SUPPORTING BIODIVERSITY WITH THE HELP OF FLOWERIG SHRUBS IN THE CORN FIELD

František TOŠOVSKÝ[1], František HOREJŠ[1], Milan KROULÍK[1], Václav NOVÁK[2]

[1]Czech University of Life Sciences Prague, Faculty of Engineering, Department of Agricultural Machines [2]Czech University of Life Sciences Prague, Faculty of Engineering, Department of Machinery Utilization

Abstract
This paper presents the evaluation of above-ground biomass production in buffer strips established in tramlines of maize fields. The field experiment was carried out in 2025 at the Statek Bureš farm in Bučina near Vysoké Mýto, Czech Republic. The objective was to determine the effect of buffer strips on maize stand density in adjacent rows and on biomass production within the strips. Plant density was assessed in six row zones, and biomass samples were collected from four locations. The results showed a higher number of maize plants in rows adjacent to the strips with increased seeding rates, confirming the edge effect. Biomass production of the strips ranged from 3,62 to 8,3 t·ha⁻¹, with a variable proportion of weeds (21,05–77,36%). These findings demonstrate that buffer strips can enhance the ecological stability of maize fields, but their effectiveness strongly depends on establishment quality and subsequent management.

Keywords: *maize, tramlines, biomass production, buffer strips, crop density*

INTRODUCTION

Maize *(Zea mays L.)* is one of the most important crops worldwide and in Central Europe, including the Czech Republic. In the EU, maize is cultivated on more than 8 million hectares annually, with a strong orientation towards both grain and silage production. In the Czech Republic, the crop covers more than 300,000 hectares, making it a dominant wide-row crop in many regions. Its economic importance is based on its high yield potential, versatility of use, and key role in livestock feeding systems. However, the wide-row structure of maize also increases the vulnerability of this crop to soil degradation processes, particularly water erosion, runoff, and loss of soil organic matter *(Hůla, Procházková, & Hůlová, 2014)*.

Soil erosion represents one of the most significant threats to sustainable maize production. In sloping terrains, water erosion can result in substantial topsoil loss, reduced soil fertility, and deterioration of soil structure *(Lal, 2015)*. Wind erosion can occur in early developmental stages when maize plants do not yet provide sufficient soil cover. Climate change further aggravates these problems by increasing the frequency of extreme rainfall events and prolonged droughts. In addition to erosion, intensive maize cultivation has been associated with a decline in biodiversity, particularly due to simplified crop rotations and heavy reliance on agrochemicals *(Tilman et al., 2002)*.

To address these challenges, agro-environmental measures have been introduced within both national policies and the European Union's Common Agricultural Policy *(CAP)*. Among them, the establishment of buffer strips is considered an effective and practical solution *(Křen et al., 2015)*. In maize fields, buffer strips are often placed in tramlines, i.e., the compacted tracks of sprayers or other machinery, which are otherwise prone to erosion and reduced plant stand density. Buffer strips can increase ground cover, reduce runoff velocity, enhance infiltration, and improve soil organic carbon sequestration. In addition, they may provide ecological services such as habitat for beneficial insects, food resources for pollinators, and increased landscape heterogeneity *(Procházka & Kvítek, 2017; Smith et al., 2014)*.

From an agronomic perspective, one important phenomenon linked to buffer strips is the edge effect. Plants growing in rows adjacent to the strip may exhibit higher vigor and density compared to plants inside the field. This may result from improved light penetration, lower intraspecific competition, and more favorable microclimatic conditions *(Novák et al., 2019)*. Earlier studies have demonstrated that row spacing, plant geometry, and density are critical factors determining maize yield and biomass production *(Baker & Reddy, 2001; Gupta et al., 2011)*. Therefore, evaluating how buffer strips influence adjacent maize rows is essential for understanding both production and ecological consequences of this practice.

Despite the recognized importance of buffer strips, there is still a need for robust field-based methodologies that can reliably quantify their effects. Many previous studies focused primarily on erosion reduction, but less attention has been given to the production of above-ground biomass within the strips and to the changes in maize stand density caused by their establishment. The objective of this study was therefore to evaluate the effect of buffer strips in maize stands on both crop density and above-ground biomass production.

MATERIALS AND METHODS

The field experiment was conducted in 2025 at the farm Statek Bureš s.r.o. in Bučina near Vysoké Mýto, Pardubice Region, Czech Republic. The experimental site is located at an altitude of 324–400 m a.s.l., with an average annual precipitation of 670 mm and mean annual temperature of 8,5 °C. The soils are classified as Cambisols and Luvisols, typical for the maize production region in the Czech Republic.

Buffer strips were established in tramlines of a self-propelled sprayer. Each strip was 3 m wide, corresponding to three rows of maize that were omitted, with a spacing of 36 m between strips, matching the machine track width. The buffer strips were sown on 28 April 2025 using a multi-component seed mixture containing legumes, phacelia, buckwheat, oil radish, and camelina. The mixture was designed to provide rapid ground cover, erosion protection, and flowering resources for pollinators.

Maize *(Zea mays L.)* was sown with a row spacing of 0,75 m. In rows adjacent to the buffer strips, the seeding rate was increased to 115,000 plants·ha^{-1}, while the rest of the stand was sown at 85,000 plants·ha^{-1}. This modification was applied to compensate for the potential yield reduction in tramlines and to assess the effect of higher density near strips. Fertilization and plant protection were carried out according to standard farm practice.

On 24 June 2025, the number of maize plants was determined in six different zones *(A–F)*. For each zone, four replications were conducted on 2 m sections of the row, and the results were converted to the number of plants per meter. Zones A and D represented rows with increased seeding rates adjacent to buffer strips, while B, C, E, and F represented control rows with standard seeding density inside the stand.

Biomass production in buffer strips was evaluated on 21 July 2025 at four locations within the experimental field. Plant material was harvested from central parts of the strips using 0,25 m² frames. Samples were sorted into sown species and weeds, dried at 105 °C for 24 h, and weighed. The results were recalculated to tonnes of dry matter per hectare.

The data were analyzed using one-way analysis of variance *(ANOVA)*. Treatment means were compared with Tukey's HSD test at a significance level of $\alpha = 0,05$. Statistical analyses were performed using Statgraphics® Plus software.

RESULTS AND DISCUSSION

Plant density differed significantly among the evaluated row zones *(Tab. 1)*. The increased seeding rate on the left side of the buffer strip resulted in the highest plant density *(8,52 plants·m^{-1})*, while the lowest value was recorded in the control rows *(6,1 plants·m^{-1})*. These findings clearly demonstrate the presence of the edge effect, where maize plants situated next to vegetation strips are exposed to modified microenvironmental conditions such as improved light penetration, lower intraspecific competition, and higher soil moisture retention.

The asymmetric response, with significant differences only on the left side of the buffer strip, suggests the influence of local soil heterogeneity, wheel-track compaction patterns, and microclimate gradients. Such inconsistencies are well documented by Gupta et al. *(2011)* and Weerasekara et al. *(2020)*, who emphasized that edge responses can differ sharply across small spatial scales.

Our findings are consistent with Baker & Reddy *(2001)* and Novák et al. *(2019)*, who observed higher emergence and vigor in border rows. However, unlike their controlled research conditions, our experiment was conducted on a commercial farm, where field variability is naturally higher. This realistic setting may explain why only one side of the buffer strip exhibited a statistically significant improvement in plant density.

Tab. 1 Plant density of maize *(plants·m⁻¹)* in different row zones *(2025)*

Zone	Description	Plants·m⁻¹
A	Increased seeding rate, left side	8,52
B	Control, standard rate, left side	6,1
C	Control, standard rate, left side	6,52
D	Increased seeding rate, right side	7,68
E	Control, standard rate, right side	6,86
F	Control, standard rate, right side	6,1

Biomass production in the buffer strips ranged from 3.62 to 8.3 t·ha⁻¹ across the four evaluated locations *(Tab. 2)*. The large variability reflects differences in seedbed quality, competition dynamics, and micro-site factors. Locations with a high proportion of sown species *(particularly location 1 and 3)* achieved substantially higher biomass, confirming that the establishment success of the mixture is critical. In contrast, at location 4, weeds made up 77.36 % of the biomass, reducing the functional performance of the strip.

These results agree with Smith et al. *(2014)* and Keet et al. *(2021)*, who demonstrated that competition from spontaneous vegetation can drastically alter biomass production and nutrient dynamics in diversified strips. Similarly, Thorup-Kristensen et al. *(2020)* pointed out that root-system interactions play a major role in determining competitive outcomes.

Our total biomass results fall within the range reported by Blanco-Canqui *(2018)* for mixed cover-crop strips *(4–10 t·ha⁻¹)*, though our variability is higher due to real-farm conditions. The variability between locations also corresponds with the findings of Sekaran et al. *(2022)*, who showed that even small differences in seedbed preparation can lead to biomass fluctuations of up to 60 % in similar systems.

Tab. 2 Above-ground biomass production in buffer strips *(2025)*

Location	Sown species *(t·ha⁻¹)*	Weeds *(t·ha⁻¹)*	Total biomass *(t·ha⁻¹)*	Weeds share *(%)*
1	6,21	2,09	8,3	25,18
2	2,14	1,48	3,62	40,88
3	4,5	1,2	5,7	21,05
4	1,15	3,93	5,08	77,36

Compared with existing studies on buffer strips and cover crops:

- Our biomass values *(3.62–8.3 t·ha⁻¹)* fall within the range reported for mixed cover crop stands in temperate Europe *(Ertl et al., 2016)*, though variability was higher due to differing weed pressure.
- The documented edge effect is consistent with row geometry studies *(Baker & Reddy, 2001)* but our results highlight its spatial variability, which is less commonly reported.
- The strong dependence on local conditions aligns with findings of Tilman et al. *(2002)*, who emphasize that ecosystem services of agro-environmental measures are highly context-dependent.

Unlike many published studies, which rely on controlled research plots, our experiment was implemented under real farm conditions, increasing the practical relevance of our findings but also contributing to variability.

The presence of weeds—although undesirable from a biomass-production standpoint—may contribute positively to biodiversity by providing nectar resources and habitat structure. This dual function of weeds has also been emphasized by Procházka & Kvítek *(2017)* and Tilman et al. *(2002)*. Therefore,

management strategies should not aim to eliminate all weeds but maintain their proportion at a balanced level.
From an agronomic perspective, the increased seeding rate in rows adjacent to buffer strips appears to be a useful adaptation strategy, helping to compensate for the lower competition and slightly modified microclimate next to the strips. The combined results confirm that buffer strips influence both crop density and biomass production in maize fields. Increased seeding rates in rows adjacent to strips enhanced plant density, confirming the significance of edge effects, while biomass production in strips was highly site-specific and affected by the proportion of weeds. These findings highlight the multifunctionality of buffer strips: they act as erosion-control measures, sources of organic matter, and habitats for beneficial organisms *(Tilman et al., 2002; Ertl et al., 2016)*. At the same time, their agronomic performance depends on careful establishment and maintenance.
The presented methodology provides a robust framework for evaluating the agronomic and ecological roles of buffer strips in maize stands. By integrating crop density assessment with biomass measurements, it contributes to a better understanding of the interactions between production and environmental functions.

CONCLUSION

The field experiment conducted in 2025 demonstrated that buffer strips established in maize tramlines have a measurable influence on both crop density and above-ground biomass production. Rows adjacent to the strips with an increased seeding rate showed higher plant density, confirming the presence of the edge effect; however, its magnitude differed between the left and right side of the strip, highlighting the strong influence of local soil and microclimatic conditions.
Biomass production in the buffer strips varied substantially between locations, ranging from 3.62 to 8.3 $t \cdot ha^{-1}$. The proportion of weeds proved to be a key factor shaping the functional performance of the strips. In locations with high weed pressure, the contribution of sown species was reduced, which limited the ecological benefits of the buffer strip. These results underline that the success of buffer strips depends not only on the seed mixture used but also on the suitability of the site and early vegetation dynamics.
Overall, the implemented methodology proved suitable for evaluating the agronomic and ecological functions of buffer strips under real farm conditions. The combined assessment of plant density and biomass production provides a deeper understanding of how buffer strips interact with adjacent maize stands and how they contribute to soil protection, biodiversity support, and landscape sustainability.
The variability observed in this study also points to the need for careful establishment and management of buffer strips, including the selection of appropriate seed mixtures, timely mowing or mulching, and adaptation of seeding strategies in adjacent crop rows. These findings support the implementation of buffer strips as a practical and effective agro-environmental measure aligned with the objectives of the Common Agricultural Policy, particularly the GAEC standards aimed at soil conservation and biodiversity enhancement.

ACKNOWLEDGMENT

Supported by the Faculty of Engineering *(CULS)* – IGA no. 2025:31160/1312/3105

REFERENCES

1. Baker, R. J., & Reddy, V. R. *(2001)*. The effect of row spacing on maize grain yield. Field Crops Research, 72*(2)*, 159–167.
2. Blanco-Canqui, H. *(2018)*. Cover crops and water quality: What we know and what we need to know. Agricultural Water Management, 217, 34–49.
3. Chytrý, M., Kučera, T., & Kočí, M. *(2010)*. Katalog biotopů České republiky. Praha: AOPK ČR.
4. Ertl, P., Novák, V., & Janeček, M. *(2016)*. Effect of different cover crops on soil erosion in maize. Plant, Soil and Environment, 62*(9)*, 405–411.
5. Gupta, R. K., Singh, Y., & Ladha, J. K. *(2011)*. Influence of planting geometry on maize productivity. Agricultural Sciences, 2*(3)*, 131–137.
6. Hůla, J., Procházková, B., & Hůlová, J. *(2014)*. Půdoochranné technologie pěstování kukuřice. Praha: ÚZPI.

7. Keet, J.-H., le Roux, J. J., & Esler, K. J. *(2021)*. Competition dynamics between weeds and crops in diversified buffer strips. Agronomy, 11*(4)*, 701.
8. Křen, J., Vopravil, J., & Kovář, P. *(2015)*. Využití ochranných pásů v zemědělské krajině. Agroecology Research, 10*(2)*, 45–52.
9. Lal, R. *(2015)*. Restoring soil quality to mitigate soil degradation. Sustainability, 7*(5)*,
10. Novák, P., Dvořák, J., & Kumhála, F. *(2019)*. Vliv hustoty porostu na výnos kukuřice seté. Úroda, 67*(7)*, 215–221.
11. Procházka, J., & Kvítek, T. *(2017)*. Biopásy jako opatření pro zvýšení biodiverzity v zemědělské krajině. Journal of Landscape Management, 8*(1)*, 25–32.
12. Sekaran, U., Koala, J., & Dube, T. *(2022)*. Spatial variability of cover-crop biomass under contrasting soil preparation systems. Agricultural Systems, 197, 103351.
13. Smith, R. G., Atwood, L. W., & Pollnac, F. W. *(2014)*. Cover-crop species and functional diversity influence weed suppression. Agronomy Journal, 106*(6)*, 1946–1954.
14. Thorup-Kristensen, K., Dresbøll, D. B., & Kristensen, H. L. *(2020)*. Root growth and soil nitrogen dynamics in cover crop mixtures. Plant and Soil, 455*(1)*, 1–16.
15. Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. *(2002)*. Agricultural sustainability and intensive production practices. Nature, 418*(6898)*, 671–677.
16. Weerasekara, C., de Silva, C. S., & Marambe, B. *(2020)*. Edge effects on crop microclimate and productivity in maize-based cropping systems. International Journal of Agronomy, 2020, 1–12.

Corresponding author:
Ing. et Ing. František Tošovský, Department of Agricultural Machines, Faculty of Engineering, Czech University of Life Sciences Prague, Kamýcká 129, Praha 6, Prague, 16521, Czech Republic, phone: +420 737 762 193, e-mail: tosovsky@tf.czu.cz