

APPLICATION OF AGROTECHNICAL MEASURES AND ECONOMIC SUCCESS IN WHEAT AND MAIZE CULTIVATION IN THE BRČKO DISTRICT AREA

Merima Makaš^{*1}, Dimitrije Ševo¹, Drena Gadžo¹, Emir Bećirović¹

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Abstract

In Bosnia and Herzegovina, wheat and maize are the most important crops, holding a dominant position in the country's arable land. Consequently, this paper analyses wheat and maize production in the Brčko District, focusing on the applied agrotechnical measures and the economic results, as reflected by the gross margin per hectare. The research involved 30 farms in the district, with more than 1.5 hectares of the targeted crops. Data was collected through structured survey questionnaires, which included detailed questions about the applied agrotechnical practices, yields, costs, and revenues. The results indicate that average yields are 5.3 tons/ha for wheat and 8.7 tons/ha for corn. Economic analysis shows that the gross margin was 639 KM/ha for wheat and 1,611 KM/ha for corn. The higher financial results for maize are partly due to higher yields and more stable production. Conversely, the moderate gross margin for wheat highlights the need to optimize agrotechnical measures to boost productivity and economic profitability. The largest share of total costs is for mechanization and mineral fertilizers, while the most notable irregularities in applying agrotechnics occurred in fertilization, mainly due to the lack of soil fertility analysis. Therefore, this paper recommends conducting soil analysis before fertilization to optimize costs and prevent unnecessary fertilizer application.

Keywords: *corn, wheat, Brčko District, agrotechnical measures, gross margin*

INTRODUCTION

Wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) represent two of the most important cereal crops within the crop production systems of Bosnia and Herzegovina. According to data from the Agency for Statistics of BH (2025), the harvested area of wheat was 59,569 ha, and that of maize was 121,966 ha, which accounted for 44.2% of the total cultivated arable land in BiH. Sustainable and profitable production of these crops depends on a wide range of factors, among which agrotechnical measures play a central role—from the choice of variety or hybrid, crop rotation, and soil tillage, to sowing, fertilization, plant protection, harvesting, and storage.

¹ University of Sarajevo, Faculty of Agriculture and Food Sciences, Bosnia and Herzegovina

*Correspondence: m.makas@ppf.unsa.ba

Each of these elements must be viewed as equally important, as final yield is often limited by the step that is executed least effectively (Marinković *et al.*, 2008). Agrotechnics forms the foundation for organizing and executing all production processes in agriculture, and its importance is particularly evident in arable crop systems. As a set of interconnected measures, it aims to create optimal conditions for plant growth and development, ensure the efficient use of land and inputs, and ultimately achieve high and stable yields (Glišić & Đurović, 2015). Several authors emphasize that both the choice of variety/hybrid and the level of applied agrotechnics have a comparable influence on cereal yields (Kovačević & Rastija, 2014), while weather conditions contribute to yield variability that can often be mitigated through timely and proper implementation of technical measures. Particularly important are measures such as soil tillage, crop rotation, fertilization, weed, disease and pest control, irrigation, and the selection of well-adapted varieties or hybrids. The proper combination of these practices forms the basis of sustainable production, enabling a balance between economic efficiency and the preservation of the agroecosystem (Tomić & Marković, 2019).

Under the growing pressures of climate change, particularly more frequent droughts and heatwaves, the importance of agrotechnical practices becomes even more pronounced. Recent study shows that integrated crop management (ICM) can increase wheat and maize yields by 16-30 % while improving resource-use efficiency (Deng *et al.*, 2022; Yamini *et al.*, 2025). At the same time, diversifying crop rotations—especially by including legumes and other complementary crops—tends to increase yields and net returns while reducing greenhouse gas emissions (Yang *et al.*, 2024).

Additionally, in dry climate conditions, adjusting irrigation and sowing density improves the physiological and agronomic parameters of cereal crops, thereby increasing their resistance to stress (García-Caparrós *et al.*, 2025). Furthermore, agroecological practices such as intercropping contribute to reducing weeds and the need for mineral fertilizers, increase nitrogen use efficiency, and stabilize yields (van Cossel *et al.*, 2025). Modern trends in agriculture focus on integrated management of agronomic practices, combining traditional knowledge with precision agriculture technologies, digital monitoring, and soil conservation (FAO, 2020). Such an approach allows for resource reduction, biodiversity preservation, and adaptation of production to the demands of sustainable development (Lal, 2021).

Jaćimović *et al.* (2011) observed that nitrogen has the greatest impact on wheat yield when examining the efficiency of mineral nutrition, where the application of only nitrogen (100 kg N/ha) resulted in an increase in yield of 85% or 2 tons/ha compared to the control. The greatest increase in yield per kilogram of fertilizer used was with nitrogen (an average of 32.20 kg of grain per kg of N used over two years); followed by phosphorus (10.52 kg of grain per kg of P_2O_5), and the least with potassium (5.85 kg of grain per kg of K_2O). The agronomic efficiency of nitrogen tended to decrease with increasing fertilization intensity.

The effects of inter-row cultivation depend on whether herbicides were applied or not, the level of weed infestation, and whether the year was normal, wet, or dry. Lazić *et al.*

(1995) documented that on a plot partially weeded with wild mustard, one cultivation increased the yield by 4.4%, and two cultivations by 18.9%. Also, in another study by the same author, in the second year, one cultivation increased the yield by 7.8%, and two by 9.8%.

Crop rotation can significantly reduce the number of weeds in crops (Liebman and Dyck, 1993). Crop sequences, whether two-year or three-year, as a single system of plant production, can be more effective in weed suppression than monoculture. Weed infestation is mainly a logical consequence of improper selection of predecessors, the effects of crop rotation, and untimely or insufficient weed control. Growing crops in rotation is sometimes not only the most important measure but also the only one that effectively supports weed protection. Crop rotation practically prevents the overrepresentation of certain species and hinders their spread (Kovačević *et al.*, 2008). Regarding soil contamination, Saulić *et al.* (2017) observed twice as much weed seed in soybean monoculture compared to when it was grown in a soybean-wheat-maize rotation. Increased amounts of weed seed in monoculture were also noted by Forcella and Lindstrom (1988), who reported levels twice as high as in the soybean-maize rotation.

With modern scientific advances, high-yielding varieties and hybrids have been developed, and to express their potential, it is necessary to increase soil fertility through fertilization. To achieve a significant increase in yield, overall agricultural techniques need to be elevated to a new level, with fertilization playing a particularly important role, as it contributes 50 to 70% to yield increase (Gašpar, 2000).

Brčko District of Bosnia and Herzegovina possesses exceptional natural resources for the development of primary agricultural production. Agricultural land covers 16,980 hectares (2024), which accounts for 71.5% of the total district territory, with the largest part located along the Sava River and classified as high-quality land. Of this area, arable land (plowed and cultivated land) occupies 12,427 hectares, or 68.1% of the total land. In the structure of arable land, the most represented are arable lands at 60.7% (Study, 2007).

In most of the territory, pseudogley soils are present, which have poorer physical and chemical characteristics (clayey, more difficult to cultivate, acidic reactions), while more favorable agricultural lands (eutric cambisols, fluvisols, humofluvisols) are found in the valleys of the Tinja, Brka, and Sava rivers (Study, 2007). According to data from 2024 (BHAS, 2025), the most widespread arable crop in the Brčko District was grain corn, covering 5,027 hectares, which confirms its role as a strategic crop in human nutrition as well as in livestock. In addition to corn, significant areas are occupied by wheat (1,978 ha), soybeans (2,041 ha), oats (682 ha), barley (886 ha), rapeseed (2,437 ha). This production structure indicates a relatively diversified crop system but also a dominant orientation toward cereal production.

Despite the demonstrated importance of these two crops in agriculture in Bosnia and Herzegovina, as well as in the Brčko District, there are no extensive studies dealing with the economic aspects of cultivating these two crops on a larger number of farms. This was precisely the main motivation for creating this research.

MATERIALS AND METHODS

The research was conducted on a sample of 30 agricultural farms from different parts of the Brčko District. A semi-structured interview was used to collect information about land ownership structure, applied agrotechnical measures (crop rotation, soil cultivation, sowing, fertilization, crop protection), used machinery and fuel consumption, as well as achieved yields and selling prices. The average farm size in the sample was 71.8 hectares, with a predominance of mixed farms (crop-livestock). Based on the collected data, calculations of income and variable costs per hectare for wheat and maize were made. Income was calculated as the product of yield and purchase price in the harvest year, including subsidies per hectare, while variable costs included seeds, mineral fertilizers, plant protection products, machinery costs (fuel, services), and other direct costs. The gross margin (GM) was defined as the difference between total income and total variable costs per hectare (Kay *et al.*, 2015):

$$\text{GM} = \text{Revenue} - \text{Variable cost}$$

Data consolidation and all necessary calculations have been done in MS Excel.

It is known that yields in agriculture are prone to variability, and the prices of products on the Bosnian market are quite unstable, so an additional sensitivity analysis of these crops to their changes was conducted. It was verified how the success of the achieved GM would change with variations in prices and yields within the range of 15 – 50%.

RESULTS AND DISCUSSION

In the production of wheat and maize in the Brčko District, farmers mainly apply recommended agrotechnical measures throughout the annual production cycle. This primarily includes systematic soil cultivation, including ploughing, harrowing, or disking. Then, soil fertilization and timely sowing. As observed in the interviews conducted, a shortcoming in farmers' work is the lack of adequate soil analysis. Such an analysis would reveal the actual nutrient requirements of the soil and help improve soil fertility, thereby advancing agricultural production and agrotechnical practices. Additionally, research has shown that farmers do not practice crop rotation, and these two crops are grown in monoculture. This practice certainly affects the increased occurrence of weeds, diseases, and pests. It can also lead to a higher need for chemical treatments.

Therefore, although most agrotechnical measures are implemented to an adequate method used in this area, the lack of adequate crop rotation and soil analysis certainly could affect the quantity and quality of yields achieved.

The results of the wheat production calculation (Table 1) per hectare indicate relatively modest economic efficiency, consistent with general trends across Bosnia and Herzegovina's continental regions. The achieved yield of 5.3 tons/ha can be considered satisfactory for the agro-ecological conditions of the Brčko District, but the total income of 1,890 KM, including subsidies, shows that opportunities for a more significant economic result are limited. Variable costs of 1,251 KM/ha make up nearly two-thirds of the total income, resulting in GM of only 639 KM/ha. It is noticeable that wheat, as a crop with a lower market price and smaller yields, struggles to achieve high profitability without extremely rational input use.

Table 1. Calculations of gross margin in wheat production per ha

				(BAM/ha)
Description	Unit	Quantity	Price	Total
A) REVENUE				
Wheat	Kg	5,300	0.30	1,590.00
Subsidies	Ha	1	300	300.00
Total Revenue				1,890.00
B) VARIABLE COSTS				
Seeds	Kg	270	1.00	270.00
NPK 15:15:15	Kg	250	0.75	187.00
KAN 27%	Kg	356	0.53	188.29
Plant protection				136.00
Mechanization costs				390.00
Other expenses				80.00
Variable costs				1,251.29
GM (A-B)				638.71

The cost structure shows that mechanization (390 KM) and mineral fertilizers (a total of 375 KM) account for over 60% of total variable expenses, which is consistent with the cost profile of this crop in Bosnia and Herzegovina. On the other hand, costs for seeds (270 KM) and plant protection (136 KM) indicate standard production intensity, without significant deviations from usual practices. It is worth noting that the lack of systematic soil fertility analysis leads to non-selective use of mineral fertilizers, which increases costs and does not necessarily improve yield.

Table 2. Calculations of gross margin in maize production per ha

				(BAM/ha)
Description	Unit	Quantity	Price	Total
A) REVENUE				
Maize	kg	8.700	0.30	2,610.00
Subsidies	ha	1	300	300.00
Total Revenue				2,910.00
B) VARIABLE COSTS				
Seeds *	packing	2,5	80.00	200.00
NPK 15:15:15	kg	270	0.75	202.00
KAN 27%	kg	340	0,53	180.00
Plant protection products				110.00
Mechanization costs				407.00
Other expenses				200.00
Total variable costs				1,299.00
PVT				1,611.00

*Note: one package contains 25,000 grains

Results of the calculation for maize (Table 2) per hectare show a significantly more favorable economic picture. An achieved yield of 8.7 tons/ha, with a selling price of 0.30 KM/kg and a subsidy of 300 KM, results in a total revenue of 2,910 KM. After deducting variable costs of 1,299 KM, the producer achieves GM of 1,611 KM/ha, which is a highly positive result. The results clearly indicate that corn, as a higher-yielding crop with prices similar to those of wheat, has greater potential to generate economic profit, especially in years with favorable weather conditions.

The cost structure shows that the dominant items are machinery (407 KM) and mineral fertilizers (382 KM), which together account for about 60% of total variable costs. Costs for seeds (200 KM) and plant protection (110 KM) demonstrate a reasonable balance between price and the technological requirements of the hybrids most used in this area. It is worth noting that protection costs are lower, which may be due to favorable climatic conditions or moderate weed and disease pressure, despite the lack of adequate crop rotation when cultivating this crop. Besides, the machinery at the investigated sites is mostly over 15, some even over 25 years old, which certainly reduces their efficiency and increases resource consumption in the form of fuel and lubricants, as well as the frequency of machinery breakdowns and the need for repairs.

To assess how price and yield affect the gross margin, a sensitivity analysis was conducted.

Table 3. Sensitivity analysis of gross margin in wheat production in the Brčko District area

		In BAM						
Change in %		Yield						
		-50	-30	-15	0	15	30	50
Price	-50	-554	-395	-276	-156	-37	82	241
	-30	-395	-172	-5	162	329	496	718
	-15	-276	-5	197	400	603	806	1,076
	0	-156	162	400	639	877	1,116	1,434
	15	-37	329	603	877	1,151	1,426	1,791
	30	82	496	806	1,116	1,426	1,736	2,149
	50	241	718	1,076	1,434	1,791	2,149	2,626

The sensitivity analysis of gross margin for wheat (Table 3) shows that this crop is extremely sensitive to changes in yield and selling price. The basic scenario underestimates yield to 5,300 kg/ha, with a wheat selling price of 0.3 BAM, variable cultivation costs of 1,251.29 BAM/ha, and an achieved gross margin of 638.71 BAM/ha. It is evident that even with a 15% drop in yield and price, PVT enters the negative zone, indicating a relatively narrow economic margin for producing wheat profitably. The lowest scenario (–50% yield and –50% price) results in a loss of –554 KM/ha.

It is observed that a 30% increase in yield and price results in a visible improvement in GM, and that with an increase in either parameter within these limits, GM increases by as much as 75%, or 477 BAM. If yields and prices increase by 30%, this would enable the realization of GM of 1,736 BAM, an increase of 172% compared to the initial scenario.

Positive scenarios confirm that a combination of price and yield increases of up to +50% can raise the GM to a respectable 2,626 KM/ha, but such situations are the exception, not a realistic basis for production planning. The results clearly indicate that wheat's economic stability is relatively fragile and that, for sustainable profitability, it is crucial to improve fertilization precision and reduce mechanization costs by adopting more efficient technological solutions and purchasing newer mechanization.

The sensitivity analysis of maize production (Table 4) shows that this crop is significantly more resilient to changes in yield and selling price. It is already noticeable at the outset that maize retains the ability to achieve a positive or at least marginally sustainable GM even in negative scenarios, as can be seen from the fact that the combination of –15% price and –15% yield still yields 887 KM/ha. Only the extreme negative scenario (–50/–50) results in a loss of –347 KM/ha, which is significantly milder than for wheat.

Table 4. Sensitivity analysis of gross margin in maize production in the Brčko District area

		In BAM						
Change in %		Yield						
		-50	-30	-15	0	15	30	50
Price	-50	-347	-86	110	306	502	698	959
	-30	-86	280	554	828	1,102	1,376	1,742
	-15	110	554	887	1,220	1,552	1,885	2,329
	0	306	828	1,220	1,611	2,003	2,394	2,916
	15	502	1,102	1,552	2,003	2,453	2,903	3,503
	30	698	1,376	1,885	2,394	2,903	3,412	4,091
	50	959	1,742	2,329	2,916	3,503	4,091	4,874

The results clearly indicate that maize enters the high GM zone in the baseline scenario (1,611 KM/ha), while positive price or yield gap variations of 15–30% lead to a strong increase in GM, reaching 2,003 BAM/ha—an increase of 24%. With a simultaneous 30% increase in yield and price, the achieved GM would amount to 3,412 KM/ha, an increase of up to 112%.

CONCLUSIONS

This study offers a clear and practical overview of how agrotechnical practices and economic outcomes shape wheat and maize production on farms in the Brčko District. The results show that most farmers adhere to the main principles of crop production - timely soil preparation, fertilization, sowing, and crop protection. Yet, two shortcomings stand out: the lack of soil fertility analysis and the widespread use of monoculture. Both issues increase the risk of nutrient imbalances, greater weed and pest pressure, and ultimately more variable yields, all of which directly influence economic performance.

The economic calculations reveal a noticeable contrast between the two crops. Wheat, with an average yield of 5.3 t/ha, achieves a relatively modest gross margin of 639 BAM/ha. Mechanization and fertilizer expenses account for more than 60% of total variable costs, making wheat highly sensitive to changes in input prices and yield levels. The sensitivity analysis underscores this fragility, showing how even moderate declines in yield or price can push wheat into negative economic results.

Maize shows a considerably stronger and more stable economic position. With an average yield of 8.7 t/ha and a gross margin of 1,611 BAM/ha, maize remains profitable even with partial reductions in yield or price. Optimistic scenarios amplify economic returns, confirming that maize is better aligned with the agro-ecological conditions of the Brčko District and generally more resilient to production risks.

Taken together, the findings highlight the need for greater agrotechnical precision - especially through regular soil testing, more balanced fertilization, and the introduction of crop rotation. These improvements would increase resource efficiency and support more stable yields and higher gross margins over time.

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PRIMJENA AGROTEHNIČKIH MJERA I EKONOMSKI USPJEH U PROIZVODNJI PŠENICE I KUKURUZA NA PODRUČJU BRČKO DISTRIKTA

Sažetak

U Bosni i Hercegovini pšenica i kukuruz predstavljaju najvažnije ratarske kulture, koje zauzimaju dominantno mjesto u strukturi korištenih oraničnih površina. Stoga, u ovom radu se analizira proizvodnja pšenice i kukuruza na području Brčko Distrikta, s naglaskom na analizu primjenjenih agrotehničkih mjera i postignutih ekonomskih rezultata izraženih putem pokrića varijabilnih troškova po hektaru. Istraživanje je obuhvatilo 30 poljoprivrednih gazdinstava u Distriktu, a osnovni uslov je bio da imaju proizvodnju na više od 1,5 ha pod posmatranim kulturama. Informacije su prikupljene kroz strukturirane anketne upitnike, koji su sadržavali detaljna pitanja o primijenjenim agrotehničkim praksama, prinosima, troškovima i prihodima. Rezultati pokazuju da prosječni prinosi iznose 5,3 t/ha za pšenicu i 8,7 t/ha za kukuruz. Ekonomskom analizom utvrđeno je da je pokriće varijabilnih troškova iznosilo 639 KM/ha za pšenicu i 1.611 KM/ha za kukuruz. Bolji finansijski rezultat kukuruza djelomično je posljedica viših prinosa i stabilnije proizvodnje. S druge strane, umjerenije pokriće troškova kod pšenice ukazuje na potrebu za optimizacijom agrotehničkih mjera radi povećanja produktivnosti i ekonomske isplativosti.

Najveći udio u ukupnim troškovima imaju troškovi mehanizacije i upotreba mineralnih đubriva, dok su najznačajnije nepravilnosti u primjeni agrotehnike zabilježene upravo u segmentu đubrenja, zbog izostanka analize plodnosti tla. Stoga preporuka ovoga rada jeste sprovođenje analize tla prije đubrenja radi optimizacije troškova i izbjegavanja nepotrebne primjene hranjiva

Ključne riječi: *kukuruz, pšenica, Brčko Distrikt, agrotehničke mjere, pokriće varijabilnih troškova*