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Evaluation of the Possibilities of Using Green Manure as Based Fertilizer

Yeşil Gübrelemenin Taban Gübresi Olarak Kullanım Olanaklarının Değerlendirilmesi

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EVALUATION OF THE POSSIBILITIES OF USING GREEN MANURE AS BASED FERTILIZER

ABSTRACT

This study investigated the effect of using green manure plants as an alternative to chemical fertilization (Control) used as a base fertilizer on peppers growth and early yield values. In chemical base fertilizer application, 25 kg (15-15-15) compound fertilizer was applied per decare. The seeds of the broad bean (*Vicia faba* L.cv. Gölyaka) plant, which is used as a green manure plant, were sown and mixed into the soil during the whole florescence period. According to the results, the highest organic matter content in the soil was obtained with green manure application. In contrast, the N, P and K contents increased significantly ($P<0.05$) with chemical fertilization. Among the plant growth parameters, the highest plant height (48.6 cm) was obtained from green manure application. In contrast, the highest stem diameter (8.3 mm), number of fruits (38) and yield (326.5 g/plant) values were obtained from chemical fertilizer application. As a result, green manuring increases the amount of organic matter in the soil and will have positive effects in the long term. However, it has been determined that the use of chemical fertilizers positively affects development and productivity in the short term.

Keywords: Pepper, Broad Bean, Organic Fertilization, Yield.

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YEŞİL GÜBRELEMENİN TABAN GÜBRESİ OLARAK KULLANIM OLANAKLARININ DEĞERLENDİRİLMESİ

ÖZ

Bu çalışmada, taban gübresi olarak kullanılan kimyasal gübrelemeye (Kontrol) alternatif olarak yeşil gübre bitkisi kullanımının biberin büyüme ve erkenci verim değerlerine etkisi araştırılmıştır. Kimyasal taban gübresi uygulamasında dekara 25 kg (15-15-15) kompoze gübre uygulaması yapılmıştır. Yeşil gübre bitkisi olarak kullanılan bakla (*Vicia faba* L.cv. Gölyaka) bitkisinin tohumları ekilerek tam çiçeklenme dönemlerinde toprağa karıştırılmıştır. Sonuçlara göre toprakta en yüksek organik madde içeriği yeşil gübre uygulamasında elde edilirken, kimyasal gübreleme ile N, P ve K içeriği önemli ($P<0.05$) oranda artmıştır. Bitki büyüme parametrelerinden en yüksek bitki boyu (48.6 cm) yeşil gübre uygulamasından elde edilirken, en yüksek gövde çapı (8.3 mm), meyve sayısı (38) ve verim (326.5 g/bitki) değerleri kimyasal gübre uygulamasından elde edilmiştir. Sonuç olarak ye-

şil gübreleme topraktaki organik madde miktarını arttırarak olması uzun vadede olumlu etkileri olacaktır. Ancak, kimyasal gübre kullanımının kısa vadede gelişme ve verimi olumlu olarak etkilediği belirlenmiştir.

Anahtar Kelimeler: Biber, Bakla, Organik Gübreleme, Verim.

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1. INTRODUCTION

Substantial challenges have emerged in addressing food demand due to the increase in global population. To tackle this issue, a widely shared consensus among all stakeholders emphasizes the importance of augmenting the yield per unit area. Although the desired yield increase seems to be achieved by using chemical pesticides and fertilizers, the current system supports monoculture and increase in input use. These practices have encountered critical environmental problems such as deterioration of the soil's physical structure and nutrient balance, salinization and barrenness. In addition, excessive use of chemical pesticides and fertilizers have affect human healty adversely (Uzun, 2002; Demir and Gül, 2004; Duyar, 2007; Alagöz, 2017;Özer, 2017).

Increase organic matter content of the soil is one of the effective method to improve soil structure and it leads to enhance both microorganism activities and diversity within the soil. Additionally, preventing monoculture and elevating the organic matter content in the soil are effective strategies to augment the quantity and diversity of living organism in rootzone. For instance, it is widely recognized that soil bacteria play a crucial role in facilitating nutrient uptake by plants and engaging in biological control against soil-borne pests. (Antoun, 2003; Hubbel and Kidde, 2003; Altın and Bora, 2005; Duyar, 2007; Alagöz et al., 2020). In rhizosphere bacteria play a crucial role in geochemical nutrient cycling, influencing nutrient availability for both plants and the soil microbial community. Some organisms in the rhizosphere, such as *Rhizobium* and related genera, fix nitrogen through specialized structures, while others, like *Azospirillum* and *Acetobacter*, establish associative relationships for nitrogen fixation. Additionally, bacterial ammonifiers and nitrifiers convert organic nitrogen compounds into plant-accessible inorganic forms ($NH4^+$ and NO_3^-). Furthermore, rhizosphere bacteria contribute to phosphorus availability by enhancing the solubility of insoluble minerals through the production of organic acids or phosphatases, affecting both native and applied phosphorus (Mohammadi et al., 2011).

Microbial communities such as bacteria, fungi play vital roles in ecosystem services such as nutrient cycling, pathogen suppression, soil aggregate stabilization,

and xenobiotic degradation. The response of soil microbial biomass, activity, and community structure to agricultural management practices has been demonstrated (Biederbeck et al., 2005). Green manure applications are among the common agricultural practices to increase soil organic matter, microorganism biomass, and diversity (Gardiano et al., 2014; Alagöz et al., 2020). Green manures retrieve nutrients from the soil, hinder nutrient leaching, and gradually release the absorbed nutrients locked in during decomposition (He et al., 2020). Introducing green manures into the soil enhances soil organic matter, thereby enhancing soil structure and fertility, facilitating improved plant growth (Froseth et al., 2014).

Additionally, in a study by Gardiano et al. (2014), the effects of 6 winter species and 13 summer species of plants evaluated as green manure on the population of *Rotylenchulus reniformis,* a species of parasitic nematode of plants, in naturally infested soil. They reported that all winter species and 8 summer species of green manure reduced the population of *R. reniformis* after cultivation in infested soil compared to the control. It may indicate the robust positive correlation between the modification of soil microbial communities and the suppression of soil-borne pathogens (Ma et al., 2015). implies that green manure enhances soil nutrition and enriches beneficial microbes with bio-control capabilities (LeBlanck, 2022). In another study by Kim et al. (2023), spinach green manure application as a pre-plant soil treatment improved soil nutrition and pepper growth, fruit yield, and suppressed weed population. It is indicated that green manure also improves plant growth and yield of plants cultivated post-treatment of green manure. However, the effectiveness of green manuring may vary significantly depending on the type of green manure employed (Dong et al., 2021).

This study aimed to determine the effects of green manuring and chemical fertilization on plant growth parameters of sweet pepper (Capsicum annuum L. cv. 'Karizma').

2. MATERIAL AND METHOD

2.1. Experimental Site and Plant Matertials

The study was carried out in an open field located in Ondokuz Mayıs University Faculty of Agriculture Research and Implementation area (41° 37′ 24.71″ N, 36° 21′ 11.02″ E and 137 m altitude) between March 1 and July 15, 2023. Broad bean (*Vicia faba* L.) plants of the Gölyaka variety were used for green manuring and sweet pepper seedlings (*Capsicum annuum* L. cv. 'Karizma') were used as plant material for post-treatment cultivation.

2.2. Experimental Design and Treatments

Two different applications were planned in two different cultivation areas (raised beds; 1x1.5 m) in the study. In green manuring application, broad been seeds were planted (27 kg da^{-1}) in the raised beds, with 25 cm between the rows and 13 cm above the row on March 1, 2023. Then broad bean plants were mixed into the soil as a basal fertilization when the plants reached full bloom period (April 30, 2023). In the second application, 25 kg da^{-1} of chemical fertilizer (15:15:15, N:P:K) was applied to the raised bed as a control five days before planting of pepper seedlings. Drip irrigation and black PE mulch was applied to both application areas and pepper seedlings were planted on May 15, 2023 (45x45cm). Cultural procedures have been carried out since planting and no additional fertilization has been applied. The soil properties of the trial area are given in Table 1 before and after applying basal fertilizers. Soil analyses were carried out according the methods specified in Kacar and İnal (2008).

Stem diameter (mm), plant height (cm), and the number of leaves were measured at 25-day intervals after planting (Figures 1, 2 and 3). The yield (g/plant) and number of fruits obtained from the first harvest to the last harvest date were also calculated and given in Figures 4 and 5.

2.3. Statistical Analysis

The research used a split plot design divided into randomized blocks with three replications and nine observation plants in each replication. SPSS 15.0 statistical analysis program was used to evaluate the data obtained as a result of the research. Differences between the obtained averages were determined by t-test analysis.

3. RESULTS AND DISCUSSION

The physical and chemical properties of the initial and post-treatment soil samples taken from the area where the study was conducted are provided in Table 1. The soil's organic matter was 2.3% at the initial stage, which increased by 41% (3.25%) after applying green manure. In chemical fertilizer application, the amount of organic matter decreased, which was determined to be 1.74% (Table 1). On the other hand, N, P and K contents of soil increased with applying chemical fertilizers at the end of the study (Table 1).

Table 1. Some physical and chemical properties of soil

	pH	E.C. (dS m^{-1})	Organic matter (%)	N (%)	P (ppm)	K mg/100g
Beginning	8.0 a*	0.25 c	2.3 b	0.10 b	11.4 c	0.42 c
Based Fertilizers						
Control	7.37 b	0.53 b	1.74 c	0.19 a*	275 a*	1.25 a*
Green Manure	7.34 b	0.81 a*	3.25 a*	0.13 b	182 b	1.02 b

*: P≤0.05

Similar to our study, studies conducted using broad bean plants (planted seed; 25x13 cm) and green manure also report that the organic matter content of the soil can be increased up to 100% (Özer, 2012; Alagöz et al. 2020). In our study, it was observed that the increase in the amount of organic matter in green manure application was higher than in the control. However, the increase in plant nutrients (N, P and K) was limited and may arisen from the mineralization process occurring in the soil since the mineralization of organic matter is much slower than chemical fertilizers (Özer, 2012; Durmuş and Kızılkaya, 2018). Coşkun (2021) reports that green manure applications in cotton cultivation significantly increase soil Zn, Ec., lime, organic matter, phosphorus and potassium content. We observed that plant nutritional elements in chemical fertilization and green manuring increased significantly compared to the initial values (Table 1). Although there is a significant increase in plant nutrients with green fertilization, it is limited compared to chemical fertilization. Bellitürk et al. (2009) determined a significant negative relationship between soil organic matter amounts and mineralization capacities. The fact that the mineralization of organic matter is slower than chemical fertilizers limits the rate of nutrient uptake by plants (Alagöz et al., 2020). Although this may seem like a disadvantage in the short term, in the long term, it contributes to the productivity of slow and steady-growing plants by increasing their green period (Özer, 2012). In our study, it can be said that green manure applications can compete with chemical fertilizers in plant growth and leaf formation rates. However, while there was a linear increase in trunk diameter in a particular plane when applying green manure, a parabolic increase was observed in applying chemical fertilizer (Figure 1).

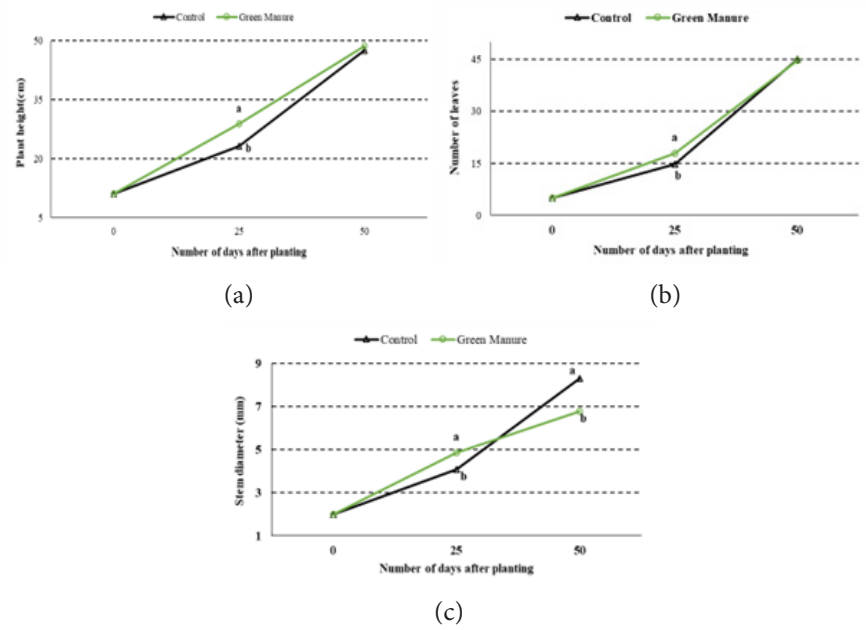
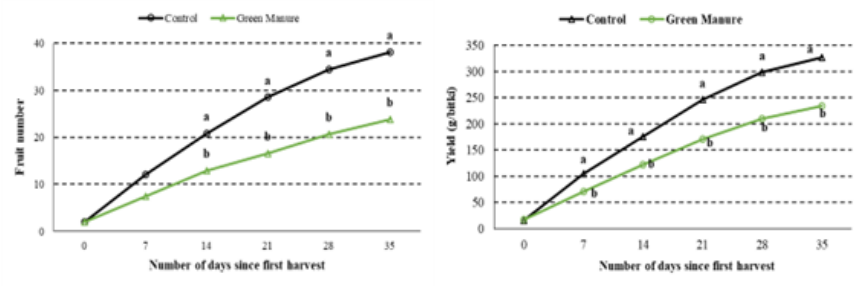


Figure 1. *Effect of different base fertilizer (control and green manuring) applications on pepper plant height (a) (cm), the number of pepper leaves (b) and stem diameter (mm) (c) in pepper*

Özer (2012) reported that organic fertilizer applications and shading in tomato cultivation significantly slowed the plant growth rate and increased the green period. In this way, they achieved significant productivity increases in tomato cultivation. When we examined our study, significant effects of base fertilizer applications on plant height, stem diameter, number of fruits and yield values were determined ($P \leq 0.05$). It was determined that the highest stem diameter (8.3 mm), number of fruits (38.1) and early yield (326.5 g/plant) values were obtained from the application of chemical fertilizer as base fertilizer (Figure 1). In contrast, the highest plant height (48.6 cm) values were obtained from green manure application (Figure 1). Although green manure application was initially prominent in the number of leaves, no statistical differences were detected.



(a) (b)

Figure 2. *Effect of different base fertilizer (control and green manuring) applications on the increase in the cumulative fruit number (a) and yield (g/plant) (b) (g/plant) of pepper*

Unlike our study, it was determined that using green manure plants (broad beans) in broccoli cultivation significantly increased the yield compared to the control. However, this study applied additional fertilization (2.5 kg/da) after planting green manure plant seeds. Similarly, the amount of soil organic matter in the study increased significantly (Yılmaz, 2013). In the study where they examined the effects of different applications (mixing them into the soil and as mulch) of different green manure plants (wheat, barley, vetch, clover and canola) on yield in tomato cultivation, it was determined that the application of live mulch significantly increased the yield compared to mixing them into the soil. The control application obtained the highest efficiency, similar to our study (Kaya, 2011). It is reported that using organic or inorganic mulch increases soil water retention capacity and significantly affects yield by increasing plant stomatal conductivity (Özer, 2017). In another study, Duyar (2007) determined the effects of using different green manure plants (soybeans, corn, forage cowpeas) under greenhouse cultivation on the cultivation of lettuce and tomatoes grown after green manure plants. The highest yield in lettuce was obtained from corn + chicken manure application, and the highest yield in tomato was obtained from soybean application. Unlike our study, it was determined that early yield increased by green manure application. Additionally, chicken manure was used with green manure; however, no additional fertilizer was applied in our study. It has been determined that using different green manure plants (cowpeas, beans) in organic strawberry cultivation (covered and open) significantly increases the yield. According to the results, the highest yield in all areas was determined from cowpea + farm manure application.

Additionally, it has been determined that green manuring is the most economical method (Saygı, 2014). In all studies, adding a source of organic fertilizer in addition to green manure plants was taken as a basis. This is mainly because while organic substances are decomposed by microorganisms in the soil, micro-

organisms need the mineral nitrogen available (Durmuş and Kızılkaya, 2018). In our study, as in the study of Özer (2012), there was a decrease in the soil due to the nitrogen need of the microorganism. This situation has caused decreases in productivity in green manuring.

4. CONCLUSION

As a result, it has been determined that applying green manure as a base fertilizer positively affects pepper cultivation by increasing the soil's organic matter. However, it has been determined that chemical fertilizer is a better base fertilization application for early yield and growth rate. It is thought that using additional nitrogen sources to increase the success of green manure applications will increase both the chance of success and competition. The application of broad bean as green manure in the conventional cultivation system can increase the amount of microbial diversity and quantity by increasing the amount of organic matter in our country's soil. In this way, soil-borne diseases and pests will be suppressed, positively affecting productivity and quality.

Conflict of Interest

The aurhors declare that there is no conflict of interest.

Ethics

This study does not require ethics committee approval.

Author Contribution Rates

Design of Study: BI(%30), AÇT(%30), AA(%10), HÖ(%30)

Data Acquisition: BI(%30), AÇT(%30), AA(%10), HÖ(%30)

Data Analysis: BI(%20), AÇT(%20), AA(%20), HÖ(%40)

Writing Up: BI(%20), AÇT(%20), AA(%10), HÖ(%50)

Submission and Revision: BI(%10), AÇT(%70), AA(%10), HÖ(%10)

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