



Effects of Organic Fertilizers at Different Doses on the Growth Parameters of Wheat (*Triticum aestivum*)

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Abstract: This study was conducted to determine the effects of different organic liquid fertilizers and their combinations with chemical fertilizers on the development of wheat plants (*Triticum aestivum* L.). The experiment was carried out under greenhouse conditions in pots, where five different organic formulations (B, D, E, F, T) were applied at four dosage levels (1%, 3%, 5%, and 10%). Combinations involving 3% doses of these formulations with NPK fertilizer were also evaluated. Plant height (cm) and dry biomass (g/plant) were considered the primary metrics, and the applications were compared with both a negative control (no fertilizer) and a positive control (NPK-only). The results showed that the effect of organic liquid fertilizers on wheat development varied depending on the composition and dose. Especially the formulations based on hazelnut vinegar (F) and poultry manure vinegar (T) applied at 1% and 3% concentrations, as well as their combinations with NPK, produced the most favorable results in terms of plant development and biomass production. In contrast, the B and D formulations at 5% and 10% concentrations had phytotoxic effects that negatively impacted plant growth. Statistical analysis revealed significant differences among the fertilizer types in terms of plant height and dry matter values ($p < 0.05$). Notably, the D fertilizer resulted in significantly lower growth values, while the T and F fertilizers yielded statistically superior outcomes. The findings indicate that the effects of organic fertilizers are strongly influenced by both their composition and application rate. Identifying the optimal dosage is crucial for maximizing yield while minimizing the risk of phytotoxicity.

Keywords: *Triticum aestivum*, Soil science, Plant nutrition, Organic liquid fertilizer, Dose Optimization, Sustainable Agriculture.

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1. Introduction

Today, the increasing population and the pressure of intensive agricultural production have made it imperative to preserve soil fertility and adopt sustainable farming practices. Although chemical fertilizers widely used in conventional agriculture support plant development in the short term, they can cause soil degradation, a decline in microbial diversity, and environmental pollution in the long run (Chen, 2006; Savci, 2012). These problems have made environmentally friendly and sustainable alternatives, particularly organic fertilizers, more attractive. Organic fertilizers are products derived from natural sources such as animal waste, plant extracts, and microbial

products. They are applied to the soil to supply plant nutrients in organic forms. In addition to providing nutrients, these products stimulate microbial activity in the soil, contribute to humus formation, and improve the physical, chemical, and biological properties of the soil (Gopinath et al., 2008; Diacono & Montemurro, 2010). Especially when applied in liquid form, organic fertilizers can be absorbed more quickly by plants, giving them an advantage over chemical fertilizers (Canali et al., 2010).

In this context, this study aims to investigate the effects of five different organic formulations (B, D, E, F, T) on the development of wheat plants (*Triticum aestivum* L.) in a pot experiment conducted under greenhouse conditions. The effects of these formulations, applied at varying dosage levels (1%, 3%, 5%,



and 10%), on plant height and dry matter production were evaluated. The results were compared with both chemical fertilizer and unfertilized control groups. The findings emphasize that the effectiveness of organic fertilizers varies depending on their content and application dose, highlighting the importance of dose optimization in the use of organic fertilizers.

2. Materials and Methods

2.1. MATERIALS

The study utilized five different types of organic fertilizers: B (a blend of plant extracts), D (a mix of animal and plant-derived materials), E (a commercial liquid organic fertilizer - Evomax), F (a pyrolygneous product obtained from hazelnut shells), T (a pyrolygneous product obtained from poultry manure). The wheat variety used in the study was Pehlivan bread wheat (*Triticum aestivum* L.).

2.2. Greenhouse Trial Setup and Implementation

The research was conducted in the tissue culture research greenhouses of Firat University to evaluate the effects of different organic fertilizers and their doses on the growth of wheat plants. Some of the physical and chemical properties of the soil used in the experiment are presented in Table 1. The wheat plants were grown in pots containing 2.5 kg of soil. For optimal wheat growth, NPK fertilization was applied as follows: 100 mg/kg nitrogen (as $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$), 100 mg/kg phosphorus (as KH_2PO_4). This application was referred to as "fertilizer" in the experimental design. Applications involving only chemical fertilizer or chemical fertilizer combined with organic fertilizers were considered positive controls, while treatments with no fertilizer were considered negative controls. The effects of organic liquid fertilizers (B, D, E, F, T), either alone or in combination with chemical fertilizer, on wheat growth were investigated.

During the trial setup, chemical fertilizers were mixed into the soil before sowing in the relevant treatment groups. For all other treatments, stock solutions of each organic fertilizer at 1%, 3%, 5%, and 10% concentrations were prepared. Before sowing, 50 ml of the appropriate solution was applied to each pot. Subsequently, 10 ml of the solution was added to irrigation water twice weekly, totaling 150 ml of fertilizer per application.

Twelve seeds were sown in each pot, later thinned to eight plants per pot after emergence. The trial was conducted with four replications. Plants were grown for 55 days under suitable greenhouse temperature and regular irrigation conditions (60–70% field capacity). After visual observations, four plants from each treatment were harvested at the soil level and dried at 60°C for 3 hours to determine dry biomass. Plant growth was visually monitored, and differences in plant height (cm) and dry biomass (g/plant) were evaluated.

2.3. Experimental Design and Fertilizer Application Groups

In this experiment, each organic fertilizer was applied at four different doses (1%, 3%, 5%, and 10%) to the pots. The applied liquid organic fertilizers are coded and described below:

B and D: These are organic/organomineral liquid fertilizers with formulations provided in Table 2.

E: A commercially available organic liquid fertilizer branded as "Evomax".

F: A liquid fertilizer obtained by pyrolysis of hazelnut shells, referred to as "hazelnut vinegar".

T: A liquid fertilizer derived from the pyrolysis of poultry manure.

Table 2. Composition of Organic Liquid Fertilizers Coded B and D

Component	B (Organic Liquid Fertilizer)	D (Organomineral Liquid Fertilizer)
1. Vinegar type	Pigeon vinegar: 150 ml	Chicken vinegar: 150 ml
2. Molasses	100 ml	50 ml
3. Leonardite	100 ml	50 ml
4. Extract of oleander	25 ml	–
5. Extract of <i>Eremurus spectabilis</i>	25 ml	25 ml
6. Extract of <i>Verbascum</i> spp.	25 ml	25 ml
7. Orange peel extract	25 ml	–
8. Lemon peel extract	25 ml	–
9. Corn extract	25 ml	–
10. Hazelnut vinegar	–	25 ml
11. Organic ethyl alcohol	–	25 ml
12. Limonene	–	25 ml
13. Mineral supplements	–	Sodium (50 mg/L), Potassium (50 mg/L)

2.4. Fertilizer Application Groups

The applications were classified into three main groups:

Negative Control: No fertilizer applied.

Positive Control: Only mineral NPK fertilizer applied.

Combined Applications: 3% doses of B, D, E, F, or T organic fertilizers combined with mineral NPK fertilizer.

Table 3. Fertilizer Application Groups and Their Content

Application Code	Description
Control	No fertilizer (negative control)
NPK	Mineral fertilizer only (positive control)
B (%1, %3, %5, %10)	Organic liquid fertilizer B
D (%1, %3, %5, %10)	Organic liquid fertilizer D
E (%1, %3, %5, %10)	Commercial organic fertilizer Evomax
F (%1, %3, %5, %10)	Hazelnut vinegar-based fertilizer
T (%1, %3, %5, %10)	Poultry vinegar-based fertilizer
NPK + %3 B	NPK + 3% B
NPK + %3 D	NPK + 3% D
NPK + %3 E	NPK + 3% E
NPK + %3 F	NPK + 3% F
NPK + %3 T	NPK + 3% T

3. Research Findings and Discussion

The effects of various organic fertilizer formulations with different compositions and properties applied at four concentrations (1%, 3%, 5%, and 10%) on the growth of wheat plants (*Triticum aest. var. aest. L.*) were evaluated based on visual parameters, plant height (cm), and dry biomass (g/plant). Observations were made individually for each treatment throughout the experiment, focusing on plant health, leaf coloration, growth rate, and morphological structure.

3.1. Effects of Fertilizer Applications on Plant Development

3.1.1. Effects of “B” Organic Liquid Fertilizer on Wheat Growth

The B organic liquid fertilizer formulation consists of animal- and plant-derived extracts, organic acids, and natural compounds (Table 2). Each component possesses unique biological and chemical properties that support plant growth. For instance: Pigeon vinegar, due to its acetic acid content, helps regulate soil pH and suppress harmful microorganisms. When applied at low doses, it has been reported to stimulate root development (Motsa et al., 2015). Molasses, a by-product of sugar beet, provides a rich source of carbon that enhances microbial activity in the soil. It also

supplies potassium and small amounts of amino acids that positively affect plant metabolism (Seneviratne et al., 2010). Leonardite is rich in humic and fulvic acids, which improve root growth and nutrient uptake, and enhance the plant's tolerance to stress (Karakurt et al., 2010). Plant extracts such as oleander, *Eremurus spectabilis*, mullein, and citrus peel (orange and lemon) are rich in phenolic compounds, flavonoids, and essential oils. Oleander and *Eremurus spectabilis* have natural antimicrobial and antifungal properties, while citrus peels, with their vitamin C and limonoid content, can strengthen plant immunity (Ahmad et al., 2012; Belitz et al., 2009). Mullein extract is known for containing natural growth-promoting hormones. Limonene, a monoterpene compound derived from citrus fruits, is recognized for its antimicrobial and insecticidal properties. Studies have also shown that limonene can have a stimulatory effect on plant physiology as a volatile organic compound (Zunino et al., 2016).

Overall, the B formulation offers both nutritional support and biological stimulation for wheat plants. The combination of pigeon vinegar, leonardite, and molasses supports soil fertility and plant metabolism, while the plant-based extracts and volatile compounds may enhance the plant's resistance to stress and disease. It is expected that the B formulation will have a positive effect, particularly in the early growth stages of wheat.

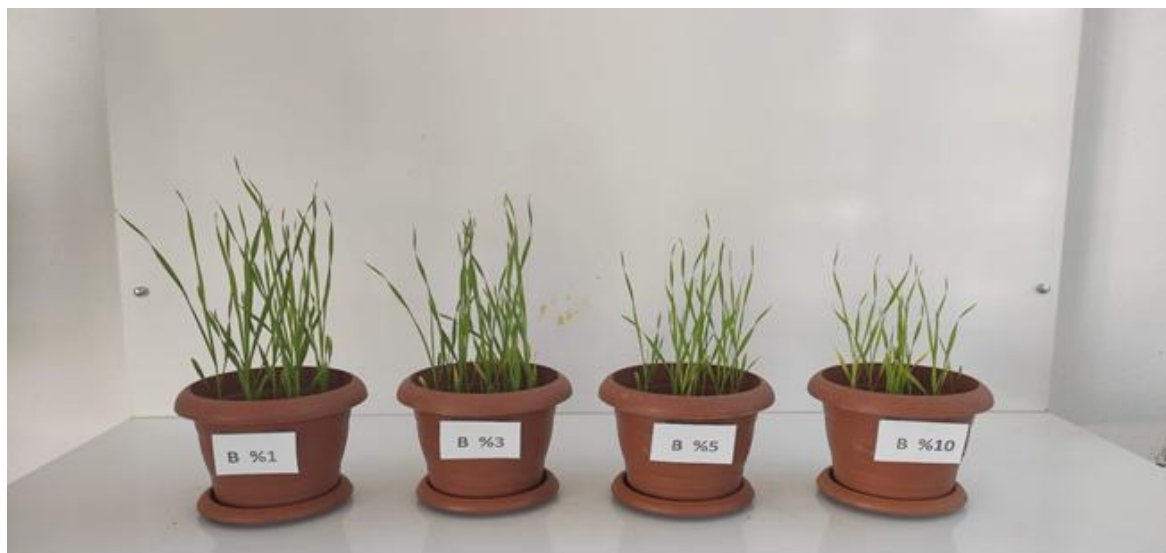


Figure 1. Visual Comparison of the Effects of "B" Fertilizer Applied at Four Different Doses on Wheat Plant Growth

Applications of the B organic liquid fertilizer at different doses revealed the following:

At 1% and 3%, the fertilizer produced positive effects on wheat plants, with notable improvements in plant growth, leaf color, and uprightness. At 5%, and especially 10%, signs of plant stress were observed. This stress is likely due to the presence of toxic components such as oleander or highly concentrated compounds like vinegar and limonene.

In general: At low doses, the B fertilizer exhibited stimulatory (growth-promoting) effects. At high doses, it showed inhibitory (growth-suppressing) effects. These observations are consistent with findings in the literature, which suggest that organic compounds often have a biostimulant effect at low doses and phytotoxic effects at high doses (Canellas et al., 2015; Bulgari et al., 2019).

3.1.2. Effects of "D" Organomineral Liquid Fertilizer on Wheat Growth

The D organomineral liquid fertilizer formulation contains nutrient supplements, carbon sources that enhance microbial activity, and plant growth-regulating extracts, all of which contribute positively to plant development. In generally; poultry vinegar, obtained through pyrolysis, is rich in organic acids (especially acetic acid). These acids improve soil microbial

structure and nutrient uptake, while also suppressing certain pathogens (Liang et al., 2021).

Macronutrients such as nitrogen and phosphorus directly stimulate plant growth. Wine pomace and by-products are rich in phenolic compounds, flavonoids, and organic acids. These materials enrich soil microbiota and boost plant stress tolerance, especially by encouraging microbial biomass production (Ma et al., 2022).

Leonardite enhances ion exchange in the soil with its humic and fulvic acids, accelerating root development and nutrient uptake (Karakurt et al., 2010). Molasses serves as an energy source for beneficial microorganisms in the soil. Hazelnut vinegar, derived from pyrolyzed hazelnut shells, contains polyphenols, tannins, and antioxidants that activate the plant's defense systems. Ethyl alcohol can improve water use efficiency and suppress harmful microorganisms (Kang et al., 2013). It also facilitates the transport of bioactive compounds in extracts. Plant extracts like *Eremurus spectabilis* and mullein, due to their flavonoids, saponins, and natural growth regulators, contribute positively to development. Mineral supplements, especially potassium, support photosynthetic efficiency and osmotic regulation. Low doses of sodium can help maintain ionic balance when potassium levels are low (Subbarao et al., 2003).

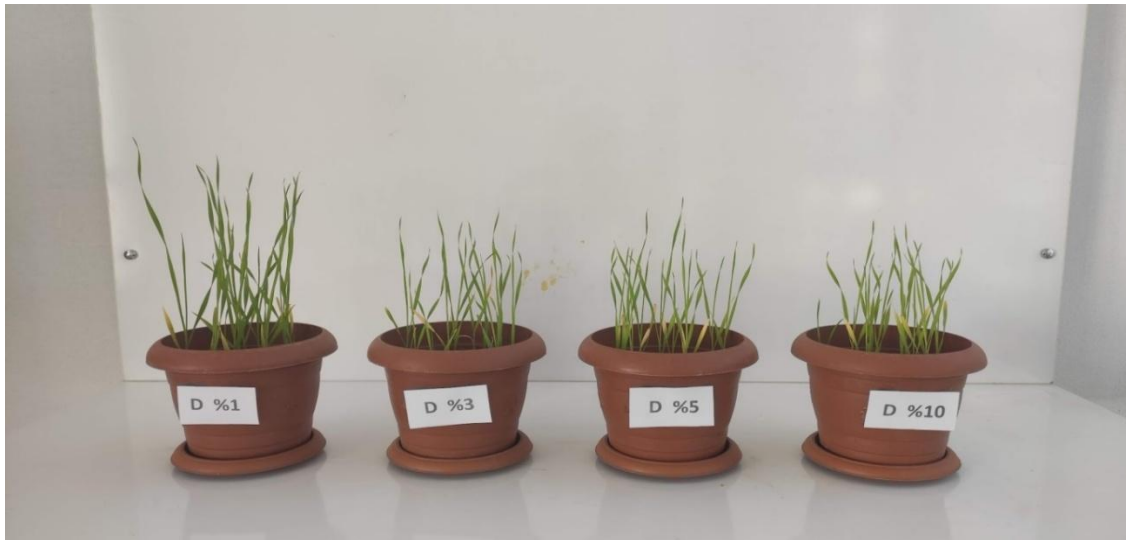


Figure 2. Visual Comparison of the Effects of "D" Fertilizer Applied at Four Different Doses on Wheat Plant Growth

The different dose applications of the D organomineral liquid fertilizer yielded the following observations: At 1% and 3%, there were positive results in terms of plant height and leaf health. This suggests that the organic materials and microbial regulators in the formulation stimulated plant growth. At 5%, growth slowed, and symptoms such as developmental inhibition and deteriorated leaf health appeared. This may be due to excessive organic acids or phenolic compounds, which caused physiological stress. At 10%, there were visible yellowing and stunted growth, indicating a strong phytotoxic effect at high doses. These results align with existing literature that emphasizes the dual nature of organic compounds: stimulatory at low doses and inhibitory at high doses. Therefore, determining the optimum application dose is critical to maximizing yield and minimizing the risk of phytotoxicity (Rouphael & Colla, 2020). Special attention must be paid to high-dose applications of formulations rich in vinegar and wine waste due to their potent biological content (Mahdavi et al., 2014; Ma et al., 2022).

3.1.3. Effects of Commercial Liquid Organic Fertilizer "Evomax" on Wheat Growth

Evomax is a commercial liquid organic fertilizer composed of plant-based ingredients. It contains 30% organic matter and 16% organic carbon, which support microbial activity in the soil and improve its physical structure. In generally; it contains 2% total nitrogen (N), which is considered a safe level for young plants. However, for crops with high nitrogen demand, additional fertilization may be necessary. The fertilizer includes 5% water-soluble potassium (K_2O), which can be beneficial for fruit setting, grain filling, and enhancing stress tolerance. With a pH range of 4–6, Evomax may help improve the availability of micronutrients in alkaline soils, thus optimizing nutrient balance. Although Evomax contains high levels of organic matter and potassium, applying it at high doses could increase the risk of phytotoxicity. Therefore, dose planning based on soil analysis is recommended before application.



Figure 3. Visual Comparison of the Effects of "Evomax" (Commercial Liquid Organic Fertilizer) Applied at Four Different Doses on Wheat Plant Growth

Visual assessments of Evomax applications at various doses showed relatively consistent plant development: 1%, 3%, and 5% doses caused no significant adverse effects. At 10%, a slight decrease in leaf number and plant height was observed. However, compared to other organic formulations, Evomax exhibited minimal toxicity even at high concentrations. This demonstrates that Evomax is safe for use at multiple dose levels. However, for optimal green biomass formation during tillering and stem elongation, its nitrogen content may be insufficient, and supplementary mineral NPK fertilizers may be required.

3.1.4. Effects of “F” (Hazelnut Vinegar) Liquid Organic Fertilizer on Wheat Growth

Hazelnut vinegars are liquid products obtained through pyrolysis or fermentation of hazelnut shells and kernels. These

vinegars contain organic acids (mainly acetic acid), alcohols (such as ethanol and butanediol derivatives), and phenolic compounds, which enhance soil health and stimulate plant growth. Studies show that hazelnut vinegars also contain volatile organic compounds and natural pesticide-like substances (e.g., hymexazol, dazomet, iprobenfos), providing protective effects against harmful organisms in biological pest control. Additionally, their typically low pH range (3–5) can: Increase micronutrient solubility in the soil. Inhibit pathogen proliferation in the root zone. However, their effectiveness in agriculture is highly dependent on dose and application method. At high concentrations, some compounds in hazelnut vinegar can exhibit phytotoxic effects. Therefore, controlled use, dilution, and crop-specific dose optimization are critical for ensuring both safety and effectiveness.



Figure 4. Visual Comparison of the Effects of “F” (Hazelnut Vinegar) Fertilizer Applied at Four Different Doses on Wheat Plant Growth

At 1% and 3%, hazelnut vinegar supported plant development effectively. At 5%, signs of leaf thinning and growth stagnation were observed. At 10%, plants appeared shorter, sparser, and weaker. These results suggest that high concentrations of pyrolysis-derived compounds in hazelnut vinegar may suppress plant growth. Hence, low-dose applications are preferable for achieving biostimulant effects without inducing toxicity.

3.1.5. Effects of “T” (Poultry Manure Vinegar) Liquid Organic Fertilizer on Wheat Growth

Poultry manure vinegar (T) is a nutrient-rich liquid organic input obtained through pyrolysis or fermentation of organic

poultry waste. With its diverse organic content and biologically active compounds, this fertilizer has the potential to act as both a soil enhancer and a biocontrol agent. However, due to its high levels of pesticide-like substances, direct and high-dose applications are not recommended. In agricultural practice especially with sensitive crops like wheat it is advised to conduct preliminary trials before implementing the product on a larger scale (Cömertpay & Aktaş, 2020).



Figure 5. Visual Comparison of the Effects of “T” (Poultry Manure Vinegar) Fertilizer Applied at Four Different Doses on Wheat Plant Growth

In generally Result fot this applications;

At 1% and 3%, poultry manure vinegar promoted healthy development. At 5%, there was a slight decline in growth. At 10%, clear developmental retardation and leaf yellowing were observed.

These outcomes suggest that high concentrations of pyrolysis-based organic compounds in the T formulation can lead to phytotoxic effects. As with other bio-based inputs, optimal dosage is essential to balance stimulatory and toxic impacts.



Figure 6. Visual Comparison of the Effects of “T” (Poultry Manure Vinegar) Fertilizer Applied at Four Different Doses on Wheat Plant Growth

In generally result fot this applications; At 1% and 3%, poultry manure vinegar promoted healthy development. At 5%, there was a slight decline in growth. At 10%, clear developmental retardation and leaf yellowing were observed. These outcomes

suggest that high concentrations of pyrolysis-based organic compounds in the T formulation can lead to phytotoxic effects. As with other bio-based inputs, optimal dosage is essential to balance stimulatory and toxic impacts.

3.1.6. Overall Assessment of All Fertilizer Doses (1%, 3%, 5%, 10%) on Wheat Development

The effect of doses on all fertilizers is shown in Figure 7 -9.



Figure 7. Visual Comparison of Wheat Growth under Control, NPK, and 5% Doses of B, D, E, F, and T Fertilizers



Figure 8. Visual Comparison of Wheat Growth under Control, NPK, and 10% Doses of B, D, E, F, and T Fertilizers



Figure 9. Visual Comparison of Wheat Growth under Control, NPK, and NPK + 3% Doses of B, D, E, F, and T Fertilizers

3.1.2.1. Evaluation of the Effects of Different Fertilizer Types and Doses on Wheat (*Triticum aest. var. aest. L.*) Plant Height

The 1% doses of F (hazelnut vinegar) and T (poultry vinegar) yielded particularly striking results in terms of vegetative growth. At this stage, no phytotoxic symptoms were observed; the plants developed in a healthy and upright manner (Figure 5). Likewise, 3% doses, especially when combined with NPK, significantly enhanced plant growth. The combinations of NPK + 3% D, E, and F resulted in maximum vegetative mass and tillering density in wheat (Figures 7 and 10). At 5%, some fertilizers—particularly B and D—caused signs of growth retardation, leaf yellowing, and thin stems. In contrast, F (5%) and T (5%) were better tolerated and showed no strong phytotoxic symptoms (Figure 7). At 10%, B and D formulations showed clear phytotoxic effects, including leaf discoloration, dwarf growth, and lack of

vitality (Figure 10). Even though F (10%) and T (10%) performed relatively better under these conditions, these doses are still not recommended for optimal yield (Figure 8). Overall, the 1% and 3% doses of B (plant extract blend), D (animal and plant-based mix), E (Evomax commercial liquid fertilizer), F (hazelnut shell pyrolysis product), and T (poultry manure pyrolysis product) — whether applied alone or with NPK — had a positive impact on plant development. These levels can be considered safe and effective as biostimulants or complementary fertilizers.

However, 5% and especially 10% doses of these fertilizers showed phytotoxic effects likely caused by organic acids or pesticide-like compounds, confirming once again that large-scale application should not proceed without prior testing (Cömertpay & Aktaş, 2020).

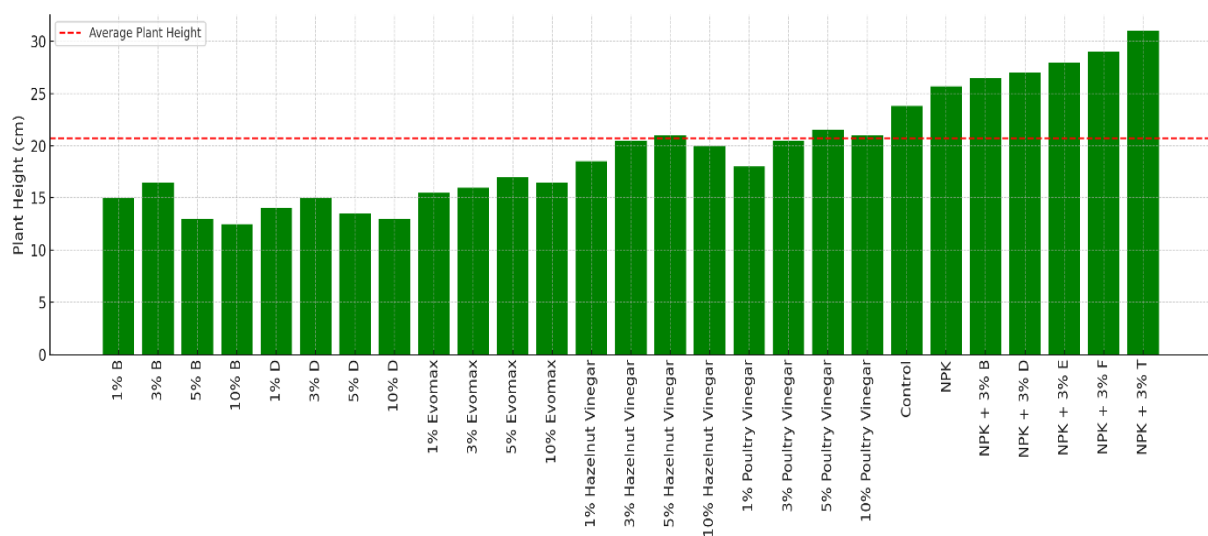


Figure 10. Effects of Different Fertilizer Types and Doses on Wheat Plant Height

In Figure 10, a red dashed line (~20.7 cm) indicates the overall average plant height across all treatments. The highest plant height, 31.0 cm, was observed in the “NPK + 3% T (poultry vinegar)” treatment. This value was significantly greater than both the control group (23.8 cm) and the NPK-only group (25.7 cm). Similarly, treatments with “NPK + 3% D”, “NPK + 3% B”, and “NPK + 3% E” also increased plant height, demonstrating a synergistic effect when organic liquid fertilizers were combined with mineral fertilizers. Hazelnut vinegar and poultry vinegar emerged as promising biostimulant alternatives for supporting plant growth. Interestingly, the control group (23.8 cm) performed better than several synthetic fertilizer applications, suggesting that excessive chemical fertilization may restrict growth, whereas

organic and NPK-based strategies enhance development. In conclusion, both the type of organic fertilizer and the application dose play a critical role in wheat growth. The data also support the idea that combining NPK with organic supplements (such as vinegar-based solutions) is an effective way to optimize plant development.

3.1.2.2. Evaluation of the Effects of Different Fertilizer Types and Doses on Wheat Dry Biomass (g/plant)

Figure 11 visualizes the effects of various organic fertilizers and their 3% NPK combinations on the dry biomass production of wheat. The red dashed line represents the average value across all treatments (~9 g/plant).

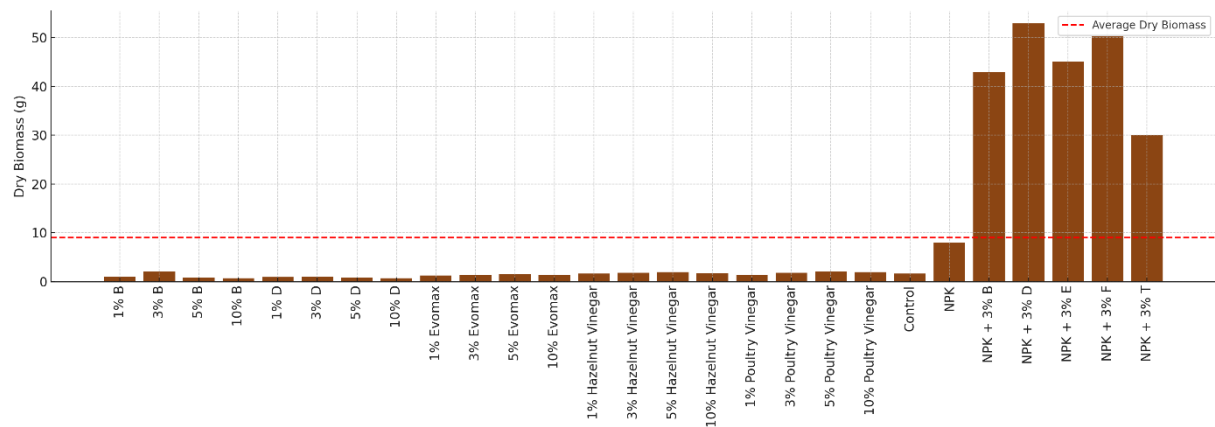


Figure 11. Effects of Different Fertilizer Types and Applications on Wheat Dry Biomass (g)

The highest dry biomass was recorded in the “NPK + 3% D” group: 52.87 g/plant. This was followed by: NPK + 3% F: 50.30 g, NPK + 3% E: 45.02 g, NPK + 3% B: 42.98 g. These results show that applying organic liquid fertilizers together with NPK creates a significant synergistic effect on plant biomass. Looking only at organic fertilizers applied alone, the 1% F (hazelnut vinegar) and 1% T (poultry vinegar) treatments stood out. Both produced significantly more dry matter than the control group (1.60 g), confirming their biostimulant potential. The stimulating effect of hazelnut vinegar is believed to stem from volatile organic compounds in its structure, which may enhance plant metabolism and promote dry matter accumulation. On the other hand, B and D formulations at 5% and 10% doses were linked to marked reductions in dry biomass, showing clear signs of phytotoxicity. These findings emphasize that high doses of organic fertilizers can inhibit plant growth and that dose optimization must be carefully determined in advance.

This study clearly demonstrates that the effects of organic fertilizers on plant development are directly dependent on composition and dosage. While low doses (1% and 3%) generally promote growth, higher concentrations (5% and 10%) tend to cause phytotoxic effects. This is likely due to compounds such as

molasses, organic acids, and phenolic compounds, which, in excessive amounts, may suppress plant metabolism (Zhou et al., 2017; Canali et al., 2010).Organic fertilizers labeled B and D, which include various plant extracts and fermented organic materials, showed stimulatory effects at low doses but caused phytotoxicity at high doses. This finding highlights the importance of evaluating not only the composition but also the application rate of organic extracts (Kocsis et al., 2020).

In contrast, the commercial organic fertilizer Evomax (E) delivered consistent results even at high doses. This may be due to its optimized formulation, ingredient stability, and low toxicity, making it a safer option for agricultural production (Diacono & Montemurro, 2010).Hazelnut vinegar (F) and poultry vinegar (T), both obtained through pyrolysis, were shown to negatively affect plant development at higher concentrations. These adverse effects are likely due to the presence of phenolic compounds and soluble toxic fractions in pyrolysis-derived materials (Pan et al., 2012).

3.1.3. Statistical Evaluation of the Effects of the Investigated Organic Fertilizers on Wheat Plant Growth

The effect of organic fertilizers on wheat plant growth is shown in Table 4.

Table 4. Statistical Evaluation of the Effects of Organic Fertilizers on Wheat Plant Height and Dry Biomass

Measurement	Fertilizer Type	N	Mean	Std. Deviation	p-Value
Plant Height (cm)	D Fertilizer	4	14.43	2.99	0.001
	B Fertilizer	4	17.43	2.36	
	Evomax	4	17.85	.90	
	Hazelnut vinegar	4	21.05	1.37	
	Chicken Vinegar	4	21.68	2.03	
Dry Biomass (g/plant)	D Fertilizer	4	.52	.13	0.001
	B Fertilizer	4	1.00	.36	
	Evomax	4	1.30	.03	
	Hazelnut vinegar	4	1.58	.42	
	Chicken Vinegar	4	1.61	.43	

Statistical analysis showed that there were significant differences in both plant height and dry biomass depending on the fertilizer type ($p < 0.05$):

1. The plant height achieved with D fertilizer was significantly lower than that achieved with Evomax, hazelnut vinegar, and poultry vinegar.
2. Similarly, the B fertilizer resulted in shorter plants compared to hazelnut and poultry vinegar.
3. The Evomax fertilizer, though better than B and D, still resulted in lower plant height than hazelnut and poultry vinegar.

In terms of dry biomass:

1. D and B fertilizers yielded significantly lower values compared to Evomax, hazelnut vinegar, and poultry vinegar.
2. Hazelnut and poultry vinegar treatments achieved the highest biomass values, confirming their superior biostimulant performance.

5. Conclusion

Fertilization is a fundamental practice in achieving the desired yield and quality in agricultural production. In Turkey, where soils typically have low organic matter content, the addition of organic materials is crucial for both environmental sustainability and soil health. This study evaluated the effects of five different organic liquid fertilizers (B, D, E, F, T) applied at four doses (1%, 3%, 5%, and 10%) on wheat development. Applications were performed both independently and in combination with chemical fertilizer (NPK). Plant height and dry matter production were used as primary indicators.

The effectiveness of organic fertilizers varied depending on composition and dosage. 1% and 3% doses supported plant growth without phytotoxic effects, often matching or outperforming NPK alone. In contrast, 5% and 10% doses, particularly of B and D, caused growth inhibition, leaf yellowing, and weak stems due to phytotoxicity. Evomax (E) exhibited a stable performance across all doses, with minimal toxic effects even at higher levels. Hazelnut (F) and poultry vinegar (T) were highly effective at low doses, but their pyrolytic derivatives caused phytotoxicity at high concentrations.

Statistical data confirmed that hazelnut and poultry vinegar fertilizers (at low doses) performed significantly better than B and D. The combination with NPK resulted in synergistic effects, significantly increasing both height and biomass. In summary, organic liquid fertilizers—when properly formulated and dosed—are valuable tools in promoting sustainable wheat production. Especially in organic-matter-deficient soils, their adoption can both increase productivity and minimize environmental impacts. However, these positive outcomes should be further validated through long-term and large-scale field trials under various soil and climate conditions.

References

1. Ahmad, N. et al. (2012). Medicinal uses and phytochemistry of Nerium oleander. *Journal of Medicinal Plants Research*.
2. Ateş, K., ve Demirkıran, A. R., İnik, O. (2019). Toprağa bazı doğal ve yapay gübre ilavelerinin çilek bitkisinin verim parametreleri üzerine olan etkileri, Bingöl Üniversitesi, Ziraat Fakültesi Toprak Bilimi ve Bitki Besleme Bölümü, Bingöl, s. 23-28.
3. Belitz, H. D., et al. (2009). *Food Chemistry*. Springer.
4. Bulgari, R., Franzoni, G., & Ferrante, A. (2019). Biostimulants application in horticultural crops under abiotic stress conditions.
5. Canellas, L. P., Olivares, F. L., Aguiar, N. O., Jones, D. L., Nebbioso, A., Mazzei, P., & Piccolo, A. (2015). Humic and fulvic acids as biostimulants in horticulture. *Scientia Horticulturae*, 196, 15–27.
6. Chen, J. H. (2006). The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. *International Workshop on Sustained Management of the Soil-Rhizosphere System for Efficient Crop Production and Fertilizer Use*, 16, 1-11.
7. Cömertpay, G., & Aktaş, H. (2020). Organik Gübrelerin Buğdayda Büyüme ve Verim Üzerine Etkileri: Uygulama Dozu ve Fitotoksiste Açısından Değerlendirme. *Tarım Bilimleri Dergisi*, 26(2), 145-152.
8. El-Mokadem, M. T., et al. (2018). Effect of corn steep liquor as biostimulant. *Egyptian Journal of Agronomy*.
9. Gopinath, K. A., et al. (2008). Biofertilizers for sustainable agriculture. *Journal of Indian Society of Soil Science*, 56(4), 450-454.
10. Gümüş İ, Şeker C (2014) Farklı Organik Gübrelerin Mısır-Buğday Ekim Nöbetinde Buğdayın Verimine Bakiye Etkileri. *Toprak Su Dergisi*, 3 (1): (1-5)
11. Kang, H. M., et al. (2013). Effects of ethanol on plant physiology under drought stress. *Plant Physiology Reports*.
12. Karakaya, S., et al. (2020). Phytochemical analysis and biological activities of Asphodelus species. *Turkish Journal of Botany*.
13. Karakurt, Y., et al. (2010). Effects of humic acid on plant growth and nutrient uptake. *Journal of Plant Nutrition*.
14. Karakurt, Y., et al. (2010). Effects of humic acid on plant growth and nutrient uptake. *Journal of Plant Nutrition*.
15. Kızıl, S., et al. (2008). Chemical composition and antimicrobial activity of Verbascum spp. *Journal of Medicinal Plants Research*.
16. Liang, Z., et al. (2021). Pyroligneous acid derived from poultry manure enhances soil quality and crop performance. *Journal of Cleaner Production*.
17. Ma, H., et al. (2022). Utilization of wine production by-products in agriculture: A review. *Waste Management*.
18. Ma, H., Gao, Y., & Wang, Z. (2022). Utilization of wine production by-products in agriculture: A review. *Waste Management*, 138, 208–219.

19. Mahdavi, A., Rahimi, A., & Tavakkoli, H. (2014). Effect of vinegar on soil microbial activity and plant growth. *Journal of Organic Agriculture*, 1(3), 45–51.
20. Motsa, N. M., et al. (2015). Effect of vinegar on seed germination and early growth. *African Journal of Agricultural Research*.
21. Özkan, G., & Bilek, S. E. (2015). Production and evaluation of pyroligneous acid from hazelnut shells. *Waste and Biomass Valorization*.
22. Pan, G., et al. (2012). Biochar application for climate change mitigation and soil improvement: A review. *Renewable and Sustainable Energy Reviews*, 16(2), 1036-1042.
23. Rouphael, Y., & Colla, G. (2020). Biostimulants in agriculture. *Frontiers in Plant Science*, 11, 40.
24. Savci, S. (2012). An agricultural pollutant: Chemical fertilizer. *International Journal of Environmental Science and Development*, 3(1), 77-80.
25. Seneviratne, G., et al. (2010). Carbon supplementation in organic agriculture: use of molasses as a microbial activator. *Organic Agriculture*.
26. Subbarao, G. V., et al. (2003). Sodium—a functional plant nutrient. *Critical Reviews in Plant Sciences*.
27. Taş, F., Özgen, İ., Aydoğmuş, E., ve Koç, İ. (2022). Farklı Organik Kaynaklardan Elde Edilen Gübrelerin Çilek Bitkisinin Bazı Verim Parametreleri İle Topraktaki Nematot Trofik Yapısına Etkileri. 2. Başkent International Conference on Multidisciplinary Studies, February 24-25, Ankara, Full Text Book, s. 374-380.
28. Zhou, Y., et al. (2017). Pyrolysis of animal manure for biochar and bio-oil production. *Waste Management*, 68, 1-10.
29. Zunino, M. P., et al. (2016). Monoterpenes and their effects on plant physiology. *Journal of Essential Oil Research*.