Influence of basic tillage on the productivity of leguminous crops

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Abstract. The studies were carried out in order to identify the most effective method (plowing, loosening, their alternation in crop rotation, without main processing) of a mid-depth (20-22 and 12-14 cm) main processing of leached heavy loamy chernozem during cultivation of grain legume crops (peas, chickpeas) in the northern forest-steppe Tyumen region. The work was carried out in 2016–2019. Meteorological conditions in the study area are characterized by long cold winters, warm short summers, short spring and autumn, late spring and early autumn frosts. The highest yield of legumes was noted after plowing by 20-22 cm, so when cultivating peas, it was higher than after loosening to a similar depth, by 0.39 t/ha, chickpea - by 0.53 t/ha, compared with the option of alternating plowing and loosening in crop rotation, by 0.38 and 0.32 t/ha, respectively. With a decrease in tilling depth, the yield of peas and chickpeas decreased: for plowing - by 0.32 and 0.35 t/ha, after loosening - by 0.33 and 0.30 t/ha, in the variant with alternating plowing and loosening - by 0.26 and 0.21 t/ha. The lowest yield in the experiment was noted without basic tillage. The best results after plowing at 20-22 cm were due to the highest yield, as well as the highest mass of 1000 grains, the yield of fodder and grain units in this variant.

1. Introduction
The share of leguminous crops in world agriculture accounts for about 13-14% of the sown area [1]. In the Russian Federation, it is necessary not only to expand their crops, but also to rationally place crops according to biological characteristics, a complex of natural and climatic factors and possibilities of using them for food, feeding and industrial purposes. Today, in the Central and Siberian Federal Districts (FD), the leading positions are occupied by peas, in the Volga FD chickpea crops prevail, in the South and North Caucasian FDs - chickpea and peas [2].

Production of leguminous crops is especially important in modern conditions [3, 4]. In cultivation of agricultural crops, technology plays an important role, productivity depends on it. Among the most important elements of the technology is the main tillage, which determines agrophysical and microbiological properties of soil and phytosanitary state [5, 7]. At the same time, one and the same technological method can prove itself in different ways in different soil and climatic conditions [6].

Plowing as a method of basic processing and a system of basic processing contribute to an increase in productivity [8, 9]. A decrease in the depth of soil cultivation leads to a decrease in yield of agricultural crops [10]. The highest yield of peas was formed during sowing by plowing, and replacement of moldboard processing by differentiated one leads to its decrease [11]. Yield of agricultural crops in the northern forest-steppe of the Tyumen region depends not only on climatic conditions, but also on the method of processing [12].
The purpose of the research is to study the effect of basic tillage on the productivity of leguminous crops (peas, chickpeas) in the northern forest-steppe of the Tyumen region.

To achieve it, the tasks of determining influence of main tillage and its depth on the yield, the mass of 1000 grains, and the yield of fodder and grain units of leguminous crops were solved.

2. Conditions, materials and methods

The studies were carried out in 2016–2019. on the basis of the experimental field of the SAU of the Northern Trans-Urals (1.5 km from the village of Uteshevo). The experiment on the basic tillage was laid in 2015. The soil of the experimental field is leached chernozem of heavy loamy granulometric composition with a humus content in the 0-20 cm layer of 5.0-5.1%, mobile phosphorus and potassium - 1.20-1.22 and 1.09-1.10 mg / kg, respectively. by the method of Chirikov FV [13].

The experiment scheme included the following options:

- Moldboard, 20-22 cm, plow PN-4-35 (control); Moldboard, 12-14 cm with a plow PN-4-35; Non-moldboard, 20-22 cm tool with SibIME racks; Non-moldboard, 12-14 cm cultivator KOSB (UNIA); Differentiated (alternation of plowing and loosening by years in a crop rotation), 20-22 cm (for the studied crops - plowing, 20-22 cm); Differentiated, (alternation of plowing and loosening by years in a crop rotation), 12-14 cm (for the studied crops - plowing, 12-14 cm); Without basic tillage.

The studies were carried out in a crop rotation: seed fallow (annual grasses - peas with oats) - spring wheat - legumes (peas, chickpeas). In variants with alternating methods of tillage in crop rotation under annual grasses, loosening was carried out by 20-22 cm and 12-14 cm, for spring wheat - plowing by 28-30 cm and 14-16 cm, for peas and chickpeas - plowing by 20-22 and 12-14 cm.

Cultivation technology of the studied crops provided for early spring harrowing for plowing and loosening is BZSS-1 in two tracks across the direction of the main cultivation, in the variant without main cultivation, harrowing was carried out by BIG-3.0. When the optimal time came, pre-sowing soil cultivation was carried out with a KPS-4 cultivator to a depth of 6-8 cm. Before sowing, N70 was applied in the form of ammonium nitrate according to recommendations for the use of nitrogen fertilizers in the Tyumen region [14]. The peas of the Yamalskiy variety and the chickpeas of the Vector variety were sown with an SZM-200 seeder. Harvesting was carried out with a TERRION-200 combine. The main tillage was carried out after harvesting according to the variants of the experiment.

The area of one field is 237.5 m² (12.5x19.0 m), the accounting area is 128.0 m² (8.0x16.0 m). The experiment was repeated three times. The placement is consistent. The yield is taken into account according to the variants of the experiment with the TERRION-200 combine in three replications. Harvesting was carried out at 16% grain moisture. Bunker yield from each field is weighed and converted to 16% moisture and 100% purity [15]. The weight of 1000 grains was determined in accordance with GOST 10842-89, in triplicate. The yield of fodder and grain units is the conversion of yield into fodder units using the coefficient for peas 1.28, chickpeas 1.22, for cereals - 0.99 peas, 0.84 chickpeas [16, 17]. Statistical data processing was carried out by the method of analysis of variance using the Snedekor DEMO program.

Climate of the Tyumen region is continental, with long cold winters and short warm summers. Annual precipitation is 374 mm, of which 232 mm falls during the growing season of agricultural crops. The sum of temperatures above 5 °C varies within 1900-2050 °C, above 10 °C - 1860-1940 °C. The duration of the period with temperatures above 0 °C in the northern forest-steppe is 194 days. The last spring frosts are possible until May 21, early autumn frosts begin from August 19. Frost-free period lasts 111 days. The average long-term value of the GTC is 1.2-1.3, which characterizes the territory as moderately humid. This creates optimal conditions for normal growth and development of main crops cultivated in the region.

In 2019, in May and July, an excess of air temperature over the long-term average was noted, although in June of this year it was lower than average by 1.9 °C. In 2016, the air temperature exceeded the long-term average values. In 2017, the air temperature in May, June and August exceeded the long-term average by 0.4, 1.4 and 2.3 °C, and in July and September it was below the norm by 1.3 and 0.8 °C.
C. In 2018, the temperature indicators in May and June were lower than average by 3.0 and 2.0 °C, in July and September - higher by 2.0 and 1.8 °C, in August they were at the normal level - 15.5 °C.

The largest amount of precipitation for the period of research was noted in 2019, when in May, June, August and September, their amount exceeded long-term average annual by 18.4; 43.5; 1.5 and 8.1 mm, respectively, and in July it was below the norm by 1.8 mm. In 2018, the amount of precipitation in May, June and August was higher than long-term average annual by 16.9; 59.3 and 99.6 mm, respectively, in July and September - 51 and 16.6 mm lower. In 2017, precipitation fell less than in 2018 and 2019, the excess of the norm was noted in May, July and September - by 5.4; 14.2 and 5.4 mm, respectively, and in June and August the amount of precipitation was lower than long-term average annual by 30.9 and 30.0 mm. In 2016, precipitation was less than normal.

3. Results and discussion

On average, over four years of research (2016-2019), the highest yield of peas was obtained on the control option (20-22 cm) - 2.22 t/ha, according to the option without the main treatment, a lower yield was formed - 1.20 t/ha, which is 1.02 t/ha is less than control (table 1).

The yield decreased with a decrease in depth of main cultivation, namely, by 0.32 t/ha (14.4%) for moldboard, by 0.33 t/ha (18.0%) for non-moldboard and by 0.26 t/ha (14.1%) for differentiated tillage.

Table 1. Productivity of peas and chickpeas, t/ha, 2016-2019.

| Basic tillage                      | Crop yield | Position towards control, +/- |
|------------------------------------|------------|-------------------------------|
|                                    | peas       | chickpeas                     | peas | chickpeas |
| 1. Moldboard, 20-22 cm control     | 2.22       | -                             | -    | -         |
| 2. Moldboard, 12-14 cm             | 1.90       | 1.98                          | -0.32| -0.35     |
| 3. Non-moldboard, 20-22 cm         | 1.83       | 1.80                          | -0.39| -0.53     |
| 4. Non-moldboard, 12-14 cm         | 1.50       | 1.50                          | -0.72| -0.83     |
| 5. Differentiated, 20-22 cm         | 1.84       | 2.01                          | -0.38| -0.32     |
| 6. Differentiated, 12-14 cm         | 1.58       | 1.80                          | -0.64| -0.53     |
| 7. Without basic tillage           | 1.20       | 1.38                          | -1.02| -0.95     |
|                                    | Control    | Non-moldboard                 | Moldboard | Differentiated |
|                                    | HCP<sub>05</sub> |                                |               |

The highest yield of peas was noted in 2016 with moldboard cultivation (20-22 cm), control - 2.41 t/ha, for non-moldboard and differentiated (20-22 cm) higher by 0.57 and 0.56 t/ha. A decrease in depth of basic cultivation led to a decrease in yields for moldboard by 0.39, for non-moldboard by 0.61 and for differentiated by 0.34 t/ha.

In 2017, the yield of peas was less due to weather conditions and the highest was observed with moldboard tillage (20-22 cm) - 2.05 t/ha. According to the option without the basic tillage, a lower yield was formed - 1.12 t/ha, which is less than the control one by 0.93 t/ha.

A decrease in the depth of tillage contributed to a decrease in yields for moldboard by 0.22, for non-moldboard by 0.14 and for differentiated by 0.13 t/ha.

For 2018, the maximum yield was obtained according to a control option - 2.19 t/ha. The tendency to a decrease in yield persisted in connection with a decrease in depth of basic cultivation, for example, by moldboard by 0.26, by non-moldboard by 0.23 and by differentiated by 0.34 t/ha. The variant without tillage had a lower yield of 1.10 t/ha.

The yield of peas in 2019 varied within 1.92-2.22 t/ha with soil tillage by 20-22 cm and 1.57-1.81 t/ha with tillage by 12-14 cm. A decrease in the depth of cultivation led to a decrease in the yield of peas on moldboard by 0.41, on non-moldboard by 0.36 and on differentiated by 0.26 t/ha.

On average, during years under study (2016-2019), the yield of chickpea was 1.80-2.33 t/ha for processing options for 20-22 cm and 1.50-1.98 for options for shallow processing for 12-14 cm.
The yield of chickpea in the control (moldboard tillage, 20-22 cm) was 2.33 t/ha, which is 0.53 t/ha higher than non-moldboard (20-22 cm) and differentiated by 0.32 t/ha. Comparing deep and shallow tillage, we see that for moldboard the yield is lower by 0.35 t/ha (15.0%), for non-moldboard by 0.30 t/ha (16.7%) and for differentiated by 0.21 t/ha (10.5%).

The highest yield of chickpea was obtained in 2016 by moldboard tillage (20-22 cm, control) - 2.61 t/ha, which is 0.69 and 0.61 t/ha higher than non-moldboard and differentiated (20-22 cm). Zero cultivation was noted with a lower yield - 1.42 t/ha, which is 1.19 t/ha less than the control. Shallow tillage options (12-14 cm) formed a lower yield of chickpea 1.44-2.15 t/ha.

In 2017, the yield of chickpea for tillage by 20-22 cm varied within 1.54-2.14 t/ha, for small tillage (12-14 cm) within 1.21-1.75 t/ha. A decrease in depth of the basic cultivation led to a decrease in yields for moldboard tillage by 0.39, by 0.33 for non-moldboard cultivation and by 0.17 t/ha for differentiated tillage. The highest yield was noted with moldboard tillage at 20-22 cm (control) - 2.14 t/ha.

The chickpea yield in 2018 was in the range of 1.32-2.24 t/ha for all studied options. For zero tillage, the lowest yield is 1.32 t/ha, which is 0.92 t/ha less than the control. A decrease in the yield of chickpea occurred due to a decrease in the depth of the basic tillage by 0.24 for moldboard, by 0.19 for non-moldboard and by 0.22 t/ha for differentiated.

In 2019, the highest yield was obtained with moldboard tillage (20-22 cm, control) - 2.31 t/ha. A decrease in the tillage depth contributed to a decrease in yields for moldboard tillage by 0.30, for non-moldboard tillage by 0.22 and for differentiated tillage by 0.18 t/ha.

So, the highest yield of peas and chickpeas in 2016-2019 was marked according to a control variant (moldboard, 20-22 cm) - 2.22 and 2.33 t/ha, respectively.

The mass of a thousand pea grains over four years of research was in the range of 118.2-220.2 g, the largest was observed in the control - moldboard cultivation (20-22 cm) - 220.2 g, the smallest for zero tillage - 118.2 g, which is less than the control (plowing, 20-22 cm) by 102.0 g.

A decrease in the depth of tillage led to a decrease in the mass of a thousand grains, namely, by moldboard tillage by 26.5 g, by non-moldboard tillage by 25.4 g, by differentiated tillage 28.7 g.

In relation to the control, the mass of 1000 pea grains is lower by 40.1 g according to non-moldboard tillage (20-22 cm), by 36.9 g according to differentiated one (20-22 cm).

Comparing shallow tillage (12-14 cm) with the control variant, it can be seen that with moldboard tillage it is less by 25.6 g, with non-moldboard tillage by 65.5 g, with differentiated tillage 65.6 g.

The mass of a thousand chickpea grains over four years of research was in the range of 227.1-266.5 g, the largest was obtained during moldboard tillage (20-22 cm) control - 266.5 g, for non-moldboard (20-22 cm) was 248.4 g, for differentiated (20-22 cm) - 245.5 g.

A decrease in the depth of basic cultivation led to a decrease in the mass of a thousand grains, namely, on moldboard by 12.6 g, by non-moldboard by 16.0 g, by the differentiated by 6.8 g, the smallest mass of 1000 grains was noted according to the option without basic tillage (zero) - 227.1 g, which is 39.4 g less than the control.

Thus, the largest weight of one thousand grains of peas (220.2 g) and chickpeas (266.5 g) was characterized by the variant of moldboard tillage (20-22 cm) control.

On average, over four years of research (2016-2019), the yield of pea feed units varied within 1.54-2.84 t/ha for all variants of basic tillage.

A decrease in the depth of basic cultivation led to a decrease in the yield of pea feed units, namely, by moldboard cultivation by 0.41 t/ha, by non-moldboard cultivation by 0.42 t/ha, by differentiated tillage by 0.34 t/ha. The smallest yield of feed units is 1.54 because units/ha recorded for the option without basic tillage.

In comparison with the control, the yield of fodder units for deep tillage (20-22 cm) was obtained less by 0.50 t/ha for non-moldboard, and by 0.48 t/ha in differentiated soil.

For 2016-2019 the highest yield of fodder units of chickpea was noted for moldboard tillage (20-22 cm), control - 2.84 because units/ha, in general, when tillage to a depth of 20-22 cm, varied within 2.20-2.84 t/ha, at a depth of 12-14 cm, the indicators of fodder units were 1.83-2.42 t/ha.
By reducing the depth of basic tillage, the yield of fodder units of chickpea also decreases, namely, by 0.42 for moldboard, by 0.37 for non- moldboard and by 0.25 t/ha for differentiated tillage. The variant without basic tillage formed the smallest yield of fodder units - 1.68 t/ha.

For four years of research (2016-2019), when cultivating peas and chickpeas, the best indicators of the yield of fodder units were noted for the option of moldboard tillage (20-22 cm, control) - 2.84 t/ha for two crops.

In the cultivation of peas for basic cultivation for 2016-2019 the yield of grain units was in the range of 1.19-2.20 t/ha, namely, according to cultivation options to a depth of 20-22 cm in the range of 1.81-2.20 t/ha, to a depth of 12-14 cm were 1.49-1.88 t/ha, i.e. decreased with a decrease in the depth of basic tillage, for example, by moldboard by 0.32 t/ha, by non- moldboard by 0.32 t/ha, by differentiated by 0.26 t/ha. The smallest yield of grain units of peas was noted for the option without basic tillage (zero) - 1.19, which is 1.01 t/ha lower than the control.

The largest yield of grain chickpea units in 2016-2019 recorded according to the control variant (moldboard, 20-22 cm) - 1.96 t/ha. The variant without basic tillage formed a smaller yield of grain units - 1.16 t/ha. A decrease in the depth of tillage led to a decrease in the yield of grain units by 0.30 for moldboard, by 0.25 for non- moldboard and by 0.18 t/ha for differentiated tillage.

For the studied years (2016-2019), the yield of grain units of peas and chickpeas varied within 1.19-2.20 t/ha and 1.16-1.96 t/ha, respectively. The best indicators were marked by the option of moldboard tillage (20-22 cm) - 2.20 and 1.96 t/ha.

4. Conclusions
When cultivating leguminous crops in the northern forest-steppe of the Tyumen region, plowing to a depth of 20-22 cm should be considered the best method of basic soil cultivation. Its use provides the highest yield, a thousand grain weight, fodder and grain units, an improvement in the agrochemical properties of the soil and a decrease in weediness of crops against the background of herbicide treatment.

On average, over four years of research, the yield of peas for moldboard (20-22 cm) was 2.22 t/ha, chickpea - 2.33 t/ha. Replacement of moldboard tillage with non-moldboard or alternation of these methods in crop rotation, a decrease in the depth of tillage and, especially, the rejection of basic tillage contributed to a decrease in the yield of studied crops. High value of this indicator was largely associated with the mass of 1000 grains, which for peas for plowing was 220.2 g, for chickpeas - 266.5 g, which is higher than in the variant with loosening (20-22 cm) by 40.1 g and 18.1, respectively. g; with alternating plowing and loosening (by 20-22 cm) - by 36.9 g and 21.0 g. The highest yield of fodder and grain units of peas (2.84 and 2.20 t/ha) and chickpea (2.84 and 1.96 t/ha) was noted according to the control variant - moldboard tillage by 20-22 cm.

References
[1] Aldoshin N V and Mosyakov M A 2018 Improving the design of combing devices for harvesting leguminous crops Bulletin of the Moscow State Agroengineering University named after V. P. Goryachkin 2(84) 23-7
[2] Zotikov V I, Sidorenko V S and Gryadunova N V 2018 Development of the production of leguminous crops in the Russian Federation Leguminous and cereal crops 2(26) 4-10
[3] Pittelkowa C M, et al. 2015 When does no-till yield more? A global meta-analysis A global meta-analysis Field Crops Research 183 156-68
[4] Foley J A, et al. 2011 Solutions for a cultivated planet Nature 478 337-42
[5] Rusu T 2013 Influence of tillage systems on soil properties, humus and water conservation Scientific Research 12 35-40
[6] Amato G, et al. 2014 Long-term tillage and crop sequence effects on wheat grain yield and quality Agron 105 13-7
[7] Kuzmina S P, Kazydub N G and Konovalova E A 2019 Study of the nodule-forming ability and productivity of leguminous crops in the conditions of the Omsk region The role of young scientists in the innovative development of agriculture. Materials of the International
839(2021) 022043

Tyutyunov S I, Solntsev P I and Khoroshilova Yu V 2020 Influence of methods of basic tillage, fertilizers and plant protection products on the productivity of winter wheat. Achievements of science and technology of the agro-industrial complex 34(5) 18-23

Akhmetzyanov M R and Talanov I P 2019 Influence of the systems of basic tillage and nutritional backgrounds on the productivity of crops in the field crop rotation link. Achievements of science and technology of the agro-industrial complex 33(5) 10-3

Rzaeva V 2021 Productivity of crop rotation by the main tillage in the Tyumen region. IOP Conference Series: Earth and Environmental Science 52079

Dubovik D V, et al. 2020 Minimization of the main tillage for peas in the Kursk region. Achievements of science and technology of the agro-industrial complex 34(11) 26-31

Kazak A 2020 Medium-Early Spring Wheat Cultivars Depending on The Level of Mineral Nutrition in The Northern Forest-Steppe of The Tyumen Region. Amazonia Investiga 9(25) 143-52

GOST 26204-91. Soils. Determination of mobile compounds of phosphorus and potassium by Chirikov's method modified by TsINAO.

Eremina D V 2018 Agroeconomic assessment of mineral fertilizers used in the Tyumen region. Izvestia of the Orenburg State Agrarian University 2018 23-4

Dospekhov B A 1985 Experimental methodology (Armor. - M.: Agropromizdat) p. 351

Kalashnikov A P 2003 Feeding rates for farm animals Reference manual (Moscow) 456

Posypanov G S, et al. 2007 Plant growing (M.: Kolos S)