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Productivity and economic efficiency of growing hybrids of corn of different groups of maturity in conditions of irrigation

Vozhegova R.[1], Vlashchuk A.[2], Drobit O.[3]

Institute of irrigation farming of NAAS, Naddnip-rianskyi, Kherson, 73483, Ukraine; e-mail: [1] izz.ua@ukr.net, [2] izz_nasinnytstvo@ukr.net, [3] kolpakovalesya80@gmail.com

The purpose. To determine economic efficiency of elements of technique of growing hybrids of corn of different groups of maturity in conditions of irrigation of South Steppe of Ukraine. **Methods.** Results of researches spent during 2014 – 2016 were generalized by systems analysis, field, laboratory, analytical, mathematical-statistical and calculation-comparative methods. **Results.** Potential is determined of productivity of hybrids of corn of different groups of maturity in conditions of irrigation of South Steppe of Ukraine. Results are given of experimental researches in influence of times of sowing and plant stand on productivity and economic efficiency of growing hybrids of corn of different groups FAO on dark-chestnut soils of South steppe zone of Ukraine at irrigation. Conclusions. It is determined that the maximum indexes of productivity of grain of hybrids of corn of different groups of maturity can be reached at sowing in the third ten-day period of April of hybrid Tendra with plant stand 90 thousand plants/hectare, middle-early ripening Skadovskyi — 90, middle-ripe-ning Kakhovskyi — 70 thousand plants/hectare. By results of analysis of economic indexes of growing of hybrids of corn for 2014 – 2016 the cost of gross output for 1 hectares at all terms of sowing and different plant stand was maximum at hybrid Kakhovskyi and made in alternatives of experience 37,7 – 43,8 thousand hrn/ton, a little bit less — at hybrid Skadovskyi — 32,8 – 38,1, and the lowest — at hybrid Tendra — 31,9 – 35,1 thousand hrn/ton. The minimum cost price of 1 ton of grain was at middle-ripening hybrid of corn Kakhovskyi — 1779 hrn/ton at sowing in the third ten-day period of April and with plant stand of 70 thousand plants/hectare. Calculation of economic efficiency of growing hybrids of different groups of maturity testify to the superiority of sowing in the third ten-day period of April of middle-ripening hybrid of corn Kakhovskyi with plant stand of 70 thousand plants/hectare.

Key words: *corn, hybrids, times of sowing, plant stand, productivity, profitableness.*

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Problem setting. Yields is the main parameter determining efficiency of corn cultivation. Improvement of variety cultivation technology elements of new hybrids of different ripening groups gives facilities to increase crop productivity. Therewith, development of technological measures providing high grain yields of corn is necessarily accompanied by comprehensive economic evaluation [1-2].

Analysis of last researches and publications on the subject. Grain economy development happens on the basis of increase in economic efficiency of grain production. In these conditions the gross output of grain crops is insured, material and technical basis of the branch is strengthening [3-4].

In the conditions of modern market, when the main goal is maximizing of profits, production efficiency increase becomes the necessary condition of activity of every agricultural enterprise. Directly for production of grain corn as one of the principal grain crops use of the high-productive domestic bred hybrids granting high yields under the low costs and labor expenditures can be proposed [5-6].

To substantiate the most efficient combination of the agrotechnical measures we calculated economic efficiency of corn cultivation in the irrigated conditions of the South Steppe of Ukraine.

Goal of the study. The goal of the study was to determine the influence of terms of sowing and plants densities on economic efficiency of cultivating corn hybrids of different ripening groups at the irrigation.

Materials and methods. On the basis of national and foreign scientific literature analysis we have concluded that there is no common idea about the influence of terms of sowing and plants densities on

productivity of the crop. This fact testifies an insufficient study of the issue, particularly in the irrigated conditions, that has prompted us to carry out these studies [7-8].

To calculate production expenditures we have used technological map of the crop cultivation developed at the Institute of Irrigated Agriculture of the NAAS. According to the stock exchange data of Ukrainian market, price of corn grain was 3200 UAH/t.

The study was carried out during 2014-2016 at the experimental field of the Institute of Irrigated Agriculture of the NAAS, which is situated in the South of Ukraine in a zone of the Inhulets Irrigation System. The trials were carried out in accordance with common methodology and recommendations for holding on field experiments [9-10].

Domestic bred corn hybrids of different ripening groups: Tendra, Skadovskyi and Kahovskyi were sown at the 1st term (2nd decade of April), the 2nd term (3rd decade of April) and the 3rd term (1st decade of May); plants densities were 70000, 80000, 90000 plants/ha.

Results of the study. The study showed dependence of grain yields on terms of sowing and plants densities in corn hybrids of all the ripening groups (table 1).

Table 1 – Yields of corn hybrids depending on terms of sowing and plants densities, t/ha (average for 2014-2016)

Factor A, terms pf sowing	Factor B, hybrid	Factor C, plants density, plants/ha	Grain yields, t/ha	Mean values		
				By the Factor A	By the Factor B	By the Factor C
2nd decade of April	Tendra	70000	10.23	11.30	10.46	11.38
		80000	10.51			11.57
		90000	10.64			11.46
	Skadovskyi	70000	11.16		11.25	
		80000	11.34			
		90000	11.45			
	Kahovskyi	70000	12.20		12.70	
		80000	12.36			
		90000	11.78			
3rd decade of April	Tendra	70000	10.16	11.77		
		80000	10.67			
		90000	10.96			
	Skadovskyi	70000	11.38			
		80000	11.80			
		90000	11.92			
	Kahovskyi	70000	13.69			
		80000	13.35			
		90000	12.02			
1st decade of May	Tendra	70000	9.98	11.34		
		80000	10.42			
		90000	10.59			
	Skadovskyi	70000	10.26			
		80000	10.75			
		90000	11.20			
	Kahovskyi	70000	13.39			
		80000	12.95			
		90000	12.54			

Significance of the partial differences		
LSD_{05}, t/ha	A =	0.09
	B =	0.06
	C =	0.08
Significance of the major differences		
LSD_{05}, t/ha	A =	0.03
	B =	0.02
	C =	0.03

Results of the conducted during 2014-2016 studies established that sowing in the 3rd decade of April had show the maximum corn grain yields averaged to 11.77 t/ha. Sowing in the 2nd decade of April and in the 1st decade of May led to decrease in corn grain yields to 11.30 and 11.34 t/ha, correspondingly, or to 4.0 and 3.7%.

The hybrids used in the trials made significant influence on forming grain productivity of the crop. The most favorable conditions for forming grain yield were stated in the crops of Kahovskyi hybrid, which turned out the most productive among the studied corn hybrids during the field experiments in 2014-2016.

The yields of Kahovskyi hybrid plants averaged to 12.70 t/ha, slightly lower yields was formed by Skadovskyi hybrid – 11.25 t/ha, and the lowest values of this index were determined of Tendra hybrid – 10.46 t/ha, that can be explained by the biological characteristics of hybrid ripening group (LSD_{05} A – 0.03; B – 0.02; C – 0.03 t/ha).

Hybrid's genotype significantly reacted to plants densities. Early-ripening Tendra hybrid showed the maximum yields under plants density of 90000 plants/ha at all the terms of sowing.

Middle-early Skadovskyi hybrid also formed the maximum yields under plants density of 90000 plants/ha both at optimal and relatively early and delayed terms of sowing.

Middle-ripening Kahovskyi hybrid showed the maximum yields in the trials – 13.69 t/ha at sowing in the 3rd decade of April and plants density of 70000 plants/ha. At sowing in the 1st decade of April hybrid's yields was also the highest under plants density of 70000 plants/ha, and at sowing in the 2nd decade of April the hybrid formed the maximum yields under plants density of 80000 plants/ha.

The trials ascertained significant affect of the studied factors not only to grain productivity of corn, but to the gross products value, too (table 2).

The maximum gross products value – 43.8 thousand UAH per hectare was obtained under sowing Kahovskyi hybrid in the 3rd decade of April with plants density of 70000 plants/ha.

Table 2 – The gross products value at the corn hybrids cultivation depending on terms of sowing and plants densities (average for 2014-2016)

Factor A, terms pf sowing	Factor B, hybrid	Factor C, plants density, plants/ha	The gross products value, thousand UAH per hectare	Mean values		
				By the Factor A	By the Factor B	By the Factor C
2nd decade of April	Tendra	70000	32.7	36.1	33.5	36.4
		80000	33.6			37.0
		90000	34.0			36.6
	Skadovskyi	70000	35.7		36.0	
		80000	36.3			
		90000	36.6			
	Kahovskyi	70000	39.0		40.6	
		80000	39.5			
		90000	37.7			
3rd decade of April	Tendra	70000	32.5	37.7		
		80000	34.1			
		90000	35.1			
	Skadovskyi	70000	36.4			
		80000	37.8			
		90000	38.1			
	Kahovskyi	70000	43.8			
		80000	42.7			
		90000	38.5			
1st decade of May	Tendra	70000	31.9	36.3		
		80000	33.3			
		90000	33.9			
	Skadovskyi	70000	32.8			
		80000	34.4			
		90000	35.8			
	Kahovskyi	70000	42.8			
		80000	41.4			
		90000	40.1			

The biggest average gross products value by the factor – 37.7 thousand UAH per hectare was stated at sowing in the 3rd decade of April. At sowing in the 2nd decade of April and the 1st decade of May a tendency to decrease of this index was stated to 4.2% that is 1.6 thousand UAH per hectare and to 3.7% that is 1.4 thousand UAH per hectare, correspondingly. Departure from the optimal terms of sowing and carrying it out in comparatively early or delayed term leads to some losses both of the gross products and costs. Difference in the gross products value between the 1st and the 2nd terms of sowing is 1.6 thousand UAH per unit area; from 100 ha – 160000 UAH, that is very considerable for every producer.

The maximum average index of the gross products value was obtained at middle-ripening Kahovskyi hybrid – 40.6 thousand UAH per hectare, the least was obtained at Tendra hybrid – 33.5 thousand UAH per hectare. The difference in the gross products value between these hybrids was 17.5% that is to say 7.1 thousand UAH per hectare.

Studying the plants density an insignificant tendency of the gross products value fluctuations was determined. The maximum value of the index – 37.0 thousand UAH per hectare was got at plants density of 80000 plants/ha.

The study ascertained that productive expenditures at the corn cultivation were affected by all the studied factors (table 3).

Table 3 – Productive expenditures at the corn hybrids cultivation depending on terms of sowing and plants densities (average for 2014-2016)

Factor A, terms pf sowing	Factor B, hybrid	Factor C, plants density, plants/ha	Productive expenditures, thousand UAH per hectare	Mean values		
				By the Factor A	By the Factor B	By the Factor C
2nd decade of April	Tendra	70000	23.3	23.8	23.5	23.6
		80000	23.5			23.8
		90000	23.7			24.1
	Skadovskyi	70000	23.3		23.6	
		80000	23.6			
		90000	23.8			
	Kahovskyi	70000	24.2		24.5	
		80000	24.4			
		90000	24.6			
3rd decade of April	Tendra	70000	23.3	23.9		
		80000	23.5			
		90000	23.8			
	Skadovskyi	70000	23.4			
		80000	23.6			
		90000	23.8			
	Kahovskyi	70000	24.3			
		80000	24.5			
		90000	24.6			
1st decade of May	Tendra	70000	23.3	23.8		
		80000	23.5			
		90000	23.7			
	Skadovskyi	70000	23.3			
		80000	23.5			
		90000	23.8			
	Kahovskyi	70000	24.3			
		80000	24.5			
		90000	24.7			

So, in average for 2014-2016, productive expenditures at sowing in the 2nd, the 3rd decades of April and the 1st decade of May were at the same level and had no significant financial variations – 23.8-23.9 thousand UAH per hectare. The least index among the studied hybrids was determined of Tendra hybrid – 23.5 thousand UAH per hectare, the highest one was of Kahovskyi hybrid – 24.5 thousand UAH per hectare. Concerning the studied treatments of plants densities by the factor productive expenditures were at the same level, had no considerable fluctuations and averaged to 23.6-24.1 thousand UAH per hectare.

Conditional pure profit was calculated in the process of economic analysis of the corn hybrids cultivation (table 4).

Table 4 – Conditional pure profit at the corn hybrids cultivation depending on terms of sowing and plants densities (average for 2014-2016)

Factor A, terms pf sowing	Factor B, hybrid	Factor C, plants density, plants/ha	Conditional pure profit, thousand UAH per hectare	Mean values		
				By the Factor A	By the Factor B	By the Factor C
2nd decade of April	Tendra	70000	9.4	12.3	9.9	12.8
		80000	10.1			13.2
		90000	10.3			12.6
	Skadovskyi	70000	12.3		12.4	
		80000	12.7			
		90000	12.8			
	Kahovskyi	70000	14.8		16.1	
		80000	15.1			
		90000	13.1			
3rd decade of April	Tendra	70000	9.2	13.8		
		80000	10.6			
		90000	11.3			
	Skadovskyi	70000	13.0			
		80000	14.1			
		90000	14.3			
	Kahovskyi	70000	19.5			
		80000	18.2			
		90000	13.8			
1st decade of May	Tendra	70000	8.7	12.4		
		80000	9.8			
		90000	10.1			
	Skadovskyi	70000	9.5			
		80000	10.9			
		90000	12.0			
	Kahovskyi	70000	18.5			
		80000	16.9			
		90000	15.4			

Among the studied terms of sowing the most advantage in getting the highest conditional pure profit had the second term – the 2nd decade of April, where conditional pure profit was 13.8 thousand UAH per hectare, that is more to 10.9-10.1% in comparison to the first and the third sowing terms.

Concerning the influence of genotype, by the factor, the highest conditional pure profit was got at cultivating Kahovskyi hybrid, where it averaged to 16.1 thousand UAH per hectare, that is 38.5 and 23.0% more, than of Tendra and Skadovskyi hybrids. The highest conditional pure profit was favored by plants density of 80000 plants/ha, when this index averaged to 13.2 thousand UAH per hectare. Both decrease and increase of plants density from 70000 to 90000 plants/ha led to decrease of conditional pure profit to 0.4 and 0.6 thousand UAH per hectare. The maximum conditional pure profit during the 2014-2016 averaged to 19.5 thousand UAH per hectare at sowing Kahovskyi hybrid in the 3rd decade of April with plants density 70000 plants/ha. The minimum index value – 8.7 thousand UAH per hectare stated sowing of Tendra hybrid in the 1st decade of May with plants density 70000 plants/ha.

Analyzing the prime cost of 1 tonne of corn grain production we should mention that the least index value of 2043 UAH/t was stated under sowing in the 3rd decade of April. Sowing in the 2nd decade of April and the 1st decade of May led to increase of prime cost of 1 tonne of grain, respectively, to 3.6 and 3.8% (table 5).

Among the studied hybrids the least prime cost of 1 tonne of grain was at Kahovskyi hybrid and averaged to 1933 UAH/t. Tendra and Skadovskyi hybrids had higher index values of 2.25-2.01 thousand UAH per 1 tonne of grain, correspondingly.

As to say about plants density we observed variation of prime cost from 2.08 to 2.10 thousand UAH per tonne. The least index value of 2075 UAH/t was stated at plants density of 80000 plants/ha.

The lowest prime cost during the study averaged to 1779 UAH/t was at sowing Kahovskyi hybrid in the 3rd decade of April with plants density 80000 plants/ha.

Table 5 – Prime cost of 1 tonne of grain at the corn hybrids cultivation depending on terms of sowing and plants densities (average for 2014-2016)

Factor A, terms pf sowing	Factor B, hybrid	Factor C, plants density, plants/ha	Prime cost, UAH/t	Mean values		
				By the Factor A	By the Factor B	By the Factor C
2nd decade of April	Tendra	70000	2276	2117	2248	2100
		80000	2237			2075
		90000	2231			2105
	Skadovskyi	70000	2093		2099	
		80000	2080			
		90000	2079			
	Kahovskyi	70000	1986		1933	
		80000	1978			
		90000	2089			
3rd decade of April	Tendra	70000	2291	2043		
		80000	2205			
		90000	2168			
	Skadovskyi	70000	2054			
		80000	2002			
		90000	2000			
	Kahovskyi	70000	1779			
		80000	1837			
		90000	2049			
1st decade of May	Tendra	70000	2331	2121		
		80000	2256			
		90000	2241			
	Skadovskyi	70000	2269			
		80000	2189			
		90000	2123			
	Kahovskyi	70000	1817			
		80000	1892			
		90000	1968			

Analyzing profitability level of the studied treatments we should stress that the best index of productive profitability of 80% was stated at the treatment with sowing Kahovskyi hybrid in the 3rd decade of April with plants density 80000 plants/ha (table 6)

The most influential factor among the studied was genotype structure (Factor A), when profitability level was variated from 42 to 66%. Terms of sowing and plants densities had much more less influence on the forming of this index.

It should be mentioned that the highest profitability level by the factor B was fixed at sowing in the 3rd decade of April and it averaged to 58%.

Study of the plants densities treatments showed that the highest profitability level averaged to 55% was obtained at plants density of 80000 plants/ha.

Table 6 – Profitability level at the corn hybrids cultivation depending on terms of sowing and plants densities (average for 2014-2016)

Factor A, terms pf sowing	Factor B, hybrid	Factor C, plants density, plants/ha	Profitability level, %	Mean values		
				By the Factor A	By the Factor B	By the Factor C
2nd decade of April	Tendra	70000	41	52	42	54
		80000	43			55
		90000	43			52
	Skadovskyi	70000	53		53	
		80000	54			
		90000	54			
	Kahovskyi	70000	61		66	
		80000	62			
		90000	53			
3rd decade of April	Tendra	70000	40	58		
		80000	45			
		90000	48			
	Skadovskyi	70000	56			
		80000	60			
		90000	60			
	Kahovskyi	70000	80			
		80000	74			
		90000	56			
1st decade of May	Tendra	70000	37	52		
		80000	42			
		90000	43			
	Skadovskyi	70000	41			
		80000	46			
		90000	51			
	Kahovskyi	70000	76			
		80000	69			
		90000	63			

Conclusions and prospects of further investigations in this direction

Analysis of results of the trials, which were held on during 2014-2016, allowed us to conclude that cultivation of new domestic corn hybrids of different ripening groups in combination with different terms of sowing and plants densities in the irrigated conditions is one of the main factors of forming the crop productivity, and depends on soil and climatic conditions of zone, agrotechnology and morphological and biological plants characteristics.

It was determined that in the irrigated conditions of the South Steppe of Ukraine the optimal treatment is sowing of corn hybrids belonging to different ripening groups in the 3rd decade of April with plants

densities at all the terms of sowing for Tendra early-ripening hybrid and Skadovskyi middle-early hybrid of 90000 plants/ha, and for Kahovskyi middle-ripening hybrid of 70000 plants/ha, that guaranteed provides high grain yields per hectare.

The calculations of economic efficiency of cultivating the hybrids of different ripening groups proved the advantages of sowing Kahovskyi corn hybrid in the 3rd decade of April with plants density of 70000 plants/ha.

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