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ORGANIC AGRICULTURE HAS DEFECTS IN THE SCOPE OF MINERAL FERTILIZATION

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Abstract

The organic agriculture system refuses mineral fertilizers in a wide range; however, plants utilize essential plant nutrients in mineral forms. This is because the elements bonded to the structure of organic matter are not readily available for plant uptake. Thanks to the mineralization process that leads to mineral nutrients released from organic matter, the decomposition rate depends on several environmental factors. Thus, either lower or higher nutrient amounts may appear in the soil which would be far from meeting plant nutrient requirements or ecological concerns may arise. Nitrogen has a priority in the scope of environmental issues. The results gathered by the working group revealed that nitrate concentration may be even higher in organic farming systems on average. Some researchers draw attention to mineral fertilizer production's economic and environmental costs. Yet, ammonia gas sources in the livestock industry threaten the atmosphere and may be sources of organic agriculture-friendly nitrogenous fertilizer. This article was prepared to highlight that using mineral fertilizers from certain sources should be allowed in organic agriculture within certain limits and based on soil analysis.

Key words: *organic agriculture, global warming, ammonia emission, food security.*

INTRODUCTION

The organic farming system, which appears as a new concept, refers to the agricultural system before the discovery of pesticides and fertilizers. In other words, organic farming is not an innovative system but a return to pre-discovery of agro-biocides and mineral fertilizers.

The priority in the organic farming system is to establish a healthy soil-plant-environment system without harming the environment and preventing the misuse of inputs (Bello, 2008). But the yield obtained from areas where organic farming techniques are applied is generally lower than in areas where conventional farming is done (Reddy, 2010; Röös et al., 2018). Therefore, revolutionary developments are required in today's organic farming system to improve yield. Yet, in today's organic farming concept, there are strict prohibitions on mineral fertilizers containing macro elements, especially nitrogenous fertilizers. However, renewable nitrogen sources should be developed and included in the system (Röös et al., 2018). While many producers want to shift to organic farming for economic reasons, research has shown that in some cases, inputs may be even higher than in conventional production (Cacek & Langner, 1986). Although the positive effects of organic farming are often mentioned, organic farming methods also have some negative environmental effects.

These effects include reduced soil fertility due to the decrease in the soil's nutrient pool, possible increases in soil acidity (Conacher & Conacher, 1998). There is also evidence that organic farming areas are not very safe in terms of nitrate pollution, which is the biggest concern in the conventional farming system (Erol et al., 2010). Similar concerns also arise in the livestock sector.

The effects of organic farming on livestock are also unclear, and it is difficult to find data that would allow a definitive judgment on this issue (Cabaret, 2003).

Veisi et al. (2017) reported that the motivation for organic farming is environmental protection, increasing farmers' income, and reducing input costs, while social ethical rules are less important. Therefore, additional measures to alleviate economic concerns may encourage producers planning to switch to organic farming. The measures taken could also alleviate concerns that organic farming will not meet the requirement of the rapidly growing population (Jouzi et al., 2017) worldwide.

There are basically two reasons for the prohibition of the use of nitrogenous mineral fertilizers in organic farming: (1) to prevent the presence of high amount of mineral nitrogen in the soil instantly and the environmental concerns that excess mineral nitrogen will cause, and (2) the high energy input used during the production of mineral fertilizers and the environmental pollution that occurs during production. This study includes explanations that will eliminate both concerns. In summary, this study aimed to compile some of the studies existing in the literature and to reveal that allowing the controlled use of nitrogenous mineral fertilizer such as nitrate and ammonium in the organic farming system can provide both economic and environmental benefits.

Obtaining environmentally friendly nitrogenous fertilizer

It is thought that an environmentally friendly nitrogenous fertilizer production is possible based on the patented ammonia trap design (Coşkan & Atılgan, 2018). In other words, nitrogen fertilizers obtained from the ammonia trap system do not conflict with the philosophy of organic agriculture. In the ammonia trap system (Figure 1) polyethylene balls are placed in a closed barrel to obtain a high surface area. Then, 6N phosphoric acid solution is added to the barrel and the balls are continuously wetted with the acid solution under the system via a small magnetic pump. At the same time, the barn atmosphere is passed over the balls with the help of a small-scale kitchen fan. As a result, the ammonia gas, which is a base, reacts with the acid and allows the ammonium phosphate fertilizer to be obtained (Coskan & Atilgan, 2018). The appearance of the system developed by Atilgan et al. (2018) is shown in Figure 1. The protection of the utility model with the patent number TR201213292 (Anonymous, 2026) has already been expired.

Mineral fertilizers are commonly produced by the Haber-Bosch method, in which ammonia is obtained from nitrogen and hydrogen gas under high temperature and pressure. This production is responsible for 1-2% of the global greenhouse gas emissions (Lin et al., 2023). However, it is possible to obtain nitrogenous mineral fertilizers from rather less available natural sources in the environment, in limited quantities, without causing environmental pollution. One of these sources is ammonia gas released into the atmosphere in broiler barns (Coskan & Atilgan, 2012). It is possible to convert this gas into nitrogenous mineral fertilizer by capturing it with an acid that is allowed for use in organic farming, such as phosphoric acid. In this way, far from polluting the environment, the health of the personnel working in the poultry house can be protected while reducing atmospheric pollution according to the equation below (Coskan & Atilgan, 2018):

$$NH_4OH + H_3PO_4 \rightarrow NH_4H_2PO_4 + H_2O$$

The bound $NH_4H_2PO_4$ is an ammonium phosphate, which is frequently used in agricultural production as a mineral fertilizer. By obtaining this fertilizer via this process, both the contribution to global warming can be reduced and the quality of the air inside the barns can be increased.

Figure 1. Patented ammonia trap system (Atilgan et al., 2018)

The changes in ammonia concentration inside the barn after activation of the ammonia trap system are presented in Figure 2. As seen from Figure 2, the overall ammonia level in the broiler barn has reduced significantly over time.

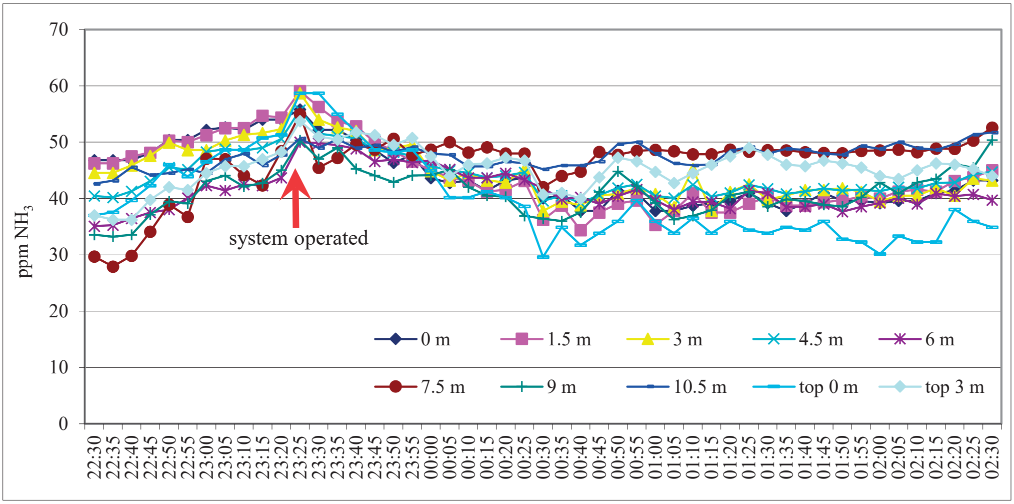

Figure 2. Ammonia reduction by ammonia trap (Atilgan et al., 2018)

Thus, obtained fertilizer can be compatible with the philosophy of organic agriculture since it uses very little energy compared to the Haber Bosch method and reduces environmental pollution. It is obvious that if this fertilizer is allowed to be used in organic agriculture within certain limits, it can be produced in animal breeding farms, and thus the profitability of these enterprises can be increased.

Although it is obtained while protecting the environment and provides multiple benefits, this fertilizer is not allowed to be used in organic agriculture. In conventional agriculture, it would not be wrong to say that mineral fertilization, which is carried out based on soil and plant analyses and is aware of all reactions that the given fertilizer will be involved in, will have a minimal negative impact on the environment and human health. Moreover, even under strict organic farming rules, the excess amount of mineral nitrogen may be abundant in the soil. Agricultural pesticides and synthetic plant growth regulators are excluded from this assessment. However, organic fertilization should look favourably on such new approaches in terms of mineral fertilizers.

Soil mineral nitrogen content in organic and conventional farming systems

The philosophy of organic farming emphasizes that the use of nitrogenous mineral fertilizers can cause an increase in mineral nitrogen forms in the soil. In order to test this view, soil samples were collected from 7 conventionally and 12 organically farmed areas. Nitrate, nitrite, and ammonium contents of these samples were determined. In addition, biological activity parameters and organic matter, and microbial biomass carbon analyses were also performed on the samples. However, only mineral nitrogen amounts were used in this study (Erol et al., 2010).

The soil mineral nitrogen contents in conventional and organic farming systems are presented in Figure 3 as mean values.

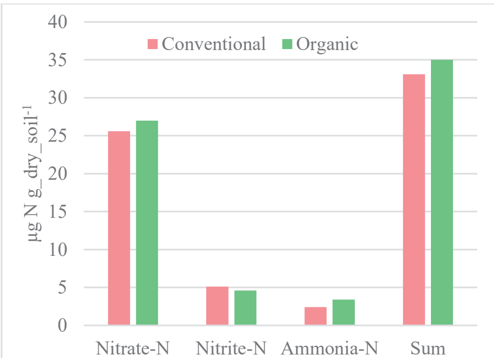

Figure 3. Nitrogen contents of conventional and organic farms (Erol et al., 2010)

As seen in Figure 3, while nitrite content was found to be slightly lower in conventional agriculture, areas where organic farming was performed had higher levels in other forms and total mineral nitrogen. This result is not consistent with studies such as Bello (2008), Reddy (2010), Röös (2018), and others not cited here, which report that organic farming is less risky for the environment. This situation is most likely related to the inability to control at what speed and over what time the organic fertilizers used will mineralize. It is possible that organic matter that remained from previous years and could not be mineralized due to unsuitable conditions can also be mineralized rapidly under suitable conditions. The fact that more organic matter was determined in areas where organic farming is carried out (Erol et al., 2010) supports this idea. Therefore, it is difficult to manage nitrogen that may come from organic matter, and this has been demonstrated by this study. Based on the results of this study, it can be said that by slightly reducing the dose of organic fertilizer, the use of slow-release nitrogenous fertilizers produced with environmentally friendly methods, in case of a possible deficiency, can prevent instant high nitrate formation in the soil, and further research on this subject is required.

Plants-available N forms and plant nitrogen uptake

While plants can take up nitrogen as low molecular weight compounds such as nitrate, ammonium, and amino acids, complex organic compounds are not directly available to the plants (Paungfoo-Lonhienne et al., 2008). Kacar (2012) reported that plants receive 95% of the nitrogen they need in the form of nitrate and/or ammonium, while the remaining 5% can be obtained in the form of various organic compounds, including urea. In general, it is seen from these studies that it is not possible to provide adequate plant nutrition with organic fertilizers alone without the mineralization process. When viewed from this perspective, the fate of nitrogen provided by organic fertilization depends on the mineralization process, which is hard to predict its rate. Therefore, it is quite difficult to control the amount of mineral nitrogen originating from organic matter in the soil. In conclusion, if plants receive a significant portion of the nitrogen they need in mineral form and if it is difficult to control mineral nitrogen in the soil in organic farming (Erol et al., 2010), the controlled use of mineral nitrogen should be discussed before it is rejected outright.

Mineralization rates of organic fertilizers

The rate of mineralization of organic matter depends on many factors, and organic matter from different sources mineralizes at different timescales (Geisseler et al., 2021). The behaviour of some organic matter sources in the soil may be more attractive than others. For instance, if chicken manure is applied together with other fertilizers, an increase in the rate of mineralization may occur (Ribeiro et al., 2010). Cassity-Duffey et al. (2020) reported that nitrogen mineralization occurs over a wide range depending on the type of organic matter used. The researchers added new information to the literature by showing that commercial organic fertilizers are rapidly mineralized immediately after application and that organic fertilizers, which have been considered slow release until now, may not be the case. More interestingly, repeated long-term organic matter applications further increase the mineralization rate. Going one step further, it has been shown that repeated organic matter applications increase the mineralization rate even more (Zhang et al., 2012).

From the information in the literature, it has been observed that the mineralization rate and, therefore, the amount of mineral nitrogen in the soil are affected by many factors. Temperature and humidity have been shown to have strong effects on the release of nitrate and ammonium from organic matter (Cannavo et al., 2022). Therefore, generalizing on mineral nutrient release will not always yield precise results. It has been observed that giving nitrogen in organic form does not instantly reduce the presence of mineral nitrogen in the soil and may even increase it. Considering this information, it is open to debate whether organic nitrogen should be given instead of mineral nitrogen to protect the environment.

CONCLUSIONS

The reaction against mineral fertilization is due to a simple illusion. Because plants use nutrients in mineral form. The elements in the organic structure of organic fertilizers incorporated into the soil are not usable by plants in a wide range. When farm manure, harvest residues or green manure are applied, the plant nutrients they contain are converted into forms that can be used by plants through a process called mineralization (Gök et al., 1998, 1999). The rate of mineralization depends on many environmental factors and can cause the presence of elements in the soil that are sometimes insufficient that threating plant nutrition and sometimes excessive threating the environment. This situation is an indication that the amount of mineral nitrogen in the soil cannot be controlled by organic fertilization. On the other hand, the rule that the elements needed by plants should be present in the soil at the time they are needed can be provided to a limited extent by organic fertilizer applications. Another important issue is that organic matter should be mixed into the soil, therefore, it shows that dressing fertilization can be done to a limited extent, especially in plant cultivation where the soil surface is completely covered. In other words, it can be said that the entire organic matter application should be made before planting the seeds. Organic farming advocates claim that the organic matter given at the beginning gradually provides the nutrient elements in parallel with the plant's needs. However, it is also thought that this may not be exactly the case (Cassity-Duffey et al., 2020). Zhang et al. (2012) reported that repeated organic matter applications further increased mineralization. This may be the factor responsible for the high nitrate abundance of organic farming sites' soils, as Erol et al. (2010) reported. It should be noted that long-term mineral N applications accelerate the mineralization of the soil's permanent humus and may threaten soil health in this respect. General information has revealed the negative effects of mineral nitrogen fertilizers on the environment. However, this situation is not related to whether mineral fertilizers are used, but to the dosage. Therefore, it is thought that the negative effects of well-adjusted mineral fertilizers on the environment may be the same or even less than organic fertilizers. In addition, organic fertilization accelerates the formation of nitrate in the soil via the nitrification process (Zhang et al., 2012).

Organic farmers also face challenges such as pest and weed control when farming in areas previously farmed using conventional methods (Conacher and Conacher, 1998). In this study, only the situation in terms of mineral substances was evaluated. If reliable, environmentally friendly chemical solution proposals for pest and weed control emerge, it should be evaluated whether allowing the use of these substrates can be a tool to meet the needs of the increasing population.

As a result, (1) plants can mainly uptake nutrients in mineral forms, (2) more nitrate may accumulate in organic farming areas and this can threaten the environment, (3) mineral nitrogen fertilizer can be obtained with environmentally friendly methods, (4) allowing the use of mineral nitrogen in organic farming, even if limited, can eliminate concerns about yield loss. The main idea that is intended to be conveyed in this study is that if the controlled use of mineral fertilizers is allowed in organic agriculture, the decrease in yield experienced in organic agriculture can be prevented while protecting the environment.

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