Acta fytotechn zootechn, 27, 2024(3): 241–249
http://www.acta.fapz.uniag.sk

Original Paper

Evaluation of Yield and Yield Components of Maize in Conditions of Changing Climate

Ľubomíra Hromadová[1], Joanna Korczyk-Szabó*[1], Milan Macák[1], Miroslav Habán[1, 2]
[1]*Slovak University of Agriculture in Nitra, Faculty of Agrobiology and Food Resources,*
Institute of Crop Production, Slovakia
[2]*Comenius University in Bratislava, Faculty of Pharmacy, Department of Pharmacognosy and Botany, Slovakia*

Article Details: Received: 2024-06-20 | Accepted: 2024-07-29 | Available online: 2024-09-30

https://doi.org/10.15414/afz.2024.27.03.241-249

This research investigates the effects of industrial fertilisers and the incorporation of plant biomass, including catch crops, on the yield and yield components of maize (*Zea mays* L.) within a crop rotation system. The field experiment was conducted from 2017 to 2019 at the Slovak University of Agriculture in Nitra (48° 19' N, 18° 09' E). The study period was characterized by warm to exceptionally warm and predominantly dry conditions, except for 2019, which aligned more closely with the long-term average. The experimental treatments, combining the ploughing of above-ground biomass and the application of industrial fertilisers, resulted in the highest yield component values. Notably, the number of grains per cob reached 36, and the number of grains per hectare was 27.49 million. Total seed weight (TSW) was also significantly influenced by fertilisation, with the highest TSW values ranging from 220.1 g to 225.9 g, compared to the unfertilised treatment values of 194.4 g to 207.3 g. The highest maize grain yields, ranging from 5.76 $t \cdot ha^{-1}$ to 6.2 $t \cdot ha^{-1}$, and above-ground biomass production, ranging from 12.45 $t \cdot ha^{-1}$ to 12.60 $t \cdot ha^{-1}$, were achieved in treatments incorporating both industrial fertilisers and the ploughing of biomass from forecrops or catch crops. These results underscore the importance of fertilisation, organic matter incorporation, and a balanced combination of adaptive measures in enhancing maize productivity.

Keywords: adaptation measure, fertiliser, maize, crop residues

1 Introduction

Maize (*Zea mays* L.), a pivotal grain indigenous to the Americas (Serna-Sardival, 2015), boasts diverse applications spanning human food production, animal feed, industrial raw materials, and energy. Climate change related to rising temperatures and decreasing precipitation, which is becoming increasingly uneven, negatively impacts the agro-industry. As a result, crop technologies and varieties more tolerant of environmental growing conditions are emerging. Many countries have adopted ambitious climate change mitigation and adaptation targets that will exacerbate the problem (Benitez-Alfonso et al., 2023). Cover cropping is a promising and sustainable agronomic practice to ameliorate soil health and crop performance in agroecosystems. Cover crops may regulate several ecosystem services such as nutrient cycling, soil fertility, moderation of extreme meteorological events, and climate and water regulation; in addition and have considerable effects on plant and soil biodiversity (Quintarelli et al., 2022; Ivanič Porhajášová and Babošová, 2022). To boost agricultural output, it is required to improve the most critical factors that comprise the final crop (Laurett et al., 2020). More appropriate organic matter management can improve the yield components of sustainable management. The soil will obtain the required nutrients, and the quality of the soil's physical, chemical, and biological qualities will improve (Kmeťová and Kováčik, 2014; Kováčik et al., 2015; Macák et al., 2020). Organic matter can be ploughed into the soil through catch crops and crop residues (Hou et al., 2020). Maize can be successfully incorporated into a postharvest system of winter silage rye, fertilised with presowing digestate using rye stubble as an anti-erosion factor (Pazdera et al., 2023).

***Corresponding Author:** Joanna Korczyk-Szabó, Slovak University of Agriculture in Nitra, Faculty of Agrobiology and Food Resources, Institute of Crop Production, Slovakia, ✉ joanna.korczyk-szabo@uniag.sk

The goal of our research was to examine the influence of adaptation practices on maize yield and yield components (*Zea mays* L.).

2 Material and Methods

2.1 A brief description of the observed location

We observed the impact of organic and mineral fertilization treatments on yield and the yield components of maize (*Zea mays* L.) on the experimental plots of the Slovak University of Agriculture in Nitra, specifically in an experimental site of Dolná Malanta (Nitra, Slovakia: 48° 19′ N and 18° 09′ E) as part of our experimental research from 2017 to 2019.

The specified location is distinguished by its flat terrain. The monitored experimental areas belong to the maize production area and are in a very warm and dry sub-area at an altitude of 173 m above sea level. As per the long-term average 1951–1980, there is an average total annual precipitation of 561 mm and an average annual air temperature of 10.6 °C. The soil type was classified as the Haplic Luvisol. Soils also have a bulk density of 1.5–1.68 g·cm^{-3}. More information about the experimental site was published by Šimanský (2017).

2.2 Crop cultivation and experimental treatments

From 2017 to 2019, the field experiment was conducted. Randomized block design, in factorial arrangement, with four replications was used.

In each plot, different experimental treatments of grown crops were tested. We defined the factors for the individual experimental treatments before the experiment.

The first factor considers organic matter management on two levels: a) ploughing of forecrop by-products (straw, or dried corn stalks); and b) removal of the by-products from the plot.

The second factor indicated the usage of catch crops. The catch crop (white mustard, *Sinapis alba* L.) was used between the winter wheat – white mustard – milk thistle and milk thistle – white mustard – maize crop sequences. The aboveground biomass of catch crops was used as green manure.

The third factor considers fertilisation in two levels: a) using industrial fertilisers and b) not using industrial fertilisers. Mineral fertilizers calculated to the designed yield level in a dose of pure nutrients as follows: nitrogen in pure nutrient 75 kg N (before sowing) +75 kg N (8–10 leaves of maize stand), phosphorus 48 kg P, potassium 200 K kg before ploughing.

On the experimental plots, maize (*Zea mays* L.) was cultivated as part of a multifunctional crop rotation with four other crops that rotated on four plots as follows: Milk thistle (*Silybum marianum* (L.) Gaertn.) – Maize (*Zea mays* L.) – Field pea (*Pisum sativum* L.) – Durum wheat (*Triticum durum* Desf.).

The field experiment was conducted on plots of 5 × 10 m each and there were 1 m wide sidewalks. The sowing density was 75 thousand seeds per hectare. The sowing depth ranged from 4–6 cm. Milk thistle (*Silybum marianum* (L.) Gaertn.) was the forecrop. If a catch crop was included in the planting operation, it was white mustard (*Sinapis alba* L.) seeded at a 16 kg seed·ha^{-1} rate. On the plots, the inter-row distance was 0.7 m. grain variety LG 30.315, FAO 300, Sc (two-line hybrid). Management data of field experiment in the order of sowing date, and harvest date: 10. 4.–20. 10. 2017; 13. 4.–11. 10. 2018; 3. 4.–28. 10. 2019.

In all replications, samples relating to maize yield components (mechanical analysis) were collected as follows:

- the average number of cobs per ha – we calculated the average number of cobs per plot by counting four rows of maize by 10 m in length;
- average number of grains in a cob – we counted the number of grains in a cob from 10 randomly selected plants and averaged the results of four replications;
- average number of grains per hectare – we multiplied the average number of cobs per hectare by the average number of grains per cob;
- weight of a thousand seeds (TSW) at 14% humidity – grains were counted by DIPOS machine on the principle of photocell three times 500 grains. The values were recalculated according to the measured dry matter content % at harvest, then converted to a moisture content of 14%;
- the yield of dry maize stalks at 15% humidity – yield of dry maize stalks calculated to 15% of humidity. A 100 g sample is created from dry maize stalks from four samples for moisture analysis by weighing before and after drying at 105 °C for 12–24 hours, respectively, to constant dry matter. 10 plants for each replication were used to determine the stalk yield;
- grain yield at 14% humidity – yield at harvest dry matter in t·ha^{-1} for grain was calculated according to formula ($K \times G/1000$). Here, K represents the weight of a thousand grains (TSW) at harvest humidity, and G is the average number of grains per hectare in millions.

Analysis of variance (ANOVA) was used for statistical evaluation of experimental data. Significant differences between the factors were determined by the *F*-test.

Significantly different means were calculated by Fisher's least significant difference (LSD) test. All statistical analyses were carried out by the STATISTICA software version 13.0 (TIBCO Software Inc., Tulsa, OK, USA).

3 Results and Discussion

3.1 The Weather Conditions Throughout the Research

Dolná Malanta experimental area, as compared to the long-term average (LTA) 1951–1980, revealed that there was 25% less precipitation in 2017 (422 mm) than LTA (561 mm), with considerable fluctuations between individual months (for example, 9.9 mm in March and 93 mm in September). In 2018, the amount of precipitation differed from LTA was less than 35%. In August of 2018, we similarly noted an exceptionally dry period (only 3 mm of precipitation). The amount of yearly precipitation in 2019 did not differ from the LTA.

Figure 1 depicts the level of precipitation for each month from 2017 to 2019. There was 57 mm more precipitation in 2017 than in 2018, but it was still a dry year (Kožnárová and Klabzuba, 2002). The largest amount of rainfall was recorded during 2019, hence it fits into the category of average years. However, the amount of precipitation was inconsistent, with May 2019 having the most precipitation (115 mm). The consequences of climate change were most visible during the experiment by the variability of precipitation, which occurs when the dry season alternates with the rainy season.

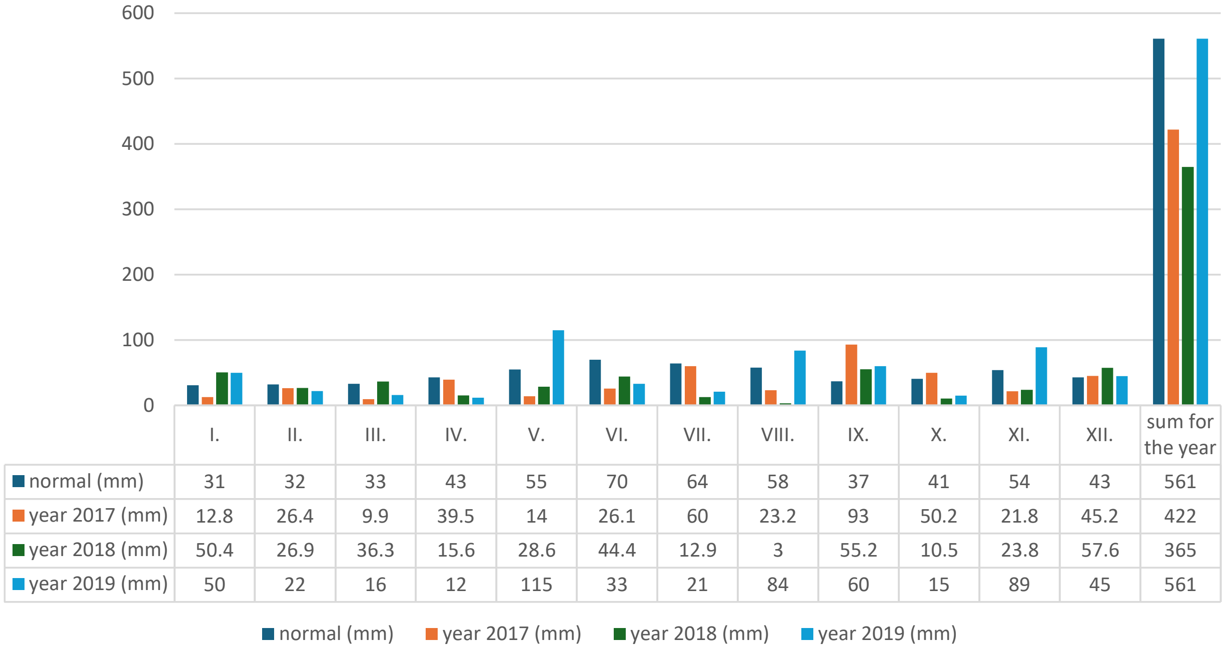
Precipitation before the flowering of female maize flowers shows a considerable positive link with viable components, according to Wang et al. (2021). However, due to our country's ongoing climate change, overall precipitation reduces throughout that period, causing problems with maize growth.

3.1.1 Air Temperature

In 2017, the average annual air temperature in Dolná Malanta increased by 0.6 °C compared to the long-term average (9.7 °C) and by 1.6 °C in 2018, while the average annual temperature increased by 1.2 °C in 2019 (Figure 2).

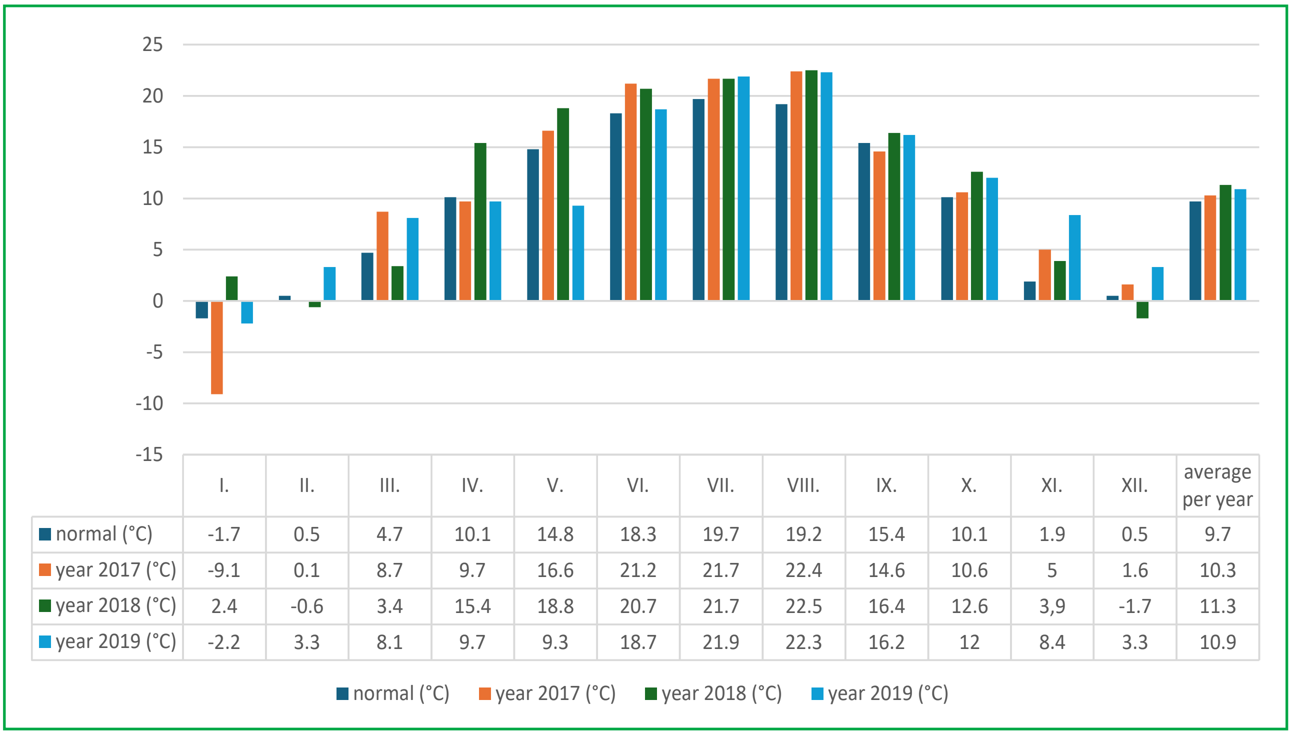
According to the criteria of Kožnarová and Klabzuba (2002), the years 2017 and 2019 were classified as warm and the year 2018 was extraordinarily warm.

The analysis of the values reveals that temperatures are rising during the months since recent years have been much warmer than LTA. Precipitation, on the other hand, was on the decline. The irregular occurrence of precipitation after months is indeed an issue. Weather fluctuations were observed in southwestern Slovakia. As Zhang et al. (2015) reported rising temperatures over the long term (multiple years to decades) have potentially negative effects on maize yields, so agricultural technology must adapt to the ongoing climate change. In this case, better agricultural technology in practice entails minimising labour operations on the plot to keep as much water in the soil as possible, selecting drought-



	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	sum for the year
■ normal (mm)	31	32	33	43	55	70	64	58	37	41	54	43	561
■ year 2017 (mm)	12.8	26.4	9.9	39.5	14	26.1	60	23.2	93	50.2	21.8	45.2	422
■ year 2018 (mm)	50.4	26.9	36.3	15.6	28.6	44.4	12.9	3	55.2	10.5	23.8	57.6	365
■ year 2019 (mm)	50	22	16	12	115	33	21	84	60	15	89	45	561

Figure 1 Monthly precipitation (mm) at Dolná Malanta, Slovakia, from 2017 to 2019
normal – as average values for 1951–1980



	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	average per year
normal (°C)	-1.7	0.5	4.7	10.1	14.8	18.3	19.7	19.2	15.4	10.1	1.9	0.5	9.7
year 2017 (°C)	-9.1	0.1	8.7	9.7	16.6	21.2	21.7	22.4	14.6	10.6	5	1.6	10.3
year 2018 (°C)	2.4	-0.6	3.4	15.4	18.8	20.7	21.7	22.5	16.4	12.6	3,9	-1.7	11.3
year 2019 (°C)	-2.2	3.3	8.1	9.7	9.3	18.7	21.9	22.3	16.2	12	8.4	3.3	10.9

Figure 2 Temperature development (°C) Dolná Malanta, Slovakia from 2017 to 2019
normal – as average values for 1951–1980

resistant varieties, and planting earlier (possibly with post-sowing rolling) so that the plant uses as much water as possible from the winter and spring moisture reserves (Dóka, 2008).

3.2 *Evaluation of the maize yield components (Zea mays L.)*

The growing year conditions and industrial fertilizers had a significant impact on the yield of grain and evaluated yield components of maize. The significance of the achieved values is indicated directly in the individual tables.

The average amount of maize cobs in 1 ha. The highest amount of precipitation in 2019 had a favourable impact on the maize harvest, as it resulted in the highest number of cobs per unit area (Table 1). The plots with the lowest number of cobs had a combination of treatments including ploughing of the forecrop above-ground biomass – milk thistle (*Silybum marianum* L.), and the absence of industrial fertiliser (RB0, RM0).

In 2017, the lowest average number of cobs was in the range of 60,242–71,530 number per ha with an average of 67 297 number per ha, which is consistent with climatic conditions in that year, even the least

Table 1 The average amount of maize cobs on a 1 ha area in pieces at the Dolná Malanta, from 2017 to 2019

Treatments	The average amount of maize cobs on a 1 ha area in pieces			
	2017	2018	2019	average per treatment
KM0	67,945	72,748	77,078	72,591b
KB0	66,688	75,704	74,020	72,137b
RB0	65,778	65,296	72,153	67,742a
RM0	60,424	71,786	73,710	68,640a
KMF	67,239	72,250	79,267	72,918b
KBF	69,332	72,888	84,279	75,500c
RBF	69,442	78,425	75,410	74,426c
RMF	71,530	74,714	76,106	74,116c
Average per year	67,297A	72,976B	76,502C	–

R – ploughing of precursor crop by-products, K – removal of by-products, M – use of catch crop, B – without use of catch crop, F – use of industrial fertilisers, 0 – without industrial fertilisers, different letter refer to significant differences of the treatment means and year conditions at p <0.05

Table 2 An average number of grains in cobs in pieces, at the Dolná Malanta, from 2017 to 2019

Treatments	The number of grains in the cob			
	2017	2018	2019	average per treatment
KM0	271.0	284.8	330.6	295.5a
KB0	253.0	276.3	305.3	278.2c
RB0	301.2	286.5	293.0	293.6a
RM0	252.0	290.5	302.3	281.6a
KMF	340.0	367.6	355.9	354.5b
KBF	343.7	350.3	373.7	355.9b
RBF	361.0	366.0	380.6	369.2b
RMF	335.1	367.7	345.5	349.4b
Average per year	307.12A	323.71B	335.87C	–

R – ploughing of precursor crop by-products, K – removal of by-products, M – use of catch crop, B – without use of catch crop, F – use of industrial fertilisers, 0 – without industrial fertilisers, different letter refer to significant differences of the treatment means and year conditions at $p < 0.05$

favourable conditions for the establishment and formation of ears were recorded, even though the total amount of precipitation was higher than in the following year 2018, but the precipitation was distributed inappropriately. In 2018, the average number of cobs per ha was in the range of 65,296–78,425 per ha. In 2019, the interval varied from 72,153–84,279 during the period with the most favourable conditions for cobs formation (in an average of 76,502).

The number of grains in the cobs is very important crop-forming factor. The findings of our investigation suggest that fertilising with ammonium nitrate-containing fertilisers has a good effect. Ploughing of the above-ground phytomass of the by-product in conjunction with the use of industrial fertilisers proved to be one of the most optimal steps in maize farming techniques, as the combination of these factors resulted in the significantly highest number of grains in the cob (RBF). The lowest values were found on unfertilized treatments, particularly those without ploughing the residues or including a catch crop. The average number of grains in the cobs ranged from 252.0 to 361.0 pieces in 2017, 284.8 to 367.6 pieces in 2018, and 293.0 to 380.6 pieces in the growing year of 2019. Growing circumstances in a particular year, like the previous harvesting aspect, have already indicated an increasing trend from year to year. The least favourable conditions occurred in 2017 when the average number of grains in cobs was 307.12 (Table 2). Even though the total amount of precipitation for the year was less than in 2017, the average was 323.7 pieces in 2018. However, precipitation was more evenly distributed, and temperatures reached greater levels in 2018. The best climatic conditions were reported in 2019 when the average number of grains in cobs reached 335.87.

The quantification of grain yield per unit area arises from the interplay of two primary yield components: the density of cob-bearing plants per unit area and the number of grains per cob. Among the investigated years, 2017 exhibited the lowest productivity, primarily attributable to suboptimal conditions conducive to grain development. On the contrary, the best conditions to produce maize generative organs occurred in 2019, when the best values were obtained across all treatments. The integration of fertilization factors with the incorporation of above-ground biomass through ploughing resulted in the highest recorded values of grain per ha. Conversely, non-fertilized treatments demonstrated a significantly lower number of grains per ha (Table 3). The number of grains per cob also depended on the dose of nitrogen fertilizer (Belay and Kiya, 2020).

The weight of a thousand seeds is an important factor for yield and yield stability. Seed size is genetically determined and varies within a small range. TSW of maize ranged from 189.78 g to 234.59 g in 2017. In the year 2018, the weight of maize seeds ranged from 187.86 to 229.85 g. In 2019, the interval was narrower from 199.18 g to 228.10 g. Fertilization treatment supports better grain development in the average range (Table 4). These results support the findings of Szulc et al. (2023).

The yield of dry corn stalks is essential in silage maize and green maize stands. On the other hand, the amount of biomass production is significant for the adaptation efforts, absorbing the by-product into the soil, and managing organic matter in general. The lowest values of dry corn stalks biomass at 15% humidity were reported on treatments in the combination of variables without industrial fertilisers with removing above-ground biomass of the by-product. Good results are obtained when industrial fertilization is used also by incorporation

Table 3 Number of grains per 1 ha in millions at Dolná Malanta, from 2017 to 2019

Treatments	The number of grains per ha (millions)			
	2017	2018	2019	average per treatment
KM0	18.41	20.72	25.48	21.54a
KB0	16.87	20.92	22.60	20.13a
RB0	19.81	18.71	21.14	19.89a
RM0	15.23	20.85	22.28	19.45a
KMF	22.87	26.56	28.21	25.88b
KBF	23.83	25.53	31.50	26.95b
RBF	25.07	28.70	28.70	27.49b
RMF	23.97	27.47	26.30	25.91b
Average per year	20.76A	23.68B	25.78C	–

R – ploughing of precursor crop by-products, K – removal of by-products, M – use of catch crop, B – without catch crop, F – use of industrial fertilisers, 0 – without industrial fertilisers, different letters refer to significant differences of the treatment means and year conditions at $p < 0.05$

Table 4 TSW of maize at 14% humidity per specified treatments at Dolná Malanta, from 2017 to 2019

Treatments	TSW maize at 14% humidity (g)			
	2017	2018	2019	average per treatment
KM0	196.16	187.86	199.18	194.40a
KB0	213.00	209.27	199.70	207.32a
RB0	189.78	212.59	212.44	204.94a
RM0	195.58	213.28	202.79	203.88a
KMF	225.10	217.45	217.80	220.11c
KBF	221.59	219.15	209.52	214.34b
RBF	234.59	215.01	228.10	225.90c
RMF	219.02	229.85	217.47	222.11c
Average per year	211.85A	213.06A	210.87A	–

R – ploughing of precursor crop by-products, K – removal of by-products, M – use of catch crop, B – without catch crop, F – use of industrial fertilisers, 0 – without industrial fertilisers, different letters refer to significant differences of the treatment means and year conditions at $p < 0.05$

Table 5 Yield of dry maize stalks across assessed treatments, Dolná Malanta, from 2017–2019

Treatments	The yield of dry corn stalks at 15% humidity ($t \cdot ha^{-1}$)			
	2017	2018	2019	average per treatment
KM0	10.58	11.83	11.14	11.18a
KB0	10.16	11.90	12.30	11.45a
RB0	10.38	10.16	12.81	11.12a
RM0	11.33	9.82	11.98	11.02a
KMF	12.79	12.39	12.84	12.67b
KBF	12.55	11.17	12.60	12.11b
RBF	11.92	12.94	12.93	12.60b
RMF	11.55	13.35	12.46	12.45b
Average per year	11.41A	11.70A	12.38B	–

R – ploughing of precursor crop by-products, K – removal of by-products, M – use of catch crop, B – without catch crop, F – use of industrial fertilisers, 0 – without industrial fertilisers, different letters refer to significant differences of the treatment means and year conditions at $p < 0.05$

Table 6 Biological yield of maize grain at 14% humidity (t·ha^{-1}) at Dolná Malanta, from 2017 to 2019

Treatments	The biological yield of maize grain at 14% humidity (t·ha^{-1})			
	2017	2018	2019	average per treatment
KM0	3.63	3.94	5.06	4.21a
KB0	3.60	4.37	4.56	4.17a
RB0	3.76	4.01	4.50	4.09a
RM0	2.98	4.45	4.53	3.98a
KMF	5.15	5.75	6.15	5.68b
KBF	5.29	5.59	6.68	5.84b
RBF	5.88	6.16	6.56	6.20c
RMF	5.24	6.32	5.73	5.76b
Average per year	4.44A	5.06B	5.46C	–

R – ploughing of forecrop by-products, K – removal of by-products, M – use of catch crop, B – without catch crop, F – use of industrial fertilisers, 0 – without industrial fertilisers, different letters refer to significant differences of the treatment means at p <0.05

of aboveground biomass (Table 5). The effect of different nitrogen rates on the mass per plant was reported by Mitova and Vasileva (2024). The yield of dry corn stalks was in the range of 10.16–12.79 t·ha^{-1} in 2017, 9.82–13.35 t·ha^{-1} in 2018, and 11.14–13.84 t·ha^{-1} in 2019. The average value of the yield of dry corn stalks was significantly higher in 2019 (12.38 t·ha^{-1}). The discrepancies between years (0.97 t·ha^{-1}) were primarily due to meteorological conditions, which were most favourable in 2019 and least suitable in 2017, due to a precipitation deficit.

3.2.1 The yield of maize grain

Maize yield and variability are closely related to the assessed yield components, which constitute the ultimate result of the product of the number of seeds per unit area, and in the evaluation of the impact of treatments used (Tables 3 and 4).

It is obvious from the foregoing that the conditions of seed production and development were controlled by fertilisation factors and treatments (Table 6).

The integration of preceding crop phytomass alongside industrial fertilizers has demonstrated superior efficacy in augmenting final crop yield, as evidenced in Table 6. Furthermore, Jahangir et al. (2024) highlighted that residue management alone led to notable enhancements in nitrogen-use efficiency, with increases of 12–19% observed in potatoes, 10% in maize, and 13–20% in winter rice.

Treatments in the combination of factors without fertilisers or ploughing organic matter (above-ground biomass of the by-product) were on the same significantly lower production level. The higher yield was achieved by treatments on a combination of factors using fertilisers and ploughing aboveground biomass. The positive effect

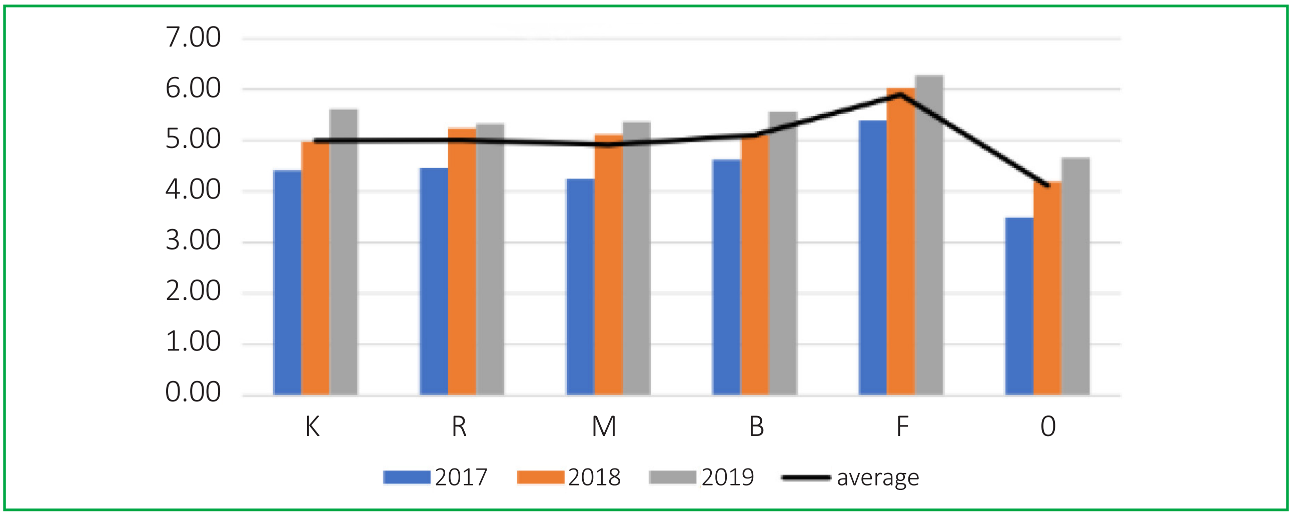


Figure 3 Yield of maize grain in t·ha^{-1} at 14% humidity, based on assessed treatments at Dolná Malanta from 2017 to 2019
R – ploughing of precursor crop by-products, K – removal of by-products, M – use of catch crop, B – without use of catch crop, F – use of industrial fertilisers, 0 – without industrial fertilisers

of fertilization and organic matter management factors on maize grain yield was supported by the results of other authors (Jin et al., 2019; Gao et al., 2020).

The average expression of the environmental potential of the locality over the investigated period of three years was at the level of 5 tons of grain yield per hectare. In 2017, the yield of maize grain at 14% humidity was in a wide interval of 2.98–5.88 t·ha^{-1}, in 2018 in the interval of 3.94–6.32 t·ha^{-1}, and in 2019 in the interval of 4.50–6.68 t·ha^{-1}.

The average value of the yield of maize grain was significantly lower in 2017 (4.44 t·ha^{-1}) with comparison to other evaluated years (5.07–5.47 t·ha^{-1}). The conditions of the two most contrasting years were expressed by the difference in the production of maize grain of 1.03 t·ha^{-1} to the detriment of the precipitation deficient year 2017.

Figure 3 depicts the differences in the biological yield of maize grain between the individual factors.

Grain yield disparities are the largest in treatments with industrial fertiliser application due to factors connected to varied fertilisation management. The highest grain yield (5.68–6.2 t·ha^{-1}) was achieved on all treatments when industrial fertilisers were applied.

We discovered that ploughing the by-above-ground product's biomass reduced variability across growing years when compared to versions that removed the above-ground biomass.

4 Conclusions

In the dry and warm and extraordinarily warm conditions of 2017 and 2018 respectively and the precipitation normal but warm year conditions of 2019, we evaluated the influence of adaptation measures on yield and yield components of maize for grain. The results of this three-year field trial have shown that ploughing of forecrop aboveground biomass with the application of industrial NPK fertilization may contribute to the proper management of organic matter in dry and warm conditions which was reflected in a positive effect on the evaluated parameter of maize. The finding reinforces the significance of a well-balanced set of adaptation measures, for the particular yield components. The very important yield indicator number of grains per unit area showed clear tendencies, with the greatest values obtained on fertilized treatments with incorporation of aboveground crop biomass – 27.49 million in comparison to control treatment with 20.13 million grains per 1 ha. The fertilized treatments showed the greatest positive impact on maize grain development as the unfertilized treatments. The variability of maize biomass production was only influenced by treatments in the combination of factors with NPK fertiliser application and ploughing of the forecrop aboveground biomass. The current climatic conditions were also reflected in the yield of maize grain in t·ha^{-1}. The organic matter management of the forecrop or catch crops separately has no significant effect on maize crop yields and yield components. Only the combined treatments with the application of industrial fertilisers and incorporation of aboveground biomass of crops indicate a positive effect in terms of yield increase. Our research contributes new insights into the effectiveness of specific adaptation measures in maize cultivation under varying climatic conditions. The key finding is that combining ploughing of forecrop biomass with industrial NPK fertilization significantly enhances maize yield and yield components, particularly in dry and warm conditions. This practice optimizes organic matter management and nutrient availability, which are critical for sustaining high yields.

Acknowledgements

This research was funded by VEGA (Scientific Grant Agency of the Ministry of Education, Science, Research and Sports of the Slovak Republic and the Slovak Academy of Sciences), 1/0749/21 "En-vironmental screening of variability of secondary metabolites of plant natural resources in soil-climatic conditions of Slovakia".

The authors would like to thank Ing. Radoslav Ražný from the Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra for providing the technical support.

References

Belay, M., & Adare, K. (2020). Response of growth, yield components, and yield of hybrid maize (*Zea mays* L.) varieties to newly introduced blended NPS and N fertilizer rates at Haramaya, Eastern Ethiopia. *Cogent Food and Agriculture*, 6(1), 1771115. https://doi.org/10.1080/23311932.2020.1771115

Benitez-Alfonso, Y. et al. (2023). Enhancing climate change resilience in agricultural crops. *Current Biology*, 33(23), R1246–R1261. https://doi.org/10.1016/j.cub.2023.10.028

Dóka, L.F. (2008). Effect of some agrotechnical factors on water husbandry of soil and yield in monoculture maize (*Zea mays* L.) product. *Environmental protection and food safety in crop production*, 133–137.

Gao, C. et al. (2020). The Integration of Bio and Organic Fertilizers Improve Plant Growth, Grain Yield, Quality and Metabolism of Hybrid Maize (*Zea mays* L.). *Agronomy*, 10(3), 319. https://doi.org/10.3390/agronomy10030319

Ivanič Porhajašová, J., & Babošová, M. (2022). Impact of arable farming management on the biodiversity of Carabidae (Coleoptera). *Saudi Journal of Biological Science*, 29, 103371. https://doi.org/10.1016/j.sjbs.2022.103371

Jahangir, R.M.M. et al. (2024). Integrating nitrogen fertilization with crop residues to improve nitrogen management in intensively managed cropping systems. *Archives of Agronomy and Soil Science*, 70(1), 1–16. https://doi.org/10.1080/03650340.2023.2283191

Hou, D. et al. (2020). Sustainable soil use and management: An interdisciplinary and systematic approach. Science of the Total Environment, 729, 138961. https://doi.org/10.1016/j.scitotenv.2020.138961

Jin, Z. et al. (2019). The crucial factors of soil fertility and rapeseed yield – a five year field trial with biochar addition in upland red soil, China. *Science of the Total Environment*, 649, 1467–1480. https://doi.org/10.1016/j.scitotenv.2018.08.412

Kmeťová, M., & Kováčik, P. (2014). The impact of vermicompost application on the yield parameters of maize (*Zea mays* L.) observed in selected phenological growth stages (BBCH-SCALE). *Acta fytotechnica et zootechnica*, 17(4), 100–108. https://doi.org/10.15414/afz.2014.17.04.100–108

Kováčik, P. et al. (2015). Impact of vermicompost extract application into soil and on plant leaves on maize phytomass formation. *Journal of Ecological Engineering*, 16(4), 143–153. https://doi.org/10.12911/22998993/59363

Kožnárová, V., & Klabzuba, J. (2002). Recommendation of World Meteorological Organization to describing meteorological or climatological conditions. *Plant, Soil and Environment*, 48(4), 190–192. https://doi.org/10.17221/4219-PSE

Laurett, R., Paço, A., & Mainardes, E.W. (2020). Sustainable Development in Agriculture and its Antecedents, Barriers and Consequences – An Exploratory Study. *Sustainable Production and Consumption*, 27, 298–311. https://doi.org/10.1016/j.spc.2020.10.032

Macák, M. et al. (2020). The Influence of Different Fertilization Strategies on the Grain Yield of Field Peas (*Pisum sativum* L.) under Conventional and Conservation Tillage. *Agronomy*, 10, 1728. https://www.mdpi.com/2073-4395/10/11/1728

Mitova, I., & Vasileva, V. (2024). Growth and yield response of maize (*Zea mays* var. *saccharata*) to different nitrogen fertilization sources and rates. *Journal of Central European Agriculture*, 25(1), 137–145. https://doi.org/10.5513/JCEA01/25.1.4056

Pazdera, J. et al. (2023). Effect of different fertilizers and no-till versus strip-till on silage maize yield in a dual cropping system. *Acta fytotechnica et zootechnica*, 26(4), 438–444. https://doi.org/10.15414/afz.2023.26.04.438-444

Quintarelli, V. et al. (2022). Cover Crops for Sustainable Cropping Systems: A Review. *Agriculture*, 12, 2076. https://doi.org/10.3390/agriculture12122076

Serna-Saldivar, S.O. (2015). History of Corn and Wheat Tortillas – Chapter 1. *Tortillas: Wheat Flour and Corn Products, Imprint:* Woodhead Publishing and AACC International Press, (pp. 1–28).

Šimanský, V. (2017). Is the Period of 18 Years Sufficient for an Evaluation of Changes in Soil Organic Carbon under a Variety of Different Soil Management Practices? *Communications in Soil Science and Plant Analysis*, 48(1), 37–42. http://dx.doi.org/10.1080/00103624.2016.1253717

Szulc, P. et al. (2023). Response of Maize Varieties (*Zea mays* L.) to the Application of Classic and Stabilized Nitrogen Fertilizers – Nitrogen as a Predictor of Generative Yield. *Plants*, 12, 600. https://doi.org/10.3390/plants12030600

Wang, X. et al. (2021). Multi-site evaluation of accumulated temperature and rainfall for maize yield and disease in Loess Plateau. *Agriculture*, 11(4), 373. https://doi.org/10.3390/agriculture11040373

Zhang, Q. et al. (2015). The impacts of long-term and year-to-year temperature change on corn yield in China. *Theoretical Applied Climatology*, 119, 77–82. https://doi.org/10.1007/s00704-014-1093-3