fruit juice compared to Macrophylla at harvest time. Grafting Clementine Mandarin (strain 88) on Troyer Citrange rootstock increases TSS compared to Citrumelo 1452 and Macrophylla during fruit ripening time, and the change in TA plays an obvious role in changing maturity coefficient value compared to the change in TSS.

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Relationship between seed density, some characteristics of the sowing apparatus and the amount of seed sown

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Abstract. *Grain production provides significant resources for the food industry and animal husbandry. One of the most important moments in the cultivation of cereals is the planting of seeds in the soil. The sowing process is influenced by many factors. This study examines the impact of two such factors: seed density and the length of the sowing apparatus. These factors affect the quantity of seeds sown. Factor analysis demonstrated that changes in seed density exert a more substantial influence on seed quantity alterations. A functional relationship has been determined between the amount of seed sown, the length of the sowing apparatus in the seed box and the density of the crop used.*

Keywords: seed density, length of the sowing apparatus, amount of seeds sown

Introduction

The sowing apparatus is one of the most important working bodies in the construction of the drill. It plays a major role in seed dosing, distribution and delivery (Firsov and Golubev, 2013; Hristova, 2017). It is used to separate a certain number of seeds from the total mass and to form them into a stream with certain parameters. Sowing apparatuses vary in both purpose and design (Klishin, 2003; Krasovskikh and Klishin, 2007). Drum apparatuses are versatile, suitable for sowing various crops.They have a relatively simple construction and easily adapt to different sowing rates. Their main disadvantage, laid down in their principle of operation, is the uneven supply of seeds. The uneven arrangement of the seeds in the field is also affected by the working speed (Maga and Krištof, 2017). Research indicates that the optimal uniformity and the highest biological yield for sowing winter wheat are achieved at a speed of 12 km.h^{-1}.

To achieve a specific sowing rate, one can adjust the working length of the sowing apparatus. The amount of seeds sown can also be adjusted by changing its rotation speed. It has been found that high rotation speed damages the seeds. In order to minimize this damage and to ensure greater uniformity of sowing the seeds, it is necessary to choose the possible minimum speed and the maximum working length of the sowing apparatus (Valiev et al., 2013).

The push for improving sowing machines stems from the diverse technological properties of seeds, varied sowing schemes, methods, standards, as well as differing soil-climatic conditions and agronomic requirements. It is considered that the most promising and reliable, with good quality indicators and accurate maintenance of the sowing rate, is the mechanical drive of the sowing apparatus (Antonov and Buchma, 2010; Laryushin et al., 2010; Laryushin and Antonov, 2011). Only those seed properties that significantly influence the sowing process are considered technological (Kapustin, 2012). These include shape, size, density and mass, coefficient of friction, the ability of the seed to withstand certain types of deformation, etc. The shape of the seeds can be ellipsoidal, spherical, lenticular, bean-shaped, pyramidal. The length of cereal seeds varies from 4 (spring wheat) to 18.6 mm (oats), their width - from 1.4 to 4 mm, and thickness - from 1 to 4.5 mm. The shape and size of the seeds influence the process of pouring the seeds from the

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opening of the hopper, the choice of the type of sowing machine and the parameters of the sockets in the sowing discs of the precision seed drills depend on them. When sowing cereals with an aggregated surface, density becomes a vital parameter for adjusting the seed drill (Lovrich, 2003). Studies show that it varies considerably for different crops (Vezirov and Kozlev, 2002).

Based on the analysis made so far, the following conclusions can be made and the purpose of the study can be formulated:

The widely used gutter sowing apparatus feeds the seeds in portions (pulse), due to which there is an uneven distribution of their working stroke. The amount of seeds sown depends on the speed of rotation and the length of the part of the apparatus located in the seed box. The length of the gutter sowing apparatus is structurally limited. The use of part of it during work leads to an increase in seed trauma. The density of the studied materials varies from 300 to 900 kg.m^{-3}, and in the studied literature there are insufficient data on its influence on the amount of seeds sown.

The primary objective of this study is to examine how the length of the sowing apparatus within the hopper and the seed density affect the quantity of seeds sown.

Material and methods

Observations have been conducted in the research laboratory of the Department of Mechanization of Agriculture, Agricultural University - Plovdiv. We utilized a sowing apparatus characterized by a length of 32 mm, diameter of 44 mm, with 10 grooves each 3 mm deep. The length of the sowing apparatus inside the seed box was measured using a caliper, accurate to ± 0.05 mm. We used a digital scale, FR-H 6000 (https://emsi-bg.com/vezni-precizni-laboratorni-tehnicheski-zlatarski.htm), with an accuracy of ± 0.1 g to measure the quantity of seeds sown over 10 revolutions of the sowing apparatus.

The experiment has been conducted according to plan B2 (Mitkov and Minkov, 1993). The independent variables (factors) are: seed density and length of the sowing apparatus located in the seed box. Each of the two factors changed on three levels. Seeds with a density of 250, 537 and 825 kg.m^{-3} were selected for the density. Regarding the other factor, the length of the sowing apparatus, the following values are selected - 5, 15 and 25 mm.

Before each trial, the seed box was refilled. We performed 15 rotations of the sowing apparatus to clear any remaining seeds from the previous experimental set point. Then the sowing machine was turned 10 times, the seeds sown were collected and weighed on the scales. At each point in the experimental plan, the operation was repeated 3 times.

With the averaged data, factor and regression analyses have been performed with the help of the statistical program Statistics V.7.

We conducted the factor analysis using the Main diagonal method. With its help, the degree of influence of each of the two factors on the change of the monitored indicator has been established.

Regression analysis has been employed to ascertain the functional relationship between the two factors and the indicator, based on the following model:

$$Y = b_0 + b_1 * X1 + b_2 * X2 + b_{11}^2 * X1^2 + b_{22}^2 * X2^2 + b_{12} * X1 * X2 \quad (1)$$

where b_0, b_1, ... b_{nn} are the regression coefficients, X1 - seed density, kg.m^{-3}, X2 - sowing length, mm.

A stepwise search for the regression coefficients has been performed. At each step, the coefficient at which it had the highest value at the significance level has been removed (Draper and Smith, 1986). All coefficients for which the significance level is less than or equal to 0.05 ($p \leq 0.05$) are significant and remain in the model.

Results and discussion

The design of the experiment and the mean values are presented in Table 1. Table 2 showcases the results of the factor analysis based on data from Table 1.The results of the regression analysis are shown in Table 3.

Table 1. Experimental plan and quantity of seeds sown for 10 revolutions of the sowing apparatus, g

Factors		Sown quantity of seeds for 10 revolutions of the sowing apparatus, g	
Density X1, kg.m^{-3}	Gutter length X2, mm	Mean	SD
250	5	14.7	0.36
250	25	64.0	1.25
825	5	15.3	0.36
825	25	128.7	1.31
537	5	15.0	0.26
537	25	97.3	0.79
250	15	33.0	0.75
825	15	67.3	0.79

Table 2. Factor analysis to determine the degree of influence of the density and length of the trough on the sown amount of seeds.

Eigenvalues (Density, Gutter length) Extraction: Principal components				
Factors	Eigenvalue	% Total	Cumulative	Cumulative
Density	1.956765	65.22550	1.956765	65.22550
Gutter length	1.000000	33.33333	2.956765	98.55883

Table 3. Regression analysis for the influence of the density and length of the trough on the sown amount of seeds

Regression Summary for Dependent Variable: Amount of seeds sown; R= 0,9997 ; R²= 0,9994; Adjusted R²= 0,9990; F(3,4)=2414,8; p<0,00001			
Regression coefficients	b	t(4)	p-level
Intercept	11.588	6.933	0.0023
X1	-0.024	-6.320	0.0032
X2^2	0.039	9.495	0.0006
X1.X2	0.005	25.138	0.0001

The results of the experiments shown in Table 1 and their processing, reveal a good grouping around the mean values. The standard deviation at each point in the experiment is small. This suggests that there are no gross errors in the measurements and the data obtained can be used in factor and regression analyses (Draper and Smith, 1986).

As the density and groove length in the seed box increase, there is a corresponding rise in the amount of seeds sown. This trend is less pronounced at the shortest groove lengths, with minimal differences observed across the three seed densities. With the small volume of the grooves, the seeds with smaller sizes fill it better, while with the seeds with larger sizes the filling coefficient is lower. The significant influence of the shape and size of the seeds on the sown amount is confirmed by the study (Kapustin, 2012). As the length of the grooves increases, their volume increases, too. Larger seeds align more compactly, enhancing the fill factor. This leads to a difference in the sown quantities at different densities of the seeds used.

The results of the factor analysis (Table 2) confirm previous studies (Lovrich, 2003) that the amount of seeds sown is strongly influenced by their density. About 65% are due to it. 33% of the change in the observed indicator is due to the change in the length of the part of the sowing apparatus located in the seed box.

Notably, 98.5% of the variance in the sown amount of seeds can be attributed to the two aforementioned factors. Only 1.5% of this change was due to other factors not reported in the present study. According to leading authors (Mitkov and Minkov, 1993), this is a prerequisite to perform a regression analysis with only these 2 factors (density and length of the grooves).

The required model has the form:

$$Y = 11.588 - 0.024 * X1 + 0.039 * X2^2 + 0.005 * X1 * X2 \quad (2)$$

Table 3 confirms the adequacy of the model in fitting the experimental data (p = 0.00001), suggesting its potential utility in predictive and optimization tasks, as discussed by Draper and Smith (1986). The model is presented in graphical form in the following Figure 1.

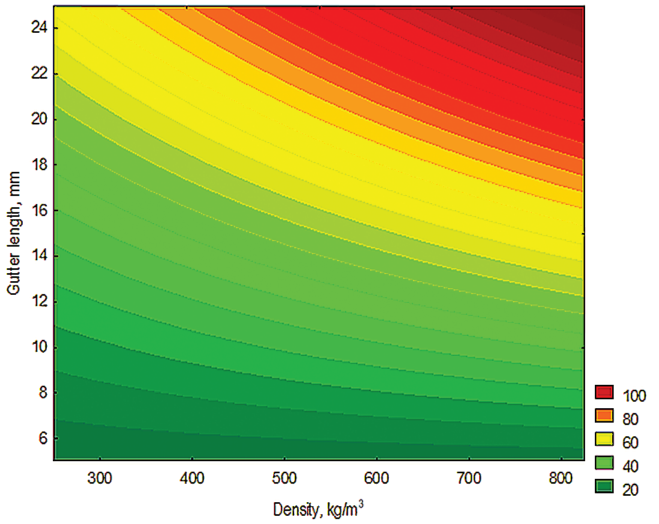

Figure 1. Change in the amount of seeds sown depending on the density and length of the sowing apparatus

It has been confirmed that with increasing bulk density, with a small length of the grooves, there is a small difference in the amount of seeds sown. A significant difference has been obtained by increasing the length of the grooves at the same density of the seeds used.

Conclusion

Based on the findings of this study, we conclude that we have established a functional relationship among the quantity of seeds sown, the length of the sowing apparatus within the seed box, and the seed density. As the density and working length of the sowing apparatus increase, the amount of seeds sown also increases. Approximately 65% of this variation can be attributed to changes in seed density.

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Effects of the share types of an inter-row cultivator at different working depths on weed control and plant growth in cotton production

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Abstract. *Different share types of tine type inter-row cultivator are used to remove the weeds and loosen the soil surface between the rows during the first true leaf stage of cotton. The efficiency of these shares can be changed by soil properties and working parameters. Therefore, this study evaluated the effects of different share geometries for a tine inter-row cultivator on weed control and plant growth parameters at three different working depths (100, 150 and 200 mm) and a constant working speed (5.4 km. h^{-1}) under cotton planted field conditions. Measurements included the weeding efficiency within row and between rows, the percentage of damaged plants, root dry weight, shoot dry weight, NDVI (Normalized difference vegetation index), SPAD (the relative content of chlorophyll) values and seed cotton yield. The results indicated that the inter-row cultivation at the first true leaf stage of cotton significantly increased the plant growth parameters (root dry weight, shoot dry weight, NDVI, SPAD) and seed cotton yield. The share types had a strong effect on the weeding efficiency and the percentage of damaged plants. The increased working depth increased the weeding efficiency, plant growth parameters and seed cotton yield, but also significantly increased the percentage of damaged plants. Overall, the results from this study suggest that the inter-row cultivation during the early stage of cotton will be an effective approach in improving the weed control and the plant growth in cotton production. These outcomes depend on the share type and working depth of the tine type inter-row cultivator.*

Keywords: cotton, damaged plant, inter-row cultivation, plant growth, weeding efficiency

Introduction

Cotton is one of the most widely cultivated crops in the world. Achieving high cotton yield and quality requires effective management of agronomic practices such as soil bed preparation, planting, fertilizing, inter-row cultivation, watering, and harvesting (Dai and Dong, 2014; Özaslan et al., 2015; Feng et al., 2017). Among these agronomic practices, inter-row cultivation has a significant effect on plant growth and yield because it destroys weeds between rows and loosens the soil surface, thereby improving soil aeration, reducing water evaporation and breaking soil crusts (Amonov et al., 2006). Several researchers (e.g. Buckingham, 1984; Buhler et al., 1995; Cloutier and Leblanc, 2001; Steinmann, 2002; Cloutier et al., 2007) reported that inter-row cultivation would improve the crop yield even in the absence of weeds. These authors emphasized that this positive contribution to yield could be attributed to the fact that soil loosening by cultivators influences the quantity of air in soil by disturbing the soil crust and restores the air regime, particularly after rain. Also, they stated that inter-row cultivation during the early stage of plant growth broke up soil capillaries, preventing water evaporation under warm and dry growing conditions; it could enhance mineralization of organic matter and improve water infiltration in the soil. However, the crop could be damaged by being uprooted or buried by soil tillers during inter-row cultivation.

Inter-row cultivation starts very soon after planting, during germination of young crops, and continues about four to five months until the end of the growing season. Therefore, several inter-row cultivation tools are developed

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