ORIGINAL PAPER

SPATIAL DISTRIBUTION IN A DRY ONION FIELD (A PRECISION FARMING APPLICATION IN TURKEY)

Bahattin AKDEMIR[1], Korkmaz BELLITURK[2], Can Burak SISMAN[3], Simon BLACKMORE[4]

[1]Trakya University, Tekirdağ Agricultural Faculty, Department of Agricultural Machinery, Tekirdag, Phone: +90 282 2931442/118, e-mail: bakdemir@tu.tzf.edu.tr.

[2]Trakya University, Tekirdağ Agricultural Faculty, Department of Soil Science, Tekirdag

[3]Trakya University, Tekirdağ Agricultural Faculty, Department of Farm Structure and Irrigation, Tekirdag

[4]Danish Royal Agricultural University, Precision Farming Centre, Kopenhagen, Denmark

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ABSTRACT

Objective of this study is to determine spatial variability in a dry onion field and to produce a management strategy which is based on spatial variability of yield and soil components. The onion field properties were determined and given in maps. Soil samples were taken to determine properties of soil such as pH, salt, humidity, $CaCO_3$, organic matter, total N, Zn, Fe, P_2O_5, Ca+Mg, K, texture. Longitudinal slope was also measured. Results were used to produce maps. Most percentage of the field soils was determined as clay-loam. Small part of the field was loam. Yield of dry onion decreased by increasing of Organic Matter, Total Nitrogen, Iron, and Zinc in the field according to the related maps. Relationship between yield and phosphorous, $CaCO_3$, Ca+Mg and salt was positive according to the related maps.

KEY WORDS: Precision Farming, Spatial Variability, Yield Map, Dry Onion.

INTRODUCTION

Growing of dry onion by sets considers in 3 steps; seed growing, onion set growing and dry onion growing. The parameter for planting of sets were; 200-250 mm row space, 100-160 mm distance in row, 20-40 mm planting depth of sets and 25-45 pieces/m^2 by hand into row opened by cultivator or harrow in February and March for dry onion growing. The sets are covered by harrow in the conventional method. Plants are hoed 2-3 times by hand in May and June. Onions are dug by hand in August and dried approximately 7-10 days in the field [1].

The first is production of dry onion by onion sets and the second by seeds which is only used for irrigated area. There are some problems such as planting of onion seeds for the production of onion sets. The planting of seed is realized by man labour, because row spaces between seeds are very narrow (3cm).

There are two methods for dry onion production. One of them is production of dry onion from seeds, other method is production of dry onion from onion sets which is most widely used method in Turkey. Growing of dry onion by sets considers in 3 steps; seed growing, onion set growing, and dry onion growing [1].

Onion seeds growing; middle size dry onions diameter 60-80 mm use for seed production because these onions can show their characteristics. Cultivator open furrow tilled soil. Onions are planted by hand. Width of furrow opener are selecting bigger than that classic furrow opener. Planting norm is 12 onions per square meter. Planting depth is equal to maximum diameter of onion. Hoeing and spraying are doing by machines. Seeds are harvested by hand when onions are green because of preventing of onion seeds spilling over the field. Harvesting is generally doing in July. Then seeds ore dried and tractor is passing over dried seeds. The seeds are collected and are blustered to separate other particles in front of a ventilator. After separation of seeds, the seed is plunged into water for a short time to separate small particle on the seed surface. The seed are drying and stored [2].

Onion sets growing; Primary tillage is deep ploughing with single or double furrow plough in the August. After autumn's rain, second tillage is doing with spring tine cultivators. Generally metering unit with toothed roller used in cereals planting machines are used for seeding. Distances between rows, and seeding depth are 3 cm, 2-4 cm, respectively. Seeding rate is 120-140 kg/ha [2]. Onion sets have been harvested by hand by using a special onion hoe. Onion sets have been harvested when leaves have been green because harvesting digging is easy. Required man labour for digging is varying between 80 and 300 man/ha due to soil type and humidity. Workers have also been help for collecting of onion sets. Onion sets classify and put in a sack by using classification machine. 40 kg, 50 kg and 60 kg sacks use for storage of onion sets. 12-14 kg onion sets put the sacks and/or put wooden boxes generally used for tomatoes carrying [3].

Dry onion growing; The parameters for planting were; 200-250 mm row space, 100-160 mm distance in row, 20-40 mm planting depth and 25-45 pieces/m^2 by hand into row opened by cultivator or harrow in February and March for dry onion growing. The sets are covered by harrow in the conventional method. Plants are hoed 2-3 times by hand in May and June. Onions are dug by hand in August and dried approximately 7-10 days in the field. Many agricultural operations such as planting of onion set, hoeing of weeds, harvesting of dry onion, digging and picking of dry onion from field and putting in sucks have been doing by hand except tillage, fertiliser and spreading of pesticides [2].

Yield maps are important tools for producers or scientists practicing site-specific management in precision agriculture programs. Detailed yield maps can be linked by global positioning systems (GPS) coordinates to other maps that show soil chemical and physical properties, soil depth and topography, Remote sensing data, weeds, diseases, nematodes, insects; and cultural practices [4].

There are a number of ways to measure crop yields. Most of methods developed over the years have involved weighing the crop after it has been separated, and cleaned. Three major yield measurement approaches are listed below. Yield monitoring has been most widely applied to grain harvesting, but is certainly not limited grains. Yield monitors are being, or have been developed for several non-grain crops as potatoes, tomatoes, sugar beet, peanuts, cotton and forage crops [5].

Yield mapping and soil sampling tend to be the first stage in implementing PF. Yields are produced by processing data from an adapted combine that has a vehicle positioning system integrated with a yield recording system. The combine has a fitted to it that can be identified by the GPS receiver on the roof of the cab and the differential aerial above the engine. The output from the combine is a data file that recorded every 1.2 seconds the position of the combine in Longitude and Latitude with the yield at that point. This data set can then be processed by various geostatistical techniques (usually involving Kriging) into a yield map [6].

Main objective of this paper is to determine spatial variability in a dry onion field and to produce a management strategy which is based on spatial variability of yield and soil components to improve yield for dry onion production in Turkey. There was not any machine or GPS for measurement and monitoring yield, soil properties and positioning of the data in this research. All data were measured by using transportable weighbridge and evaluated by known software.

This research has been carried out in Tekirdag, Turkey, in 2002.

MATERIALS AND METHODS

Materials were onion field and dry onion. The onion field properties were determined and given in maps. Dry onion variety is Yarim Imrali.

The field is in Tekirdag (Thrace Region) which is located in North-West of Turkey. Climatic data of Tekirdag; annual average temperature is 13.8 ˚C, average rainfall total is 572.7 kg m^{-2}, average atmospheric pressure is 1015.9 hPa and average relative humidity is 77.7% [7].

According to classification of the soils, There are Vertisol, Inceptisol, Alfisol, Entisoland Mollisol Ordo in Thrace region [8]. There are many different soil texture types such as clay (C), clay-loam (CL) and sandy-clay-loam (SCL). The majority of the soils (90%) in the region are low or very low organic matter, 45% of soils were rich in phosphorus [9].

Soil samples were taken to determine properties of soil such as pH, salt, humidity, $CaCO_3$, organic material, total N, Zn, Fe, P_2O_5, Ca+Mg, K, texture (Clay, Silt and Sand) and longitudinally slope ([10]; [11]; [12]).

Longitudinal slope was measured with nivelman and evaluated. Accuracy of the Nivelman was ± 0.2 % [13].

Field divided grids that its dimensions were 10 m x 10 m. Field markers were used to determine grids position in the field. Each grid was harvested by hand and dry onions put in sacks and were weighed with weighbridge.

Measured results were used to produce maps (yield maps, texture maps, plant nutrition elements maps etc.) to show relationship between yield variability and soil properties. The maps are produced by using a methodology that developed and published by Denmark Royal Veterinary and Agricultural University, Centre for Precision Farming ([14]; [15]; [16]). Positioning of data points on the maps were determined due to field size. Coordinates of the onion field is given in Table 1.

Data will also be used to determine next year fertilizing strategy for different agricultural applications such as chemical applications, seeding rate, etc. Produced maps will be used to investigate reasons of the yield variability in the field. In addition, effect of soil properties and field slope on the yield will be evaluated.

RESULTS AND DISCUSSIONS

Produced maps are given below. Variability of the soil, yield, pH, Ca, Zn, and others can be seen on these maps. These maps can be used to determine spatial variability and to apply variable rate application in that field.

When evaluated the yield map, it can be seen that there is variability for yield in the field (Figure 1). The yield is changed between 10 and 50 t ha^{-1}. The yield is generally low between 4541890 and 4540970 northing coordinates. In the other parts of the field, there is big variability for the yield.

In the research field, there are two type soil textures (Figure 2). One of them is clay loam and the other is loam. Sandy loam soils also provide an excellent growing medium, if they are well supplied with organic matter, nutrients, and a uniform supply of moisture. Onions grown on light sandy loam will generally mature earlier than on heavier soils. The heavier soils such as clay should be avoided because they make become hard and compact. This makes the emergence of seedlings difficult and causes misshapen bulbs [17].

Level of the organic matter in the research field changed between 1 and 2.5 % (Figure 3). This level is not enough suitable for onion production. These levels of organic matters in the field are evaluated as low level according to the literature [18].

Amount of the nitrogen taken from soil by determined amount of dry onion such as 35 t ha^{-1} during growing season was 120 kg ha^{-1} in respect of Kemmler and Hobt [19]. Nitrogen value varied between 0.03 and 0.13 % (Figure 4). Nitrogen value of the field is evaluated as poor according to the literature ([12]).

Contents of the zinc in the field varied between 0.1 and 0.26 ppm (Figure 5). This value is smaller than that minimum required value (< 0.5 ppm) for onion production [20].There are three levels for iron contents of the research field (Figure 6). Iron varied between 2 and 4 ppm. These levels are evaluated as medium level according to literature [20]. pH of the research field varied between 7 and 7.50 (Figure 7). Although onions are grown best on a slightly acid-neutral soils (pH 5.8 to 7.0), satisfactory yields can be obtained on organic soils where the pH is as low as 4 [17].

Most part of the research field was poor according to Olsen and Dean [21] (Figure 8). Available phosphorus deficiency causes slow growth, delayed maturity, light green foliage, and high proportion of thick necks [17].

Total amount of exchangeable calcium and magnesium varied between 30 and 55 meq per 100g of soils (Figure 9). Onion plants develop a chlorosis of lack of normal green colour of the older or outer leaves when the magnesium supply is inadequate [17].

Percentage of the salt varied 0.04 and 0.05 (Figure 10). When investigated percentage of salt in the soil samples,

Table 1. Coordinates of the onion field.

Point	UTM		Longitude	Latitude
	y	x		
1	4541970	542000	27° 29’ 59.9” E	41° 2’ 41.9” N
2	4541970	541970	27° 29’ 58.6” E	41° 2’ 41.7” N
3	4541770	542000	27° 29’ 59.9” E	41° 2’ 35.4” N
4	4541770	541970	27° 29’ 58.6” E	41° 2’ 35.2” N

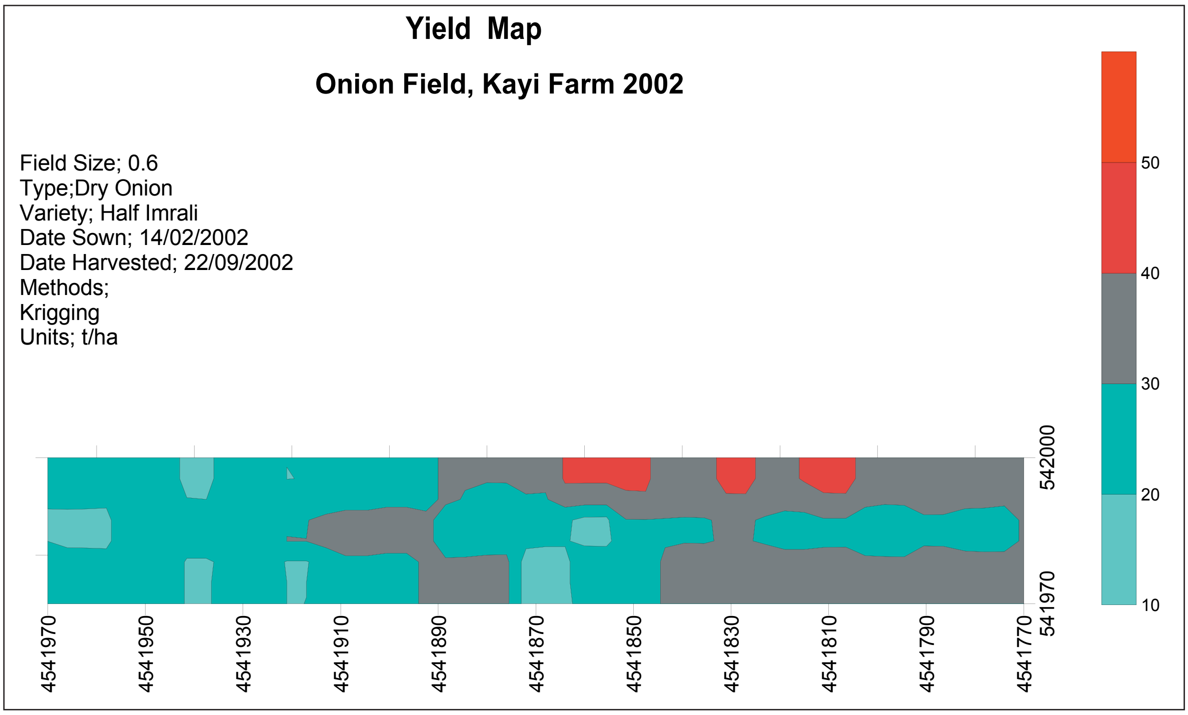

Figure 1. Yield map

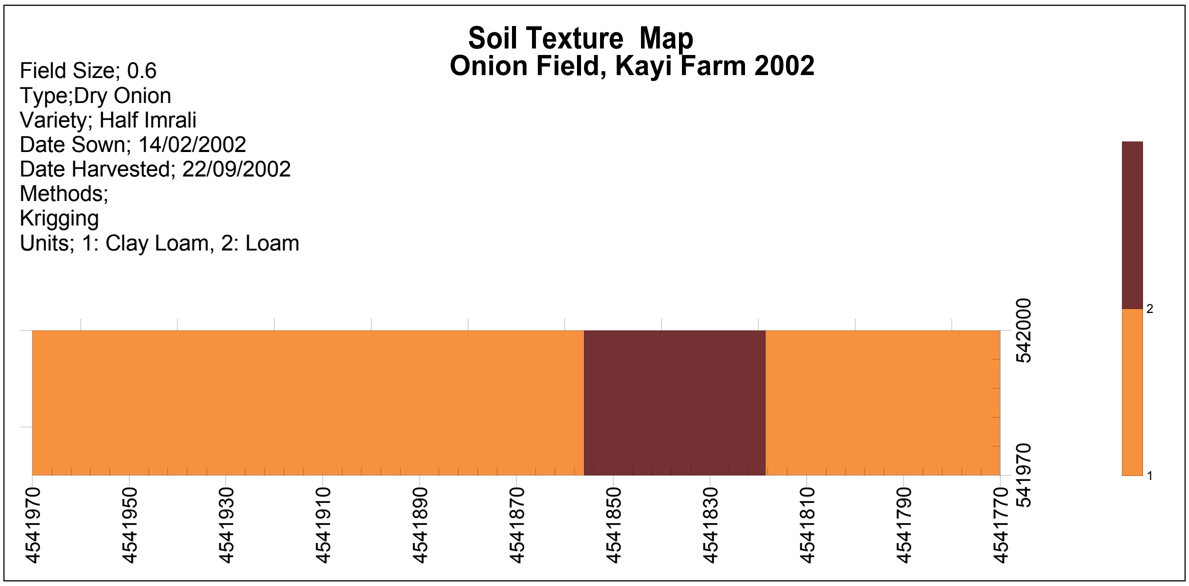

Figure 2. Texture map

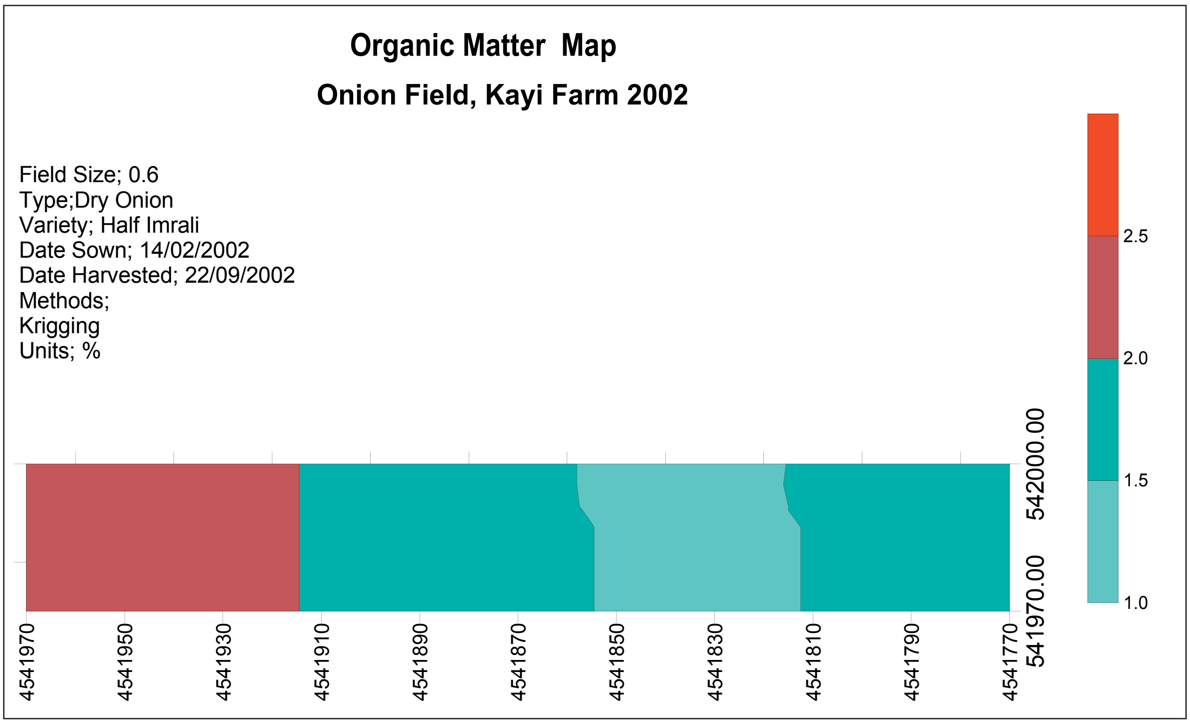

Figure 3. Organic matter map

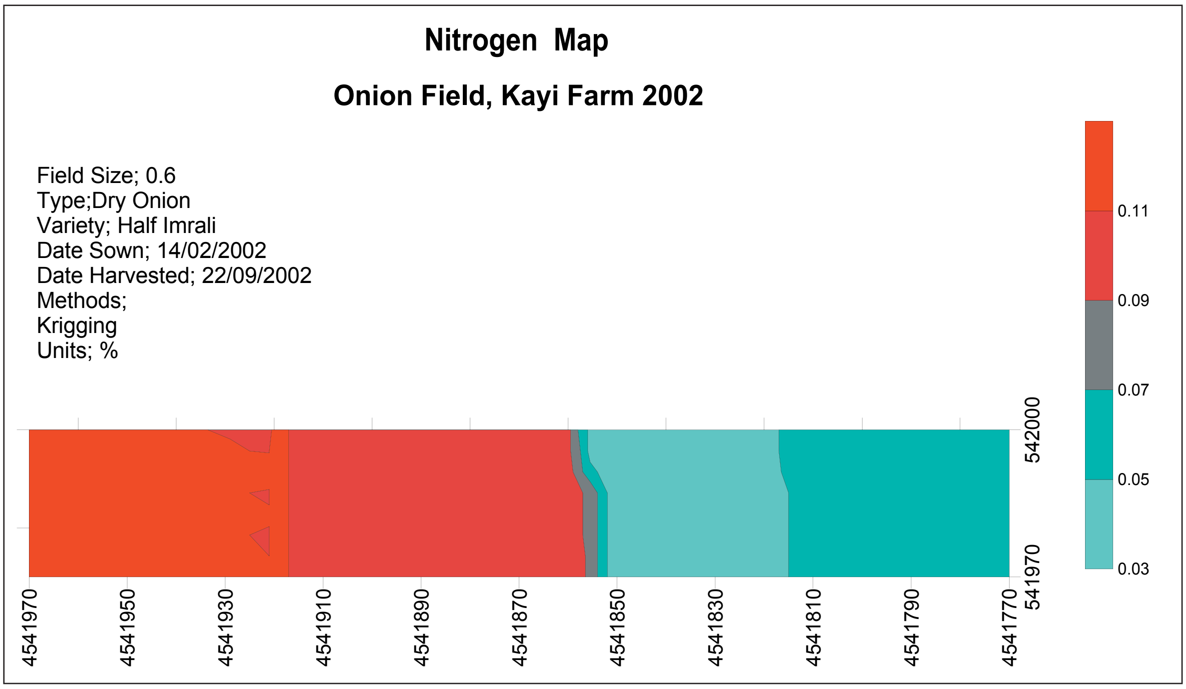

Figure 4. Total nitrogen map

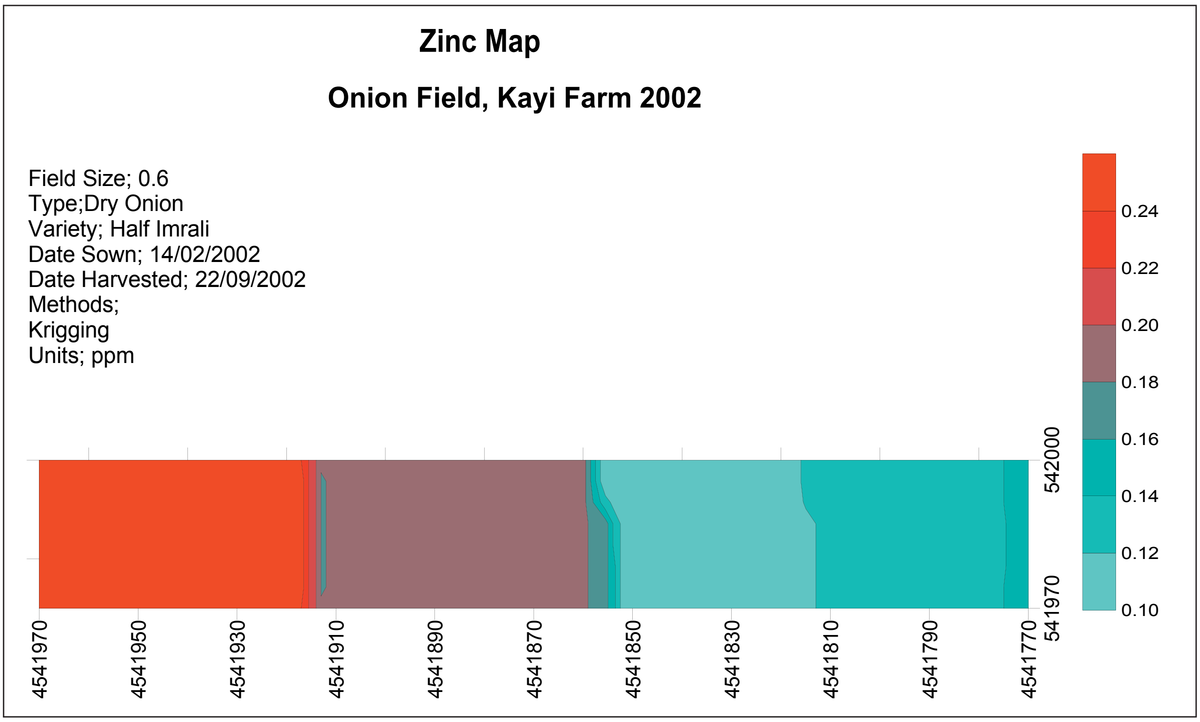

Figure 5. Zn map

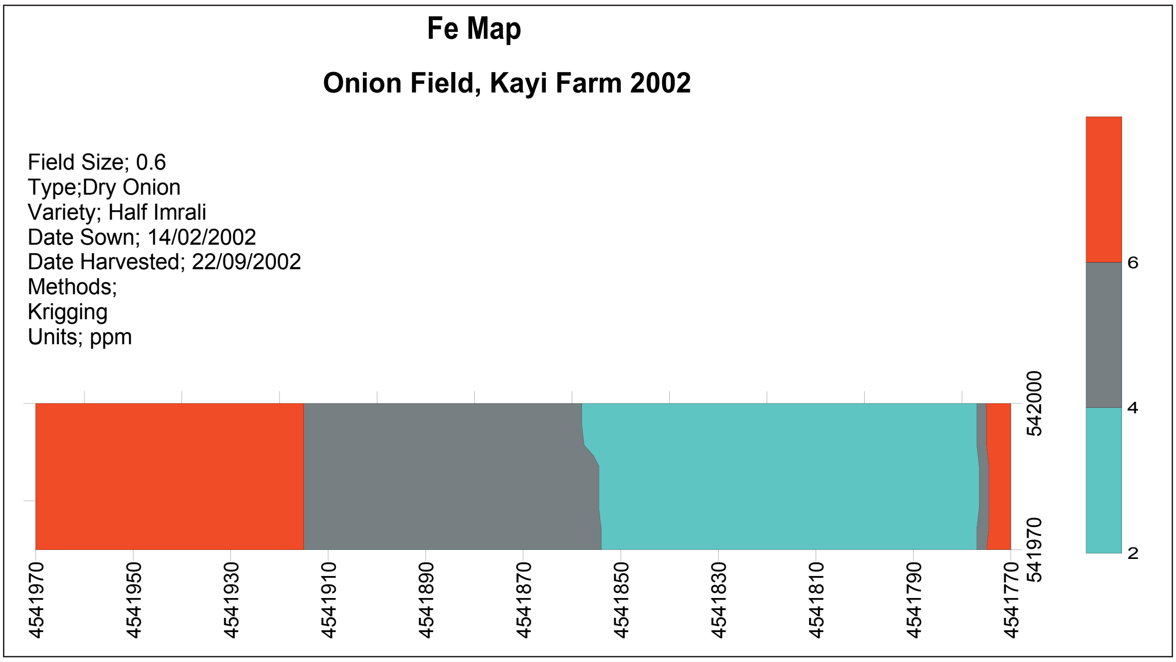

Figure 6. Fe map

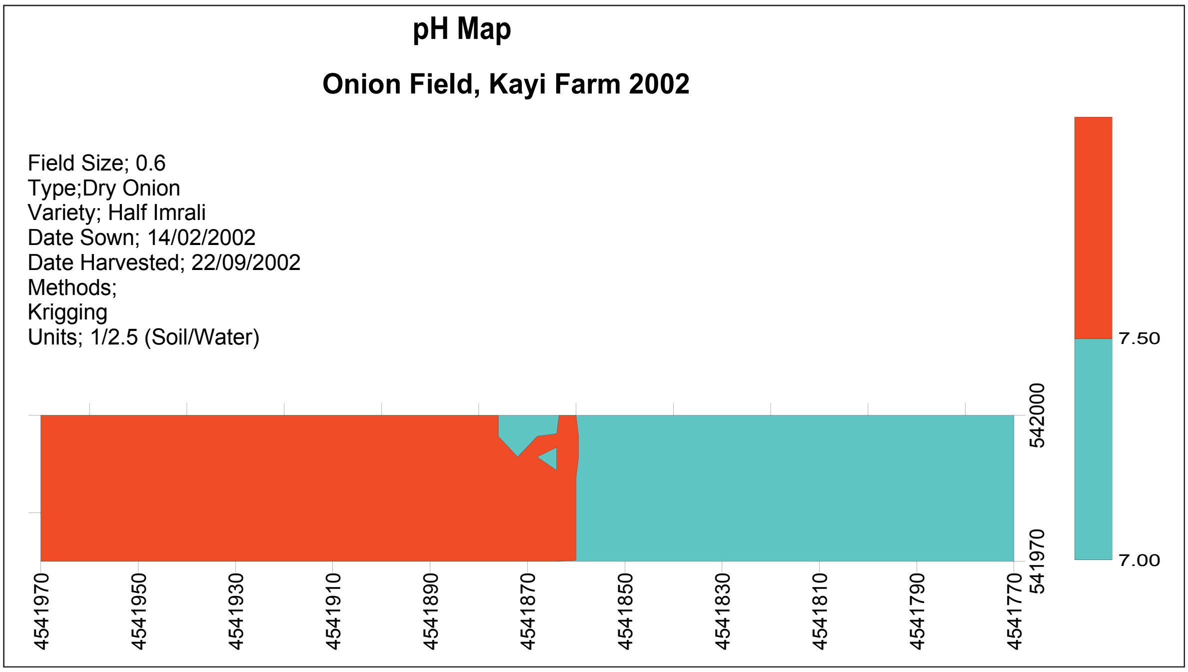

Figure 7. pH map

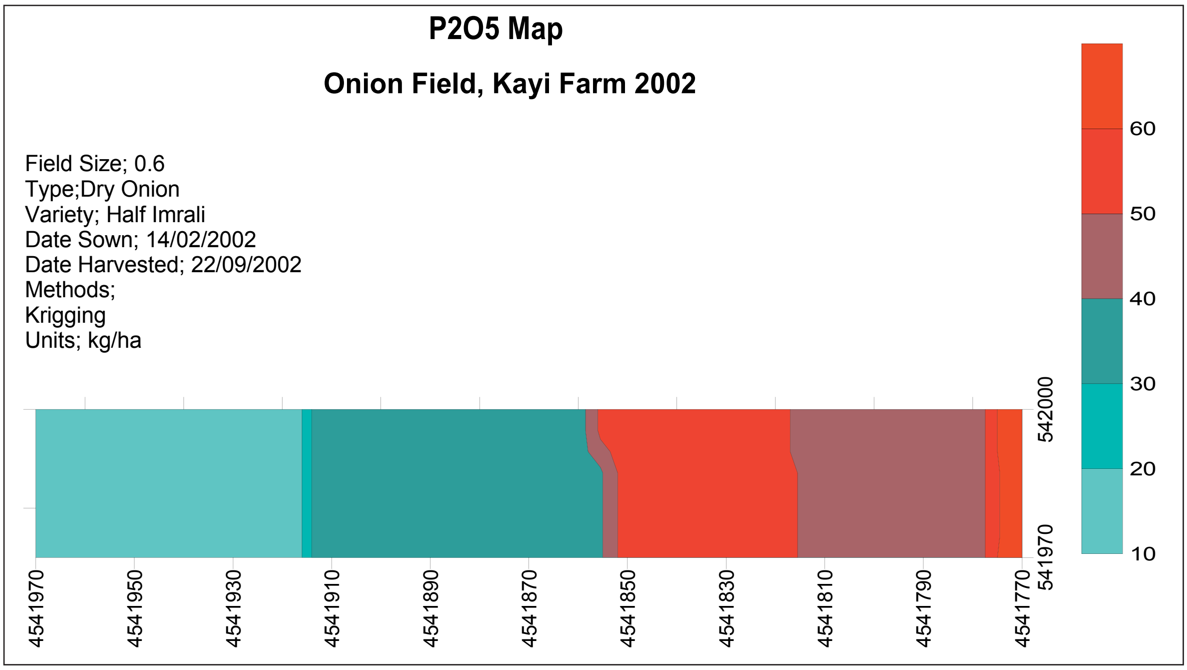

Figure 8. P2O5 map

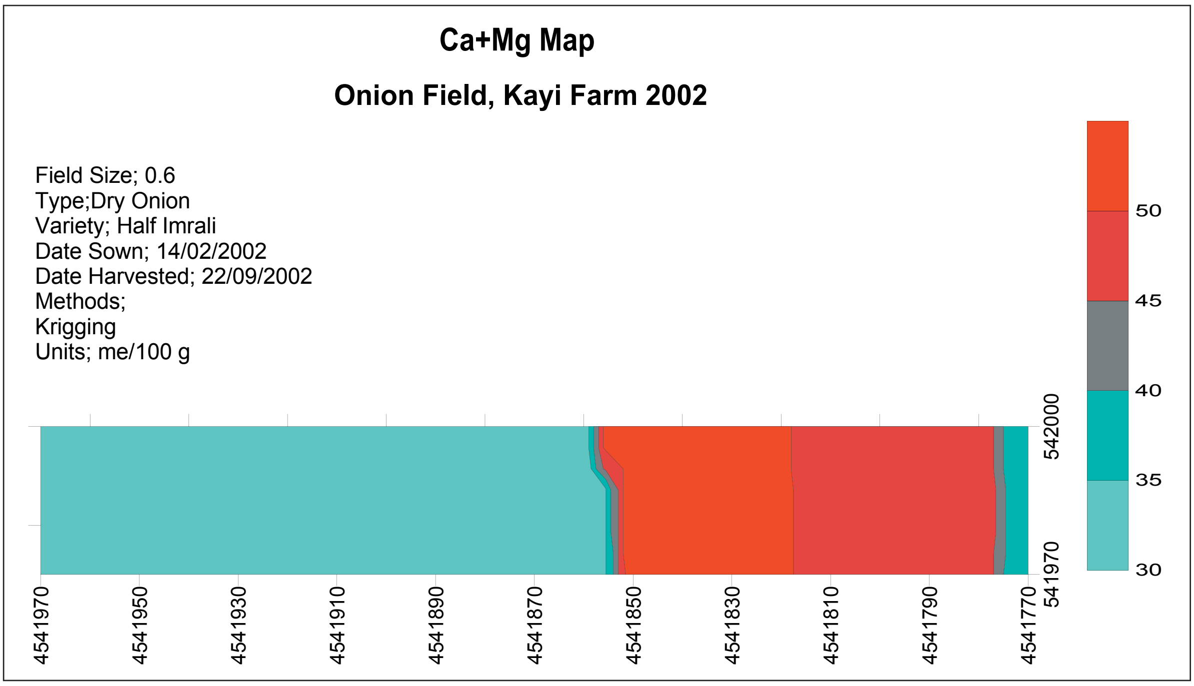

Figure 9. Ca+Mg map

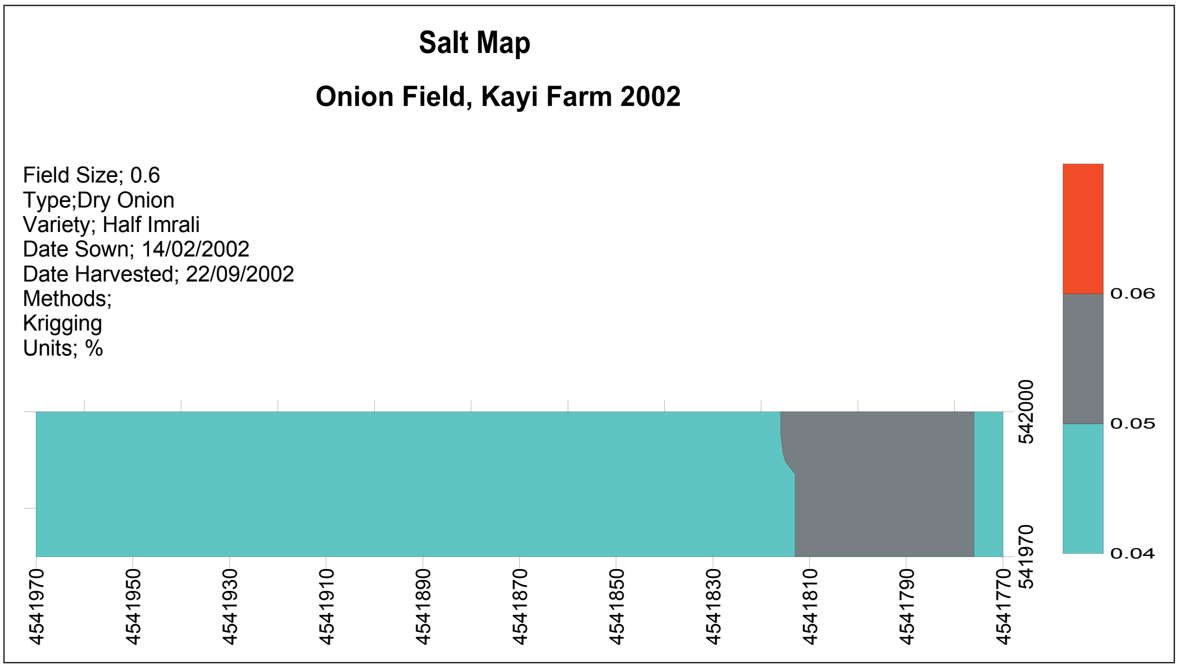

Figure 10. Salt map

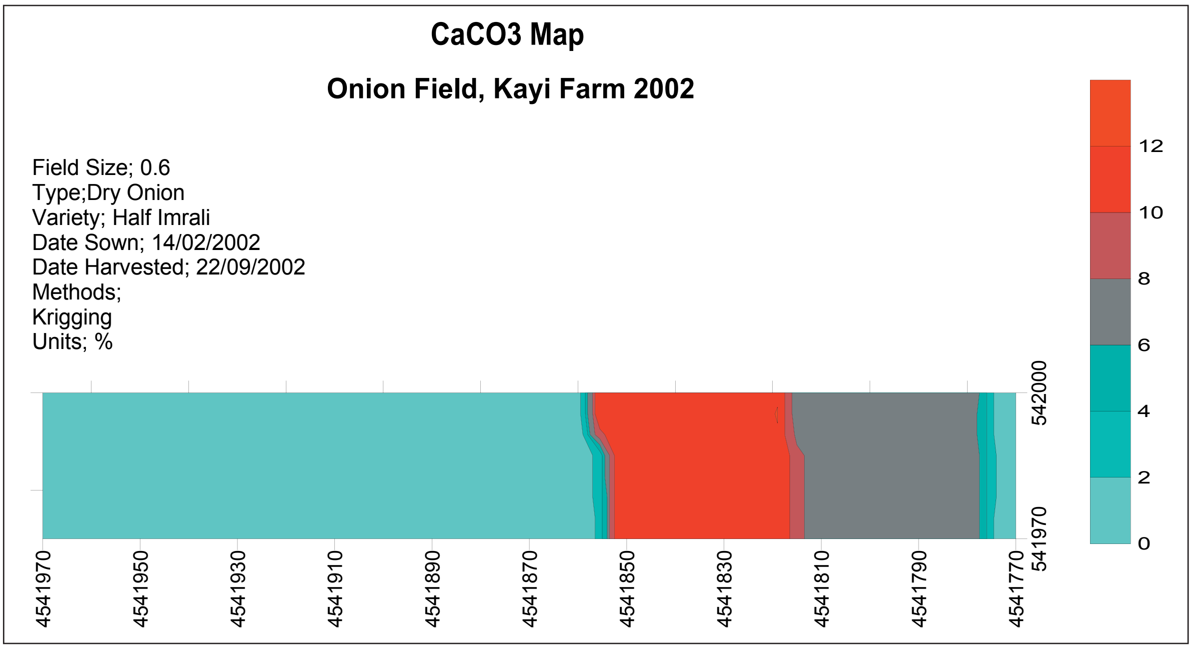

Figure 11. CaCO3 map

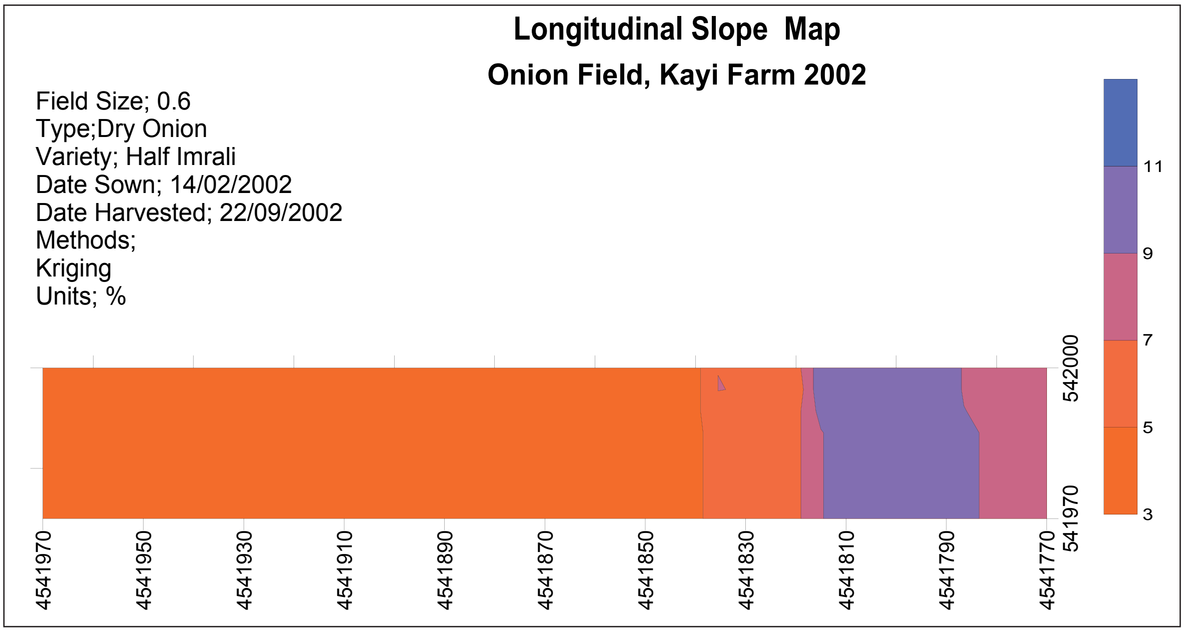

Figure 12. Longitudinal slope map

all soils were determined as “without salt class” [22].

According to the results, 50% of the research field was evaluated as low level lime, other parts of the field was evaluated as medium level lime according to the Ulgen and Yurtsever [23] (Figure 11).

Longitudinal slope of the field varied between 2% and 20% (Figure 12). There is not big changing for yield although big changing for longitudinal slope in the research field. In the most part of the field, slope varied between 2 and 9 %. As a result of this variation of the slope, there was not effect on the yield.

Most percentage of the field soils was determined as clay-loam. Small part of the field was loam. There is not big difference in the research field for soil texture. Both determined soil textures were located closely on the soil classification triangle [24]. Consequently, content of these two soils was quite same. There is no effect of the soil texture on the yield as shown figure 1, because both of the soil textures were suitable for the onion production in this research.

When investigate pH and yield map; it was determined that there was a negative relationship between yield and pH in this research field. Fertilisers with nitrogen should be applied as Ammonium sulphate instead of Ammonium nitrate applied in the field for decreasing pH.

Yield of dry onion decreased by increasing of Organic Matter, Total Nitrogen (N), Iron (Fe), and Zinc (Zn) in the field according to the related maps. The results were measured after harvesting of dry onions. The results showed that dry onions used these nutrients while growing season. Consequently, the yield was higher in this part of the field where amount of these nutrients was also small than that other parts of the field.

Relationship between yield and phosphorous, $CaCO_3$, Ca+Mg and salt was positive according to the related maps. Amount of phosphorous increased with increasing of longitudinal slope in the field. It can be seen that there is an obviously leaching of phosphorous in the field.

Especially, unconsciously and unnecessary fertilising practices cause economical losses and environmental pollution. Fertilisers with N and P should be applied with required technical solutions protected accumulation and leaching of nitrogen and phosphorous. Accumulation and leaching of nitrogen and phosphorous in the soil may prevent by using right and stable fertiliser applications. If fertilisation applies according to the soil-plant analyses, excessive fertiliser can be preventing. It is getting important application of fertilisers at desired amount for the right using of source, profitability, environmental pollution and health.

CONCLUSIONS

Turkey has big potential for the application of precision agriculture but it requires time to solve the problems such as education of farmers, implementation of pilot precision farming projects. If it is realised chemical use in the agriculture will be reduced and yield of agricultural products will be increased.

Precision farming applications generally require high technology but there are some opportunities such as creating yield map for tea, hazelnut, olive or dry onion production may apply in Turkey. Turkey has different mechanization levels for different products. Soil tillage, pesticide application, fertilisation, planting has been doing by agricultural machines. Some processes of products such as fruit, tea, dry onion harvesting etc. have been doing by hand. In that fields precision farming applications can be used. Farmer’s should be educated for sustainable agriculture and they can learn what does it means precision farming. They can start create their specific precision farming solutions.

REFERENCES

[1] Ulger P., Akdemir B., Arin S., Mechanized planting and harvesting of onion. agricultural mechanization in Asia. Africa and Latin America (AMA), Vol. 24, (1993) 4: 23-26.

[2] Akdemir B., Ulger P., Mechanisation problems of onion production in Turkey. Proceedings of Union Scientists-Rousse Second Conference Energy efficiency and agricultural engineering, Association of Agricultural Engineering in South-eastern Europe, Rousse, Bulgaria 3-5 June 2004, ISSN 131-9974 (2004) 168-175,

[3] Gokturk B., A Research on Determination of Dry Onion Properties Related With Harvesting, Developing Knife Type Onion Digger and Comparing With Another Harvesting Methods. Trakya University, Graduate School of natural and Applied Sciences, PhD Thesis, 1999.

[4] Schubert A.M., Trostle C., Porter D., Precision Agriculture Yield Mapping System For Peanuts On The Texas South Plains. Texas A&M University Agricultural Research &Extension Center Lubbock-Halfway-Pecos, 2002.

[5] Morgan M., Ess D., The precision farming guide for agriculturists. ISBN 0-86691-245-2, Deere and Company, (1997) IL:29,31,42.

[6] Blackmore S., Yield Mapping (b) (Article on University Homepage). Centre for Precision Farming, Cranfield University, England, 1999.

[7] Anonymous, Climatic Data of Tekirdag Province. Turkish State Meteorological Service, Directorship of

Tekirdag, 2005.

[8] Cangir C. and Boyraz D. Out of Purpose Land Use in Thrace Region and Classification of Land. I. Thrace Soil and Fertilizer Symposium, 20-22 October 1997, (1997), 19-28.

[9] Belliturk K. and Saglam M.T. A Research on the Urea Hydrolysis Rate in the Soil of Turkey, Pakistan Journal of Biological Science 8(3), (2005), 446-449.

[10] Saglam M.T., Chemical Analysis Methods of Soil and Water. T.U. Tekirdag Agricultural Faculty. Publication No:189, Book No: 5, Tekirdag:154, 2001.

[11] Tuzuner A., Analysis Soil and Water-Laboratory Handbook. Republic of Turkey General Directorate of Rural Services, Ankara, 1990.

[12] Kacar B., Chemical Analyses of Soil and Plant. III, Ankara University Agricultural Faculty Education, Research and Development Fund, Publication No. 3, Ankara, 1995.

[13] Yuksel A.N., Albut S., Measuring. Thrace Univ. Agricultural Faculty Farm Structure and Irrigation Department Publication Number112, Tekirdag, 1998.

[14] Blackmore S., Marshall B.C.J., Yield mapping; Errors and algorithms. The Centre for Precision Farming, School of Agriculture Food and Environment, Cranfield University, Silsoe, Bedford, MK45 4DT, England, (1996).

[15] Blackmore S. (a), Yield Map Primer. Silsoe College, Cranfield University, Silsoe Bedford, MK45 DT, England, (1999).

[16] Akdemir B., Blackmore S., A methodology for production of yield mapping. Journal of Agricultural Sciences, ISBN, 1300-7580, (2004) 10 (1): 38-44.

[17] Allen D.M., Timbrell D., Onions. Ministry of Agriculture and Food. Ontario, Canada: 27, 1987.

[18] Eyuboglu F., Situation of Turkey Soils Fertility, Republic of Turkey General Directorate of Rural Services Institute of Soil and Fertiliser Research . Technical Publication No::T-67, General Publication No::220, Ankara, Turkey, 1999.

[19] Kemmler G., Hobt H., Fertilisers (K+S), FRG, Kassel, Germany, (1984) 54-55.

[20] Viets F.G., Lindsay W.L. Testing soil for zinc, copper, manganese, and iron. Soil testing and plant analysis (Editor: L. M. Walls and J. D. Beaten) Soil Sci. Soc. Of America, Inc. Madison, Wisconsin, USA, 1978.

[21] Olsen S.R., Dean L.A., Phosphorus methods and soil analysis. Part 2. Chemical and microbiological properties (Editor: C. A. Black) Amer. Soc. Of Agronomy, Inc. Madison, Wisconsin, USA, 1965.

[22] U. S. Soil Survey Staff, Soil survey manual. Agric. Research Administration. U.S. Dept. Agriculture. Handbook no:18, U.S. Govt. Print Office, Washington D.C., 1951.

[23] Ulgen N., Yurtsever N., Guide of Turkey Fertiliser and Fertilisation, 4th edition, . Institute of Soil and Fertiliser Research . General Publication No: 209, Technical Publication No:T-66, Ankara, 1995.

[24] Saglam M. T., Bahtiyar M., Cangir C., Tok H.H., Soil Science. Anadolu Press, Tekirdag. 230-233, 1993.