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THE INFLUENCE OF CERTAIN AGROTECHNICAL MEASURES APPLIED IN CARROT TECHNOLOGY UNDER PEDOCLIMATIC CONDITIONS OF VERESTI COMMUNE, SUCEAVA COUNTY

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Abstract

Carrots are not particularly sensitive regarding cultivation technology but they require increased attention at certain stages. Some of these stages include the preparation of the seed bed, sowing and fertilization. These factors are: the timing and method of seedbed preparation, the sowing scheme, and the method of fertilization. The study was conducted over three years under the pedoclimatic conditions of Veresti Commune, Suceava County. The aim was to develop an innovative technology to increase production. Following the analysis of the data from the three years of study (2016, 2017, 2018) and the comparative analysis of the experimental variants, a significantly positive difference in production was highlighted in the experimental variant where the seedbed was prepared in the fall, the land was shaped, the sowing scheme was 15+15+75+15+15 and fertilization was done with NPK. In this variant, the production increase was 19786 kg/ha, compared to the variant where the seedbed was prepared in the spring, the land was not shaped, the applied sowing scheme was 15+15+75+15+15s, and fertilization was with NPK.

***Key words**: fertilizers, seedbeds, quality, production, sowing scheme.*

INTRODUCTION

The focus of Scientific Research has shifted towards development and efficiency to increase productivity. Optimizing agricultural production is a very important and widely discussed aspect, as it is the only sustainable solution to ensure the food supply for the population (Gamez-Vazquez et al., 2022).
Food insecurity has increased in densely populated, urbanized areas with rising incomes. It is expected that these increases in insecurity will be particularly recorded in developing countries with rapid economic growth. All these changes create a favourable environment for the development of farms worldwide, and the food crisis can only be overcome through the involvement of the scientific community.
One of the crops that play an important role nutritionally and has health benefits is the carrot (Stoleru et al., 2016). This plant is among the top ten vegetables cultivated worldwide and represents a significant source of vitamin A (Barbu et al., 2022). After plants in the *Solanaceae* family, such as the potato, carrot roots are the most cultivated for their taste and nutritional properties (Omenn et al., 2005). The carotenoids are must influenced by technological factors as cultivars, fertilizers and irrigation regimes (Stoleru et al., 2020)
Carrots are a plant of significant importance from a dietary, medicinal and industrial perspective. This crop has a high economic yield because it is very productive, and the selling price is attractive for farmers (Mităluț et al., 2021).
The factors that influence production include pedo-climatic conditions, the variety or hybrid, the cultivation technology applied, etc. For example, for producing one ton of vegetable product requird to apply 3 kg N s.a., 1.5 kg P_2O_5 s.a., 5 kg K_2O. The amount of manure recommended for organic fertilization, is 30 t/ha for carrots crop (Dușan & Stan, 2023).
The study aims to observe the influence of innovative elements in carrot cultivation technology with positive effects on production. The experimental factors studied are the type and timing of seedbed preparation, the sowing

scheme, and fertilization (Merlin & Bertrand, 2020).

The purpose of this paper is to study the influence of the period and method of seedbed preparation, the sowing scheme, and fertilization on production.

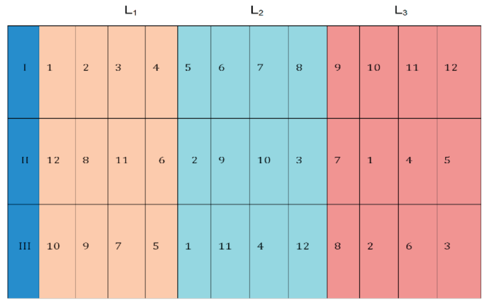
MATERIALS AND METHODS

The study aims to observe the influence of innovative elements in carrot cultivation technology with positive effects on production. Three experimental factors were studied: the first two factors with two levels and the third with three levels, as presented in Table 1.

Table 1. Experimental Factors

Experimental factors	Graduations of the experimental factors
Experimental factor A: Germinal bed preparation	A1 – Conventional seed bed preparation system (the spring, unshaped land)
	A2 – Unconventional seed bed preparation system (the autumn, shaped land)
Experimental factor B: Planting scheme	B1 – Conventional system (planting rows forming strips of 150 cm, distance between rows of 15 cm);
	B2 – Unconventional system (planting, 15 cm+15 cm+75 cm+15 cm +15 cm)
Experimental factor C: Fertilization	C1 – Fertilization with NPK C2 – Fertilization with manure C3 – Fertilization with manure and NPK

The method used to set up the experiment is the Latin rectangle, developed in 1952 by Mudra. This method was employed to study a large number of variants without increasing the number of replications. Mudra divided the columns into sub-columns, which together form a complete column. The number of variants must be divisible by the number of replications. The randomization of variants across columns does not depend on the randomization of variants across blocks; the only condition is that a variant must appear only once per column and also per block. Complete replications allow, within the method, uniform working conditions both in terms of blocks and columns. The large number of variants reduces the value of errors in obtaining results.



Replications: I, II, III; Sub-columns: L1, L2, L3
Experimental Variants: 1, 2, 3, ..., 12

Figure 1. Experimental Plot Layout

The biological material sown over the three years of the experiment is the Laguna F1 hybrid (Figure 2). This is a Nantes-type hybrid with a smooth, somewhat cylindrical root, uniform and very rapid growth. The colour is pleasant, intense orange, and has a commercially appealing appearance.

Figure 2. The hybrid F1 Laguna

In order to determine the physical, chemical, agronomic and morphological properties of the soil, soil samples were collected.

The soil samples were taken along the diagonals of the experimental plot, and laboratory analyses were performed at different depths (0-20 cm, 20-40 cm and 40-60 cm, respectively). Samples were collected on April 6th 2016, April 6th 2017 and April 6th 2018 using a soil auger, from 5 different points along each diagonal of the plot (Rusu, 2005).

The following agrochemical indices were determined: granulometric analysis by the pipette method with result interpretation; pH by the potentiometric method; humus (%) by the Walkley-Black method; total N (%) by the

Kjeldahl method; potassium availability by the flame photometric method; phosphorus availability by the colorimetric method; and base saturation degree (V% = SB / T x 100) (Table 2).

Table 2. Agrochemical indices of the Soil

The bottom (cm)	0-20	20-40	40-60
The coarse sand	0.10	0.09	0.047
The fine sand	46.67	36.03	35.62
The dust I	10.40	18.03	22.79
The dust II	14.92	13.49	8.84
The clay	27.91	32.36	32.70
The interpretation of soil texture	The sandy loam	The loam	The loam
pH	7.68	7.80	7.92
The interpretation	Slightly alkaline	Slightly alkaline	Slightly alkaline
The carbons $CaCO_3$	1.5	1.8	1.80
The interpretation	Slightly carbonated	Slightly carbonat ed	Slightly carbonate d
The humus %	2.15	2.39	1.38
The interpretation	Slightly	Medium	Slightly
Total N %	0.174	0.219	0.187
The interpretation	Moderate	Good	Moderate
The mobile P_20_5 ppm	40	29	30
The interpretation	Good	Moderate	Moderate
The mobile K_20 ppm	140	116	110
The interpretation	Good	Moderate	Moderate

Carrots are a plant that develops in a temperate climate. Seeds germinate at minimum temperatures of 3-4°C, with a germination period of 20 days at these temperatures. At optimal germination temperatures, between 20-25°C, the germination period shortens to 10 - 12 days (Apahidean and Apahidean, 2000). The optimal temperature for root growth is in the range of 18-22°C. High temperatures favour more vigorous leaf development and result in smaller roots. Root shape is influenced by temperature; lower temperatures and high precipitation favour the formation of sharp, long, and poorly coloured roots. Carrot plants can withstand temperatures as low as -5°C. The vernalisation process occurs at temperatures of 5-10°C over a period of 36-70 days (Indrea et al., 2012).

For normal carrot crop development, soil moisture should be between 65-75% of field capacity during the initial growth period, and then increase to 75-80% during root thickening. The most sensitive periods to moisture are germination, leaf formation, and root thickening (Bender et al., 2009). The climatic parameters in Verești commune are similar to those in Suceava city, considering the geographical position relative to the city and the distance of approximately 21 km. Minor differences may be recorded due to the presence of the two rivers, Siret and Suceava.

The year 2016 was climatically erratic, with alternating drought months and months of abundant precipitation. In June and August, reduced precipitation and high temperatures favoured the occurrence of soil drought, while the abundant precipitation in October led to significant losses in agricultural production.

As shown in Figure 3, the maximum temperature from January 1 to December 1, 2016, was recorded at the end of June and exceeded 35°C. The minimum temperature was below -10°C and was recorded in January (Figure 3).

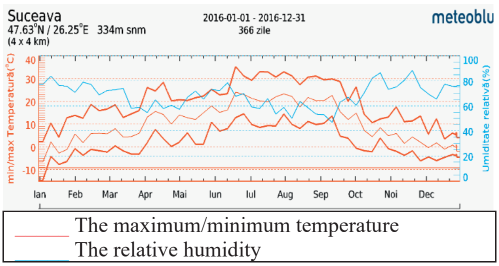


Figure 3. The evolution of air temperature and humidity during January-December 2016
Source: www.meteoblue.com

Precipitation from January 1, 2016, to December 31, 2016, can be observed in Figure 4. In mid-October, the recorded values were over 65 mm, while the smallest amounts of precipitation were recorded in September (20 mm).

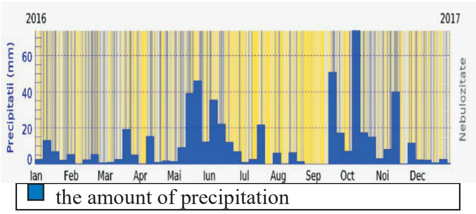


Figure 4. The precipitation evolution during January-December 2016
Source: www.meteoblue.com

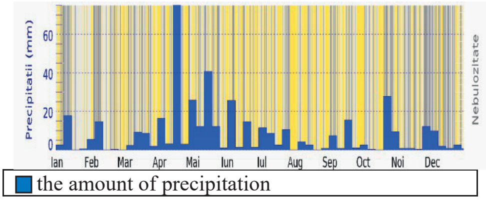


Figure 6. The precipitation evolution during January-December 2017
Source: www.meteoblue.com

In 2017, from the perspective of the most important climatic parameters - temperature and precipitation - the year was relatively erratic. The amount of precipitation was low and uneven. Monthly average temperatures fell within the multiyear averages (8°C), but they varied only in March, July, and August. Large temperature differences between day and night had negative effects on agricultural production.
In the spring, we faced temperature fluctuations and recorded late frosts that affected the carrot crop. During the summer, precipitation was low, and temperatures were high (Figure 5).
The maximum temperature from January 1 to December 1, 2017, was recorded in mid-August and was approximately 40°C. The minimum temperature was recorded in January and was approximately -20°C.

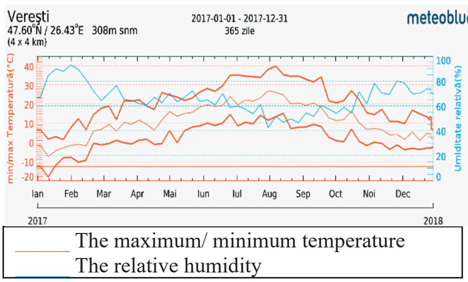


Figure 5. The evolution of air temperature and humidity during January-December 2017
Source: www.meteoblue.com

Precipitation from January 1, 2017, to December 31, 2017, can be observed in Figure 6. The maximum amount of precipitation was recorded in mid-April, exceeding 65 mm, while the minimum amount of precipitation was below 5 mm in mid-October.

In 2018, the year was not as erratic as 2017, and the climatic conditions were favourable for carrot cultivation. Precipitation was adequate and temperatures were moderate. In the spring, we faced reduced precipitation and high temperatures, which was a critical period for soil water availability. There were also temperature fluctuations during this time. In the summer, precipitation was balanced and temperatures were moderate.
The maximum temperature from January 1 to December 1, 2018, was recorded in the latter part of August and was around 35°C. The minimum temperature was recorded at the end of February and was below -15°C (Figure 7).

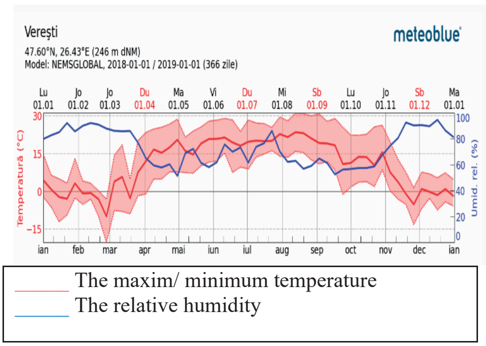
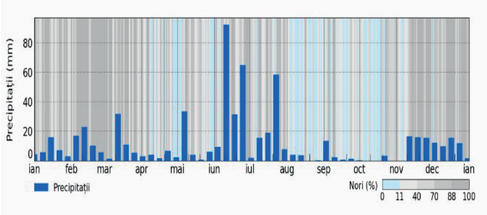


Figure 7. The evolution of air temperature and humidity during January-December 2018
Source: www.meteoblue.com

Precipitation from January 1, 2018, to December 31, 2018, can be observed in figure 8. The maximum amount of precipitation was recorded in mid-June, exceeding 89 mm, while the minimum amount of precipitation was 0 mm from the end of September to the end of October (Figure 8).



the amount of precipitation

Figure 8. The precipitation evolution during January-December 2018 source: www.meteoblue.com

Observations were made on the development stage of the crop in different phenophases of the carrot plants (Figure 9). The uniformity of the crop and the development of the roots in length and diameter were monitored. The height of the carrot leaves was measured at 10 points of each experimental plot, and samples consisting of 10 carrots were taken to measure the diameter and length of the roots.

Figure 9. The observations in experimental field

The evaluation of agricultural production was determined to establish the quantity. This action was carried out periodically, in pheno-phases specific to the species, especially after root thickening, 10-20 days before harvest and after harvest.

Production was evaluated through gravimetric measurements, and the obtained results were processed in Microsoft Excel.

The interpretation of the results was carried out using the multi-comparison test method, specifically the Duncan test. This type of test is especially applied in multifactorial experiments. Data processing was conducted using the DSAASTAT.xls database.

RESULTS AND DISCUSSIONS

The results obtained from the experimental field from 2015-2018 are presented in Table 3, where differences in production under the influence of experimental factors can be observed.

Table 3. The productions obtained in 2015-2018

Experimental variants	Repetition I kg/ha	Repetition II kg/ha	Repetition III kg/ha	Arithmetic average kg/ha
a1b1c1	39866	46523	41900	42763
a1b1c2	46400	48113	42166	45560
a1b1c3	34600	35520	36100	35406
a2b1c1	38300	38646	38166	38371
a2b1c2	44916	42450	43066	43477
a2b1c3	37066	37280	46116	40154
a1b2c1	44500	43500	46116	44705
a1b2c2	38836	37906	39233	38658
a1b2c3	63403	44113	43100	50205
a2b2c1	65286	54380	54806	58157
a2b2c2	56833	39336	44723	46964
a2b2c3	46700	43263	42533	44165

As observed in the graphical representation of the yields obtained (Table 3) during the period 2015-2018, the best results were achieved in the experimental variant where the seedbed was prepared in the fall, the soil was ridged, seeds were sown according to scheme 15+15+75+15+15, and fertilization was done with NPK. In contrast, the experimental variant V3 yielded the lowest average production per replication, at 35520 kg/ha. In this experimen-tal plot, the seedbed was prepared in the spring, the soil was not ridged, seeds were sown in bands of 150 cm with 15 cm between rows, and fertilization was done with NPK and manure. Good results were also obtained in experi-mental variants where the seedbed was prepared in the fall, the soil was ridged, seeds were sown according to scheme 15+15+75+15+15, and fertilization was done with NPK and manure. It can be seen that average yields of over 40000 kg were also obtained in experimental variants where the seedbed was prepared in the spring, seeds were sown in bands of 150 cm width with a distance of 15 cm between rows, and fertilization was done with manure.

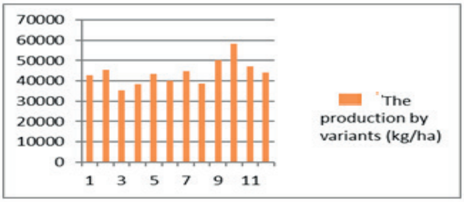


Figure 10. The production by variants, 2015-2018

In Table 4 we can observe the difference of production between variants due to the influence of experimental factors.

Table 4. The comparative interpretation of data - influence of factor A to B and C (The planting seed scheme, the preparation of seeds bed and fertilization)

Variant	Production	%	Difference	Difference of significance
$a_1b_1c_1$	42763	100	0	Mt
$a_2b_1c_1$	44705	104	1942	*
$a_1b_1c_2$	45559	100	0	Mt
$a_2b_1c_2$	38658	84	-6901	0
$a_1b_1c_3$	35406	100	0	Mt
$a_2b_1c_3$	50205	142	14798	***
$a_1b_2c_1$	38370	100	0	Mt
$a_2b_2c_1$	58157	151	19786	***
$a_1b_2c_2$	43477	100	0	Mt
$a_2b_2c_2$	46964	108	3486	-
$a_1b_2c_3$	40154	100	0	Mt
$a_2b_2c_3$	44165	110	4011	-
DL (p 5%) = 435 kg/ha; DL (p 1%) = 898 kg/ha; DL (p 0.1%) = 1082 kg/ha;				
*positive not significant difference 0 - negative not significant difference ***distinctly highly significant positive difference - not significant difference				

As we can observe (Table 4), the best results in terms of production were obtained in the variant where the seedbed was prepared in the fall, the soil was ridged, seeds were sown according to scheme 15+15+75+15+15, and fertilization was done with NPK. Compared with the variant where the seedbed was prepared in the spring, while the sowing scheme and fertilization were carried out in the same manner as in the previously mentioned variant, a production increase of 19786 kg was recorded. Distinctly highly significant positive results were also obtained in the variant where the seedbed was prepared in the fall, the soil was ridged, seeds were sown in bands of 150 cm with a distance of 15 cm between rows, and fertilization was done with NPK during the growing season, with manure applied during seedbed preparation.

In Table 5 we can observe the difference between variants generated by experimental factors.

Table 5. The comparative interpretation of data's - influence of factor B to A and C (The planting seed scheme, the preparation of seeds bed and fertilization)

Variants	Production	%	Difference	Difference of significance
$b_1a_1c_1$	42763	100	0	Mt
$b_2a_1c_1$	38370	89	-4392	00
$b_1a_1c_2$	45559	100	0	Mt
$b_2a_1c_2$	43477	95	-2082	0
$b_1a_1c_3$	35406	100	0	Mt
$b_2a_1c_3$	40154	113	4747	*
$b_1a_2c_1$	44705	100	0	Mt
$b_2a_2c_1$	58157	130	13452	***
$b_1a_2c_2$	38658	100	0	Mt
$b_2a_2c_2$	46964	122	8305	*
$b_1a_2c_3$	50205	100	0	Mt
$b_2a_2c_3$	44165	88	-6040	-
DL (p 5%)= 731 kg/ha; DL (p 1%)= 1061 kg/ha; DL (p 0.1%)= 1620 kg/ha;				
*positive not significant difference ***distinctly highly significant positive difference 0 - negative not significant difference 00 - significantly negative difference - not significant difference				

From the comparative analysis of the experimental factors B, A, and C, we can observe that the highest yield was obtained in the experimental variant where the sowing scheme was 15+15+75+15+15, the seedbed was prepared in the fall, the soil was ridged, and fertilization was done with NPK. In this variant, the production difference is distinctly highly significant positive, with an increase of 30%, compared to the variant where the sowing scheme was in bands of 150 cm with a distance of 15 cm between rows, fertilization was done with NPK, and the same seedbed preparation method was used. Thus, we can recommend that the carrot crop be sown according to sowing scheme 15+15+75+15+15, the seedbed be prepared in the fall, the soil be ridged, and fertilization be done with NPK.

Table 6. The comparative interpretation of dates - influence of factor C, A to B (The fertilization method, preparation of seeds bed and planting scheme)

Variant	Production	%	Difference	Difference of significance
$c_1a_1b_1$	42763	100	0	Mt
$c_2a_1b_1$	45559	107	2796	*
$c_3a_1b_1$	35406	83	-7356	00
$c_1a_1b_2$	38370	100	0	Mt
$c_2a_1b_2$	43477	114	5106	**
$c_3a_1b_2$	40155	115	1783	*
$c_1a_2b_1$	44705	100	0	Mt
$c_2a_2b_1$	38658	87	-6047	0
$c_3a_2b_1$	50205	112	5500	**
$c_1a_2b_2$	44165	100	0	Mt
$c_2a_2b_2$	46964	106	2798	*
$c_3a_2b_2$	58157	131,68	13992	***
DL (p 5%)= 1421 ha/kg; DL (p 1%)= 1622 kg/ha; DL (p 0.1%)= 2472 kg/ha;				
*positive not significant difference ***distinctly highly significant positive difference 00 - significantly negative difference - not significant difference				

A comparative analysis of the results obtained in the experimental variants under the influence of the gradations of experimental factor C, in relation to factors A and B, showed that the highest production was achieved in the experimental variant where fertilization was done with NPK and manure, the seedbed was prepared in the fall and ridged, and sowing was done according to scheme 15+15+75+15+15. The production differences were distinctly highly significant positive compared to the variant where fertilization was done with NPK and the seedbed was prepared in the fall, ridged, and the sowing scheme was 15+15+75+15+15. It is recommended to fertilize the carrot crop with manure and NPK, provided that the seedbed is prepared in the fall, the soil is ridged, and sowing is done according to scheme 15+15+75+15+15. Distinctly significant negative differences were recorded in the variant where fertilization was done with NPK and manure, the seedbed was prepared in the spring, the soil was not ridged, and sowing was done in bands of 150 cm with a distance of 15 cm between rows.

Table 7. The synthesis of the comparison through the Duncan test

No.	Variants	Production	Classification
1	$a_1b_1C_3$	35406	A
2	$a_1b_2C_1$	38370	AB
3	$a_2b_1C_2$	38658	ABC
4	$a_1b_2C_3$	40154	ABC
5	$a_1b_1C_1$	42763	ABCD
6	$a_1b_2C_2$	43477	ABCD
7	$a_2b_1C_3$	44165	BCD
8	$a_2b_2C_1$	44705	BCD
9	$a_1b_1C_2$	45559	BCD
10	$a_2b_2C_2$	46964	CD
11	$a_2b_1C_3$	50205	D
12	$a_2b_2C_1$	58157	E

In the interpretation of the data using Duncan's test, it can be observed that variants with similar influences and productions are marked with common symbols in the classification column. Thus, there are no significant differences between the variants where the seedbed was prepared in the spring, sowing was done in bands of 150 cm with a distance between rows of 15 m, and fertilization was done with manure, and the variants where the seedbed was prepared in the spring, the soil was not ridged, sowing was done according to scheme 15+15+75+15+15, and fertilization was done with NPK and manure. Comparing the results from all experimental variants, it can be observed that significant production differences were obtained in the variant where the seedbed was prepared in the fall, the soil was ridged, sowing was done according to scheme 15+15+75+15+15, and fertilization was done with NPK. On the opposite end, with a production of 35406 kg and significant negative results, is the variant where the seedbed was prepared in the spring, the soil was not ridged, sowing was done in bands of 150 cm with a distance of 15 cm between rows, and fertilization was done with NPK and manure. In recent years and especially at the U.S.A.M.V. Different studies were carried out in Cluj-Napoca with the aim of improving carrot culture technology. Bota, during three years, studied the optimal time for seeding and fertilization specific to root vegetable crops, including carrot crops. Mănuțiu, he studied the behaviour of 2 carrot hybrids (FLAKKER-3, NANTES-5), in the period 2010-2012, under the influence of sowing time and facial chemical fertilization. The best production results were obtained for the Flakker-3 hybrid, in the first sowing season (March) with an increase of 5.08 t. He found that the Fakker-3 hybrid reacted favourably (35.30 t), when sown in the first stage (March) and chemical phase fertilization, while Nantes-5 hybrid reacted favourably to manure fertilization (29.02 t) and sown in the same period (March).

The productions obtained in the other experimental variants are close in values. The linear regression of production, based on the interaction of the experimental factors, shows a uniformly upward trend across the entire graphical representation.

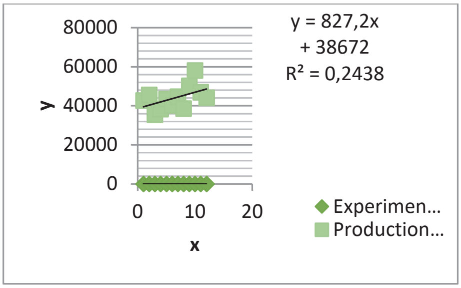


Figure 11. The linear regression of production

From the graphical representation, it can be observed that production can either increase or decrease depending on the method of seedbed preparation. It is noted that if the seedbed is prepared in the fall, the soil is ridged, sowing is done according to scheme 15+15+75+15+15, and fertilization is done with NPK, the production difference is distinctly highly significant positive, compared to the variant where the seedbed is prepared in the spring, the soil is not ridged, sowing is done in bands of 150 cm with a distance between rows of 15 cm, and fertilization is done with NPK.

CONCLUSIONS

Thus, based on the three years of studies and the comparative analysis of the experimental variants under the influence of the three experimental factors, a distinctly highly significant positive production difference is highlighted in the experimental variant where the seedbed was prepared in the fall, the soil was ridged, sowing was done according to scheme 15+15+75+15+15, and fertilization was done with NPK. In this variant, the production increase is 19786,66 kg/ha, compared to the variant where the seedbed was prepared in the spring, the soil was not ridged, sowing was done according to scheme 15+15+75+15+15, and fertilization was done with NPK. Therefore, it is recommended to prepare the seedbed in the fall, ridge the soil, sow according to scheme 15+15+75+15+15, and fertilize with NPK. The other variants yielded significant positive results with similar values.

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