

Doi: 10.46793/MAK2026.258B

INFLUENCE OF SEEDING DATE AND TYPE OF FERTILIZER ON SPELT GRAIN YIELD

Jovana Brdar^{1*}, Svetlana Roljević Nikolić², Milan Miroslavljević³,
Jasmina Oljača¹, Snežana Đorđević⁴, Željko Dolijanović¹

¹University of Belgrade Faculty of Agriculture, Belgrade, Serbia,

²“Tamiš” Research and Development Institute, Pančevo, Serbia,

³Institute of Field and Vegetable Crops Novi Sad, Serbia,

⁴Biounik, Research and Development, Zemun, Serbia,

*Corresponding author: jovanabrdar@gmail.com

Abstract: Spelt (*Triticum spelta* L.) is an ancient wheat species that holds an important place among alternative cereals and is increasingly attractive due to its highly favourable agronomic, nutritional and medicinal characteristics. This cereal should play a leading role in organic plant-based food production. The aim of this research was to determine the influence of sowing time and fertiliser type on the yield of the spelt varieties Nirvana and Ostro. The one-year study (2023/24) was conducted at the Experimental Farm of the Research and Development Institute “Tamiš” in Pančevo, on a plot certified for organic production, using a split-plot design with four replications. Sowing time significantly affected the dynamics of phenophase occurrence and duration. The longest vegetation period during the study was achieved with sowing on 16 October (256 days), while the shortest was with sowing on 31 October (241 days). Sowing time had a notable impact on yield in both varieties: later sowing resulted in higher grain yield. This is explained by the milder winter compared to previous years and the later onset of cold periods, which allowed later-sown varieties to be better prepared. Organic fertilizers (Guanito) and microbiological fertilizers (Unimax and Slavol) influenced the number of spikelets: with top-dressing in any combination, the number of fertilized spikelets increased while unfertilized spikelets decreased. Spelt grain possesses high nutritional value and deserves much greater attention in the system of producing safe and healthy food.

Keywords: Spelt, Organic production, Sowing time, Organic and microbiological fertilizers, Yield

INTRODUCTION

Consumer perceptions that spelt wheat (*Triticum spelta* L., syn. *T. aestivum* ssp. *spelta* (L.) Thell.) has a higher nutritional value than common wheat (*Triticum aestivum* L., syn. *T. aestivum* ssp. *aestivum* (L.) Thell.) have resulted in a rapid increase in demand for spelt wheat products globally (Technavio, 2024). This alternative small grain is also of interest because it can be grown at higher altitudes; in Serbia, it can be cultivated at over 800 m above sea level (Vojnov et al., 2020).

Spelt grain has consistently been shown to have higher protein and lipid content, but lower insoluble and total fibre content than common wheat (Escarnot et al., 2012). A recent extensive retail survey of UK and German wheat flour brands showed that, at the consumer

level, spelt wheat flour has significantly higher antioxidant capacity and concentrations of phenolic compounds and certain minerals (e.g. Cu, Fe, Zn) than common wheat flour (Wang et al., 2020). The same study also reported significant interactions between production protocols (organic vs conventional) and wheat species (common vs spelt wheat) with respect to antioxidant and mineral composition.

Grain yield and seed quality in wheat depends on environmental conditions, genetic factors, crop management practices, and the interaction between these factors (Bansod et al., 2013). Among the measures applied to achieve high yields, the time of sowing is particularly important. Sowing time affects the dynamics of ontogenesis, especially the duration of the vegetative phenophases and the phases of grain formation and filling. The optimal time for sowing winter wheat in the climatic conditions of our country varies and depends on the agro-ecological conditions of individual regions, the timing and quality of basic and pre-sowing tillage, and the characteristics of the variety (Dolijanović et al., 2014). When the seeding date is delayed, the periods from tillering to shooting and from tillering to earing are shortened compared with wheat sown at the optimal date (Podolska and Wyzinska, 2011). Late planting results in poor tillering; when the tillering period is reduced (Joshi et al., 1992), plants produce fewer tillers per plant, with lower grain weight and fewer grains per plant (El-Gizawy, 2009). An adequate sowing date positively affects grain yield (Podolska and Wyzinska, 2011; Silva et al., 2014), enabling the plants to better adjust their physiology and phenology to environmental conditions (Ribeiro et al., 2009). A delayed sowing date causes an increase in total protein levels in the kernel, as well as increases in the contents of albumins and globulins, α/β -gliadins, γ -gliadins, total gliadins, HMW-GS, LMW-GS, and total glutenins, but does not change the HMW-GS to LMW-GS ratio (Szymańska and Podolska, 2016).

Organic agriculture, as a system of sustainable agricultural production, today represents an indispensable component of a sustainable agricultural system (Šeremešić et al., 2017) in developing value chains for products with high nutritional value and ecological characteristics. Correct production technology in line with organic principles involves the cultivation of intercrops, the use of green manure, compost activators, and especially the application of biofertilizers with highly effective strains of microorganisms that ensure the supply of plants with biogenic elements (Šeremešić et al., 2018).

Maintaining and increasing soil fertility is a key prerequisite for organic production, and the application of fertilization, processing, and crop rotation aims to ensure the sustainability of the entire farm. Plant nutrition in organic production is based on utilizing natural soil fertility, maintained through proper crop rotation, the cultivation of legumes, and the application of compost or manure. Where the farm does not have sufficient nutrients, the use of organic and mineral fertilizers prescribed by law is permitted. Balanced plant nutrition, which influences plant composition, directly affects plant resistance to pathogens and harmful entomofauna. Some research indicates a reduction in damage caused by insects and diseases in organic production (Manojlović, 2022). Microorganisms increase the uptake and accumulation of N, P, Fe, Mn, Zn, and Cu in plant tissues, as well as the levels of antioxidants and photosynthetic pigments (Dragičević et al., 2021). According to Dolijanović et al. (2012), the highest grain yields of spelt wheat were obtained with a combination of organic and microbial fertilizers (5.84 t ha^{-1}), lower yields with a microbiological fertilizer (4.34 t ha^{-1}), while the treatment without fertilizer resulted in the

lowest yield (3.86 t ha⁻¹). However, the complexity of local agroecological conditions indicates that there is no single solution to exploit the genetic potential of the variety (Ugrenović et al., 2018). The aim of this research is to examine the influence of sowing date and fertilizer type on the grain yield of two varieties of spelt in an organic production system.

MATERIAL AND METHODS

The experiment was conducted on the experimental plot of the Research and Development Institute "Tamiš" in Pančevo, on a certified plot for organic production. Only approved inputs for plant nutrition (organic and microbiological fertilizers) were used in accordance with organic production standards. Two spelt varieties were included in the study: Nirvana and Ostro, both suitable for organic production. The experiment took place in 2023/24 as part of a multi-field crop rotation, with triticale (*Triticosecale*) as the main preceding crop. The role of the pre-crop was to suppress weed species through dense sowing and to leave the soil weed-free. Before sowing, the seeds were treated with Fusarix (a biofungicide used to control phytopathogenic fungi, particularly *Fusarium* sp.) and Slavol to ensure seed protection. In the organic cultivation system, preference is given to sowing chaff seed, as the chaff provides additional protection against soil pathogens.

During basic soil tillage in the autumn, the organic fertilizer Guanito was applied at 600 kg ha⁻¹ and Unimax at 150 kg ha⁻¹. Pre-sowing soil preparation was carried out with a seeder. Guanito is a pelletised organic fertilizer with a high phosphorus content; its primary raw material is organic matter from Guano birds from Peru, supplemented by other organic substances such as chicken manure. It is characterized by an extremely high phosphorus content in organic form, a low salt level, and a slightly acidic pH value (pH = 6.5). Its composition is: 6% N, 15% P₂O₅, 3% K₂O, 27.5% C, C/N ratio 4.6, and 3.5% humic acids. Unimax is a microbiological preparation containing bacteria (*Bacillus megatherium* 3×10⁷ cfu cm⁻³, *Azotobacter chroococcum* sp. 1×10⁷ cfu cm⁻³) applied to natural zeolite. These bacteria have high enzyme activity, are gradually released from the granules during vegetation, and break down organic nitrogen and phosphorus compounds into forms accessible to plants.

Sowing was carried out in two periods: the first on 16 October 2023, and the second 15 days later, on 31 October 2023. The seed rate was 280 kg ha⁻¹. After sowing, rolling was performed to ensure better contact between the seeds and the soil and to optimize soil moisture utilization.

The layout of the plots in the experiment was arranged according to the split-plot design with four replications. The area of the sample plot was 510 m², the calculation plot was 18 m², and the elementary plot was 4.5 m². After establishing the sample, an isolation belt ("buffer zone") was sown, where a coarse grain was also used. The purpose of the isolation belt was to separate the test plots from neighbouring plots and the local road, as a preventive measure recommended in organic production.

In spring, during the budding phase, the crop was foliar-fed with the microbiological fertilizer Slavol at a rate of 7 l ha⁻¹. Slavol is an innovative biopreparation based on microorganisms. The preparation is in a liquid state and contains bacteria (*Bacillus*

megatherium, *Bacillus licheniformis*, *Bacillus subtilis*, *Azotobacter chroococcum*, *Azotobacter vinelandii*, *Derxia* sp.), natural vitamins, enzymes, and growth stimulators. Bacteria on the root system assists in plant nutrition by converting organic and difficult-to-dissolve compounds into accessible forms and delivering them directly to the plant root system.

Harvesting with a grain harvester (Winterstieger) was carried out at the end of June, and the grain yield was measured and adjusted to 14% moisture. The results obtained were statistically analyzed using three-factor analysis of variance (ANOVA) with the F-test, and differences between mean values were determined by the LSD test.

Meteorological Conditions During the Investigation Period

Weather conditions significantly affect the morphological and economic properties of spelt (Glamočlija et al., 2013; Janković et al., 2015). High air temperatures in October, with little precipitation, marked the beginning of the 2023/2024 production year (Table 1). The first half of November was characterized by constant heavy rain, while the temperature of the sowing layer of the soil was favorable for the development of certain winter crops sown at optimal dates. In December, thermal conditions allowed relatively good development and preparation of winter crops for the period of winter dormancy. January was warmer and drier than the ten-year average, and February was also marked by a lack of precipitation and warmer weather. In April, slightly less precipitation was recorded compared to the average for this month. At the beginning of May, favorable temperature conditions in most production areas, combined with average precipitation, enabled intensified growth and the start of wheat heading. In mid-June, high temperatures accelerated the ripening stages of spelt, while rainfall slightly prolonged the harvest.

Table 1. Meteorological conditions in the area of Pančevo

Year/months		X	XI	XII	I	II	III	IV	V	VI	Average/Sum
2023/2024	°C	16.6	8.3	5.2	2.4	9.8	11.1	15.9	18.9	24.8	12.5
	mm	20.4	108.3	29.9	38.8	5.3	24.0	30.8	102.1	94.4	533.0
2010-2019	°C	13.7	9.3	3.7	2.2	4.1	9.1	14.5	18.2	22.6	10.8
	mm	48.9	39.3	40.6	56.7	50.9	54.7	48.4	110.0	85.3	591.5

RESULTS AND DISCUSSION

Table 2 presents the grain yield results for two spelt varieties (Nirvana and Ostro) according to sowing date and type of fertilizer. Statistical analysis of the data showed highly significant differences in grain yield depending on all examined factors and their interactions. Higher grain yields at the study site were achieved with the Ostro variety, particularly in treatments with individual fertilizer applications.

Based on the data in Table 2, it can be noted that later sowing times resulted in better grain yields for both tested varieties. In the Nirvana variety, sowing time showed a statistically very significant difference, while in the Ostro variety, there was a statistically significant difference in grain yield.

Table 2. The influence of different types of fertilizers, their combinations and the date of sowing on the grain yield of Nirvana and Ostro varieties (t ha⁻¹)

Varieties	Nirvana			Ostro			
	Fertiliser/date of sowing	first	second	Average	first	second	Average
Control		7.38	8.48	7.93 ^{ab}	8.48	8.66	8.57 ^{ab}
Unimax		7.56	8.56	8.06 ^a	7.93	8.10	8.02 ^b
Guanito		6.78	8.67	7.73 ^b	8.17	8.17	8.17 ^b
Guanito + Unimax		6.96	8.36	7.66 ^b	7.08	8.02	7.55 ^c
Guanito+Unimax+Slavol		6.76	7.75	7.26 ^c	8.47	9.29	8.88 ^a
Average		7.09	8.36	7.73	8.03	8.45	8.24
P value		A	B	C	AB	AC	BC ABC
		**	**	*	*	*	ns ns

A-varieties; B-sowing date; C-type of fertilizer; Different letters indicate significant differences; * $p < 0.05$; ** $p < 0.01$; ns-no statistical differences.

Differences in spelt grain yield depending on the applied fertilizers were statistically highly significant. The combined application of organic and microbiological fertilizers produced good results, especially in the second sowing period for both varieties. The lowest grain yields for the Nirvana variety were recorded with the combination of all tested fertilizers, whereas the opposite trend was observed for the Ostro variety. It can be concluded that the Ostro variety is characterized by more efficient use of soil nutrients. Optimal grain yields in the control variants indicate the good potential fertility of the soil on which the spelt crop is grown, as well as the effect of the selected crop rotation and other measures.

According to Janković et al. (2013), the highest yields of spelt wheat can be achieved on chernozem soil, but due to its lower requirements, it is often produced under restricted agroecological conditions. Earlier studies indicated that sowing date plays a significant role in achieving higher yields, as late sowing shortens the growing period and results in poor crop preparation for the winter (Protić et al., 2008). In a three-year trial, Ugrenović (2013) found the highest spelt wheat yield with the first sowing date (5 October), while delayed sowing reduced yield by 4.0 to 19.7%. Lacko-Bartošová et al. (2010) also found high variation in spelt wheat yield depending on climatic conditions. Spelt wheat has lower requirements in terms of agroecological conditions, but is also less tolerant to drought (Ugrenović, 2013). In dry seasons, yields are significantly lower, primarily due to a lack of nutrient availability under low fertilization.

Pospišil et al. (2014) examined the influence of sowing rate on the yield of spelt, varieties Ostro and Nirvana. They found that the Ostro variety produced significantly higher 1000-grain weight and yield compared to the Nirvana variety, which is consistent with the results of our research. In the aforementioned trial, the grain yield of the Nirvana variety ranged from 4.92 to 6.92 t ha⁻¹ in a two-year study in Croatia, while the yield of the Ostro variety was always over 7 t ha⁻¹. Dolijanović et al. (2014), observing average two-year yields, noted a statistically significant difference depending on feeding (3.80:3.94 t ha⁻¹). Application of only microbiological fertilizers increased yields compared to the control but not compared to other variants in which organic fertilizers or breeders were included.

CONCLUSION

The yield of winter spelt grain was found to depend on the sowing date, fertilizer, and especially on the different cultivars. In both tested varieties, a higher grain yield was obtained in the second sowing period. The yields of grain harvested from spelt grown after triticale were highest in the full treatments with fertilizer (a combination of organic and microbiological fertilizers). The lowest grain yields in both sowing dates and both varieties were obtained with the Guanito+Unimax combination. The yield of the winter spelt grain cultivar Ostro was higher than that of cultivar Nirvana in all variants.

ACKNOWLEDGMENT

The paper was produced under the "Agreement on the implementation and financing of scientific research in 2025 between the Ministry of Science, Technological Development and Innovation of the Republic of Serbia and the Faculty of Agriculture, University of Belgrade, contract registration number: 451-03-137/2025-03/200116".

REFERENCES

- Bansod, B.S., Pandey, O.P., Rajesh, N.L. Dhattewal, S. (2013). Optimisation of agricultural input applications to enhance the crop quality and yield quantity in paddy under precision farming. *Quality Assurance and Safety of Crops & Foods*, 5, 179-185.
- Dolijanović, Ž., Oljača, S., Kovačević, D., Djordjević, S., Roljević, S. (2014). Spelt grain yield depends on growing localities. *Zbornik naučnih radova Instituta PKB Agroekonomik*, 20 (1-4), 65-73.
- Dolijanović, Ž., Oljača, S., Kovačević, D., Jug, I., Stipešević, B., Poštić, D. (2012). Utjecaj agrotehničkih mjera na prinose zrna pira (*Triticum aestivum* spp. *spelta*) u organskom sustavu uzgoja (The effect of cultivation practices on spelt wheat grain yield in organic farming). *Proceedings 47th Croatian and 7th International Symposium on Agriculture, Opatija, Croatia*, 51, 1.55.
- Dragicevic, V., Dolijanović, Ž., Janosevic, B., Brankov, M., Stoilkovic, M., Dodevska, M., Simić, M. (2021). Enhanced nutritional quality of sweet maize kernel in response to cover crops and bio-fertilizer. *Agronomy*, 11(5), 981.
- El-Gizawy, N. (2009). Effect of planting date and fertilizer application on yield of wheat under no till system. *World Journal of Agricultural Sciences*, 5, 777-783.
- Escarnot, E., Jacquemin, J.M., Agneessens, R., Paquot, M. (2012). Comparative study of the content and profiles of macronutrients in spelt and wheat, a review. *Biotechnology Agronomy, Society and Environment*, 16, 243-256.
- Glamočlija, Đ., Janković, S., Popović, V., Ugrenović, V., Zekić, N., Ikanović, J., Rakić, S. (2013). Morphological and production characteristics of spelt wheat on the chernozem and degraded soil. *Book of Proceedings IV International Scientific Symposium Agrosym*, 364-369.
- Jankovic, S., Ikanovic, J., Popovic, V., Rakić, S., Pavlovic, S., Ugrenovic, V. ... *et al.* (2015). Morphological and productive traits of spelt wheat - *Triticum spelta* L. *Agriculture & Forestry*, 61(2), 173-182. doi: 10.17707/AgricultForest.61.2.15
- Janković, S., Ikanović, J., Popović, V., Rakić, S., Kuzevski, J. (2013). Agro-ecological conditions and morphoproductive properties of spelt wheat. *Biotechnology in Animal Husbandry*, 29(3), 547-554.
- Joshi, A.K., Rai, B., Sing, M.P. (1992). Technology for late sowing wheat in eastern Uttar Pradesh. *Indian Farming*, 42, 15.
- Lacko-Bartošová, M., Korczyk-Szabó, J., Raťný, R. (2010). *Triticum Spelta* - a specialty grain for ecological farming systems. *Research Journal of Agricultural Science*, 42(1), 143-147.

- Manojlović, M.S. (2022). Organska poljoprivreda: Unapređenje proizvodnje primenom đubriva, biopreparata i bioloških mera. Monograph. Univerzitet u Novom Sadu Poljoprivredni fakultet.
- Podolska, G., Wyzińska, M. (2011). Reakcja nowych odmian pszenicy ozimej na gęstość i termin siewu. *Polish Journal of Agronomics*, 6, 45-53.
- Protić, R., Marković, M., Protić, N. (2008). Winter wheat grain yield in a dry year in Serbia. *Poljoprivredne aktuelnosti*, 7(1-2), 5-19.
- Ribeiro, T.L. Cunha, P.G.R., Pires, J.L.F., Pasinato, A. (2009). Phenological responses of Brazilian wheat cultivars to vernalization and photoperiod. *Pesquisa Agropecuária Brasileira*, 44, 1383-1390.
- Šeremešić, S., Manojlović, M., Milošev, D., Latković, D., Vasiljević, M., Sikora, V., Vojnov, B. (2018). Uticaj folijarne primene različitih vrsta đubriva na prinos ozime pšenice. *Letopis naučnih radova*, 42(1), 1-8.
- Šeremešić, S., Vojnov, B., Manojlović, M., Milošev, D., Ugrenović, V., Filipović, V., Babec, B. (2017). Organska poljoprivreda u službi biodiverziteta i zdravlja. *Letopis naučnih radova*, 41(2), 51-60.
- Silva, R.R., Benin, G., Almeida, J.L., Batista Fonseca, I.C. Zucareli, C. (2014). Grain yield and baking quality of wheat under different sowing dates. *Acta Scientiarum. Agronomy*, 36, 201-210.
- Szymańska, M.M., Podolska, G. (2016). The effects of sowing date and seeding rate on spelt and common wheat protein composition and characteristics. *Quality Assurance and Safety of Crops & Foods*, 8(2), 289-300. doi: 10.3920/QAS2014.0574 289 1.
- Technavio (2024). Global Spelt Market 2024-2028. Available online: www.technavio.com/report/spelt-market-industry-analysis (accessed on 18 December 2025).
- Ugrenović, V. (2013). The effect of planting date and crop density on the ontogenesis, yield and grain quality of spelt wheat. Doctoral dissertation. University of Belgrade, Faculty of Agriculture.
- Ugrenović, V., Bodroža Solarov, M., Pezo, L., Đisalov, J., Popović, V., Marić, B., Filipović, V. (2018). Analysis of spelt variability (*Triticum spelta* L.) grown in different conditions of Serbia by organic conditions. *Genetika*, 50(2), 635-646.
- Vojnov, B., Manojlović, M., Dolijanović, Ž., Latković, D., Simić, M., Milošev, D., Babec, B., Šeremešić, S. (2020). Grain yield, yield components and protein content of organic spelt wheat (*Triticum spelta* L.) grown in different agro-ecological conditions of northern Serbia. *Ratarstvo i povrtarstvo*, 57(1), 1-7.
- Wang, J., Hasanalieva, G., Wood, L., Anagnostopoulos, C., Ampadogiannis, G., Bempelou, E., Kioussi, M., Markellou, E., Iversen, P.O., Seal, C., *et al.* (2020). Effect of wheat species (*Triticum aestivum* vs *T. spelta*), farming system (organic vs conventional) and flour type (wholegrain vs white) on composition of wheat flour Results of a retail survey in the UK and Germany 3. Pesticide residue content. *Food Chem. X* 2020, 7, 100089.