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Application of Chemical and Organic Fertilizers and Possible Effects in the Greenhouses of Mediterranean Region

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A number of survey studies was conducted in 56 villages of Adana, Mersin and Antalya provinces between 2005-2007 with the aim of determining the amounts of chemical and organic fertilizers applied and in order to check their possible effects both on environmental pollution and human health in the Mediterranean region where 83 % of Turkey's greenhouse production is performed. In order to determine the number of farms to be surveyed, Simple random sampling method was used. The number of farms to be surveyed was determined as 223 with a confidence limit of 95 % and a margin of error of 5 %. The relations between the variables were examined with a correlation analysis. The results obtained have demonstrated that 33 % of the farms apply $N + P_2O_5 + K_2O$ more than 50 kg da^{-1}. This fertilizer amount is approximately 7 folds of Turkey's average. It has been seen that producers are not aware of the possible effects of the excessive use of mineral fertilizers and it has been identified that farms which use organic fertilizers, apply less amounts of mineral fertilizers. It has been concluded that agricultural pesticide and fertilizer dealers in the region have a great influence on producers and these people whose commercial aims are of primary importance, make the producers apply fertilizers without considering its necessity. Therefore, it is determined that 76 % of the producers apply fertilizers to their soils without any soil or plant analysis. According to correlation analysis, increasing education level of producer increased the number of producer that applies organic matter while decreased the number of farmers who use higher dose of fertilizer. It has seen that producers, who have knowledge of organic fertilizers, apply more organic fertilizers than the other producers in their greenhouses. Moreover, a negative relationship has been identified between education level and the level of chemical fertilizer application. The organic fertilizer users have mostly preferred the farmyard manure.

Key Words: Chemical and organic fertilizers, Greenhouse effects, Mediterranean region.

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INTRODUCTION

It is now a requirement to increase the production per unit area since the world's agricultural fields have come to their limits, rural population continuously decreases, world population increases and-parallel to this increase- famine and malnutrition problems arise in underdeveloped and developing countries. Moreover application of fertilizers have been gained great importance as well as the elements such as irrigation, mechanization, high quality seeds, insecticide applications andtraining of the farmers in all countries where agriculture is practiced[1].

In the agricultural production, the primary inputs which cause environmental pollution and have important impacts on human health are fertilizers, pesticides and other chemicals[2]. Fertilizer is one of the most important inputs of the agricultural production and insufficient application of it causes great losses in yield and quality. However, over-use of fertilizers causes ground water pollution particularly with washing of nitrogen and phosphoric fertilizers and air pollution with the nitrous oxide (N_2O) emission[3]. Moreover, in case an over-use of nitrogen fertilizers, the amount of nitrate on leaves reaches to a level threatening human health particularly in terms of the vegetables whose leaves are eatable[4].

Efficient use of nitrogen fertilizer requires well understanding of nitrogen dynamics in the soil. Due to many loss pathways, applied nitrogen was not effectively used by plants. Denitrification-one of the major nitrogen losses process-results in economical and environmental impacts[5]. Therefore, application of nitrogen fertilizers with organic materials triggers denitrification[6].

Nitrogen fertilizer is applied extensively in greenhouses with the aim of increasing yield. A limited part of the applied chemical fertilizer is used by plants; the rest of it spreads over rivers, drinking water and environment and threatens the health of plants and animals. Furthermore, considering environmental pollution caused by fertilizer production facilities, efficient-use of mineral fertilizer becomes more important. Mostly, nitrate and ammonium contents of waste water of fertilizer production facilities are considerably higher than permitted values[7]. Moreover, the nitrogen fertilizers applied to the agricultural areas at high doses can be transformed into nitrate *via* nitrification by the microorganisms in the soil and as the nitrate is negatively charged it may lead to the existence of an excessive amount of nitrogen in the ground water by washing in the soil.

In Turkey, 83 % (197068 decares) of greenhouse production is performed in the areas subject to this study[8]. Table-1 demonstrates the amounts of greenhouse areas in these cities and in Turkey. Other important regions are Aegean and Black See regions. Similarly the mineral fertilizers, chemical

TABLE-1
GREENHOUSE AREAS ACCORDING TO THE PROVINCES DETERMINED[8] IN 2004-2005

City	Glass greenhouses area (decare)	Plastic greenhouses area (decare)	Total area (decare)
Adana	3	208	211
Antalya	54685	81919	136604
Mersin	5200	55053	60253
Sum	59888	137180	197068
Turkey	67227	171043	238270

pesticides are applied in high amounts in the regions where greenhouse production is intensive. While the cities of Adiyaman, Gaziantep, Mardin and Sanliurfa-which are included in GAP (Southeastern Anatolia Project) Region-use *ca.* 3 % of the Turkey's total pesticide amount, whereas only Antalya and Mersin use[9] *ca.* 30 %.

Mediterranean is chosen as the study area since a great part of Turkey's greenhouses exist in this region. The aim is to determine the levels of organic and chemical fertilizers applied in greenhouse production in the region and to present these fertilizers' possible adverse effects on the environment in the long-term.

EXPERIMENTAL

A great part of the data used in the study is composed of the primary data collected by the survey method from the farms which perform intensive greenhouse production in the region. The research was conducted in 18 towns and 56 villages affiliated to these towns of Adana, Antalya and Mersin Provinces. The survey data covers 2005-2007 production periods.

To determine the farms to be examined in the study, the data obtained from the records of Provincial Agriculture Directorates, Fertilizer Dealers and West Mediterranean Agricultural Research Institute about greenhouses were used. In the scope of this data, 56 villages affiliated to provinces and towns of the region-where intensive greenhouse production takes place were chosen. Agricultural farms having greenhouse activities constituted the main part of this research. While choosing the farms to be surveyed, simple random sampling method was used[10,11].

$$n = \frac{N * \sigma^2}{(N-1) * D^2 + \sigma^2}$$

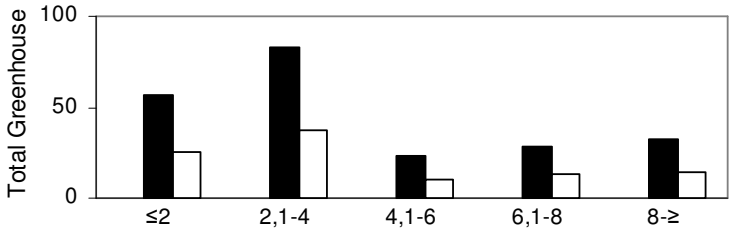
where; n = sample size; N = Number of farms in the population;
σ^2 = population variance.

$D^2 = (d/t)^2$, "d" expresses deviation at a particular rate (5 %) from average, "t" expresses t table value (1.96) which is equivalent to 95 % confidential limit. The number of farms to be surveyed was determined as 223 with a confidence limit of 95 % and a margin of error of 5 %, according to the result of calculations done with the formula above.

Correlation analysis: The parameters obtained in the study are expressed with numbers, such as a numerical value is assigned to each stage of the education level andthe relations between the values are analyzed statistically in SAS packet program by using CORR expression[12].

Findings

223 Greenhouses examined in the region were divided into 5 groups according to their size. When the distribution of the farms according to their land size is examined, it is seen that the number of greenhouse farms with a land area of 2.1-4 decares is the highest, with a rate of 37 %. It is identified that 63 % of the farms consisted of family farms with an area of < 4 da (Fig. 1).



Total Greenhouse	57	83	23	28	32
Greenhouse %	25	37	10	13	14

Fig. 1. Distribution of greenhouse farm according to land sizes

The farm which grow only tomatoes in the region compose 57 % of all farms whereas, 79 % of the farms grow other products along with tomatoes. The producers pointed out that they give priority to tomato growing as tomato has more economic advantages and its marketing is easier than the others (Fig. 2). According to the results obtained from the survey study, it is determined that application amount of chemical fertilizers is higher, particularly in the farms which grow tomatoes and that in the 33 % of these farms, apart from organic fertilizers, more than 50 kg da^{-1} ($N + P_2O_5 + K_2O$) chemical fertilizers are applied in every production period in order to make much profit (Fig. 3).

Due to the tomato production is widespread, the tomato producing farmers are focused. Considering fertilizer application doses of tomato producers, 33 % of farms applied more than 50 kg pure nutrient ($N + P_2O_5$

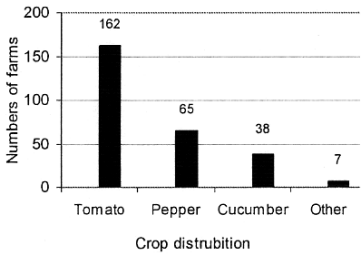


Fig. 2. Distribution of the productions grown in the farms*

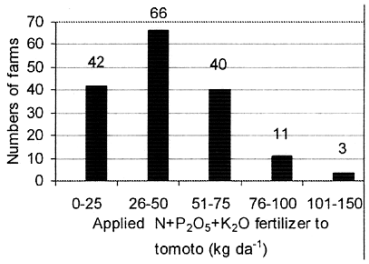


Fig. 3. Amounts of $N + P_2O_5 + K_2O$ applied to tomato plant

*Due to the some farms used two or more different organic fertilizer sources, the sum of the values on the bar higher than 223 farms

$+ K_2O$) per decare whereas 74 % applied > 25 kg per decare. The mean fertilizer application dose of Turkey[7] is 78 kg, while world mean fertilizer application dose is 101 kg pure $N + P_2O_5 + K_2O$ per hectare[13]. That values 3 and 7 times higher from Turkey and World mean application doses.

Chemical fertilizers are applied intensively in greenhouses especially in winter months. Thus water resources, particularly water wells may be hazardously polluted and vegetable production amount and product quality may be adversely affected[14]. The producers in the region noted that they meet the nutrition requirement of their plants partly from organic fertilizers and application of organic fertilizers increases the soil fertility and ameliorates the physical, chemical and biological features of the soil.

It is observed that chemical fertilizers applied without any soil analysis have differences in terms of fertilizer types used in the surveys conducted. It is determined that the producers do not have sufficient knowledge about the harms of overuse of chemical and organic fertilizers. As it is seen in Figs. 3-5, the amount of the chemical fertilizer applied changes according to the type of plant.

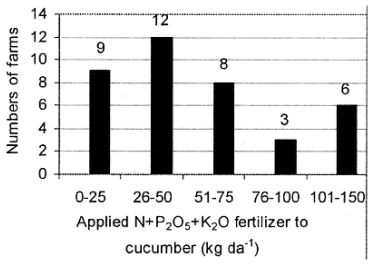


Fig. 4. Amounts of $N + P_2O_5 + K_2O$ applied to cucumber plant

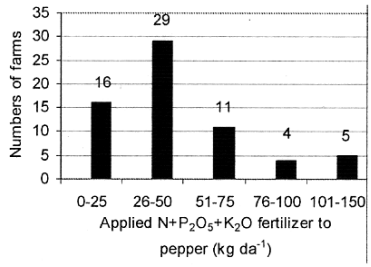


Fig. 5. Amounts of $N + P_2O_5 + K_2O$ applied to pepper plant

At present day, the amount of fertilizers produced in the world is not sufficient to meet the nutrient yielded with agricultural products obtained globally. Therefore, there is generally an upward trend in consumption of fertilizers in the world. However, while developed countries' share is decreasing in this upward trend, the share of developing countries is increasing naturally. While in 1980, 67 % of the world chemical fertilizer consumption was consumed by developed countries and 33 % by developing countries; today 37 % of world's total fertilizer consumption is consumed by developed countries and 63 % of it is consumed by developing countries. Among the developing countries, Asian countries consume 48 % of the total fertilizers production[15].

It is determined that the farms in the survey area used excessive fertilizers due to their false thoughts such as that 'the more amounts of fertilizers applied the more products would be obtained' or 'the amounts of fertilizers applied in farms of the neighborhood can be taken as reference'. As a result of the repeated application of excessive fertilizers, the soil becomes saltier. With the washing of these salty soils, ground water becomes saltier; and as this water is used as irrigation water, salinization of soil becomes faster. It is determined that none of the greenhouses have any kind of drainage. Kaplan *et al.*[14] determined that the amounts of irrigation water which is not used by the plants flows into the depths of the ground due to gravity and mix into ground water or well water within the farm concerned. Well water is presented to both human and animal use particularly in the places where greenhouses are intense and there is no drinking water transmission line available. The well water which becomes saltier loses its drinkability and healthiness features as a result of washing by a variety of ions, particularly nitrate. In some big provinces where well water is used, the nitrate concentration (NO_3^-) in water may be ascended over 45 ppm which is the acute limit value determined by World Health Organization. It is noted that the concentration of (NO_3^-) which was 16-20 mg L^{-1} in a borehole in Bursa plain increased to 110-150 mg L^{-1} in the seasons of fertilizer application[14].

A proportion of nitrogen applied for plant nutrition is used by plants and the rest of nitrogen leaching to ground water, rivers, seas depends on soil and climate conditions, or converted to gaseous nitrogen forms as N_2, N_2O, NO with denitrification by microorganisms in the soil. Moreover, another part of these gases reach to the stratosphere layer in the atmosphere. Gases of N_2O and NO which reach to the stratosphere cause ozone layer depletion. The speed of transformation of nitrate, which is applied to soil, into these compounds of gases and the type of the gases are under the influence of some factors in the soil[16-18].

The organic food materials applied provide both micro and macro nutrient to the plant. It also ameliorates the soil structure due to its nature of 'organic

material'. Using of excessive amounts of chemical fertilizers without considering plant nutrition disorder symptoms causes economic losses and ecologic impacts. Some farmers apply high amounts of chemical (synthetic) fertilizers even though they apply organic fertilizers.

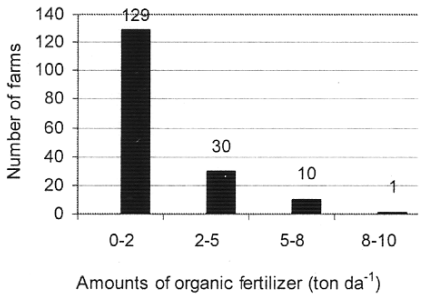


Fig. 6. Amounts of organic fertilizers applied in the farms

The answers of 'why do they use organic fertilizers' are presented in Fig. 7. Most of the farmers (26 %) expressed that they use organic fertilizer to increase the yield whereas 23 % to plant nutrition, 18 % due to the advices of agricultural pesticide dealers and 15 % for the purpose of quality, root improvement, softening the soil, adding organic materials and soil amelioration.

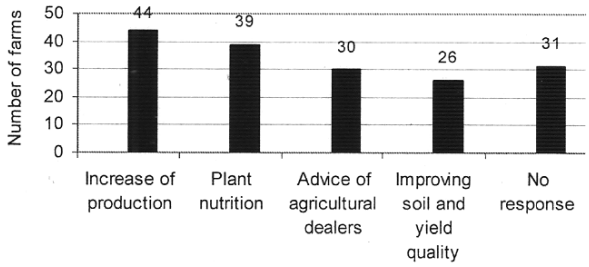


Fig. 7. Application reasons of organic fertilizers in farms

It is thought-provoking that the only reason of excessive application of chemical fertilizers together with organic fertilizers is to increase the production. It is determined that the only aim of the producers in the region is to increase their income level as high as they can and while doing that they do not notice that they harm the environment and their lands.

Nearly three-fourth of the farms which apply farmyard manure provide their farmyard manure from fertilizer market and 15 % from animal market.

15 % of the farms noted that they meet their need from the neighborhood farms. Application amounts of farmyard manure are determined as ≤ 2 ton in 58 % of the farms, 2.1-3 ton in 12 %, 3.1-5 ton in 12 %, 5.1-10 ton in 16 % and > 10 ton in 12 % (Fig. 8).

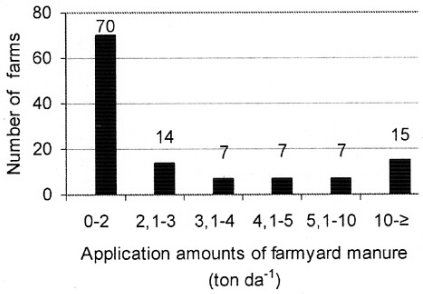


Fig. 8. Application amounts of farmyard manure in the farms

It is determined that 76 % of the farms do not perform the soil analysis before fertilizer application. The 48 % of the producers applied fertilizers according to the advices of agricultural pesticide dealers, 24 % according to analysis report, 14 % according to experience, 5 % according to plant's and weather conditions, 5 % according to advice of Provincial Directorate of Ministry of Agriculture and 4 % according to advice of agricultural engineer. Lack of widespread analysis laboratory in the region can be shown as another factor for not performing soil analysis. 44 % of the farmyard manure applied is obtained from agricultural treatment dealers, 38 % from fertilizer market and 18 % from farms of livestock and neighborhood villages. It is determined that all the chemical fertilizers were bought from fertilizer dealers in the market.

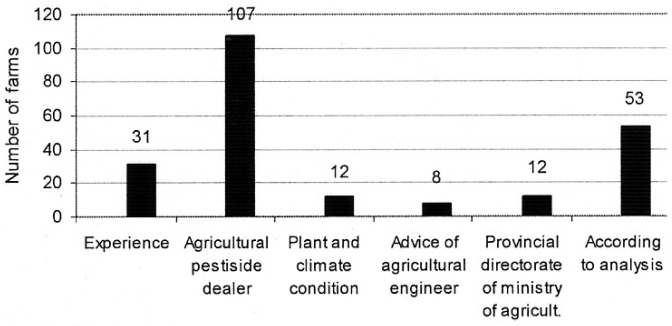


Fig. 9. Factors considered in application of fertilizers in the farms

The findings revealed that agricultural pesticide dealers have a great impression on farmers. The priority of fertilizer dealers is the commercial aims to bring more profit. Fertilizer dealers market products which would bring more profit to them with the commercial aims and they make these products spread through their advice. However, besides the advice of the fertilizer dealers without considering the scientific values, the producers still use the application forms and amounts learned from neighbors and adults in family.

The biggest proportion of the farms surveyed pointed out that they apply farmyard manure as organic fertilizer (54 %) whereas 21 % various fertilizer types which are sold in the market, 9 % liquid poultry manure, 13 % liquid fertilizers and 20 % other liquid and solid commercial fertilizers (Fig. 10). Incorporation of fresh poultry manure which requires more careful usage than the other organic fertilizers may have adverse effects on nutrition.

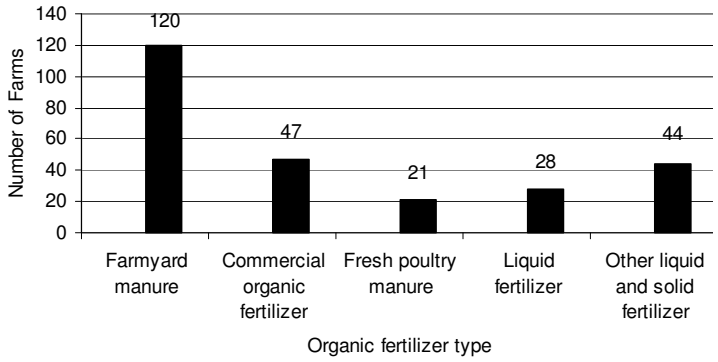


Fig. 10. Types of organic fertilizers applied in the farms (Due to the some farms used two or more different organic fertilizer sources, the sum of the values on the bar higher than 223 farms)

The farmers of 47 % graduated from primary school, 21 % from secondary school, 27 % from high school and 5 % from university. Farmers graduated from primary school (82 %) did not perform any soil or plant analysis and 37 % of these farmers apply fertilizer of 51-75 kg da^{-1}. It is determined that 75 % of graduates of secondary school did not have any soil analysis performed and 20 % of them apply fertilizers of 51-75 kg da^{-1}. According to these results, the increase in the education level of producers is directly proportional with the soil analysis made and inversely proportional with the use of chemical fertilizers.

Relations between the variants: The relations between the variants obtained in the study are examined with correlation analysis. Correlation coefficients and their significance level are given in Table-2.

TABLE-2
RELATIONS BETWEEN THE PARAMETERS
OBTAINED IN THE STUDY

	SG	EL	OFK	AOF	AOFA	AFM	ACF
EL[a]	0.1603						
OFK	0.0161	0.2188*[b]					
AOF	0.1621	0.0409	0.3062†				
AOFA	-0.0996	0.0518	0.2290*	0.5231‡			
AFM	-0.0135	0.1091	0.0980	0.2176*	0.7416‡		
ACF	-0.1009	-0.0288	-0.1974*	-0.2745†	0.5211‡	0.5129‡	
AP	-0.0797	0.2390*	0.1765	0.1326	-0.2110*	-0.1568	-0.0623

[a]EL = Education level; OFK = Organic Fertilizer Knowledge; AOF = Do they apply organic fertilizers?, AOFA = Amounts of Organic Fertilizers Applied; AFM = Amount of Farmyard Manure; ACF = Amount of Chemical Fertilizer; AP = Analysis Performed SG = Size of greenhouse.
[b]*$p < 0.05$; †$p < 0.01$; ‡$p < 0.001$ show the significance levels.

No relation determined between the size of greenhouses and analyzed parameters. The producers whose education level is higher have also knowledge of organic fertilizers ($p < 0.05$). Increase of education level increases both importance given to the soil analysis and fertilizer usage doses ($p < 0.05$). Positive correlation observed between the organic fertilizer knowledge and both organic ($p < 0.01$) and chemical fertilizers application amount ($p < 0.05$). In other words, the producers who have knowledge of organic fertilizers apply more organic and mineral fertilizers. A strong relationship between organic fertilizer usage and application amount was found ($p < 0.001$). Those who apply organic fertilizer preferred mostly farmyard manure. A medium level relationship between organic fertilizer application amount and chemical fertilizer application amount was determined ($p > 0.01$). Organic fertilizer application amount and both farmyard manure and chemical fertilizer application amount have a strong relation ($p < 0.001$), whereas an inverse relation was found between organic fertilizer application and analyses performing ($p < 0.05$). It is determined that most of the organic fertilizer applied is farmyard manure and that the relation level found between fertilizer application amount and chemical fertilizer application amount ($p < 0.001$) is also determined between farmyard manure application amount and chemical fertilizer application level.

Most of the parameters which are the subjects of this study have relation with each other. For example the producers who have knowledge of organic fertilizer applied higher organic and chemical fertilizer. Educated farmers gave importance to perform soil analysis. Education is the primary subject of greenhouse production which intensive input require. It is necessary to

raise the awareness of the producers through various publications by related agencies and institutes that would great benefits both economically and ecologically.

RESULTS AND DISCUSSION

The results obtained revealed that fertilizers are applied generally according to the advices of fertilizer dealers without any soil analysis in the greenhouses of the region investigated. Two-third of the farmers use considerably high amount of fertilizer as higher than 50 kg N + P_2O_5 + K_2O per decare. That value is also significantly high compared to Turkey mean fertilizer usage doses (7.8 kg N + P_2O_5 + K_2O per decare). Fertilization time is as much important as the fertilization dosage. Thus, fertilization should always be realized according to soil and plant analyses. Application of fertilizers without soil or plant analysis preventing the economical application of the fertilizer, increases cost, causes a decrease in the quality and quantity of the production and finally would harmful to soil and environment[19]. There are a number of papers on the subject however the announcement is insufficient to aware the farmers for optimum application dose and time. The best example of this is that producers recently come across with the problems in the potato cultivation areas of Nigde region, such as a decrease or failure to yield and storage capability[20]. It is known that an important level of nitrogen and phosphorus flow into water through surface flow from soil and drainage water as a result of misuse and excessive fertilizer application. Misuse or excessive use of nitrogen causes nitrate and nitrite accumulation in both soil reservoir and plant tissues. Nitrate and nitrite in foods are harmful when if they exceed 250 and 5 mg kg^{-1}, respectively[21]. Thus, regulations in agro-chemical use in greenhouses should be realized in advance. Agricultural publications should be prepared and awareness raising studies should be carried out by universities and other supporter institutes.

In general, easy-to-reach laboratories which perform plant and soil analysis with suitable costs should be built for producers in order to provide correct nutrition of the plants in greenhouse growing. Results revealed that farmers need qualified agriculture engineers who are able to assist to producers in nutrition programs for greenhouse plants; the truth that the most important problems of the producers about greenhouse production are plant nutrition or application of fertilizers; and the necessity for training of producers by public or private organizations. Similar results are obtained by other researchers as well[22,23].

Consequently, intensive application of chemical fertilizers would gradually decrease fertility of the soil and lead to pollution of soil and drinking water. It is very hard and expensive to clean polluted soil and not possible in

some cases. The most important point to prevent soil pollution and to improve fertility is fertilization that realized based on soil and plant analysis, especially in agricultural areas such as irrigated farmland and greenhouse production done. It is very important to prevent losses which would occur as a result of failure to apply fertilizer with a suitable method, at a suitable amount and at a suitable time. A fertilizer application program must be prepared by considering these points will provide fertilizer savings and prevention of adverse effects to the environment. As 83 % of greenhouse production in Turkey is performed in study fields, soil and plant analysis should be primarily made before application of fertilizers in greenhouses.

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