechanical treatment on the old-seeded grass of the Eastern goat

The effectiveness of sowing grass seeds on old-seeded stands has been studied by many scientists. However, there is no experimental data on the study of this technique on the mown grass of the eastern goat barn.

The favorable weather conditions of the 2013 growing season

made it possible to obtain two full-fledged mowing of the eastern goatgrass already in the year of the surface improvement techniques (Table 5).

The highest yield level in the year of surface improvement was provided by options with mechanical processing of sod in combination with the sowing of legume species: both meadow clover and eastern goatgrass – 6.8 and 7.1 t/ha per year, which is 1.8 and 2.1 t/ha higher than the control option. The sowing of cereal and bean mixtures with the addition of Timofeevka meadow in both cases in the first year did not provide a significant increase in yield. In the second year, the control variant with mechanical processing of sod provided the highest yield on the improved grass of the eastern goatgrass – 10.0 t/ha. All variants with sowing provided almost the same yield (from 7.0 to 7.6 t/ha), but that is significantly lower than the control. In the 3rd year of the experiment, the maximum yield level was observed in the variant with the sowing of seeds of the eastern goat (9.1 t /ha) and the sowing of a grass mixture of meadow clover with Timofeevka meadow (8.6 t/ha). Slightly lower yields this year were observed in the variant with 2-track disking and sowing of meadow clover (7.5 t/ha).

On average, over three years, the highest yields were obtained in the variants where mechanical processing was carried out in

combination with sowing seeds of the eastern goatgrass. Taking into account the special object of improvement, the herbage of the eastern goatgrass, a plant with the ability to vegetatively reproduce, it should be noted that sowing meadow clover seeds in our studies turned out to be an ineffective technique, since there was a great competitive influence from meadow clover plants. At the same time, sowing seeds of the eastern goatgrass into the improved herbage provided a significant increase in yield, by 0.7 t/ha. The effectiveness of the conducted methods of surface improvement on the grass stock of the eastern goatgrass was also manifested in the change in the species composition of the initial herbage.

In the year of mechanical processing of sod by disking in combination with seeding, the content of eastern goatgrass increased in all variants of the experiment, and in some reached 78% (in the variant with additional seeding of eastern goatgrass seeds). At the same time, it should be noted that in the variant where meadow clover was sown after disketing, the content of eastern goat was the lowest, which is explained, in our opinion, by its suppression by meadow clover.

During the growing season of 2015, the share of eastern goat in the grass stock increased significantly in all variants compared to 2014. In the 1st mowing, it was from 59% - the control version (fig. in 2 tracks) up to 92% - an option with disking and sowing of the eastern goat.

In the second mowing, the content of oriental goatgrass increased in almost all variants and amounted to at least 75% (control variant). The maximum content of the studied species in this mowing was in the variant with the sowing of the eastern goat and the variant with the sowing of the same species together with Timofeevka lugovaya – 91 and 85%, respectively. From the above data, it can be concluded that sowing seeds in the sod on the old-growth grass of the eastern goat is economically effective, only in the variant with disking and sowing of the eastern goat.

Thus, the studied methods of surface improvement on the old-seeded grass of the eastern goat allowed not only to dramatically increase its yield, but most importantly to significantly improve its qualitative composition. Mechanical processing of sod by 2-fold disking should be considered as a resource-saving element that allows, at minimal cost, to increase the yield of old-sown grass and significantly increase the content of the legume component in the grass and suppress the spread of pine hogweed.

The calculation of the economic efficiency of the studied methods of improving both old-seeded grass stands indicates that the minimum costs in the control version with mechanical processing of sod were 3352.6 rubles/ha for foxtail and 33428 rubles/ha for eastern goat grass.

Sowing seeds in the sod on the old-growth grass of the eastern goat is economically effective, especially in the 4th variant. Thus, the studied methods of surface improvement on the old-seeded grass of the eastern goat allowed not only to dramatically increase its yield, but most importantly to significantly improve its qualitative composition. Mechanical processing of sod by 2-fold disking should be considered as a resource-saving element that allows, at minimal cost, to increase the yield of old-sown grass and significantly increase the content of legumes in the grass.

## Conclusions

Based on 3 years of research conducted to study the effectiveness of techniques for improving degraded meadows, it has been established:

1. Mechanical processing of sod by 2-fold disking of old-seeded herbaceous stands with a predominance of plants with the ability to vegetatively reproduce is an effective means of ensuring a positive change in the species composition. Thus, disking of old-age foxtail grasses and legumes with a dominance of eastern goatgrass by stimulating the regrowth of new shoots provides an increase in the content of valuable forage grasses by 2-3 times and helps to prolong the life of these grasses.

2. Carrying out only mechanical processing on the old-age grass of meadow foxtail grass without the use of mineral fertilizers does not lead to a significant increase in their yield. The use of mineral nitrogen fertilizer in combination with rejuvenation is the most effective method, which allows not only to significantly improve the species composition of the initial herbage, but also to dramatically increase yields by 2.8-3.4 times. The yield level reached 2.7-4.4 t/ha. S. M.

3. The determination of the effectiveness of the applied doses of mineral nitrogen indicates that in highly polluted grasses, which contain many wild plants, the use of increased doses up to 120 kg / ha does not provide a significant increase in yield compared to the dose of 90 kg / ha.

4. The studied leguminous herbage with the dominance of the eastern goatgrass, a plant with short root offspring, reacted effectively to mechanical treatment, significantly increasing the participation of the bean component, up to 72% already in the year of disking. By disking in two tracks, it was possible to almost completely remove such a malignant weed as Sosnovsky hogweed from the herbage.

5. It has been established that sowing meadow clover both in its pure form and in a mixture with Timofeevka meadow, not only does not significantly improve the species composition, but also leads in the first year to a decrease in the share of eastern goatgrass, which is explained by the highly competitive capacity of meadow clover. The most effective was the sowing of eastern goatgrass seeds at a rate of 6 kg ha, when the content of eastern goatgrass reached 91% for 3 years after sowing, and the yield level was 7.8 t/ha.

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