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Research Article

THE EFFECT OF SHEEP WOOL MANURE ON GROWTH AND YIELD OF PEPPER (*Capsicum annuum*) PLANT

Ummahan Çetin Karaca*, İrfan Yarımoğlu, Mohammed Saba, Ahmed M. Yossif

Selçuk University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Konya, Turkey

*Corresponding author**
Email: ucetin@selcuk.edu.tr

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ABSTRACT. Sheep wool is an important organic fertilizer, friendly for environment, and rich in nitrogen, carbon, and sulfur. In this study, the sheep wool manure fertilizer doses (0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, and 5.0 t da^{-1}) were applied to the root area of the seedlings in the soil to investigate its effect on the pepper plant growth under greenhouse condition. The seeds of the crop were initially pre-sowed in trays, and further, transplanted into the flowerpots. Following the treatment, the plant length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, fruit weight, fruit diameter, fruit height, number of fruits per plant, water-soluble dry matter, and SPAD value were measured.The results showed that some yield characteristics of pepper plants were significantly affected ($p<0.01$) with the increment in the doses of sheep wool manure applications. Generally, in the yield components of the pepper plant, the lowest and highest values were obtained from 5.0 t da^{-1} and 1.0 t da^{-1} of the manure application, respectively. It was concluded that the ideal dose of sheep wool manure for the crop is 1.0 - 2.0 t da^{-1}.

Keywords: *Sheep wool manure, pepper, yield, yield components, soil*

INTRODUCTION

Due to their excessive use and richness in vitamins, pepper plant production is very important for the national economy and human nutrition of our country. It is necessary to increase the yield per area and quality of the pepper plant [1]. Sheep wool is one of the natural and renewable sources and a friendly fiber for environment, which is widely used in the textile industry to make clothes, rugs, socks, and carpets, besides some uses in agriculture as fertilizers.

Adi and Păcurar [2] stated that economic and environmental reasons need suitable management, and use of fertilizers for more exploitation. In addition in the agricultural sector and agribusiness, the correct use of fertilizers is not just for economic reasons, but also to protect the environment [3]. In 2011, the worldwide production of animal wool was 1.985.797 million tonnes [4].The wool can be used as a cover material especially after sowing of seeds, to reduce soil evaporation and maintain constant soil temperature to increase the crop growth [5]. Profitable yield and environmental friendliness can be achieved by using sheep wool manure as a nutrient source, hence, it is a good source of organic fertilizer for sustainable agriculture [6, 4]. Zheljazkov et al. [7] observed that the roots take up nutrients from the wool layer and can serve as a nutrient source and growth medium for five growing seasons. In addition to that, Zoccola et al. [8] reported that grass-grow yield (wet and dry matter) was greatly increased when wool was added to the soil.

Zheljazkov et al. [7] tested the usability of sheep wool as an organic fertilizer source in plant growing containers. Four different rates of wool (0 or unamended control, 20, 40, 80, and 120 g of wool per plastic pot (851 cm^3 volume)), three growth medium [(2.1) wool plus perlite, (2.2) wool plus peat, and (2.3) wool plus peat plus perlite], and two crops (chard and basil) were compared. Results showed that total basil yield increased 1.6- 5 times during five harvest periods and chard yield increased 2-5 times in four harvest periods. It was observed that when the wool was added to the growth medium, it causes the increase in biomass yields of the plants. In addition, it was concluded that one-time application of wool can supply nutrients to the grown crops for 4-5 growth seasons. Also, the result determined that wool application in containers, without any other fertilizing agent, can supply the required nutrients, besides it serve as the growth medium for the crop. According to Ordiales et al. [4] two experiments aimed to study the effect of different sheep wool manure [(0, 100, 150, 200, and 300 kg N ha^{-1} as a floraPell (10% N), 300 kg N ha^{-1} as wool pellets 8 mm (8% N), and 150 kg N ha^{-1} as a humibio (6-7-7) on tomato) and (0, 50, 100, 150, 200 kg N ha^{-1} as a floraPell (10% N), and 100 kg N ha^{-1} as a humibio (6-7-7) on Broccoli plant)] as an organic fertilizer and as a soil amendment agent on vegetable crops. The trials were conducted at the experimental fields of Centro Tecnológico Nacional Agroalimentario Extremadura (CTAEX), in Badajoz (Spain). According to the results, when different sheep wool manure was increased, total yield of tomato and broccoli plants increased, and floraPell can be used successfully as an alternative biological fertilizer at a dose of 2 t ha^{-1} in both crops. The effect of sheep wool (0, washed wool at the rate of 10 g per 1 dm^3) on dry substrate amended containers under greenhouse conditions, significantly increased sweet pepper fruit yield/plant, fruit number/plant, and mean weight/fruit [6].

Vončina and Mihelič [9] found that when sheep's wool (140 kg (W1, L1)), leather shavings (560 kg (W3, L3)), cattle manure (280 kg (W2, L2, FYM) N/ha) were applied on green asparagus plantation at Rogelj organic farm in Kranj (Slovenia) field, sheep wool significantly increased the yields of asparagus in 2008 season. Experiments were conducted to determine the effect of sheep wool residue SWR (WW, is produced from the mechanic beating of scoured wool and is formed of wool fiber residues and vegetal residues), and black wool residue (BW, is produced from the "carbonization" of the scoured and beaten wool with a solution of sulfuric acid) on sunflower (Helianthus annuus L.) by using treatments (0, WW0.5%, WW1%, WW2% and BW0.5%, BW1%, BW2%) with three replicates in 21 pots. The result showed that when SWR (white or black) applications were increased, sunflower Leaf chlorophyll content (SPAD), Leaf Area (cm^2), the number of flowers, and Leaf biomass (g) increased significantly. Also, when BW (0.5, 1, and 2%) increased, stem diameter (mm) increased, while root biomass (g) and stem biomass (g) decreased. Besides, when WW (0.5, 1, and 2%) was applied, 1% application significantly increased the stem biomass (g) and root biomass (g), but 0.5 and 2% application decreased it significantly, but stem diameter (mm) was oppositely affected [10]. The water-soluble part of the total dry matter called brix or refractometer value is an important quality criterion in both production and quality control. It is important in determining the mellowness, harvest time of fruits and is an important factor in production of fruit juice, concentrate, paste or canned food [11].

The study was carried out under greenhouse conditions to evaluate the use of sheep wool manure as an organic fertilizer in pepper plant production.

MATERIALS AND METHODS

The study was carried out in the greenhouse (in 2019) at the Department of Soil

Science and Plant Nutrition, Faculty of Agriculture, Selcuk University Konya, Turkey as a four frequency pot trial in randomized blocks factorial experimental designs. A sample of clay soil and increasing doses (0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, and 5.0 t da^{-1}) of sheep wool manure mixed with this soil were used in the study.

The results of the chemical properties of the sheep wool manure used in the study were obtained from the company that produced the fertilizer. The sheep wool manure was rich in organic matter (81.1%) and other plant nutrients (N, P, K, S, Fe) with high pH (9.1) and salt (7.5 mmhos cm^{-1}) content (Table 1).

Table 1. *The chemical properties and some nutrients content of sheep wool manure*

Properties	**Value**	**Methods**
Organic Matter %	81.1	[12]
Total Nitrojen (N) %	10.5	[13]
Total Phosphorus ($P_2 0_5$) %	0.55	[14]
Total Potassium (K_2O) %	4.2	ICP / AAS
Total Sulfur (S) %	5.8	[14]
Total Iron (Fe) %	0.33	ICP / AAS
pH	9.1	pH (1/10 potentiometric)
EC (mmhos cm^{-1})	7.5	EC (1/10 in aqueous solution)

The physical and chemical properties of the soil used in the experiment are presented on Table 2., and according to Jackson [15] was slightly alkaline (pH, 7.52), saltless (54 (µS cm^{-1}) and poor in organic matter (1.58%). However, base on Ülgen and Yurtsever [16], was very high in lime content (33.8%), and according to Bouyoucos [17] the texture of the soil was clay loam. Besides that the soil was insufficient in nitrogen (39.14 mg kg^{-1}) content [13]. Also, the soil was sufficient in phosphorus (14.8 mg kg^{-1}) and potassium (218 mg kg^{-1}) contents, and was high in calcium (6132 mg kg^{-1}) content [18]. According to Lindsay and Norvell [19] the soil was sufficient in copper (0.8 mg kg^{-1}) and insufficient in iron (0.7 mg kg^{-}1), and manganese (0.18 mg kg^{-1}). According to Richards [20] the soil was insufficient in boron (0.32 mg kg^{-1}) concentration. The soil was also sufficient in Zinc (1.4 mg kg^{-1}) concentration.

Before the establishment of the experiment, the seeds of pepper (*Capsicum annuum* L.) were sowed in trays containing a 3:1 mixture of soil and peat and irrigated with distilled water. Taking the oven-dried weight into account, 5 kg soil was used.
The doses of sheep wool manure used in the experiment were 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, and 5.0 t da^{-1}. After 15-20 days of development, the pepper seedlings were transplanted to pots containing the soil. The experiment was kept under controlled conditions in the greenhouse from the transplanting of the seedlings to the harvest stage and irrigation and other maintenance operations were carried out accordingly. The fruits were harvested at the appropriate time and necessary measurements were made**.**

Table 2. *Some physical and chemical properties of the soil used in the experiment*

Properties		**Value**	**Methods**	**Properties**		**Value**	**Methods**
Texture		Clay loam	[17, 21]	**Ca**	**(mg kg^{-1})**	6132	[26]
pH		7.52	[20]	**Mg**		227	
EC (µS cm^{-1})		54	[22]	**Na**		8.0	
O.M. (%)		1.58	[23]	**Fe**		0.7	[19]
$CaCO_3$ (%)		33.8	[24]	**Cu**		0.8	
N	**(mg kg^{-1})**	39.14	[13]	**Mn**		0.18	
P		14.8	[25]	**Zn**		1.4	
K		218	[26]	**B**		0.32	[20]

According to Kacar and İnal [27] plant height, root height, plant fresh weight, root fresh weight, plant dry weight, root dry weight, fruit weight, fruit diameter, fruit height, number of fruits per plant, water-soluble dry matter parameters were measured. SPAD value was determined using Minolta 502 SPAD meters [28]. The data obtained from the experiment were subjected to analysis of variance using MINITAB and MSTAT-C package programs. In the significance tests, 1% and 5% were used between groups. In mean separation, the least significant difference (LSD) test was used [29].

RESULTS AND DISCUSSION

Research results of the growth pepper plant

According to the research results, the sheep wool manure applications had significantly affected ($p<0.01$) the pepper plant height, plant fresh weight (g), plant dry weight (g), root height (cm), root fresh weight (g), and root dry weight (g) (Table 3). Similar results were found by [10] Abdallah et al. (2019) who found that the sheep wool residue (SWR) (white or black) applications significantly affected the number of flowers and leaf biomass of sunflower.

Plant height (cm)

As can be seen in Table 3, the pepper plant height showed differences between the sheep wool manure application doses. It was determined that the pepper plant height varied between 39.67-57.00 cm. Also, the lowest value in plant height (39.67 cm) was obtained from 5 t SWM da^{-1} of sheep wool manure (SWM) application and the highest value (57.00 cm) of plant height was obtained from 1.0 t SWM da^{-1} application. Besides that, according to control when SWM applications were increased up to 4 t SWM da^{-1}, the pepper plant height increased significantly, and while 5 t SWM da^{-1} dose significantly decreased the pepper plant height (Table 3).

Plant fresh weight (g pot^{-1})

The experiment results showed that the applications of sheep wool manure (SWM) on the soil, changed the pepper plant fresh weight between 21.43 and 39.40 g pot^{-1}. Also, the highest plant fresh weight of the crop (39.4 g pot^{-1}) was determined by 1.0 t SWM da^{-1} of sheep wool manure (SWM), and the lowest plant fresh weight (21.43 g pot^{-1}) was determined with 5.0 t SWM da^{-1} application. Also, the pepper plant fresh weight significantly increased with increase in SWM compared to control until 4.0 t SWM da^{-1} dose and after which it significantly decreased (Table 3). Similar results were observed by [7] when wool was added to the growth medium, it increased the biomass yields of the Swiss chard (*Beta vulgaris* L.) and basil (*Ocimum basilicum* L.) plants.

Plant dry weight (g pot^{-1})

In our study, when the sheep wool manure (SWM) as organic fertilizer was increasingly applied to the soil until 4.0 t SWM da^{-1}, the dry weight of pepper plant increased significantly ($p<0.01$), and then decreased. Besides that, the dry weight values of the pepper plants ranged from 4.00 g pot^{-1} (5 t SWM da^{-1}) to 7.50 g pot^{-1} (1.0 t SWM da^{-1}), and the ratio of the lowest to highest was 88% according to dry weight of pepper plants (Table 3).

Root height (cm)

According to the result of the sheep wool manure (SWM) applications on slightly alkaline reaction soil, the root height of the pepper plant ranged between 11.67 cm (5 t SWM da^{-1}) and 22.33 cm (1.0 t SWM da^{-1}) values. Also, when the SWM increased to 1.0 t SWM da^{-1}, the root height of the pepper plant increased significantly, while when it increased from 2.0 t SWM da^{-1} and more, the pepper root height decreased significantly (Table 3).

Root fresh weight (g pot^{-1})

Additionally, the results of the study showed that the ratio between the lowest root fresh weight of the pepper plant (2.67 g pot^{-1}, 5.0 t da^{-1} of sheep wool manure (SWM)) and the highest root fresh weight (9.20 g pot^{-1}, control) increased by 245%. In addition, the pepper root fresh weight decreased significantly with increasing SWM according to control (Table 3).

Root dry weight (g pot^{-1})

Depending on sheep wool manure (SWM) applications, the root dry weight values of the pepper plant ranged from 0.57 to 1.33 g pot^{-1}. The lowest dry weight of the pepper plant was 0.57 g, and it was determined in the plant in the pot, where 5 t da^{-1} of sheep wool fertilizer was applied to the root zone of the plant. Besides, when the SWM was increasing applied to the soil according to control, the root dry weight of pepper plant decreased significantly (Table 3). Additionally, the application of sheep wool manure in the soil according to control, increased the soil salinity which negatively affected the plant growth by decreasing the pepper root fresh and dry weight (Table 3). Similar results were obtained by [30] where an increase in salinity negatively affected the product amount of the plants according to the tolerance response of the plant.

Research results yield and yield components of the pepper plant

The results showed that while the fruit weight (g) and fruit diameter (mm) were non significantly ($p>0.05$) affected by the sheep wool manure applications, the fruit size (cm), number of fruits (piece), water-soluble dry matter (%), and SPAD value were significantly ($p<0.01$) affected (Table 4). In that time as a same result for number of fruits (piece) of pepper plant the effect of sheep wool when was applying according to control, affected significantly on sweet pepper fruit yield/plant, fruit number/plant and mean weight/fruit [6]. Additionally as opposite result, Vončina and Mihelič [9] found that sheep wool manure significantly affected the yields of asparagus in 2008 season.

Table 3. *The effect of increasing doses of sheep wool manure on some yield elements of pepper plant*

Fertilizer Dose (t SWM da^{-1})	Plant height (cm)	Plant fresh weight (g)	Plant dry weight (g)	Root height (cm)	Root fresh weight (g)	Root dry weight (g)
0	40.83^{C}	21.70^{C}	4.90^{BC}	18.67^{ABC}	9.20^{A}	1.33^{AB}
0.5	51.50^{AB}	31.67^{B}	6.17^{AB}	21.00^{AB}	7.10^{AB}	1.27^{AB}
1.0	57.00^{A}	39.40^{A}	7.50^{A}	22.33^{A}	8.43^{A}	1.30^{AB}
1.5	56.17^{A}	39.00^{A}	7.23^{A}	17.67^{BC}	5.20^{BC}	1.33^{AB}
2.0	53.00^{A}	37.67^{A}	6.90^{A}	14.33^{CD}	5.13^{BC}	1.30^{AB}
2.5	54.00^{A}	38.87^{A}	6.90^{A}	15.00^{CD}	4.07^{C}	1.17^{A}
3.0	50.00^{AB}	33.77^{AB}	6.47^{A}	14.33^{CD}	3.73^{C}	1.07^{B}
4.0	44.67^{BC}	29.50^{B}	6.00^{AB}	12.33^{D}	3.20^{C}	0.90^{BC}
5.0	39.67^{C}	21.43^{C}	4.00^{C}	11.67^{D}	2.67^{C}	0.57^{C}
LSD ($p<0.01$)	7.12	5.71	1.45	4.24	2.79	0.43

Different letters: significantly different at $p<0.01$, Similar letters: insignificant at $p>0.01$, LSD: Least significant difference.

Fruit weight (g pot^{-1})

According to the research results as seen in Table 4, the sheep wool manure application had different effects on the fruit weight values of the pepper plant, and it varied between 14.25-20.07 g pot^{-1}. The lowest fruit weight of the pepper plant was 14.25 g pot^{-1} in the 5.0 t da^{-1} application, whereas the highest fruit weight of pepper plant (20.07 g pot^{-1}) was determined in 2.5 t da^{-1} of sheep's wool manure fertilizer. Contrasting results were found by [4] with tomato and broccoli plants and by [6] with sweet pepper who reported that the sheep wool application significantly increased fruit yield/plant.

Fruit diameter (mm)

The results of the research showed that the lowest fruit diameter of the pepper plant was 19.10 mm which was obtained from 3.0 t da^{-1} of sheep wool manure (SWM) application to the plant root area. In addition, the highest fruit diameter of the pepper plant was 23.24 mm, which was determined in 2.5 t da^{-1} of SWM application. Generally, the fruit diameter of pepper plant decreased with an increase in the SWM application to the soil (Table 4).

Fruit size (cm)

According to the results of the research, when the sheep wool manure (SWM) fertilizer was increased, the pepper plant fruit size increased ($p<0.01$) significantly. In the study, the highest fruit length of the pepper plant was determined as 12.61 cm in the plant in the pot, where 2.0 t da^{-1} of sheep wool fertilizer was applied to the root zone of the plant.

Number of fruits (piece)

Results revealed that the lowest number of fruits of pepper plant was 4.67 and it was observed at 5 t da^{-1} of sheep's wool manure (SWM) application, and the highest number of fruits of the pepper plant (10.67) was obtained at 1.5 or 2.0 t da^{-1} of SWM to the plant root area. Also, the result showed that the number of fruit significantly increased when SWM was increased to 3.0 t da^{-1} compared to control, and it significantly decreased when SWM was increased after this dose.

Water-soluble dry matter (%)

According to the research results; and depending on the sheep wool manure (SWM) applications the water-soluble dry matter values of the pepper plant ranged from 4.16-6.40%, and the lowest water-soluble dry matter value of the pepper plant was obtained from the control treatment, and the highest water-soluble dry matter value of the pepper plant was obtained from 3.0 t da^{-1} of SWM. Additionally, the water-soluble dry matter values of the pepper plant was significantly increased when SWM increased according to control (Table 4).

SPAD value in the leaf

The resulst as seen in Table 4 showed that according to sheep wool manure (SWM) application, the leaf chlorophyll value of the crop was ranged between 48.22-60.18 SPAD. Besides that the lowest SPAD value of the pepper plant was obtained (48.22 SPAD), by 5 t da^{-1} of SWM, and the highest SPAD value in the leaf of the pepper plant was determined as 60.18 SPAD from 0.5 t da^{-1} application. In another direction, the SPAD was significantly increased when SWM was increased until 3.0 t da^{-1} application, while it decreased when SWM was increased after this dose. Similarly when sheep wool residue (SWR) (white or black) applications were increased in the soil, sunflower leaf chlorophyll content (SPAD) increased significantly [10].

Table 4. *The effect of increasing doses of sheep wool manure on yield and yield component of pepper plant and fruit*

Fertilizer Dose (t SWM da^{-1})	Fruit weight (g)	Fruit diameter (mm)	Fruit size (cm)	Number of fruits (piece)	Water soluble dry matter (%)	SPAD value
0	17.80	21.91	9.02^{D}	6.33^{CDE}	4.16^{C}	55.47^{AB}
0.5	18.94	21.70	10.06^{BCD}	9.33^{AB}	4.34^{BC}	60.18^{A}
1.0	15.85	19.19	10.27^{BCD}	7.33^{BCD}	5.38^{ABC}	58.59^{A}
1.5	19.65	21.73	11.17^{ABC}	10.67^{A}	5.54^{ABC}	57.57^{A}
2.0	17.83	21.26	12.61^{A}	10.67^{A}	5.56^{ABC}	55.59^{AB}
2.5	20.07	23.24	12.33^{A}	9.33^{AB}	5.86^{AB}	57.04^{A}
3.0	15.72	19.10	11.49^{AB}	8.67^{ABC}	6.40^{A}	55.75^{AB}
4.0	16.69	19.77	10.75^{AD}	5.67^{DE}	5.39^{ABC}	53.62^{AB}
5.0	14.25	19.44	9.40^{CD}	4.67^{E}	4.87^{ABC}	48.22^{B}
LSD (p<0.01)	N.S.	N.S.	1.87	2.48	1.44	7.09

Different letters: significantly different at p<0.01, Similar letters: insignificant at p>0.01, LSD: Least significant difference, N.S.: Not significant

CONCLUSIONS

The results of the experiment showed that the sheep wool manure (SWM) had significantly ($p<0.01$) affected the plant height, plant fresh weight (g), plant dry weight (g), root height (cm), root fresh weight (g), and root dry weight (g), the fruit size (cm), the water soluble dry matter (%), SPAD value, number of fruits (piece) of pepper plant, while non significantly affected fruit weight (g) and fruit diameter (mm) of pepper plant. Additionally, when the sheep wool manure was increased in the soil until 4 t SWM da^{-1}, the plant height, plant fresh weight (g), plant dry weight (g) of pepper plants were significantly increased, while the root height (cm), root fresh weight (g), and root dry weight (g) were significantly decreased. In addition, when the SWM increased in the soil until 3 t SWM da^{-1}, the fruit size (cm), number of fruits (piece), and SPAD value of pepper plant decreased.

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REFERENCES

[1] Bosland, P. Eric, M. and Votava, M.E. (2012): Peppers: Vegetable and Spice Capsicums (2 nd edition). Vol. 1. 240 pages.
[2] Adi, M., & Păcurar, I. (2015): Study on the use sheep wool, in soil and fertilozation as the mixture into cubes nutrients. ProEnvironment Promediu, 8(22).
[3] Adi, M., & Pacurar, I. (2016): Study Regarding the Use of Sheep Wool in Dendro-Horticultural. Bulletin UASVM series Agriculture, 73, 1.
[4] Ordiales, E., Gutiérrez, J. I., Zajara, L., Gil, J., & Lanzke, M. (2016): Assessment of utilization of sheep wool pellets as organic fertilizer and soil amendment in processing tomato and broccoli. Modern Agricultural Science and Technology, 2(2), 20-35.
[5] Johnson, N.A.G. Wood, E.J. Ingham, P.E. Mcneil, S.J. McFarlane, I.D. (2003): "Wool as a technical fiber". Journal of Textile Institute, 003/94 Part 3: 26-40.
[6] Górecki, R.S. and Górecki, M.T. (2010): "Utilization of waste wool as substrate amendment in pot cultivation of tomato, sweet pepper, and eggplant". Polish Journal Of Environmental Studies, Volume 19, No. 5: 1083-1087.
[7] Zheljazkov, V.D., Stratton, G. W., Pincock, J., Butler, S., Jeliazkova, E. A., Nedkov, N. K., & Gerard, P.D. (2009): Wool-waste as organic nutrient source for container-grown plants. Waste Management, 29(7), 2160-2164.
[8] Zoccola, M., Montarsolo, A., Mossotti, R., Patrucco, A., & Tonin, C. (2014): Green hydrolysis conversion of wool wastes into organic nitrogen fertilisers. Paper presented at the 2nd international conference on sustainable solid waste management.
[9] Vončina, A., & Mihelič, R. (2013): Sheep wool and leather waste as fertilizers in organic production of asparagus (*Asparagus officinalis* L.). Acta Agriculturae Slovenica, 101(2), 191-200.
[10] Abdallah, A.M., Ugolini, F., Baronti, S., Maienza, A., Ungaro, F., & Camilli, F.(2019): Assessment of two sheep wool residues from textile industry as organic fertilizer in sunflower and maize cultivation. Journal of Soil Science and Plant Nutrition, 19(4), 793-807.
[11] Cemeroğlu B. (1992): Fundamental analysis methods in the fruit and vegetable processing industry. Biltav Publications, Ankara, 380.
[12] Kacar B. (1994): Chemical Analysis of Plant and Soil: III Ankara University Faculty of Agriculture Publications, Ankara.

[13] Bremner, J. (1965): Total nitrogen In: Black CA (ed) Methods of Soil Analysis: Part 2 1. Madison: American Society of Agronomy Monograph, 9, 149-1176.
[14] Kacar B. ve Kütük C. (2010): Fertilizer analyzes. Nobel Publication No: 1497, First edition, 382p, Ankara.
[15] Jackson, M.L. (1962): Chemical composition of soil. In Chemistry of soil (F. E. Bear Ed.). New York, NY:: Van Nostrand Reinhold Co.
[16] Ülgen N., & Yurtsever N. (1974): Turkey Fertilizer and Fertilization Guide, Soil and Fertilizer Research Institute Technical Publications Series No: 28. In: Ankara.
[17] Bouyoucos, G.J. (1951): A recalibration of the hydrometer method for making mechanical analysis of soils 1. Agronomy journal, 43(9), 434-438.
[18] FAO. (1990): Micronutrient at the country level. An International study. (ed. M. Sillanpa). (Vol. 63). Rome, Italy.: Published by FAO.
[19] Lindsay, W.L., & Norvell, W.A. (1978): Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Science Society of America Journal, 42(3), 421-428.
[20] Richards, L. (1954): Diagnosis and improvement of saline and alkali soils. Washington: United States Salinity Laboratory, 1954. 160p. USDA. Agriculture Handbook, 60.
[21] Demiralay İ. (1977): Soil physics application. Atatürk University Faculty of Agriculture Publications, Erzurum.
[22] Staff, U.S.L. (1954): Diagnosis and improvement of saline and alkali soils. Agriculture Handbook, 60, 83-100.
[23] Smith, H. W., & Weldon, M. (1941): A comparison of some methods for the determination of soil organic matter. Soil science society of America journal, 5(C), 177-182.
[24] Hızalan E., & Ünal H. (1966): Important chemical analyzes in soils. Ankara University Faculty of Agriculture Publications, 278.
[25] Olsen, S.R. (1954): Estimation of available phosphorus in soils by extraction with sodium bicarbonate: US Department of Agriculture.
[26] Soltanpour, P.N., & Workman, S.M. (1981): Use of Inductively-Coupled Plasma Spectroscopy for the Simultaneous Determination of Macro and Micro Nutrients in NH_4HCO_3-DTPA Extracts of Soils. In Barnes R.M. (ed). Developments in Atomic Plasma Analysis, USA, pp. 673-680.
[27] Kacar B., & İnal A. (2008): Plant analyzes: Nobel Publication Distribution.
[28] Piekkielek, W., & Fox, R. (1992): Use of a chlorophyll meter to predict sidedress nitrogen requirements for maize. Agronomy journal, 84(1), 59-65.
[29] Yurtsever N. (1984): "Experimental Statistics Methods" Ministry of Agriculture, Forestry and Rural Affairs. Publications of the General Directorate of Rural Services: 623. Ankara.
[30] Chinnusamy, V. Jagendorf, A. Zhu, J. (2005): "Understanding and improving salt tolerance in plants". Crop Science, 45: 437-448.