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Changes in the structure of sowing area, yields and harvests of cereal crops in Poland in the years 1965–2015

Zmiany w strukturze zasiewów, plonowaniu i zbiorach zbóż w Polsce w latach 1965–2015

Summary. The objective of the study was to analyze the changes that took place on the Polish cereal market in the years 1965–2015 in the structure of sowing area, yields and harvests. The analysis included such cereals as wheat, rye, triticale, barley, oat, maize, buckwheat and millet, as well as cereal mixtures. Over the fifteen-year period under analysis fundamental changes were observed in the structure of the area of sowings, harvests, and yields of the cereals. The share of cereals with higher productivity (wheat, triticale, barley, maize) was gradually increasing and the area of rye and oat decreased. In the final 15 years the area of cultivation of cereals decreased, while the harvests and yields increased. The increase was especially notable in the share of cereals with a high production potential (wheat, barley, maize, triticale). In Poland, wheat is the cereal with the greatest importance for agriculture – in the analysed period it produced the highest harvests and yields as compared to other cereals. After 1990, the factor that contributed to the increase in the sowing area and harvests was the introduction of a new cereal species – triticale – in a wide agricultural practice. The variation in the harvests and yields was caused primarily by changes in sowings area, weather conditions, and mineral fertilization. The increase of the yields of cereals was caused by advances in biology (breeding of new cultivars), change in the configuration of cereals cultivation, and improved effectiveness of application of fertilizers and plant protection agents. The highest increasing trend was characteristic of the yields of wheat, and the strongest variation in the yields of cereals in Poland in the years 1965–2015 was characteristic of the yields of maize (30.3%).

Key words: cereals, structure of sowing area, harvests, yields, trends

INTRODUCTUION

Situation on the cereal market is very important for the whole food economy. Cereals are used in the food industry for the production of bread, pasta, groats, flakes and malt. The grain sector also provides basic raw material for fodder production and determines

the economic conditions of animal production, especially poultry and pig livestock [Agencja Rynku Rolnego 2013].

Over the last dozen or so years, major changes have been observed in cereal production in Poland, which are very similar to global trends. The share of cereals with high productivity (wheat, maize) increases with simultaneous increase in the share of cereals in the crop structure. About 70% of the arable land is sown with this group of plants. Excessive concentration of cereal crops is not a beneficial phenomenon due to the intensification of such phenomena as unilateral exhaustion of soil from nutrients or the severity of diseases, but it is quite persistent, which is determined by economic and organizational factors [Budzyński and Krasowicz 2008, Parylak 2007, Rachoń 2008]. At the same time, yields are also growing, which is associated with biological progress and the introduction of new, more fertile varieties into agricultural practice [Oleksiak 2003].

The research hypothesis assumed that there was a drop in the area of cereal sowings, with simultaneous increase in yields and harvests in Poland in the analyzed period.

MATERIAL AND METHODS

The aim of this study was to analyze changes in the structure of sown area, yields and cereal crops in Poland in 1965–2015. The analysis includes following cereals: wheat, rye, triticale, barley, oats, corn, buckwheat and millet as well as cereal mixes.

The scope of the research included the following activities: development of methods used in research, collection of literature, gathering and processing of statistical data (SP), and analysis of differences in sown area, yield and harvest of cereals.

Analyzed data was subjected to statistical processing using elements of descriptive statistics.

RESULTS AND DISCUSSION

Area of cereal sowings in Poland in 1965–2015

In Poland, cereals are grown on a large area and their popularity is due to relatively simple production technology, relatively low labor consumption, ease of storage, transport, and the comprehensive use of grain as a raw material for consumption and fodder.

The area of cereal cultivation in Poland in 1965–2015 was variable with a downward trend (Tab. 1). In 1965–1980, it decreased by 569 thousand hectares, while in the period of 1980–2000 with the upward trend, and in 2000 to reach the maximum – 8814 thousand hectares. In the last 15 years, i.e. in 2000–2015, the systematic decrease in the area of cereal crops lasting until now has begun again. The increase in cereal cultivation area after 1990 was associated with the extensification of agriculture at the expense of reducing the area of intensive crop cultivation (including mainly potatoes, rape, sugar beet and fodder root crops) [Kulikowski 2013]. Currently, the majority of wheat is grown, which has been the dominant cereal species in Poland for over 20 years and in the structure of cereal crops its share is about 30%, while the least – buckwheat and millet. Restrictions in the cultivation of these plants are mainly associated with smaller consumption of millet and buckwheat, that have been replaced by rice or oatmeal.

Table 1. Cereals cultivation area in Poland in the years 1965–2015 (thousands ha)

Years	Total area of cereals cultivation	Wheat cultivation area	Rye cultivation area	Triticale cultivation area	Barley cultivation area	Oat cultivation area	Maize cultivation area	Buckwheat and millet cultivation area	Cereal mixes cultivation area
1965	8416	1617	4447	–	689	1314	7	77	265
1970	8346	1985.2	3413	–	924.1	1530.3	5.1	83.1	405.2
1975	7864	1842	2792	–	1335	1291	15	46	543
1980	7847	1609	3039	–	1322	997	16	127	737
1985	8205	1885	3083	–	1242	995	16	63	921
1990	8531	2281	2314	749	1174	747	59	38	1169
1995	8571	2407	2452	616	1048	595	48	39	1366
2000	8814	2635	2130	695	1096	566	152	62	1478
2005	8329	2218	1415	1195	1113	539	339	73	1437
2010	7637	2142	1063	1330	974	577	334	117	1100
2015	7512	2395.5	725.3	1516	839	461	670.3	92	813

Source: GUS (Statistics Poland) data

Area of rye cultivation in Poland over the last fifty years has been radically reduced from around 4.500.000 ha to only 725 thousand hectares. In recent years. maize has been growing more and more because of the constant demand for its grain. mainly used for fodder purposes.

After 2000. there were significant changes in the structure of cereal sown area. as the area under wheat and triticale increased. as well as maize. at the expense of oats and rye. Cultivation of triticale is gaining more and more recognition among Polish producers. Since 2005. the area of this grain sowing has increased by 446 thousand hectares. i.e. by approximately 60% compared to 1990. Reduction in the area of oat crops was caused by the decrease in the number of horses which ceased to be the basic source of agricultural tractive force in agriculture [Kulikowski 2013]. In 2015. the area of oats amounted to 461.000 ha. i.e. by 64.3% less compared to 1975.

The area of cultivating the cereal mixtures increased remarkably until 2000 to the level of 14–16% in the structure of cereal crops. Since 2000. it has started to fall back to pre-1985 levels and is now comparable to the area of oat cultivation.

In the case of barley. the apogee of the growing area was in 1980s – 1335 thousand hectares. Starting from that period. the area of this grain cultivation has been gradually decreasing and in 2015 it was 839.000 ha.

Table 2. Descriptive statistics of cereals cultivation area in Poland in the years 1965–2015 (thousands ha)

Specification	Total	Wheat	Rye	Triticale	Burley	Oat	Maize	Buchwheat and millet	Cereal mixes
Mean	8188.4	2092.4	2443.0	1016.8	1068.7	873.8	151.0	74.3	930.4
Standard deviation	416.6	334.1	1089.5	378.1	201.5	372.5	213.2	29.4	418.6
Min.	7512.0	1609.0	725.3	616.0	689.0	461.0	5.1	38.0	265.0
Max	8814.0	2635.0	4447.0	1516.0	1335.0	1530.3	670.3	127.0	1478.0
Coefficient of variation	5.1	16.0	44.6	37.2	18.9	42.6	141.2	39.6	45.0

Source: own elaboration on the basis of GUS (Statistics Poland) data

On the basis of the coefficients of variability V (Tab. 2) it was shown that the least variability of the sown area was characterized by wheat (V = 16%) and barley (V = 18.9%) and the largest – maize (V = 141.2%).

Cereal yields in Poland in 1965–2015

The increase in yields of wheat, barley, oats and maize in 1970 was caused partly by the use of mineral fertilizers on a larger scale [Kulikowski 2013].

In 1975–1980, average yields of 4 cereals amounted to about 24 dt/ha. Very high yields of cereals were recorded in 1990, their average level was then 32.8 dt/ha. It was almost a step increase in yield (about 40%) caused mainly by a breeding progress (new

intensive varieties) [Oleksiak 2003]. Varying yields of cereals in Poland in 1965–2015 were also affected by changing weather conditions. Sometimes, these differences were very large, e.g. in 1995, grain yields in Poland amounted to 30.2 dt/ha; in 2000, they amounted to 25.3 dt/ha and were lower by 16.2%, while in 2005, they amounted to 32.3 dt/ha and were higher by 27.7% compared to 2000.

Table 3. Cereal yields in Poland in the years 1965–2015 (dt/ha)

Years	Total of cereals yields	Wheat yields	Rye yields	Triticale yields	Barley yields	Oat yields	Maize yields	Buckweath and millet yields	Cereal mixes yields
1965	19.0	20.6	18.4	–	21.0	18.8	20.4	10	17.7
1970	19.5	23.2	15.9	–	23.3	21.0	23.5	9.3	19.1
1975	24.9	28.3	22.5	–	27.3	22.6	53.3	6.4	26
1980	23.4	26	21.6	–	25.9	22.5	35.4	7.8	24.1
1985	28.9	34.3	24.7	–	32.9	27.0	43.0	14.7	29.9
1990	32.8	39.6	26.1	36.3	35.9	28.4	49.1	11.2	30.4
1995	30.2	36	25.6	33.2	31.3	25.1	49.6	11.5	28.1
2000	25.3	32.3	18.8	27.3	25.4	18.9	60.6	11.9	20.9
2005	32.3	39.5	24.1	32.7	32.2	24.6	57.3	11.3	27.3
2010	35.8	43.9	26.8	34.4	34.9	26.3	59.7	12.5	30.3
2015	37.3	45.7	27.8	35.2	35.3	26.5	47.1	11.5	27.7

Source: GUS (Statistics Poland) data

In 2015, the highest average cereal yields were recorded (37.3 dt/ha). The increase in the grain yield over the analyzed 50 years was caused by biological development (breeding of new varieties), a change in the configuration of cereal cultivation and an increase in the effectiveness of fertilizers and plant protection products [Kulikowski 2013].

Over the fifty years (1965–2015), maize was characterized by the largest increase in yields. The yield increase of this grain amounted to 26.7 dt/ha (increase by 130.9%). Very high yield increase also occurred in the case of wheat, which amounted to 25.1 dt/ha (increase by 121.8%). Barley was characterized by significant increase in yield: 14.3 dt/ha, i.e. 68.1%. A similar increase in yields occurred in the case of cereal mixtures – 10.0 dt/ha, i.e. 6.5% and rye – 9.4 dt/ha, i.e. 51.1%. Slight yield increase characterized oats – 7.7 dt/ha, i.e. 41.0%.

Table 4. Descriptive statistics of cereals yield in Poland in the years 1965–2015 (dt/ha)

Specification	Total	Wheat	Rye	Triticale	Barley	Oat	Maize	Buckwheat and millet	Cereal mixes
Mean	28.1	33.6	22.9	33.2	29.6	23.8	45.4	10.7	25.6
Standard deviation	6.2	8.3	3.9	3.2	5.2	3.3	13.7	2.3	4.5
Min.	19.0	20.6	15.9	27.3	21.0	18.8	20.4	6.4	17.7
Max.	37.3	45.7	27.8	36.3	35.9	28.4	60.6	14.7	30.4
Coefficient of variation	22.1	24.8	16.8	9.5	17.6	13.8	30.3	21.2	17.7

Source: own elaboration on the basis of GUS (Statistics Poland) data

The lowest increase in yield over fifty years characterized buckwheat and millet; their average yield increase amounted to 1.5 dt/ha, i.e. 15%. In the case of triticale, yields decreased during 25 years. The average reduction was – 1.1 dt/ha (decrease by 3.0%).

The average yield increase of all analyzed cereals from 1965 to 2015 amounted to 18.3 dt/ha, i.e. 96.3%.

Based on the variability coefficients *V*, it can be concluded that maize (30.3%) and wheat (24.8%) were characterized by the highest variability in yields among cereals grown in Poland in 1965–2015. Lower variability, in terms of yield, was demonstrated by: rye (16.8%), barley (17.6%) and cereal mixtures (17.7%). The most stable yields were recorded for triticale (9.5%).

Cereal harvests in Poland in 1965–2015

Harvests of cereals in Poland resulting from the sown area and yielding over the last fifty years, gradually increased (Tab. 5). However, there were great seasonal oscillations due to weather conditions.

Table 5. Cereals harvest in Poland in the years 1965–2015 (thousands tons)

Years	Total of cereals harvest	Wheat harvest	Rye harvest	Triticae harvest	Barley harvest	Oat harvest	Maize harvest	Buckwheat and millet harvest	Cereal mixes harvest
1965	16020	3338	8202	–	1445	2476	14	77	468
1970	16262	4608	5433	–	2149	3209	12	78	773
1975	19557	5207	6270	–	3638	2920	79	29	1414
1980	18336	4176	6566	–	3419	2245	58	99	1773
1985	23742	6461	7600	–	4086	2682	69	93	2751
1990	28014	9026	6044	2721	4217	2119	290	43	3554
1995	25905	8668	6288	2048	3278	1495	239	45	3844
2000	22341	8503	4003	1901	2783	1070	923	74	3084
2005	26928	8771	3404	3903	3582	1324	1945	83	3916
2010	27228	9408	2852	4576	3397	1516	1994	146	3339
2015	28003	10958	2013	5339	2961	1220	3156	106	2250

Source: GUS (Statistics Poland) data

Increase in the cereal harvest in 1965–1990 resulted mainly from higher levels of mineral fertilization, and a breeding progress in 1990s due to introduction of intensive varieties into the cultivation, mainly wheat and triticale. Cereal harvest in 1975 was at the level of 19,557 thousand tons, i.e. by about 20% higher than in preceding years, while in 1990, it increased up to 28,014 thousand tons. In subsequent decade, the cereal harvests slightly decreased the level of 1990 in subsequent decade, despite of the fact that the cultivation area decreased. Higher harvests were achieved mainly due to clearly higher yields.

In Poland, in the years 1965–2015, wheat and maize harvests were gradually growing (Tab. 5). The largest wheat harvest was obtained in 2015 – 10,958 thousand tons. Maize harvest in this period increased from about 50,000 tons to over 3,000 thousand tons. The decrease occurred in the size of rye and oat harvests. Clear variations in the size of crops of particular cereal types did not occur in the same periods. An example is rye, the harvests of which in 1970 were low, while the harvest of other cereals was even higher than in previous periods. Low level of rye harvest in 1990 corresponded to the high level of wheat harvest, which only in the next analyzed period fell by about 400,000 tons (a decrease of about 4% compared to the harvest in previous year). In the analyzed period, the highest rye harvests were achieved in 1965 (8,202 thousand tons), and the share of this grain in the cereal harvest amounted to as much as 51%.

The highest cereal harvests in Poland amounting to 28,014 thousand tons were obtained in 1990. In the cereal harvest structure, the share of wheat at the time was 32.2%, while 21.6% was rye, 15.1% barley, 12.7% cereal mixes, 9.71% triticale, 7.56% oats, the smallest share was of maize (1.03%) as well as buckwheat and millet (0.15%). After 15 years, the level of grain harvest was similar (28,003 thousand tons), but its structure was clearly different. The wheat content was 39.1%, triticale 19.1%, maize 11.3%, barley 10.6%, cereal mixtures 8.03%, rye 7.19%, oats 4.35%, and buckwheat and millet 0.37 %.

Table 6. Descriptive statistics of cereals harvest in Poland in the years 1965–2015 (thousands tons)

Specification	Total	Wheat	Rye	Triticale	Burley	Oat	Maize	Buchwheat and millet	Cereal mixes
Mean	22939.6	7193.1	5334.1	3414.7	3177.7	2025.1	798.1	79.4	2469.6
Standard deviation	4696.7	2528.8	1996.6	1409.3	816.1	740.7	1082.6	32.9	1220.7
Min.	16020.0	3338.0	2013.0	1901.0	1445.0	1070.0	12.0	29.0	468.0
Max.	28014.0	10958.0	8202.0	5339.0	4217.0	3209.0	3156.0	146.0	3916.0
Coefficient of variation	20.5	35.2	37.4	41.3	25.7	36.6	135.7	41.4	49.4

Source: own elaboration on the basis of GUS (Statistics Poland) data

Among the analyzed cereals (Tab. 6), the barley harvests were the least variable (V = 25.7%), and maize harvests – the highest (V = 135.7%).

CONCLUSIONS

1. The area of cereal sowings in Poland in 1965–2015 was variable with a downward trend. In 1965-1980, it decreased by 569 thousand hectares, in the period of 1980–2000, with the upward trend, reach the maximum – 8,814 thousand hectares in 2000. In the last 15 years, i.e. in 2000–2015, the systematic decrease in the area of cereal sowings lasting until now has begun again.

2. In the analyzed period, there were great changes in particular types of cereals. The wheat cultivation area increased from 19.2% to 31.9%, maize from 0.8% to 8.9% and triticale from 8.8% to 20.2%, whereas rye decreased from 52.8% to 9.7% and oat from 15.6% to 6.1%.

3. The increase in grain yield over analyzed 50 years was caused by biological progress (breeding and introduction of new varieties for cultivation), a change in the configuration of cereal cultivation and an increase in the effectiveness of fertilizers and plant protection products.

4. The increase in cereal harvest in 1965–1990 was mainly caused by the use of higher levels of mineral fertilization, and in the 1990s, due to the breeding progress by the introduction of intensive varieties, mainly wheat and triticale, to growing.

5. Wheat is the grain of the greatest importance for agriculture in Poland; in the analyzed period, it gradually increased the area of cultivation and yielded higher in comparison with other cereals.

6. The highest variability in the field of yielding of cereals in Poland in the analyzed years characterized the maize yields (30.3%).

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Streszczenie. Celem pracy była analiza zmian, jakie zaszły w Polsce w latach 1965–2015 w strukturze powierzchni zasiewów, plonowaniu i zbiorach zbóż. W analizie uwzględniono takie zboża jak: pszenica, żyto, pszenżyto, jęczmień, owies, kukurydza, gryka i proso, a także mieszanki zbożowe. W analizowanym okresie nastąpiły fundamentalne zmiany w strukturze powierzchni zasiewów, wielkości plonów i zbiorów zbóż. Sukcesywnie zwiększał się udział zbóż o wyższej produktywności (pszenica, pszenżyto, jęczmień, kukurydza) oraz zmniejszała się powierzchnia uprawy żyta i owsa. W ciągu ostatnich 15 lat zmniejszyła się powierzchnia upraw zbóż, ale plony wzrosły, co przełożyło się na większe zbiory. Wzrost ten był szczególnie zauważalny w przypadku zbóż o wysokim potencjale produkcyjnym (pszenica, jęczmień, kukurydza, pszenżyto). Po 1990 roku czynnikiem, który przyczynił się do zwiększenia powierzchni zasiewów i zbiorów, było wprowadzenie do szerokiej praktyki rolniczej nowego rodzaju zboża – pszenżyta. Różnice w zbiorach uwarunkowane były zmianami powierzchni zasiewów, warunkami pogodowymi i nawożeniem mineralnym. Wzrost plonów zbóż był spowodowany postępem biologicznym (hodowlą nowych odmian), zmianą konfiguracji upraw zbóż oraz poprawą efektywności stosowania nawozów i środków ochrony roślin. Najwyższą tendencją wzrostową charakteryzowały się plony pszenicy, a najwyższą zmiennością w zakresie plonowania charakteryzowała się kukurydza (30,3%).

Słowa kluczowe: zboża, struktura powierzchni zasiewów, plony, zbiory, trendy

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