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Variability of corn grain yield and moisture depending on the method of tillage

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Abstract. Optimisation of corn grain production requires a comprehensive approach to reducing technology costs. The purpose of the experiment and the research objective was to determine the optimal method and depth of primary soil tillage to reduce soil moisture losses and to substantiate the appropriate maturity group of the cultivated hybrids for the implementation of their genetic yield potential with maximum moisture release under field conditions of the central Forest-Steppe zone. The response of 11 mid-early and mid-season corn hybrids (FAO 210-350) was evaluated in 2019-2021 under different primary tillage methods – disc harrowing (up to 15 cm), ploughing (25-27 cm), and deep loosening (35-37 cm) – and yields and moisture release were compared across treatments and hybrid maturity groups. A statistically high correlation coefficient ($r = 0.74^{***}$) indicated the dependence of corn grain yield on the depth of the main tillage. Loosening at 35-37 cm provided an increase in the yield of corn grain from 0.7 to 1.6 t/ha compared to ploughing, and disc harrowing reduced the yield from -0.3 t/ha to -0.9* t/ha. The yield regression equation from the ripeness group (FAO) – $y = 3.5269 + 0.0117x$ – indicated the possibility of increasing grain yield when using hybrids with a longer growing season, which was confirmed by a significant positive correlation coefficient $r = +0.86^{***}$ (73.96%). Statistically significant correlation of these features with double disc harrowing – $r = +0.42^{**}$ (17.6%), with ploughing – $r = +0.22^{**}$ (4.8%), with deep loosening – $r = +0.38^{**}$ (14.4%), respectively. The trend of increasing grain moisture with increasing yield was established – $r = +0.89^{***}$ in the hybrids under study, regardless of the method of tillage. Increasing the yield of corn

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grain was possible by growing later-maturing hybrids, while the moisture content of grain will also increase. The highest grain yield was provided by mid-season hybrids with Tesla (FAO 350) – 8.95 t/ha (+1.03*t/ha) and KWS 351 (FAO 350) – 8.77 t/ha (+1.6**t/ha) against the background of deep loosening of the soil at 35-37 cm with an average humidity of 16.81% and 16.28%, respectively. As a result of the experiment, it was recommended to sow in the central Forest-Steppe with mid-season corn hybrids (FAO 300-350) using deep loosening of the soil with a disc-chisel unit up to 35-37 cm as the main treatment

Keywords: corn hybrids; correlation; regression; variation coefficient; deep loosening; depth of cultivation; FAO

INTRODUCTION

An important role in implementing the genetic potential of corn is played by the presence of sufficient moisture in the root layer of the soil. Due to the specific weather conditions of the last decade, plants mainly suffer from insufficient moisture during the most critical periods of growth – from flowering to grain filling and wax maturity. The method and depth of the main tillage is a significant factor in the possibility of preserving and effectively using the existing natural moisture reserves by the plant, and given the lack of irrigation in the vast majority of the central Forest-Steppe of Ukraine, establishing the optimal method and depth of the main tillage for corn and determining hybrids with fast moisture recovery in the field and high grain yield was relevant for study.

V. Poliakov (2020) and O. Havriushenko & V. Rudas (2025) noted that an important factor influencing the value of grain yield and its quality is the sowing of corn hybrids of certain ripeness groups that are more adapted to local growing conditions, which have their own genetic characteristics. The difference in the growing season between FAO 190 and 380, according to R. Vozhehova *et al.* (2023), is up to 19-22 days, this affects the yield properties of hybrids, maturation time, and harvesting humidity. V. Palamarchuk *et al.* (2020) and M. Kyrpa *et al.* (2023) indicated differences in moisture recovery in different ripeness groups. One of the most important energy-intensive technological operations in the cultivation of corn is tillage, which is used to create comfortable conditions for the growth and development of plants in the field. S. Dolia (2024b) noted that the method and depth of primary soil tillage play an important role in the water and air permeability of the upper layers, where the root system of plants is mainly located. There was no consensus among researchers about the absolute superiority of one or another method of primary soil tillage, since this was influenced by the predecessor, soil, climatic, and weather conditions of the growing year, terms and seeding rates, and other factors.

For agricultural production in Ukraine, ploughing is the most common and traditional method of primary soil tillage, which has a number of advantages over other methods of tillage. According to specialists from the Institute of Irrigated Agriculture, under irrigation in the Steppe zone, ploughing to a depth of 25-27 cm is the most appropriate, providing up to 14.9 t/ha of

corn grain compared with 11.2 t/ha with disc harrowing (Pysarenko *et al.*, 2020). The study by A. Kovalenko *et al.* (2022) on sunflower indicated that the proportion of influence of the method of tillage on the yield is 51-75% and the highest yield is achieved when using ploughing. T. Chaika *et al.* (2023) and A. Andriienko *et al.* (2025) established a differential response of soybean varieties to tillage methods, but traditional ploughing had the advantage. Conclusions of the dissertation by A. Kohan (2021) on sunflower in the Steppe zone of Ukraine, and experiments by M. Marenych & K. Koba (2024) on corn showed the superiority of ploughing over other methods of tillage. In the literature sources, there was also an alternative opinion about the method and depth of the main tillage, as evidenced by the conclusions from the experiments of other researchers on other crops. The advantage of deep tillage over surface tillage was proved by experiments of P. Pysarenko *et al.* (2020), which pointed out the advantage of deep loosening of the soil over ploughing and disc harrowing according to the phytosanitary state of crops, where the number of pathogens is lower and the yield is higher.

Thus, the purpose of the study was to investigate the influence of the method and depth of the main tillage on the yield and harvesting moisture of corn hybrids of different FAO groups and the level of variability of these characteristics in the conditions of the central part of the Forest-Steppe of Ukraine.

MATERIALS AND METHODS

The experiment was conducted in the central part of the Forest-Steppe during the growing season of 2019-2021 in the field crop rotation of the Uman District, Cherkasy Oblast, on podzolized chernozem with a pH of 5.9-6.2 and a humus content of up to 3.1%. The predecessor was winter wheat, the seeding rate for all hybrids was 80 thousand pcs/ha, the amount of mineral fertilisers applied ($N_{114}, P_{24}, K_{24}, S_{24}$ of active substance) and plant protection – identical for all variants of the experiment for 3 years. The temperature regime of the growing season exceeded the long-term average values of all years of the experiment. The most critical temperatures were June, July, and August. According to data from the Uman meteorological station, total precipitation during the 2019 growing season (April-August) amounted to 192 mm, in 2020 – to 232 mm, and

in 2021 – to 371 mm, compared with a long-term average of 281 mm (Novak & Novak, 2022; 2023).

The subjects under study were 11 corn hybrids of various genetic origins with FAO 210-350, which were divided into conditional ripeness groups:

1. FAO 210-250 – Gran 220 (FAO 210), Gran 310 (FAO 250), DKC 3795 (st.) (FAO 250) – standard for the group;

2. FAO 260-300 – VN 63 (FAO 280), Gran 6 (FAO 300), LG 30315 (st.) (FAO 280) – standard for the group;

3. FAO 310-350 – VN 6763 (FAO 320), Amarok 290 (FAO 320), DKC 3511 (FAO 330), Tesla (FAO 350), KWS 381 (st.) (FAO 350) – standard for the group.

Variants of the experiment were three methods of primary soil tillage:

1. Option 1 (control) – classic ploughing with a skim coulter to a depth of 25-27 cm;

2. Option 2 – double disc harrowing to a depth of 12-15 cm;

3. Option 3 – combined cultivation to a depth of 35-37 cm – deep loosening of the soil with a disc-chisel unit.

The number of repetitions was 3 for each hybrid in each of the tillage options. The area of the site was 0.56 ha (500*11.2 m). Placement of plots (hybrids) within each tillage option was randomised. Corn harvesting was carried out using a combine harvester equipped with a corn header, with grain yield determined by the weighing method and recalculated into t/ha. The grain harvest moisture was determined by the Wile 55 grain moisture meter. Statistical analysis was carried out according to generally accepted methods (Yeshchenko *et al.*, 2014) with the definition of statistical indicators of the average value (\bar{x}), standard deviation (S_x), coefficient of variation (CV,%), correlation coefficient (r), regression coefficient (b).

RESULTS AND DISCUSSION

The optimal duration of the harvesting period of technologically ripe grain is 10-20 days, provided that the threshing time increases, there are risks of significant losses due to lodging of plants, shedding of grain,

damage by pathogens and pests. Therefore, the simultaneous maturation and moisture recovery of grain at all cobs in the array is important, which is given considerable attention by breeders (Vozkhehova *et al.*, 2021; Bibel & Chernobai, 2023). High-yielding modern corn hybrids, contained in the state register of plant varieties suitable for distribution in Ukraine (2025), provide grain yields – up to 20 t/ha, silage mass – up to 80-90 t/ha. As of 2024, the known record corn yield was 39.14 t/ha on irrigation in the United States (Corteva agriscience, 2024). In Ukraine, the real yield of grain crops reached in the Steppe conditions on irrigation from 14.2 t/ha (Hadzalo *et al.*, 2024) up to 15.6 t/ha (Skoryk & Prykhodko, 2025). In the Forest-Steppe, the yield of corn hybrids of different ripeness groups without irrigation, according to O. Mishchenko *et al.* (2024) – 9.4-12.1 t/ha, according to Z. Hlupak & A. Butenko (2022) – up to 11.4 t/ha.

The experimental data obtained indicate a difference in the yield level by year, since the weather conditions were diverse during the experiment. Average temperatures from April to September (the growing season of corn) exceeded the long-term average in all years of observation. 2019 was favourable in terms of weather conditions for the development of an average yield level by corn hybrids under study (Table 1). The beginning of the corn growing season in 2020 was optimal for plant development in terms of temperature and precipitation. In May and June, a total of 171.4 mm fell, and the average temperature contributed to the active growth of plants. But extreme high temperatures and very limited precipitation during the period of flowering and grain filling (July – August) negatively affected the development of grains, so the average yield of corn ranged from 3.4 t/ha to 7.3 t/ha for hybrids of different ripeness groups. 2021 was optimal, during the experiment period, for the maximum implementation of the genetic yield potential of the corn hybrids under study. Significantly higher than the average long-term precipitation and optimal, without sharp highs, temperatures of the growing season allowed developing a grain yield from 6.5 to 12.6 t/ha.

Table 1. Precipitation and average air temperature during the corn growing season, 2019-2021

Month of the year	Precipitation, mm, by year				Average temperature, °C, by year			
	2019	2020	2021	Average long-term	2019	2020	2021	Average long-term
March	16.3	23.9	32.4	36.0	4.3	6.3	2.0	0.4
April	22.4	21.0	49.9	41.0	12.4	9.2	7.4	8.5
May	35.6	101.0	56.4	52.0	19.2	12.5	14.0	14.6
June	69.8	70.4	104.7	81.0	22.3	20.9	19.8	17.6
July	33.8	21.4	89.8	68.0	22.1	21.6	23.2	19.0
August	19.2	17.1	69.9	49.0	21.9	21.2	20.3	18.2
September	30.6	27.4	16.2	61.0	12.3	17.8	13.0	13.6
Total for the growing season of the study year	227.7	282.2	419.3	388.0				
Total for a year	376.6	478.9	641.6	586.0				

Note: according to the Uman weather station

Source: developed by the authors based on V. Novak & A. Novak (2022; 2023)

The results of the dispersion analysis of the obtained experimental data indicate a significant differentiation of hybrid yield depending on the method of primary soil tillage (Table 2).

Table 2. Average grain yield of corn hybrids based on the results of variance analysis of a two-factor experiment, 2019-2021

Method of primary soil tillage (factor A)	Hybrid name (factor B)	Average by variant, x, t/ha	Difference by factor	
			A	B
Ploughing (25-27 cm) (control)	DKC 3795 (st.)	6.99		
	Gran 220	5.54		-1.44**
	Gran 310	6.72		-0.27
	LG 30315 (st.)	6.23		
	VN 63	6.59		0.35
	Gran 6	6.73		0.50
	KWS 381 (st.)	7.16		
	VN 6763	7.03		-0.13
	Amarok 290	6.94		-0.23
	DKC 3511	7.21		0.05
	Tesla	7.92		0.76
	Disc harrowing (12-15cm)	DKC 3795 (st.)	6.25	-0.74
Gran 220		4.60	-0.94*	-1.65**
Gran 310		6.14	-0.58	-0.11
LG 30315 (st.)		5.90	-0.33	
VN 63		5.80	-0.79	-0.10
Gran 6		6.25	-0.48	0.35
KWS 381 (st.)		6.70	-0.46	
VN 6763		6.69	-0.34	-0.01
Amarok 290		6.47	-0.47	-0.23
DKC 3511		6.51	-0.70	-0.19
Tesla		6.99	-0.94*	0.29
Loosening (35-37cm)		DKC 3795 (st.)	8.04	1.06*
	Gran 220	6.59	1.05*	-1.45**
	Gran 310	7.55	0.83*	-0.49
	LG 30315 (st.)	7.71	1.47*	
	VN 63	7.45	0.86*	-0.26
	Gran 6	7.52	0.79	-0.19
	KWS 381 (st.)	8.77	1.60*	
	VN 6763	8.12	1.09*	-0.65
	Amarok 290	8.15	1.21*	-0.62
	DKC 3511	7.87	0.66	-0.89*
	Tesla	8.95	1.03*	0.19
		LSD _{0.95} by factors		0.80
	LSD _{0.99} by factors		1.84	1.10

Note: *, ** – significant at $P_{0.05}$ and $P_{0.01}$, respectively

Source: developed by the authors based on V. Skoryk & V. Prykhodko (2025)

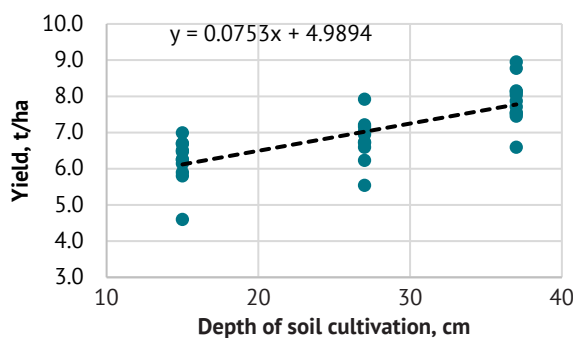
In comparison with the control (ploughing 25-27 cm) in the 12-15 cm disc harrowing variant, all corn hybrids under study formed a lower grain yield, within the limits of the experiment error. Significant reduction in yield, with $LSD_{0.95} \geq 0.80$ t/ha, found in hybrids Gran 220 (-0.94* t/ha, or -16.97%) and Tesla (-0.94* t/ha, or -11.87%) on disc harrowing compared to ploughing. When using combined deep tillage with a disc-chisel unit to a depth of 35-37 cm, the corn hybrids under study formed mainly significantly higher grain yields compared to the control. Hybrids Gran 6 (+0.79 t/ha, or +11.74%) and DKC 3511 (+0.66 t/ha, or +9.15%) gave an

increase within the statistical error of the experiment. In other hybrids under study, the increase ranged from +0.83* t/ha (+12.35%) to + 1.60* t/ha (+22.35%), which is significant at $P_{0.05}$.

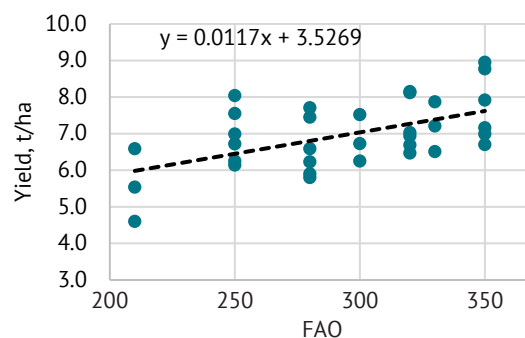
The average yield of corn grain in the experiment on different variants of primary soil tillage differs depending on the depth of processing. On average, according to the experiment for three years, the yield on the control version of ploughing at 25-27 cm was 6.82 t/ha, on disc harrowing at 12-15 cm – 6.21 t/ha, on deep combined cultivation – 7.88 t/ha. That is, in the conditions of the central Forest-Steppe, with an

increase in the depth of the main cultivation, a significant increase in grain yield by +1.06 t/ha (+15.5%) was established during deep loosening of the soil with a combined disc-chisel unit. When using disc harrowing at 12-15 cm, the yield in the experiment decreased by an average of -0.61 t/ha (-8.9%). Similar results were obtained and described in the literature sources, where when using disc harrowing, a decrease in yield compared to ploughing was recorded by more than 20% (Dolia, 2024b).

Correlation coefficient between the depth of tillage and the average experimental yield of hybrids $r = +0.74^{***}$ significant at $P_{0.001}$ and it indicates a direct significant relationship between the yield of corn



a



b

Figure 1. Graph of regression of corn grain yield from the depth of tillage (a) and ripeness groups (b)

Source: developed by the authors based on V. Skoryk & V. Prykhodko (2025)

Thus, deep loosening of the soil at 35-37 cm in the conditions of the central part of the Forest-Steppe provides a significant increase in the yield of corn grain (from +0.66 t/ha to +1.60* t/ha) in comparison with classical ploughing at 25-27 cm and has significant advantages over disc harrowing at 12-15 cm for mid-early and mid-season hybrids with FAO 210-350, which were studied in this experiment. Similar conclusions were highlighted in the dissertation by S. Dolia (2024a), which indicates the advantage of deep loosening over chiseling and disc harrowing in optimising the agrophysical state of soils. Based on the results of the analysis of variance, it also became possible to compare the yield indicator between hybrids of different ripeness groups (Table 2). Significantly lower than the standard yield for hybrids was established in the FAO 210-250 group for Gran 220 (FAO 210). With disc harrowing, the crop shortage was -1.65 t/ha (-26.40%), with ploughing - -1.44 t/ha (-20.60%), with deep loosening - -1.45 t/ha (-18.03%), with $LSD_{0.05} = 0.78$ t/ha, and with $LSD_{0.01} = 1.10$ t/ha. Gran 310 (FAO 250) in terms of grain yield was close to the standard DKC 3795 (FAO 250) within the limits of the experiment error. In the FAO 260-300 group, there was no statistically significant difference in the yield of hybrids by tillage options with a conditional standard, that is, the hybrids of this ripeness group

presented in the experiment do not significantly differ in productivity among themselves.

For the FAO 310-350 group – significantly lower yield, compared to the group standard, recorded in the hybrid DKC 3511 (FAO 330) – -0.89 t/ha (-10.15%) on deep loosening of the soil. Hybrids with FAO 320 – VN 6763 and Amarok 290 – produced lower than standard grain yields in all soil cultivation variants within the margin of error of the experiment. A small increase in grain yield was established for the Tesla hybrid (FAO 350): with disc harrowing +0.29 t/ha, with ploughing +0.76 t/ha, with deep processing +0.19 t/ha, respectively. Hybrid Gran 6 (FAO 300) formed a higher (within the limits of the experiment error) from the conditional standard of the group yield with disc harrowing +0.35 t/ha and on ploughing +0.50 t/ha. Hybrid VN 63 on average slightly exceeded the standard against the background of ploughing +0.35 t/ha. In general, according to the experiment, mid-season hybrids with a higher FAO – up to 350, compared to other ripeness groups, provided consistently high grain yields. The graph and regression equation are shown in Figure 1. Variation of the trait grain yield by year of the experiment differed significantly for all the hybrids under study. The largest, average coefficient of variation in grain yield against the background of the control variant was ploughing at 25-27 cm (Table 3).

Table 3. Variability and correlations of average values of corn grain yield and moisture according to experimental variants, 2019-2021

Primary soil tillage options by year of testing	Grain yield at 14% humidity		Harvesting moisture of grain		Correlation coefficients between traits "grain yield – grain moisture"	
	\bar{x} , t/ha	CV, %	\bar{x} , %	CV, %		
Average for the year of testing	2019	6.03	18.80	15.10	6.23	0.23**
	2020	4.62	26.28	14.70	11.29	0.18*
	2021	10.27	12.98	15.50	9.31	0.59***
	average for the experiment	6.97	38.75	15.10	9.39	0.35**
Disc harrowing at 12-15 cm	2019	5.36	17.11	15.10	7.18	0.55**
	2020	4.02	15.90	13.83	7.31	0.10
	2021	9.23	10.88	15.00	9.66	0.61**
	average for the experiment	6.21	38.32	14.60	9.01	0.42**
Ploughing 25-27cm	2019	6.05	17.06	15.21	4.89	0.10
	2020	3.88	16.26	15.24	11.98	0.13
	2021	10.54	10.24	15.68	9.54	0.59**
	average for the experiment	6.82	43.03	15.40	9.32	0.22**
Loosening 35-37cm	2019	6.67	15.94	15.02	6.51	0.15
	2020	5.94	16.57	14.99	11.30	0.21
	2021	11.04	10.95	15.87	7.95	0.50**
	average for the experiment	7.88*	31.78	15.30	9.12	0.38**

Note: *, **, *** – significance of the indicator at $P_{0.05}$, $P_{0.01}$, $P_{0.001}$, respectively

Source: compiled by the authors

Comparison of the coefficients of variation in grain yield and moisture by year allows indirectly assessing the influence of weather conditions on the implementation of the genetic potential of the corn hybrids under study. Thus, the highest average yield variation is in 2020 with extreme weather conditions (CV = 26.28%), and the lowest – in a favourable 2021 (CV = 12.98%). According to the variants of primary soil tillage, this reaction is similar. That is, severe extreme weather conditions of the growing year increase the variability of the grain yield trait in the corn hybrids under study, regardless of the method of tillage. The trend of the average harvesting humidity indicator is similar, and its variation in tillage methods is close to 9%, while the average values of the grain humidity indicator are very close to each other, regardless of the ripeness group. Thus, the corn hybrids under study with FAO 210-350

differed little in grain moisture at the time of harvesting over the years of study.

Correlation analysis of grain yield and moisture indicates a positive average significant relationship between these traits. The average correlation coefficient between yield and harvesting humidity in the experiment is positive and significant and amounts to $r = +0.35^{**}$ (or 12.3%). With disc harrowing, the correlation coefficient $r = +0.42^{**}$ (17.6%), with ploughing – $r = +0.22^{**}$ (4.8%), with deep loosening – $r = +0.38^{**}$ (14.4%), respectively (Table 3), that is, regardless of the method of primary soil tillage, a higher harvesting humidity is established with a higher grain yield. The regression graph is shown in Fig. 2. The average grain moisture content in the experiment did not change significantly according to the tillage variants – from 14.6% to 15.4%, and the difference between the options was within the limits of the experiment error at $P_{0.05}$.

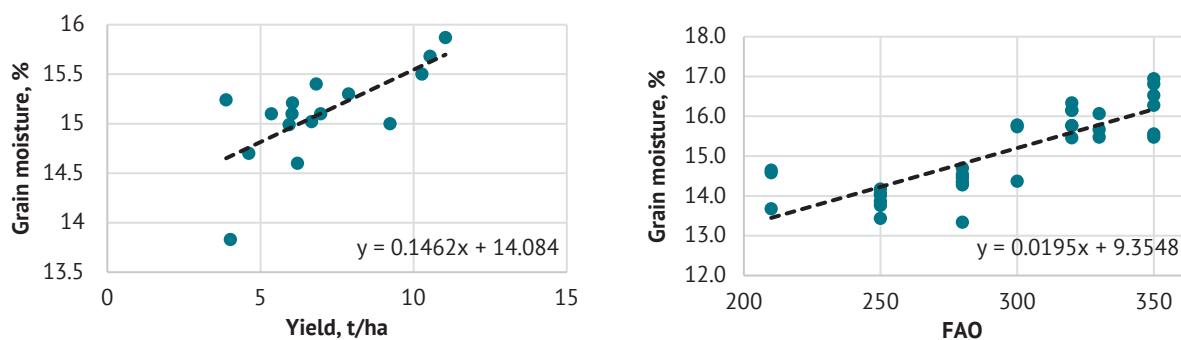


Figure 2. Regression graphs between features

Source: developed by the authors based on V. Skoryk & V. Prykhodko (2025)

The harvesting humidity of grain and the humidity of technological ripeness are extremely important when choosing a hybrid for growing in a particular region, since the profitability of growing a crop significantly depends on these indicators. Given that the corn grain must meet the humidity indicator of 14%, information on the

actual harvesting humidity of the hybrids under study is a valuable result of the experiment. Analysis of grain harvesting moisture indicators of the corn hybrids under study allows assessing the level of grain moisture loss at the time of threshing. The average values of harvesting humidity for the variants are shown in the table (Table 4).

Table 4. Average harvesting moisture content of corn hybrids on various variants of primary soil tillage, %, 2019-2021

Hybrid name (factor B)	Methods of tillage (factor A)		
	Ploughing 25-27 cm	Disc harrowing, 12-15 cm	Combined deep processing 35-37cm
Grain moisture content, %			
DKC 3795 (st.)	14.02	13.44	13.76
Gran 220	14.65	13.68	14.58
Gran 310	14.17	13.86	14.05
Average for the FAO group 210-250	14.28	13.66	14.13
LG 30315 (st.)	14.54	13.34	14.70
VN 63	14.46	14.28	14.35
Gran 6	15.78	14.37	15.74
Average for the FAO group 260-300	14.93	13.99	14.93
KWS 381 (st.)	16.53	15.55	16.28
VN 6763	15.76	15.46	16.15
Amarok 290	16.15	15.76	16.34
DKC 3511	16.07	15.67	15.48
Tesla	16.94	15.48	16.81
Average for the FAO group 310-350	16.29	15.58	16.21
LSD_{0.95} (by factor a) = 1.03%, LSD_{0.95} (by factor B) = 1.01%			

Source: developed by the authors based on V. Skoryk & V. Prykhodko (2025)

Among the hybrids under study, there is a tendency for higher harvesting moisture of grain with an increase in the ripeness group (FAO) (Fig. 2). On the control variant with ploughing, the variation in the average value of this trait for FAO 210-250 is 14.02-14.65%, for FAO 260-300 – 14.46-15.78%, for FAO 310-350 – 15.76-16.94%, respectively. Similar conclusions were obtained by Z. Hlupak & A. Butenko (2022) when studying hybrids of other breeding institutions. The same trend in the average humidity value was observed in the variants with disc harrowing and deep combined processing – the harvesting moisture content of grain was higher in hybrids with a longer growing season (FAO). The statistical substantiation of the experimental data of the experiment confirms a similar manifestation of the dependence of grain moisture during harvesting and the ripeness group of corn hybrids in the conclusions of Ya. Bielov (2022), who argued that as FAO increases, the moisture content of grain during harvesting is higher. There was no significant difference in the average humidity between the FAO 210-250 and FAO 260-300 groups in all variants of primary soil tillage in this experiment ($LSD_{0.95}(\text{factor B}) = 1.01\%$). This result is also similar to the conclusions of Ye. Bazylenko & T. Marchenko (2024) in the Steppe zone, which indi-

cates that a greater difference in humidity was clearly outlined in hybrids with a longer growing season, and FAO 190-280 did not differ much in humidity at the time of harvesting, which is confirmed by this experiment in the Forest-Steppe.

Significantly higher grain moisture content on all tillage options in hybrids with FAO over 310 compared to hybrids with a shorter growing season ($FAO \leq 300$). Comparing the indicators of harvesting humidity between hybrids of different ripeness groups, it should be noted that regardless of the method of primary soil tillage and the group of ripeness of hybrids for three years of observation (2019-2021), the maximum average value did not exceed 16.94% in ploughing in the most late-maturing of the Tesla hybrids under study (FAO 350). The low harvesting humidity of corn grain over the years of the experiment was also conditioned by rather high positive temperatures and significantly lower than normal precipitation in September-October (Novak & Novak 2022; 2023). The figure graphically shows the difference in yield and harvesting humidity of the corn hybrids under study compared to the control version of ploughing during disc harrowing and deep combined primary soil tillage (Fig. 3). The control option is taken as zero (0.00).

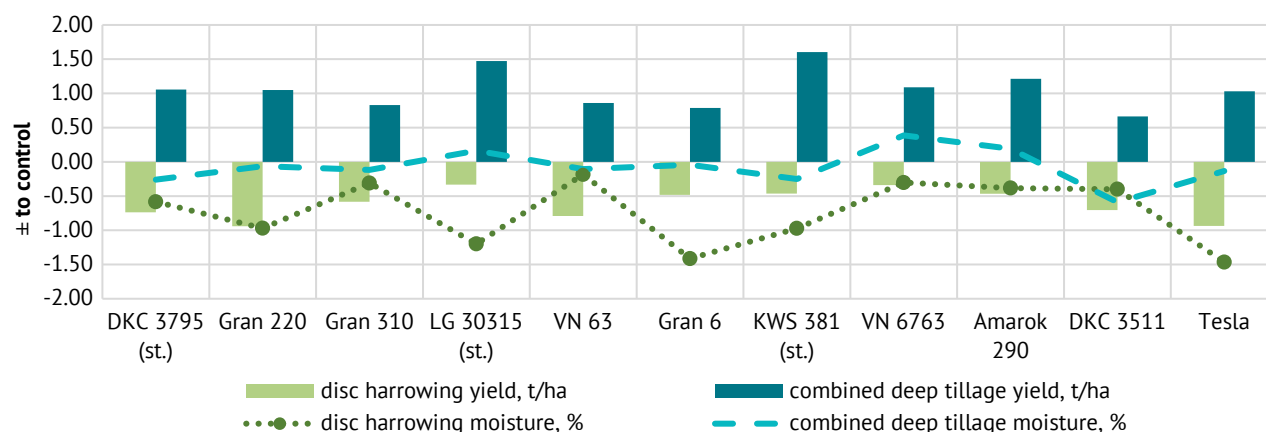


Figure 3. Average difference (\pm) of grain yield and harvesting moisture in corn hybrids of different ripeness groups compared to the control variant (ploughing – taken as 0 – zero), depending on the method of primary soil tillage in 2019-2021

Source: developed by the authors based on V. Skoryk & V. Prykhodko (2025)

Comparison of the average moisture content of grain during harvesting indicates a mostly low insignificant difference in the indicator for the main processing options compared to the control. It was found that the highest average harvesting humidity of grain was developed on the control version of ploughing at 25-27 cm, and with an increase or decrease in the depth of the main tillage, the harvesting humidity was lower within the limits of the experiment error. Corn hybrids with the disc harrowing variant (12-15 cm) had the lowest average grain humidity during harvesting compared to deeper processing options. Significantly lower humidity compared to the control was found with disc harrowing in hybrids LG 30315 (13.34%, or -1.2%*), Gran 6 (14.37%, or -1.41%*), Tesla (15.48, or -1.47%*). Insignificant low values of the correlation coefficients between the yield and harvesting humidity in 2020 also indirectly indicate a significant influence of weather conditions of the year on the nature of changes in grain humidity in an extreme year.

The highest positive and significant values for $P_{0.01}$ were correlation coefficients in 2021. In conditions favourable for the maximum realisation of the yield potential, corn hybrids showed the highest dependence of harvesting humidity on the yield level, that is, higher grain humidity was observed in more productive hybrids with higher FAO, and in early hybrids with lower yields, lower harvesting humidity was noted. This result is similar to the data by Ya. Bielov (2022) from an experiment in the Steppe, which indicates that despite the maximum water consumption of corn – 4,863 m³/ha – harvesting moisture of grain is higher in hybrids with higher FAO. Statistical analysis establishes correlation and regression coefficients between features and defines regression equations. The relationship of the ripeness group (FAO) with the experimental average yield and experimental average humidity of corn grain of the hybrids under study is significant at $P_{0.001}$.

It is determined that the correlation coefficient between FAO and yield is high positive $r = +0.86^{***}$ (regression equation – $y = 3.53 + 0.0117X$) (Fig. 1). Correlation between hybrid FAO and grain moisture of the studied samples – $r = +0.89^{***}$ (regression equation – $y = 9.36 + 0.0195X$) (Fig. 2). Therefore, in this experiment, it was established that the studied mid-early and mid-season hybrids of corn with FAO 210-350 are characterised by an increase in grain yield and an increase in harvesting humidity with the growth of FAO, that is, later hybrids form a higher yield with higher grain humidity in identical conditions. Similar results were obtained in previous experiments in the Steppe zone – V. Skoryk & V. Prykhodko (2025), and in experiments V. Poliakov (2020) found a relationship between the potential and actual yield of corn grain from the hybrid ripeness group – the larger the FAO, the higher the yield, and the yield increases from early-maturing to late-maturing. Based on the above, conclusions can be drawn that are characteristic of the cultivation conditions of mid-early and mid-season corn hybrids (FAO 210-350) under rainfed conditions in the central part of the Forest-Steppe zone of Ukraine.

CONCLUSIONS

Deep tillage at 35-37 cm with a disc-chisel unit provided a significant increase in the yield of corn of mid-early and mid-season hybrids with FAO 210-350 compared to control ploughing at 25-27 cm. Disc harrowing to a depth of 12-15 cm after the predecessor, winter wheat reduces grain yield in the studied corn hybrids and is not advisable as the main processing method. Corn hybrids with higher FAO provided an increase in grain yield with a higher percentage of humidity and identical growing conditions, which was confirmed by high significant correlation coefficients. The advantage of growing corn hybrids with FAO 320-350 in the central Forest-Steppe against the

background of deep tillage with a combined disc-chisel unit, which provides a significant increase in grain yield, was substantiated.

In the conditions of the central part of the Forest-Steppe of Ukraine without irrigation, when growing corn for grain, it is recommended to carry out combined deep primary soil tillage (35-37 cm), which is optimal in the cultivation technology, and ensures the maximum implementation of the genetic potential of hybrids. Primary shallow tillage by disc harrowing to a depth of 12-15 cm is not advisable due to a significant reduction in yield compared with ploughing and deep loosening. In addition, it is recommended to give preference to modern corn hybrids with FAO 300-350, which combine high grain yield with maximum moisture output. For further study, it will be relevant to involve more than 350 corn hybrids with FAO in the study and

substantiate the feasibility of using no-till and strip-till technologies in the Forest-Steppe of Ukraine.

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CONFLICT OF INTEREST

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Мінливість урожайності та вологості зерна кукурудзи залежно від способу обробітку ґрунту

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Анотація. Оптимізація виробництва зерна кукурудзи вимагає комплексного підходу до скорочення витрат на технологію. Визначити оптимальний спосіб та глибину основного обробітку ґрунту для зниження втрат ґрунтової вологи та обґрунтувати необхідну групу стиглості вирощуваних гібридів у реалізації генетичного потенціалу врожайності зерна з максимальною вологовіддачею в польових умовах центрального Лісостепу було метою проведеного дослідження та актуальним для вивчення. Визначено реакцію 11 середньоранніх та середньостиглих гібридів кукурудзи (ФАО 210-350) в 2019-2021 рр. за різних способів основного обробітку ґрунту – дискування (до 15 см), оранка (25-27см), глибоке розпушування (35-37 см) і проведено порівняння урожайності та вологовіддачі по варіантам і групам стиглості гібридів. Статистично високий коефіцієнт кореляції ($r = 0,74^{***}$) вказував на залежність урожайності зерна кукурудзи від глибини основного обробітку ґрунту. Розпушування на 35-37 см забезпечувало приривок урожайності зерна кукурудзи від 0,7 до 1,6 т/га в порівнянні з оранкою, а дискування знижувало урожайність від -0,3 т/га до -0,9* т/га. Рівняння регресії урожайності від групи стиглості (ФАО) – $y = 3,5269 + 0,0117x$ – показало на можливість збільшення урожайності зерна при використанні гібридів з довшим періодом вегетації, що підтверджено істотним позитивним коефіцієнтом кореляції $r = + 0,86^{***}$ (73,96 %). Статистично істотний кореляційний зв'язок цих ознак при дворазовому дискуванні – $r = + 0,42^{**}$ (17,6 %), на оранці – $r = + 0,22^{**}$ (4,8 %), на глибокому розпушуванні – $r = + 0,38^{**}$ (14,4 %) відповідно. Встановлена тенденція підвищення вологості зерна при зростанні урожайності – $r = + 0,89^{***}$ у вивчених гібридів незалежно від способу обробітку ґрунту. Підвищення урожайності зерна кукурудзи можливе шляхом вирощування більш пізньостиглих гібридів, при цьому вологість зерна також буде збільшуватись. Найвищу урожайність зерна забезпечили середньостиглі гібриди з Тесла (ФАО 350) – 8,95 т/га (+1,03*т/га) та КВС 351 (ФАО 350) – 8,77 т/га (+1,6**т/га) на фоні глибокого розпушування ґрунту на 35-37см з середньою вологістю 16,81 % та 16,28 % відповідно. В результаті проведеного дослідження рекомендовано проводити посів в центральному Лісостепу середньостиглими гібридами кукурудзи (ФАО 300-350) з використанням глибокого розпушування ґрунту диско-лаповим агрегатом до 35-37 см як основного обробітку

Ключові слова: гібриди кукурудзи; кореляція; регресія; коефіцієнт варіації; глибоке розпушування; глибина обробітку; ФАО