ULAS SENYIGIT

THE EFFECTS OF DIFFERENT IRRIGATION METHODS AND DIFFERENT NITROGEN DOSES AND FORMS ON THE YIELD AND QUALITY OF WATER-MELON

ACADEMIC YEAR 1997 - 1998

CENTRE INTERNATIONAL DE
HAUTES ETUDES AGRONOMIQUES
MEDITERRANEENNES

INTERNATIONAL CENTRE
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AGRONOMIC STUDIES

INSTITUT AGRONOMIQUE MEDITERRANEEN DE BARI

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DISSERTATION

THE EFFECTS OF DIFFERENT IRRIGATION METHODS AND NITROGEN DOSES AND FORMS ON THE YIELD AND QUALITY OF WATERMELON

Submitted by

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In Partial fulfilment of the requirements for the
MASTER OF SCIENCE

in

IRRIGATION

International Center for Advanced Mediterranean Agronomic Studies
Bari-Italy

Academic Year 1998-1999

International Center For Advanced Mediterranean Agronomic Studies

Bari – Italy

16 October, 1998

We hereby recommend that the dissertation prepared under our supervision by Ulas SENYIGIT, entitled *The Effects of Different Irrigation Methods and Nitrogen Doses and Forms on the Yield and Quality of Watermelon* be accepted as partial fulfilment of the requirements for the Degree of Master of Science.

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I dedicated this work to my father, my mother and my two sisters.

ACKNOWLEDGEMENTS

I wish to present my deepest thanks and appreciation to my advisers Prof. Dr. Riza KANBER and Prof. Dr. Atef HAMDY for their help and guidance throughout the definition and development of the subject and the structure of this study, and for their instructions about research methods.

I am also greatful to the «Instituto Agronomico Mediterraneo» (IAM-B), for granting me the scholarship. This acknowledgements is also extended to all the IAM-B staff, with special mention to the director Dr. Cosimo Laciricnola.

I am sincerely thankful to the staff and colleagues of the Irrigation and Agricultural Structures Department of Agricultural Faculty, Cukurova Universty, especially Mustafa Unlu and Metin Sezen.

I also wish to express my deep gratitute to Assistant Prof. Harun Köksal and Dr. Kenan Diker for their great encouragement.

During the preparation of this study there have been many people who, directly or indirectly, have contributed to the completion of this study. I want to take opportunity of thanking them all, in particular, Berkant, Selcuk,Alexandra and Ozlem.

Finally, I want to express special thanks to my parents for their continuous support and affection.

Thank you.

Ulas Senyigit

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SUMMARY

Different irrigation methods (S: Sprinkler; D: Drip), nitrogen forms (L: Liquid; G: Granule) with various amounts (based on applied line source sprinkler, N_1; N_2; N_3 kg/da) and two varieties of watermelon (P: Paladin; M: Madera) were studied. The research was carried out at Research and Production Farm of Agricultural Faculty, Cukurova University during 1996 and 1997 growing season. Experimental design was strip for the first year and split-strip for the second year.

Generally, plants were irrigated with 5-12 day intervals. Free water surface evaporation was used to determine irrigation water amount. Irrigation water in the plot irrigated by drip irrigation was estimated based on irrigating 70% of the soil, as volume base that were used. In only SL and SGL treatments, three different nitrogen levels were formed providing gradient situation during the irrigation season.

Based on the results, the most irrigation water amount was applied in the middle of June when the fastest growth was observed. Irrigation water amounts applied to the treatments ranged from 119.2 mm (first year) to 350.5 mm (second year). Irrigation water reduced by 14-29%. Nitrogen applications ranged from 5.1 kg/da (SL) to 10 kg/da (SG) in the treatments. Nitrogen saving reached up to 50%.

Total yield changed between 1325 kg/da (first year) and 5013 kg/da (second year) depending on year and treatments. Although the highest yield was obtained from treatments where liquid fertilizers were applied for both of the varieties in the first year of the experiment, response of varieties to nitrogen form and amounts was found different in the second year. The highest yield was obtained from SG treatments in Paladin variety. The yield decreased only by 12% in SL treatments where nitrogen was applied in liquid form. In Madera variety, the highest yield was taken from SGL treatments where granule and liquid fertilizer were applied together.

Average water use and total water use efficiencies ranged from 6.91 to 12.95 kg/da/mm and from 4.46 to 9.54 kg/da/mm respectively. Water use efficiencies under drip irrigation were higher than under sprinkler irrigation by 33% and 25% for Paladin and Madera varieties, respectively. In the same way, it was found that, the values of Madera produced 17% more than Paladin under sprinkler irrigation. Yield response factor (Ky) was 1.07 for total yield and 1.49 for marketable yield.

It was understood that the effects of irrigation methods and nitrogen levels on some quality parameters of watermelon were not important. But, fruit diameter of Madera was larger than Paladin variety. The longest fruit length was measured in Paladin-DL treatment.

As a result, it was determined that watermelon yield was increased by nitrogen which was applied through irrigation water. Therefore, it could be said that watermelon yield increased considerably with applying nitrogen together with irrigation water in each irrigation.

KEY WORDS: Watermelon, WUE, irrigation, fertigation, ET.

RESUME

On a étudié différentes méthodes d'irrigation (S: Aspersion; D: goutte à goutte), différentes formes d'azote (L: liquide; G: granulaire) en quantités différentes (basées sur l'asperseur en ligne N1, N2, N3 kg/da) et deux variétés de melon d'eau (P: Paladin; M: Madera). La recherche a été menée dans l'exploitation de Recherche et Production de la Faculté d' Agronomie de l'Université Cukurova au cours de le saison 1996 et 1997. Le plan expérimental était la bande pour la première année et les bandes subdivisées pour la deuxième année.

En général, les plantes ont été irriguées avec des intervalles de 5-12 jours. On a utilisé l'évaporation de la surface libre de l'eau pour déterminer la quantité d'eau d'irrigation. Cette dernière dans la parcelle irriguée par le goutte à goutte a été estimée, se basant sur l'irrigation de 70% du sol, comme base de volume utilisé, seulement dans les traitements SL et SGL, on a formé trois différents niveaux d'azote pour créer des conditions graduelles au cours de la saison d'irrigation.

Sur la base des résultats, la plupart des eaux d'irrigation a été appliquée à mi-juin lorsqu'on a observé la croissance la plus rapide. Les quantités d'eau d'irrigation appliquées aux traitements ont été de 119.2 mm (première année) et 350.5 mm (deuxième année). L'eau d'irrigation s'est réduite de 14-29%. Les applications d'azote varient de 5.1 kg /da (SL) à 10kg /da (SG) dans les traitements, l'économie d'azote atteint 50%.

Le rendement total a été de 1325 kg/da (première année) et de 5013 kg/da (deuxième année) selon l'année et les traitements. Même si le rendement le plus élevé a été obtenu dans les traitements où on a appliqué les engrais liquides pour les deux variétés pendant la première année de l'essai, la réponse des variétés à la forme et aux quantités d'azote a été différentes au cours de la deuxième année. Le rendement le plus élevé a été obtenu dans les traitements SG dans la variété Paladin. Le rendement a baissé de 12% seulement dans les traitements SL où l'azote était appliqué sous la forme liquide. Dans la variété Madera, le rendement le plus élevé a été obtenu dans les traitements SGL auxquels on avait appliqué l'engrais granulaire et liquide ensemble.

L'efficience d'utilisation de l'eau totale variant de 6.91 à12.95 kg/da/mm et de 4.46 à 9.54 kg/da/mm respectivement. Les valeurs d'efficience d'utilisation de l'eau dans le goutte à goutte étaient suffisantes par rapport à l'aspersion respectivement 33% et 25% pour les variétés Paladin et Madera. De même, on a trouvé que Madera a produit 17% de plus par rapport à Paladin dans l'asperseur. Le facteur de réponse du rendement (Ky) a été de 1.07 pour la production totale et de 1.49 pour la production vendable .

Il est évident que les effets des méthodes d'irrigation et des niveaux d'azote sur certains paramètres qualitatifs du melon d'eau n'ont pas été importants. Mais le diamètre des fruits de la variété Madera était plus grand par rapport à la variété Paladin. La longueur des fruits maximale a été mesurée dans le traitement Paladin - DL.

Par conséquent, on a conclu que la production de melon d'eau a été augmentée par l'azote qui a été appliquée à travers l'eau d'irrigation, on peut dire donc, que le rendement du melon d'eau a augmenté d'une manière importante lorsqu'on appliqué l'azote et l'eau d'irrigation ensemble à chaque arrosage.

Mots-clés: Melon d'eau, WUE (efficience d'utilisation de l'eau), Irrigation, Irrigation fertilisante, ET.

INTRODUCTION

Watermelon production is being taken very important place in the world agriculture for vegetable yield. There is production capacity about 29.7 million tones and 1.8 million ha planting area in the world. Turkey is the second largest watermelon producer because of 3.5 million tone yield and 120 000 ha planting area (FAO, 1995).

Watermelon became an important summer plant in Turkey because of its marketability and the high demand. In the last decade, watermelon growth in both under plastic cover and field conditions increased because it can be easily grown everywhere and it has high income rate per unit area (DIE, 1992).

Adequate irrigation water supply is of vital importance to reach high yield level because of high growth rate and short growing period (DESAI and PATIL, 1984). But, since the watermelon is planted in the rows quite apart from each other, a part of the irrigation water gets lost in the early growth stages if water is applied by traditional surface irrigation systems. On the other hand, watermelon plant is grown crawling on the soil surface. Use of traditional surface irrigation methods in the late growing season result in development of some fungal disease, branch and leaf decay and physical suffer from irrigation workers, consequently large yield losses may occur (SRINIVAS et al., 1989a). Increasing demand to irrigation water and decrease in the income by decreasing yield loss made. Selection of irrigation methods takes an importance role due to the water and yield economy.

Some problems are faced in the growing season related to application of plant nutrients because of growth manner of watermelon. Many problems which could be very difficult overcome are faced in the process of mixing fertilizer to the soil besides physical damage of plants during the applications.

Problems related to both irrigation and fertilization can be solved using pressurised irrigation systems such as drip and mini-sprinkler can provide frequent irrigation and apply plant nutrients through the irrigation system. Recently, watermelon producers already have started to widely use drip and sprinkler systems together with liquid fertilizer. This approach is defined as "fertigation". The techniques look quite hopeful to use for plants such as watermelon which have a lot of problem with irrigation and fertilization. However, some problems may occur when these systems are not properly designed and managed.

The purpose of this study was to determine effects of applying granule and liquid fertilizer through drip and sprinkler irrigation systems on the yield, water use and fruit quality of watermelon. In addition, application properties of liquid fertilizer that is used by different irrigation systems will be tried to learn. At the same time, drip and sprinkler systems which are used for irrigation of watermelon with granule and liquid fertilizer will also be compared to each other in this study.

1. LITERATURE REVIEW

Vegetables have very important place in human nourishment. They are different group of herbaceous and they are used to eat. Most of them are perennial plants. Their part as root, hypocodils, stem, lump, leaf, flower, unripe, ripe fruits were consumed. At least 30 different species in a dozen plant families are accepted as vegetable. But, these numbers increase a few times if different species, ethnic and exotic plants are considered (STANLEY and MAYNARD, 1990). The plants constitute basic source for nutrients and vitamins. For this reason, vegetables are assumed very important nourishment source to increase quality of foods because of their tastes, colors and structures (KARATAS and SEN, 1995). Watermelon used in this experiment is a good appetizer and cool summer plant. It consist of sugar (5-8%), B and C vitamins, protein, fat and Ca that is one of mineral salts (GUNAY, 1993).

In reality, vegetables are grown widely with commercial purposes and they are very profitable plants. But, there are many differences in the yield quality and quantity among the regions. These differences appear from some factors such as climate, soil productivity, labour and water amount. The factors change more depending on the irrigation and fertilization practices. Watermelon is a hot climate plant. It feels indisposed from cold, excessive hot and dry weather. Average daily temperature, minimum and maximum temperature should be 22-30 °C, 35 and 18 °C, respectively, to grow well of the plant (DOORENBOS and KASSAM, 1979; GUNAY, 1993).

Watermelon is grown better in medium-course textured, neutral soils with approximately 1.0 m of water table (BAYRAKTAR, 1981). It adapts better to light acidic soils than other vegetable species. Lime should be applied when pH is around 5.0 (GUNAY, 1993). In heavy texture soils, growth slows down and some cracks may appear on the fruits (DOORENBOS and KASSAM, 1979).

Irrigation is a vital agricultural practice for all vegetable species that need water in arid and semi-arid regions. In humid regions, yield is insured with supplemental irrigation against irregular rainfall distribution. In any case, response of vegetable crop to irrigation must be well known and understood for a successfully commercial production Relationship between irrigation and vegetable growth are effected by many factors such as growth stages and economical importance of harvested organ. The harvested parts of vegetable are unripe flowers, stem, lumps, leaves, roots, seeds and fruits. Most of vegetables can be irrigated until market maturity. Any water deficiency can be prevented with irrigation during the development of harvested organs. Therefore, probable market maturity time was given for each species in many books on vegetable production (LORENZ and MAYNARD, 1980). For example, watermelon is harvested for its fruits and seeds. Researchers determined that the growing season was 75 days for early varieties; 95 days for late varieties of watermelon. Corresponding number in Turkey is 80-100 days (SENER et al., 1995). Distribution and development of vegetable roots are other factors effecting irrigation. Knowing root distribution and development of vegetables can play very important role in scheduling irrigation programs. Irrigation method, water amount and application type affect mentioned factors above. STANLEY AND MAYNARD (1990), which have classified vegetables based on the root depth showed that watermelon with more than 121 cm root depth was put in the deep root class.

Water consumption of watermelon is effected by many factors as much as other vegetables. These can be listed as plant, soil, cultural and environmental factors (JENSEN et al., 1990). It is difficult to give a general ET value for watermelon because it grows under environmental and cultural conditions which varies in very wide range (STANLEY and MAYNARD, 1990). However, DOORENBOS and KASSAM (1979) gathered that the some results showed the annual irrigation water requirement of watermelon varied 400 and 600 mm and the crop coefficient which is the ratio between the actual and potential ET values, for maximum yield ranged from 0.4 to 1.05 based on the growth stages, and from 0.75 to 0.85 for whole season. In Israel, the water consumption, initial and seasonal crop coefficients of watermelon were 481mm, 0.27 and 1.01, respectively (GHAWI et al., 1989).

In Turkey, different results were obtained based on the irrigation scheduling used and region where the studies were conducted. GUNDUZ and KARA (1996) found the annual irrigation water requirement for watermelon was 480 mm; and ET was 560 mm under Harran conditions. CETIN and NACAR (1997) used sub-surface irrigation method in the same region. Also, they reported that irrigation water requirement for watermelon varied between 0 and 563 mm for watermelon depending on the irrigation scheduling. On the other hand, in a study by EYLEN and TOK (1988), the annual irrigation water requirement and ET of watermelon that is irrigated with mini sprinkler system for Tarsus region were found to be 135 mm and 226 mm, respectively. But, these values are very low for Tarsus. SEZGIN et al. (1997) tested different planting time and irrigation interval for watermelon under Aegean Sea conditions. They observed that ET of watermelon varied between 247 and 417 mm.

In watermelon irrigation, researchers used different approaches to establish the irrigation scheduling for getting the maximum watermelon yield. Some researchers stated that pan evaporation can be used to determine the irrigation water amount and irrigation time. SRINIVAS et al. (1989b) found that maximum fruit and dry matter yield, sugar and total soluble solids amounts were taken from irrigation program is completed in rate of 100% of evaporation. Also, in the mentioned program, the uptake of NO_3-N, N, P, K and Ca and water use efficiency were at maximum levels. YADAV and MANGAL (1984) reported that maximum yield was received when 90% of free water surface evaporation was given as irrigation water; whereas GUNDUZ and KARA (1996) applied 60% of evaporation, and 40%, CETIN and NACAR (1997); 31%, EYLEN and TOK (1988). In the same way, YADAV et al. (1989) tried 4 irrigation levels which are planned according to cumulative pan evaporation and they obtained the maximum yield with frequent irrigations performed in cumulative pan values of 83 mm. SRINIVAS et al. (1989b) obtained that the maximum yield from the treatment in which irrigation water was applied as much as 100% daily evaporation value. There is no any agreement among the researchers on irrigation intervals. Some researchers mentioned that watermelon should be irrigated with frequent interval. For example, CETIN and NACAR (1997) pointed out that it was necessary to irrigate watermelon frequently, even daily. SEZGIN et al. (1997) indicated that watermelon could be irrigated with a weekly interval and this application would have positive effect on fruit numbers, average fruit weight, fruit diameter, fruit length and peal thickness of watermelon, however, had no effect on pH and total solublesolids. GUNDUZ et al. (1997) suggested that irrigation should be practice twice a month. DOORENBOS and KASSAM (1979) determined that 8-10 day irrigation interval were enough to take optimum yield in watermelon. A research was done in California, which could be considered first irrigation study (VITTUM and FLOCKER, 1967). Researchers indicated that there was no difference between the yield with 7 times irrigated and the yield unirrigated of watermelon. It depends on deep root, sufficient moisture remaining from winter and long growing period.

Different methods are used to irrigate watermelon. Generally, pressured irrigation systems are preferred due to watermelon grown as crawl on the ground surface. ELMSTROM et al. (1981) compared that drip irrigation and sprinkler irrigation methods based on their effect on watermelon yield in two different region of Florida. They found, there is no any statistical difference on the yield between methods which are used in the soil with high water holding capacity; on the other hand, yield was increased by both methods on the deep-sandy soil. Also, 40% of irrigation water are saved with drip irrigation method. EYLEN and TOK (1988) observed that watermelon yield is increased 33% with sprinkler irrigation, drip irrigation influences on quality of watermelon increasing rates of total solublesolids and sugar and decreasing acid amount in water. Drip irrigation was suggested by SRINIVAS et al. (1989b and 1991) and EL-BEHEIDI et al. (1990) because of high water use efficiency and less use of plant nutrient matter. Furrow irrigation is suggested by GUNDUZ and KARA (1996). CETIN and NACAR (1997) reported that sub-surface irrigation method should be used for irrigation of watermelon with suitable planning and management conditions. STANLEY and MAYNARD (1990) notified that in the Florida in USA where watermelon is grown widely, sprinkler irrigation for sandy loam soil, sub-surface irrigation for acidic-flat area, and also furrow methods are used for arid and semi arid regions of west Florida are used for irrigation of watermelon. GOLDBERG et al. (1971) concluded that decreasing the yield of watermelon in furrow irrigation can be caused by using long irrigation interval and the change of soil water potential in the wide ranges.

Some researchers defend that irrigation schedules should be arranged according to growing periods of watermelon because the yield amount and quality vary with irrigations events applied in growing period. In the early sowing of watermelon, irrigations applied before flowering are not influence on the yield; whereas in the late sowing, irrigations either before sowing or in the vegetative period increased both growth and crop development. However, the irrigations applied in flowering, growth and development of fruit stages increased yield, while over irrigations applied in maturity period caused to decrease of sugar content and taste of fruits and to increase of the fibrous, in addition to create of cracks and untidy shape of fruits (DOORENBOS and KASSAM, 1979; NICHOLS, 1989; SENER et al., 1995). On the other hand, growing periods in which plant is sensitive to water or very effected by the water deficiency were determined. It is understood from works done by ROBSON and JOHNSON (1985), the flowering and fruit formation periods are most sensitive to water deficit. STANLEY and MAYNARD (1990) indicated that consumption 50% of available water in the 1.5 m deep of soil cause to appear some symptoms on the watermelon related to water deficit. They also explained that water deficit in the fruit formation period delayed the harvest time and reasoned to appear some important fluctuation on the yield. Water deficit in the vegetative period caused to become small leaf area and decrease yield. It is determined that the most decreasing in the watermelon yield is caused by water deficit in the pollination period.

Special practices are done for vegetable production, which are not applied to other plant species. These consist some approaches such as seedling instead of directly sowing, planting on the ridge, using the soil mulch, application of different plant density, multiple sowing and binding to rods or embracing to framework of plants. The most of these practices differently influence on ET, water use efficiency, yield of watermelon compared to other plants. Many studies were done and published about watermelon related to this subject (VITTUM and FLOCKER, 1967; RUDICH et al., 1978; STANLEY and MAYNARD, 1990; CLARK and MAYNARD, 1992; GUNAY, 1993; AKINCI et al., 1995; SEZGIN et al., 1997).

As it is mentioned above, the most two components of vegetable production are irrigation and fertilization (ONDER et al., 1995). For example, irrigation protects the plant either to water stress occurred by water deficit or provides to take the plant nutrient elements in adequate and constant amounts. However, it is difficult to say that producers don't give to enough consideration to use those two inputs. The unorganised and insufficient irrigation causes to be small and split fruit and to develop a bitter taste of fruits (SENER et al., 1995); whereas, excessive irrigation decrease quality and yield and reason to appear fungus diseases. In the same way, use of insufficient nitrogen dose reasons yield losses; while excessive use of nitrogen causes to cumulation of nitrogen which effects on directly human health. It is known that nitrate (NO_3) taken more than a determined level from vegetable or other foods is reduced to form of nitrite (NO_2) and it causes to produce methemoglobinemia and nitzamine which reasons cancers (ACAR, 1978; PIERCE, 1987; AKTAS et al., 1993) and to poison specially the children (GUNAY, 1993).

Plant nutrient requirement of watermelon varies from region to region, according to irrigation method and program applied. DOORENBOS and KASSAM (1979) point out that 8.8-10 kg/da N, 2.5-6.0 kg/da P and 3.5-8.0 kg/da K required to take high yield from watermelon. PIER and DOERGE (1995) explained from their study in Nebraska in which the effects of nitrogen and water level on yield of watermelon was searched that the highest marketable yields were taken from 20-33.6 kg/da N and soil water tension of 6.0-7.2 kPa conditions. SRINIVAS et al. (1991) point out that maximum watermelon yield and higher water use efficiency were obtained with 12 kg nitrogen per decare. In a study which is done for determining the plant nutrient requirements in 8 different regions of China, maximum yields (30 t:/ha) were taken with 20.5 kg N, 6.3 kg P and 13.4 kg K per decare (XU and CHENG, 1989). EL-BEHEDI et al. (1990) reported that maximum watermelon yields were taken from 107 kg/da mix fertilizer contains 1:1:2 rate of N, P and K. However, the researchers suggested that fertilizer compounds are applied by 71 kg with drip, 107 kg with sprinkler and 143 kg with surface irrigation for high yield because these numbers change depending on the irrigation methods. YADAV et al. (1989) indicated, increasing nitrogen dozes (from 4 kg/da to 8 kg/da) increased the watermelon yield continuously and did not suggest any nitrogen doses. In the same way, HEGDE (1989) reported that the highest yield of watermelon are taken with frequent irrigation (-25kPa) and 18 kg/da nitrogen level (half amount were given during sowing; remaining amount 30 days later). In some studies that were conducted in the different regions of Turkey, EYLEN and TOK (1988) explained that application of 2-3 tone manure with 8 kg N and 6 kg P per decare for every year can be enough to take high yields; however, other researchers suggested 10 kg N and 10 kg P per decare (GUNDUZ and KARA, 1996; CETIN and NACAR, 1997). GUNAY (1993) indicated that it is necessary to consider fertilization important because of watermelon is grown on light soil texture. Nitrogen requirement increases in vegetative developing period, nitrogen together with phosphorus and potassium requirements increase after first flowering period. Requirement of nutrient reaches to maximum level during period in which fruits get to grow large. Generally, the researcher has advised that 4-6 tone manure with 10-15 kg N, 15-20 kg K and 10-15 kg P per decare for every year should be applied, also, similar results were given by SMITH (1991).

2. MATERIALS and METHODS

2.1. Materials

2.1.1. Site Description

The experiment was carried out at the Research and Application Farm of Faculty of Agriculture, University of Cukurova, during 1996 and 1997 growing season. The research area is in the north of Lower Seyhan Plain, in the east of the university campus. Located at latitute 36°59′ N, longitute 35°18′ E, altitude 20 m a.s.l.

2.1.2. Soil Characteristics

Soil in the test area is Mutlu soil series which is widely spread in Cukurova have flat level topography. The soils are old vertisols that is formed on the old deposits. The soil profile is deep. All profiles consist of clay in high rate. Lime content of soil is rich. Its color is dark reddish brown (ÖZBEK et al., 1974).

Some physical and chemical properties of soil used in the experiment are given in Table 2.1.

Table 2.1 Soil Physical and Chemical Characteristics

Soil layer cm	Clay %	Sand %	Silt %	Texture	F.C. g/g	P.W.P g/g	Salt %	pH	Lime %
0-30	32.62	37.72	29.66	CL	30.40	16.93	15.8	7.80	9.29
30-60	31.59	35.68	32.72	CL	29.50	15.07	11.7	7.90	23.42
60-90	29.48	37.87	32.65	CL	23.20	11.56	8.8	7.90	27.51

Also, phosphorus and potassium content in soil layer of first 30 cm were determined and P_2O_5 and K_2O amounts were obtained as 3.7 and 382.5 kg/da, respectively.

2.1.3. Climatic Characteristics

Some average climate variables for experimental area were given in Table 2.2. Mediterranean climate is prevailing in Cukurova Region with hot and dry summer and rainy and warm winter. The annual rainfall is about 646.8 mm that has not uniform distribution. Approximately 90% of precipitation are received in winter months. According to long-term observation, average relative humidity (RH), average wind speed and temperature are 66%, 2.0 m/s, and 18.9 °C, respectively. The highest and the lowest temperatures occurred 28.1°C in August and 9.9 °C in January, respectively.

2.1.4 Fertilizers Used in Experiment

Fertilizers are contain nitrogen, phosphorus and potassium were used in the experiment. Triple super phosphate source of phosphorus (46% P_2O_5), potassium sulfate (50% K_2O) and ammonium sulfate (21% N) were used as granule fertilizer sources. In addition to, as liquid nitrogen source, UAN (Nitrogen of Urea and Ammonium Nitrate) fertilizer (32-0-0) was employed during test period.

UAN, is a clear liquid fertilizer. It contains 320 g nitrogen in 1.0 kg or 410 g in 1.0 litre and another micro nutrients as E.D.T.A complex that is required by plants. It can be applied dissolving in water through drip and sprinkler systems in even surface irrigation systems. This mentioned fertilizer has 8 g nitrate nitrogen, 8 g ammonia nitrogen and 16 g urea nitrogen per 100 g (GUBRETAS, 1995).

2.1.5. Watermelon Varieties

In this study, Paladin - F_1 and Madera - F_1, hybrid watermelon varieties were used. Paladin which is the ellipse form is in the type of sweet Crimson. Maturation period of Paladin is about 95 days. Paladin has sweet taste and dark green color of peel. Fleshy part of the vegetable's color is dark red. Fibrous content is quite low and leaf volume is high. Average yield of 4 tone per decare may be taken under normal conditions (SAPEKSA, 1995).

Table 2.2 Average Climatic Variables for Experimental Area

YEAR	CLIMATE DATA	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1996	Min. Temperature °C	5.8	6,6	8,4	10,5	16,2	20,1	24,2	24	20,6	14,8	11,1	9,4
	Max Temperature °C	14,3	16,6	17,1	21,5	29,1	32,6	33,7	33,9	31,2	26,6	23,7	17,7
	Average Temperature °C	9,6	10,9	12,2	15,5	22,8	26,6	28,7	28,6	25,7	19,6	16,2	12,7
	Precipitation, mm	152,9	108,6	122,8	51,7	16,4	15,8	–	1,5	3,4	73,7	13,6	122,5
	Relative Humidity, %	70,4	69,3	78,1	74,8	73,8	66,6	77	75,2	71	71,3	67,2	76,8
	Evaporation,mm												
	Sunshine duration, sa	4	4,8	3,8	6,5	9,9	11,6	9,7	10,4	8,8	7,1	6,3	3,9
	Solar Rad Intensity,cal/cm²/gün	179,2	244,4	281,8	417,4	509,1	571,8	503,9	483,1	390,9	286,8	209,8	152,3
1997	Min. Temperature °C	5,4	3,1	4,9	9,3	16,3	19,9	23,8	22,5	18,5	15,9	11,5	7,4
	Max Temperature °C	16,2	14,4	16,6	19,5	29	31	33,8	31,6	31,4	26,6	22,3	7,4
	Average Temperature °C	9,2	8	10,2	14,2	22,6	25,5	28,7	26,6	24,4	20,2	15,4	10,7
	Precipitation, mm	38,2	67	19,4	104,4	20,1	11,4	0,9	6,2	12,6	89,7	107,3	177,8
	Relative Humidity, %	67,5	67,6	65,3	72,9	68,2	73,3	72,7	80,1	63,4	73	74,7	79,3
	Evaporation,mm	42,95	58,52	90,8	84,75	144,46	142,5	201,19	158,1	138,25	88,22	56,03	41,26
	Sunshine duration, sa	6	6	6,4	4,9	9,5	9,1	11,3	9,4	8,2	5,7	5,6	3,4
	Solar Rad Intensity,cal/cm²/gün	202,2	247,2	348,1	341,2	506,7	492	527,1	436,7	381,9	256,7	169,2	129,7
Long-term	Min. Temperature °C	-8,4	-6,6	-4,9	0,1	7,1	9,2	11,15	14,8	9,3	2,5	-4,3	-4,4
	Max Temperature °C	26,5	26,2	30,7	36,7	41,3	42,8	44	45,6	42,7	41,5	34,3	26,7
	Average Temperature °C	9,9	10,4	13,1	17,1	21,4	25,2	27,7	28,1	25,4	21	15,1	11,1
	Precipitation, mm	111,7	92,8	67,9	51,4	46,7	22,4	5,4	5,1	14,8	43,6	67,2	118,1
	Wind Speed, m/s	2,2	2,2	2,3	2,3	2,3	2,4	2,6	2,4	2	1,6	1,6	1,9
	Relative Humidity, %	66	66	66	69	67	66	68	67	63	60	63	66
	Evaporation,mm	47,3	56,1	84,9	119,7	170,5	210,1	243,4	224,6	181	120,8	66,3	47
	Sunshine duration, sa	4,5	4,3	6,1	7,5	9,3	11	11,2	11,1	9,3	7,4	6,1	4,4
	Solar Rad Intensity,cal/cm²/gün	168,3	220,7	316,7	394,9	462,7	494,7	495	456,3	389,1	277,1	194,7	142,5

Variety of Madera which is circular form is in also the sweet Crimson. Maturation period of Madera is about 80 days. It has very sweet taste and light green color of peel. Fleshy part of the vegetable's color is dark red. Fibrous situation is quite low and leaf volume is normal. Also average yield of 4 tone per decare may be taken in normal conditions (MAY, 1995).

2.1.6. Irrigation Water Supply

Irrigation water was provided from Lower Seyhan Irrigation Project system. Irrigation water was taken from a closed system with equipped a motor-pump was used to convey to the head of the field. Irrigation water is classified as C_2S_1 quality for irrigation (USSLS., 1954). Some chemical properties of irrigation water were given in Table 2.3.

Table 2.3 Analysis Results of Irrigation Water Used in Experiment.

Irr. Wat. Class	EC dS/m	pH	Cations (me/l)			Anions (me/l)				%Na	SAR
			Na	K	Ca+Mg	CO_3	HCO_3	Cl	SO_4		
C_2S_1	0.358	7.1	0.45	0.07	3.08	-	1.60	0.94	1.06	12.5	0.36

2.2. Methods

2.2.1. Soil Sampling

Disturbed and undisturbed soil samples were taken in order to determine some physical and chemical properties of the experimental soil. The disturbed soil samples were taken from each 30 cm layer of 90 cm profile depth using principles given by PETERSEN and CALVIN (1965), however, undisturbed samples were obtained from the open profiles of the experimental area. Physical and chemical characteristics of the soil related to irrigation were analysed by methods given by BOUYOUCOS (1951); CAGLAR (1949); USSLS, (1954).

2.2.2. Experimental Design and Treatments

The study was conducted in 1996 and 1997 years in organization as explained below. The strip plot design in the first year; and split-strip plot design in the second year with three replications were used in this study. In the experiment, watermelon varieties (V_1: Paladin; V_2: Madera), two irrigation methods (S: Sprinkler; D: Drip) and different nitrogen forms (G: Granule nitrogen; L: Liquid nitrogen), application types and levels (N_1; N_2 and N_3 kg/da) were considered. Experimental design and treatments used in this study is shown in Figure 2.1.

Sprinkler Irrigation Methods (S): The system was arranged in the form which has different water level in this study. For this reason, line source sprinkler irrigation technique was used. This system gives different irrigation water amount depending on distance from sprinkler line. The line source sprinkler irrigation technique produced a water application pattern which is the uniform along the lateral line, but, gradually decrease towards the border of the plot (HANKS et al., 1976). In the experiment, this system was utilised because of that both different irrigation and nitrogen levels were proved using properties of this system explained above. Planning and management of the system was made by the methods and principles given by HANKS et al. (1976); YAZAR (1988), and KANBER et al. (1994). For this aim, 30 m length lateral pipes were place on the plots. Full or half-turning sprinkler heads were placed with 6 m distance along the lateral line (Figure-2.2). Lateral distances were 12 m. Collecting cups were placed with 2 m distance between two laterals beginning 2 m from first line. In this way, three irrigation levels were created which varied from I_1 that is near the line in which plants received much water to I_3 that is the far from line in which plants have less water. In the same condition, different nitrogen levels were obtained which varied from the most, N_1, to the least, N_3. Pipes with 110 and 75 mm diameter were used as main and lateral line, respectively. They are made by PVC. The double nozzles of sprinkler heads were employed. Uniformity coefficients of the heads were determined using methods given by WILLARDSON et al. (1987). Sprinkler system was operated with 1.5 atm pressure during irrigation season.

Drip Irrigation Methods (D): Drip system used in the study is consist of control unit and pipe network. Mesh filter, pressure regulator, valves, manometer, and water-meter were located in the control unit. Laterals with 16 mm diameter are PE pipes. In line drippers were placed with 50 cm distance along the laterals (q: 4 l/h at 2 atm pressure). Drip irrigation plots contain 3 watermelon rows and one lateral employs each row (Figure-2.3). Laterals were 30 m length. Dripper flow rate tasted with volumetric methods during irrigation. Water amount collected in the cups having known volume was measured and its nitrogen content was determined. Drip irrigation method was used in the second year of the experiment.

Nitrogen Forms-Application Type: Granule Nitrogen (G); In this plots, all nitrogen used for watermelon were provided from a granule nitrogen source (21%, ammonium-sulfate). In this treatment, 1/3 part of total nitrogen were mixed with soil by hand as base fertilizer before sowing. Remaining 2/3 of total nitrogen were applied two times. One of them (1/3 N) was applied in branching period (12 June 1996; 9 June 1997) and the rest of 1/3 N was given when the first fruits have 3-4 cm diameter (25 June 1996; 23 June 1997) (ZUANG, 1982). In this treatment, 10 kg/da pure nitrogen was applied to the plots. Different nitrogen and water level were not formed. During the first year, equal water and nitrogen level were applied to the each point of plots. In the second year, gradient water level was created with line source sprinkler irrigation technique.

Nitrogen Forms-Application Types: Granule and Liquid Nitrogen (GL); A part of required total pure N of 10 kg/da was met by granule; another part of N was from liquid nitrogen sources. Three kg per decare N as pure matter which are provided from granule N source was given by hand before planting.

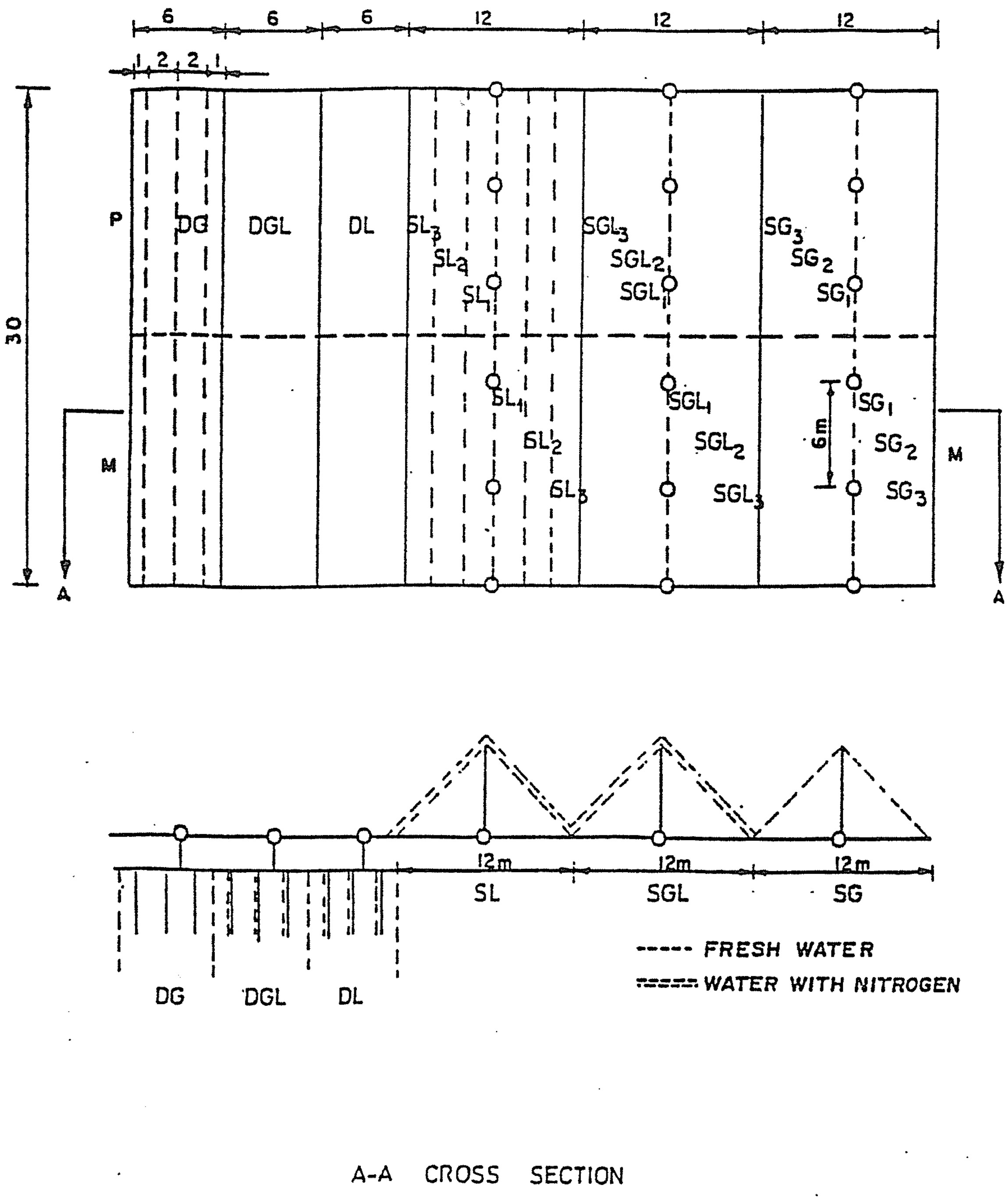


Figure 2.1 Scheme of experimental area for irrigation and nitrogen treatments

Figure 2.2 The view of the sprinkler irrigation system used in the experiment

Figure 2.3 The view of the drip irrigation system used in the experiment

Remaining part of total pure nitrogen were taken from liquid source. Liquid fertilizer source is called by UAN, which is producted by GUBRETAS. Mentioned nitrogen coming from UAN was dissolved in a fertilizer tanks placed in the control unit of sprinkler and drip systems and then injected through irrigation water. In this treatment, three applications in 1996; four applications in 1997 were done.

Nitrogen Forms-Application Types: Liquid Nitrogen (L); Required total pure N was provided from liquid source. For this reason, UAN liquid N fertilizer was used. In the mentioned treatment, any nitrogen application was done before planting. Nitrogen was given with irrigation water. Total nitrogen amounts to be given were divided to irrigation number to determine necessary nitrogen amount for each irrigation event. UAN fertilizers which are equivalent to estimated nitrogen amounts were put fertilizer tank. At the end of irrigation events, water samples were taken from collecting cups in sprinkler system and from dripper in drip system during irrigation were analysed for obtaining actual amount of nitrogen applied to the each plot. During the study, three applications in 1996; four applications in 1997 were done.

2.2.3. Agricultural Practices

(i) Soil Preparation and Sowing/Planting

The seedling growth technique was used to decrease seed losses in expensive varieties and to stimulate earliness. The seeds were sown in the torf blocks with 5x5x7 cm in dimension. Then, when seedlings reached to a sufficient size, they were transplanted the experimental area (Figure 2.4).

The soils of experimental area were ploughed using disc-plough before transplanting in autumn, in winter, harrowing was done with disc-harrow. In spring, the field was harrowed to level the surface and was prepared for transplanting watermelon seedling. Seedlings were planted with a row spacing of 2 m and plant spacing of 0.5 m. Water was applied with measured cups to each bed of watermelon in the end of transplanting.

(ii) Fertilizing

Phosphorus (P_2O_5) and potassium (K_2O) of 10 kg/da were applied by hand to the all plots. Then, they were mixed with soil by hoe before sowing (GUNAY, 1993).

(iii) Plant Protection

During study, plant protection was conducted by consulting with Plant Protection Department, Faculty of Agricultural, Cukurova University. In growing period of watermelon, Agrimec (300 cc/ha) and Marshall (150-200 g/da) were applied, respectively, for red cobweb and plant aphid; Captan-M 50 WP (250 g/100 L water) was used for fungusit.

(iv) Harvesting

Watermelon was harvested when atriums which are bounded to fruit stem dried, color of peel reached to maturity color, stems became thin (GUNDUZ and KARA, 1996). Watermelons, which are assumed to be maturity, were picked once or twice according to years. In the harvesting, different areas of plots were used with respect to treatments and application types. Generally, 0.5 m from each two sides of sprinkler heads were discarded; then, remaining parts were harvested. Based on the years, the dates of sowing/planting, harvesting and some agricultural practices were given in Table 2.4.

Table 2.4 Agricultural Processes in the Experimental Years

Agricultural Processes and Observations	1996	1997
Sowing	28 March	26 February
Transplanting of seedlings	27 April	29 April
First watering	27 April	29 April
Second watering	02 May	09 May
Third watering	07 May	15 May
First hoing	18 May	22 May
Second hoing	07 June	05 June
Branching	11 June	12 June
First harvesting	04 July	-
Last harvesting	11 July	08 July

2.2.4 Irrigation Scheduling

(i) Determination of Irrigation Time and Estimation of Water Amount

The experiment plots were irrigated by applying equal amount of irrigation water on the same day. Irrigations generally were performed with 5-10 day intervals. Irrigation treatments were started at branching stage. Free water surface evaporation was used to determine irrigation water amount to be applied. Irrigation water was calculated using cumulative evaporation (Ep) from Class A-pan values measured between consecutive irrigation (Equations 1 and 2).

$$I = kcp \times Ep \times P \qquad (1)$$

$$V_I = I \times A \qquad (2)$$

In the equations; I and V_1, irrigation water, mm, and L; kcp, plant-pan coefficient (this value consider to be one in the experiment); A, plot area, m^2; P, wetting percent (for drip irrigation).

In sprinkler plots, irrigations were ceased when water amount in the collecting cups next to laterals was equal to either I_I or V_I.

In drip plots, P was taken as 0.7. In this case, about 70% of soil was wetted in the irrigation events. Irrigations were stopped when the water-meter inside of control units showed that the necessary amount of water was applied (Figure 2.5).

(ii) Measuring of Moisture Variation in the Soil Profile

During the study, in treatments, moisture content down to 90 cm depth of soil profile was measured using the gravimetric method. That practice was repeated at transplanting, before and after irrigations, and then, it was ended at harvesting. Moisture samples were taken from mid-point in each plot and every 30 cm depth of profile.

(iii) Plot Dimensions

The essentials given by HANKS et al. (1976); and KANBER and MADANOGLU (1981) were used for dimension of sprinkler and drip plots. Therefore, sprinkler plots were 12x30=360 m^2; allowing an area of 12x15=180 m^2 for each watermelon variety. Drip plots covered an area of 6x30=180 m^2. In these plots, there were three watermelon rows and three lateral lines, each variety covered an area of 6x15=90 m^2. Totally, there were 360 watermelon plants (180 plants for each variety) in sprinkler plots and 180 watermelon plants (90 plants for each variety) in drip plots.

2.2.5 Determination of Evapotranspiration

Water budget method was used to determine water consumption (JAMES, 1988). The water budget equation is given below;

$$ET = I + P - Dp + Cp \pm Rf \pm \Delta S \quad (3)$$

In this equation, ET, I, Dp, Cp, Rf and ΔS are evapotranspiration, mm; irrigation water, mm; precipitation, mm; deep percolation loses, mm; water amount entering to root zone with capillaric rise, mm; runoff loses or profit, mm; moisture storage in soil profile, mm, respectively.

In this method, irrigation water and precipitation amounts were measured during the experiment. No runoff was allowed because plots were surrounded with a ridge. Therefore, Rf was assumed to be zero in the Equation 3.

Figure 2.4 Transplanting of the watermelon plants

Figure 2.5 Water-meter used in the drip irrigation system

In the same way, the root zone was not influenced by water table because the level of water table was quite depth (more than 6 m) in the experimental area. Hence, Cp was assumed to be zero. If the total of soil moisture content before irrigation and applied water amount with irrigation was more than field capacity, the difference was assumed to be deep percolation (KANBER et al., 1992). Moisture variation in the soil profile was obtained from gravimetric moisture samples.

2.2.6. Determination of Fruit Quality

Determination of fruit quality was performed on fruit samples taken from each plot at harvesting. In the analyses, 3-5 fruit samples from each plot were used. Average fruit weight, length and diameter, and total solublesolids were determined on fruit samples (ALAVOINE et al., 1988).

2.2.7 Water-Nitrogen-Yield Relationships

In the study, the effect of examined variables on the yield factors were investigated using variance analyses, water use efficiency and yield functions.

(i) Yield Results

Plot yields were analysed statistically using variance analyses after average yield obtained from each plot was evaluated. Strip and split-strip plot designs were used to analyse the other parameters (YURTSEVER, 1984).

(ii) Water Use Efficiency

Water use efficiency was calculated for various water and nitrogen levels in different irrigation methods. For this purpose, the equation given by HOWELL et al. (1990) was used;

$$WUE= \frac{Y}{ET\ or\ IR} \qquad (4)$$

In this equation, Y is marketable yield in kg and ET and IR are evapotranspiration and irrigation water in mm, respectively. If ET was used, total water use efficiency was obtained whereas, if IR was used, irrigation water use efficiency was obtained.

(iii) Yield Functions

Yield functions were used to determine the relationships between various water and nitrogen levels, and watermelon yield. Therefore, relationships between yields and water levels were determined (YURTSEVER, 1984). Utilising those relationships, relationships between the relative ET deficit and the relative yield decrease was estimated. The methods and approaches given by STEWART et al. (1977); HANKS (1983); DOORENBOS and KASSAM (1979); KANBER et al. (1994) were used for referred processes. The formula given below was utilised for obtaining yield response factor;

$$(1-\frac{Y}{Ym}) = Ky\,(1-\frac{ET}{ETm}) \qquad (5)$$

In this equation, Ky is yield response factor; Y, Ym, ET and ETm are actual and maximum yields in kg, and evapotranpirations in mm, respectively.

3. RESULTS AND DISCUSSION

3.1 Irrigation Applications

Similar irrigation water amounts were applied to all watermelon varieties during the study. First year, five irrigations were done in the growing season. First two applications were considered as the pre-plant irrigations. After that, irrigation treatments were started. Generally, plants were irrigated 9-12 day intervals. Maximum irrigation water amount was applied in the middle of June, which was the third irrigation of season (Table 3.1).

Three nitrogen levels were established by allowing nitrogen to decrease gradually in only SL applications during the irrigation season. The water amount in SL1 treatment, nearest to lateral, was 164.9 mm. The SL2 and SL3 treatments were taken 77% and 72.3% of the water amount applied to the SL1 treatment, respectively.

Table 3.1 Applied Water Amount in the First Year of Experiment (mm)

Irrigation No	Irrigation Date	Treatments				
		SG	SGL	SL		
				SL1	SL2	SL3
1	07.05	15.0	15.0	15.0	15.0	15.0
2	24.05	43.7	43.7	43.7	43.7	43.7
3	12.06	41.4	48.0	49.8	29.2	28.3
4	24.06	43.3	35.1	35.0	24.8	21.0
5	02.07	31.5	28.8	21.4	13.9	11.2
TOTAL		174.9	170.6	164.9	126.6	119.2

Second year of the study, seven irrigations were performed. Irrigations were applied generally 5-15 day intervals (Table 3.2). Pre-plant irrigations were given in first three applications. Irrigation treatments were started at fourth application.

Maximum irrigation water was given in the middle of the June, which was fourth application. Various water levels were created in the all treatments in the second year. Irrigation water was reduced in SG treatment by 18% (SG2) and 26% (SG3), in SGL treatment by 14% (SGL2) and 22% (SGL3), and in SL treatment by 20% (SL2) and 29% (SL3). Differences were occurred between treatments caused by spoiled water distribution uniformity due to effect of wind during irrigation.

Table 3.2 Applied Water Amount in the Second Year of Experiment (mm)

Irr. No	Irr. Date	Treatments									
		SG			SGL			SL			
		SG1	SG2	SG3	SGL1	SGL2	SGL3	SL1	SL2	SL3	D*
1	9.05	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8
2	15.05	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
3	30.05	58.4	58.4	58.4	58.4	58.4	58.4	58.4	58.4	58.4	53.8
4	13.06	68.3	57.0	47.8	75.7	68.6	66.4	68.3	62.1	57.3	46.5
5	18.06	22.7	16.9	12.8	31.3	22.9	12.4	35.5	24.9	13.8	9.6
6	25.06	65.0	40.3	29.2	62.2	40.3	33.2	67.9	40.3	25.2	37.7
7	30.06	46.8	27.9	24.8	46.2	34.1	27.0	47.4	21.8	20.6	31.2
TOTAL		334.2	273.5	246.0	346.8	297.3	270.4	350.5	280.5	248.3	251.7

* Same nitrogen amount were applied to all treatments with drip method.

3.2. Applied Nitrogen Amount

Nitrogen amounts from different nitrogen sources applied to watermelon through sprinkler and drip methods were shown in Table 3.3. As seen in Table 3.3, nitrogen amounts varied depending on applied irrigation water amount and irrigation method except granule nitrogen applications. The maximum nitrogen of 10 kg/da was applied in SG treatment. Similar relationships were obtained between this study and other studies (GUNDUZ and KARA, 1996; CETIN and NACAR, 1997). The minimum nitrogen amount of average 5.1 kg/da was applied to SL treatment. Nitrogen saving was about 50% in SL; 20% in SGL treatment as compared to SG.

During irrigation, total nitrogen saving was a result of gradually decreased water amount. For example, nitrogen amount was reduced by 24-31% in SGL, by 54-74% in SL application as compared to SG. The saving under drip irrigation was by 13-43%.

Table 3.3 Applied Total Nitrogen Amount in the Treatments (kg/da)

Treatments	1996				1997				
	3. irr.	4. irr	5. irr.	Total	4. irr.	5. irr.	6. irr.	7. irr.	Total
SG1				10.0					10.0
SG2									10.0
SG3									10.0
SGL1*	1.9	0.9	1.7	7.3	2.6	0.6	1.9	0.6	8.7
SGL2					2.4	0.5	1.3	0.5	7.7
SGL3					2.3	0.3	1.0	0.3	6.9
SL1	2.2	0.8	1.3	4.3	2.3	0.6	2.2	0.8	5.9
SL2	1.4	0.6	0.9	2.9	2.1	0.4	1.6	0.5	4.6
SL3	1.4	0.5	0.7	2.6	2.0	0.3	0.9	0.4	3.6
DG									10.0
DGL*					2.5	0.3	2.0	0.9	8.7
DL					2.5	0.3	2.0	0.9	5.7

* Granule nitrogen of 3 kg/da given during transplanting was added to total amount.

3.3. Evapotranspiration

As known, ET is a function of climate, plant, soil and agricultural practices (JENSEN et al., 1990). ET values for each variety were obtained by summation of applied total irrigation water, precipitation in growing period and moisture amount taken from soil by plants. Average seasonal ET of the treatments are given in Table 3.4. There is no significant difference between ET of watermelon varieties.

There was no significant difference between irrigation methods when same amount of water was applied, as seen in Table 3.4. This could be resulted from similar irrigation programs. However, nitrogen amounts given to treatments were quite different. Nitrogen amounts decreased by about 50% were applied to some treatments (Table 3.3). Nitrogen is a important nutrient to stimulate growth and water use for watermelon kind of plants which have very large leaf area and are able to grow very fast (YESILSOY, 1985; KIRDA et al., 1996).

Same ET values were obtained from varying nitrogen levels in this study. Here, it can be concluded that the liquid fertilizer applied in less amount than granule fertilizer had same effect on the growth and water consumption of the watermelon.

The results agreed with findings of GUNDUZ and KARA (1996); GHAWI et al., 1989; SEZGIN et al., 1997. EYLEN and TOK (1988) found that ET was 226 mm. But, this value is very low for the region of Tarsus that is in Cukurova region. In presented study, ET was 361 mm in the highest yield treatment and this value may more suitable for Cukurova conditions.

3.4. Water-Nitrogen-Yield Relationships

3.4.1 Yield Results

Total and marketable yield amounts were shown in Appendix 1; average yields were shown in Table 3.5 and 3.6. Significant differences were observed in total yield as seen in ET. In the second year, the yield increased by 70%. This could be resulted from the changes in climate, plant growth and cultural practices between the years. The maximum yields were obtained from Madera variety for both years. The yields were obtained from Madera more than, Paladin's yield by 4% (SG1) and 36% (SL2) in 1996; by 13% (SG1) and 28% (SL3) except one or two reduced of water level in 1997 for sprinkler irrigation. Similar results were obtained also for drip irrigation. Under drip irrigation, Madera variety produced 10% greater yield than the other variety. Sprinkler irrigation resulted in greater yields than that in drip

Table 3.4 Evapotranspiration of the Treatments (mm)

Treatments	1996		1997		Average	
	P	M	P	M	P	M
SG1	274	266	427	435	351	351
SG2			369	376		
SG3			356	362		
SGL1	270	272	440	443	355	358
SGL2			392	398		
SGL3			380	382		
SL1	264	260	444	438	354	349
SL2	228	238	376	380	302	309
SL3	236	226	358	361	297	294
DG			340	346	340	346
DGL			346	350	346	350
DL			339	341	339	341

The effect of nitrogen forms and amounts on the yield was found to be different under sprinkler irrigation applications. In the first year of experiment, maximum yields were obtained from treatments in which liquid fertilizers were used. In Paladin variety, yield was decreased by 21% in the treatment that 10 kg/da granule fertilizer was applied, as compared to the treatment in which liquid fertilizer was applied. Corresponding decrease was by 25% in Madera variety. The responses of varieties to nitrogen forms and amounts were different in the second year. Maximum yield was observed in SG treatment in Paladin variety. The yield decreased only by 12% in SL treatment in which liquid nitrogen was applied 50% less than granule nitrogen. Maximum yield for Madera variety was obtained from granule and liquid fertilizer treatments (SGL and SL).

Similar results were obtained in drip irrigation. In Paladin variety, the yield reduced by 11-13% using other nitrogen forms rather than granule fertilizer. In Madera variety, the yield decreased by 5% with granule fertilizer applications.

Table 3.5 The Average Total Yield Amounts of the Treatments (kg/da)

Treatments	1996				1997			
	P	%	M	%	P	%	M	%
SG1	1928	79	2003	75	4352	90	4981	99
SG2					4832	100	4466	89
SG3					4566	94	4386	87
SGL1	2233	92	2682	100	3280	68	4214	84
SGL2					3485	72	4549	91
SGL3					3108	64	4199	84
SL1	2429	100	2529	94	3567	74	3485	69
SL2	1630	67	2530	94	4236	88	4832	96
SL3	1325	54	1811	67	3611	75	5013	100
DG					3840	77	3737	74
DGL					3421	71	3822	76
DL					3343	69	3934	78

It can be seen that marketable yield was similar to total yield amounts (Table 3.6). Marketable yield varied linearly with changing total yield. It was recorded that the higher total yield given the higher marketable yield. The yields are different by 80% between the years. Marketable yield of Madera was found to be higher by 14-30% (SL1 and SG1) for 1996; except SL1 by 17-25% (SG1and SGL1) for 1997 as compared to Paladin variety under sprinkler irrigation. The yield was increased by 10% in Madera with drip irrigation. The yield was increased by 6% (Paladin) and by 10% (Madera) by sprinkler. Maximum yield, generally, was obtained either from applications of completely liquid nitrogen form or granule together with liquid nitrogen form.

Table 3.6 The Average Marketable Yield Amounts of the Treatments (kg/da)

Treatments	1996				1997			
	P	%	M	%	P	%	M	%
SG1	869	62	1244	76	3475	86	4160	100
SG2					4056	100	3953	95
SG3					3724	92	3876	93
SGL1	1205	86	1633	100	2528	62	3384	81
SGL2					2884	71	3815	92
SGL3					2341	58	3339	80
SL1	1401	100	1622	99	3040	75	2754	66
SL2	551	39	1465	90	3505	86	3972	95
SL3	425	30	806	49	2546	63	4090	98
DG					3018	74	2897	70
DGL					2801	69	3174	76
DL					2796	69	3253	78

Total and marketable yield amounts obtained from plots in both years are given in Appendix 1 and 2. Also, they were evaluated using variance analyses. The results are shown in Table 3.7.

Based on results shown in Table 3.7, there was no statistically significant differences between the varieties for total and marketable yield in the first year of experiment. The statistically impact of nitrogen applications on watermelon yields was investigated using orthogonal method. For this reason, total yields of nitrogen application were split by orthogonal method to the smallest influences. As a result, SL and SGL treatments were placed in the best class while SG took second yield class with 95% confidence.

There was no statistically significant difference between varieties and nitrogen levels according to results of second year. Significant difference was determined between the irrigation methods for total yield at 5% confidence level, whereas for marketable yield both between the irrigation methods and their

Table 3.7 Variance Analysis of Watermelon Yield

Year	Variation Source	DF	Total Yield		Marketable Yield	
			Mean Square	F values	Mean Square	F values
1996	Repl.	2	183836		40476.3	
	Variety	1	192235^{ns}	1.12	515586	2.4
	Error(1)	2	171445		214505	
	Nitrogen	2	506941	6.45	349949	1.29
	SG with Others	1	1010092*	12.85		
	SGL with SL	1	14225.7^{ns}			
	Error(2)	4	78575.9		270399	
	Variety-Nitrog. Int.	2	64276.7	0.25	16614.3	<1
	Error (3)	4	253645		100278	
	General	17	198477		190670	
1997	Repl.	2	80752.2		128576.4	
	Variety	1	2565336^{ns}	1.61	2898506^{ns}	1.34
	Error(1)	2	1596666		2155647	
	Irr. Method	1	1945989*	16.8	977791.4*	11.74
	Irr.-Variety Int.	1	461326.8	3.98	987042.3*	11.85
	Error(2)	4	115843.7		83269.1	
	Nitrogen	2	767715.5^{ns}	2.13	651673.5^{ns}	1.15
	Error(3)	4	360761.5		567588	
	Nitrog.-Variety Int.	2	1072831^{ns}	4.75	758840.1^{ns}	4.29
	Error(4)	4	225819.4		177038.3	
	Nitr.-Irr.Method Int	2	418641.8^{ns}	<1	737460.2^{ns}	0.45
	Var-Nitr-Irr.Meth.Int	2	196866.1^{ns}	<1	776754.6^{ns}	0.48
	Error(5)	8	1687448		1632834	
	General	35	554977		624528.4	

*DF: Degree of freedom

interaction with variety were significantly different at 5% confidence level. For total yield, average values were compared using Duncan test.

Duncan test results indicated that greater yield was obtained from sprinkler method ($S\bar{x} = 196.5$) as compared to drip irrigation method with 95% confidence level (Table 3.7). In the same way, average of marketable yield values related to irrigation method-variety interaction ($S\bar{x} = 68$ and $S\bar{x} = 136$) were compared to each other.

Therefore, sprinkler method constituted first yield class while drip method constituted second yield class in Madera variety; sprinkler and drip methods constituted third yield group in Paladin variety. These results agreed with those of CETIN and NACAR (1997); STANLEY and MAYNARD (1990).

Table 3.8 Comparing of Treatment Averages with Orthogonal and Duncan Multiple Range Test Methods*

Treatments	1996		1997	
	Average Yield, kg/da	$S\bar{x}$	Average Yield, kg/da	$S\bar{x}$
SL	2479.3 a			
SGL	2457.5 a (Total Yield)	161.8		
SG	1965.9 b			
S			4147 a	196.5
D			3683 b (Total Yield)	
MS			3769 a	
MD			3108 b (Marketable Yield)	68 (Irr.Met.)
PD			2872 c	136(Variety)
PS			2870 c	

* Treatments shown with same letters are in same yield class at 5% confidence level.

From results, it can be concluded that watermelon yield could be increased by liquid fertilizer. Although the amount of liquid nitrogen was applied less than granule nitrogen form by 20-50%, no statistically significant difference was observed between yields obtained from liquid and granule nitrogen. First year data indicated that the yield was increased by 5% with liquid fertilizer. On the other hand, application of granule nitrogen at planting/sowing did not influence the watermelon yield. Because, always, SL and SGL treatments took statistically same yield class.

On the other hand, yields were increased at 5% level by sprinkler system as compared to drip ; but, this factor depended on the varieties; for example, significant differences were not observed between irrigation methods in Paladin variety. For this reason, reactions of varieties to irrigation methods are different. Therefore, irrigation methods to be used, should be taken into consideration in selection of watermelon variety to be grown.

In addition, it can be concluded that there was no statistically difference between varieties. Some differences are occurred by randomly. However, detailed studies should be conducted on the varieties based on average yields shown in Table 3.5 and 3.6.

3.4.2. Water Use Efficiency (WUE)

Water use efficiencies of the treatments were calculated from marketable yield and shown in Table 3.9. Generally, water use efficiencies of irrigated plants by drip system went up by 33% for Paladin, by 25% for Madera as compared to sprinkler irrigation. EL-BEHEIDI et al. (1990) obtained that the similar results with this study. In the same way, values for Madera variety were found higher than Paladin's by 17% for sprinkler, and by 7% for drip. Maximum WUE (37%) of Paladin were obtained in drip-granule (DG) treatment in between nitrogen levels. This treatment was followed by SL1 treatment in the same variety.

Similar results were obtained in Madera variety. Maximum WUE (29%) were calculated in drip liquid (DL) treatment. SG1 treatment from same variety followed that treatment. In this case, watermelon varieties, irrigation methods, and nitrogen levels and forms had different influences on water use efficiency. Madera variety, drip irrigation system, liquid fertilizer, all together, constituted best combination for plant to achieve a better water use efficiency.

Table 3.9 Water Use Efficiency of the Treatments (kg/da-mm)

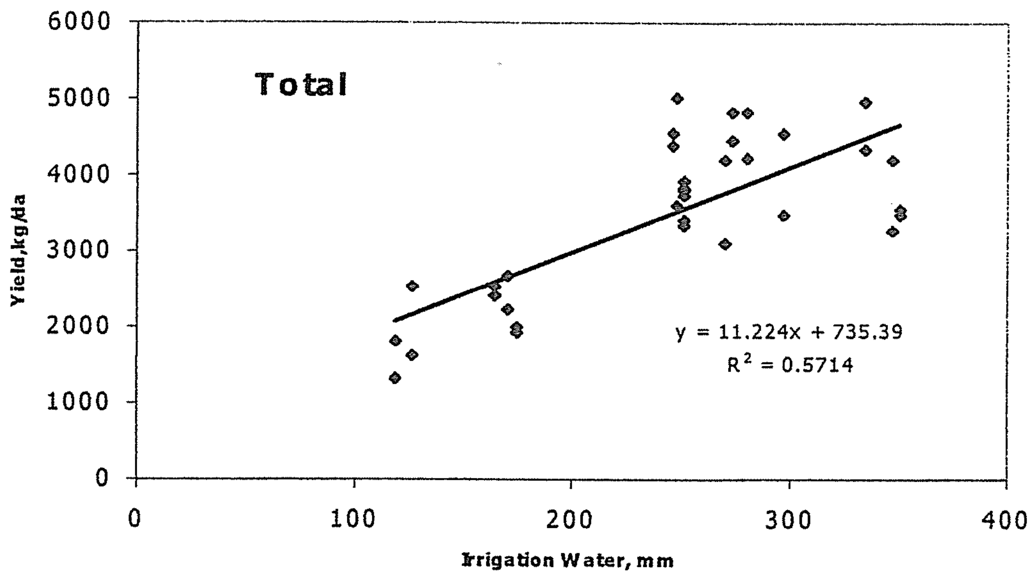
Variety	Treatments	1996		1997		Average	
		TWUE	IWUE	TWUE	IWUE	TWUE	IWUE
P	SG1	3.17	4.97	8.14	10.14	5.66	7.56
	SG2			10.99	14.83		
	SG3			10.46	15.14		
	SGL1	4.46	7.06	5.75	7.29	5.11	7.18
	SGL2			7.36	9.7		
	SGL3			6.16	8.66		
	SL1	5.31	8.50	6.85	8.67	6.08	8.59
	SL2	2.42	4.35	9.32	12.50	5.87	8.43
	SL3	1.80	3.57	7.11	10.25	4.46	6.91
	DG			8.87	11.99	8.87	11.99
	DGL			8.1	11.13	8.1	11.13
	DL			8.25	11.11	8.25	11.11
M	SG1	4.68	7.11	9.56	12.45	7.12	9.78
	SG2			10.51	14.45		
	SG3			10.71	15.76		
	SGL1	6.00	9.57	7.64	9.76	6.82	9.67
	SGL2			9.59	12.83		
	SGL3			8.74	12.35		
	SL1	6.24	9.84	6.29	7.86	6.27	8.85
	SL2	6.16	11.73	10.45	14.16	8.31	12.95
	SL3	3.57	6.76	11.33	16.47	7.45	11.62
	DG			8.37	11.51	8.37	11.51
	DGL			9.1	12.61	9.1	12.61
	DL			9.54	12.92	9.54	12.92

3.4.3. Yield Functions

(i) Water-Yield Functions

Figure 3.1 and 3.2 show the relationships between the yields (total and marketable) and irrigation water, and ET, respectively.

In the relationships, yields of both varieties were used together. As shown in Figure 3.1, there were significant relationships between yields (total and marketable) and irrigation water amounts at 1% confidence level.



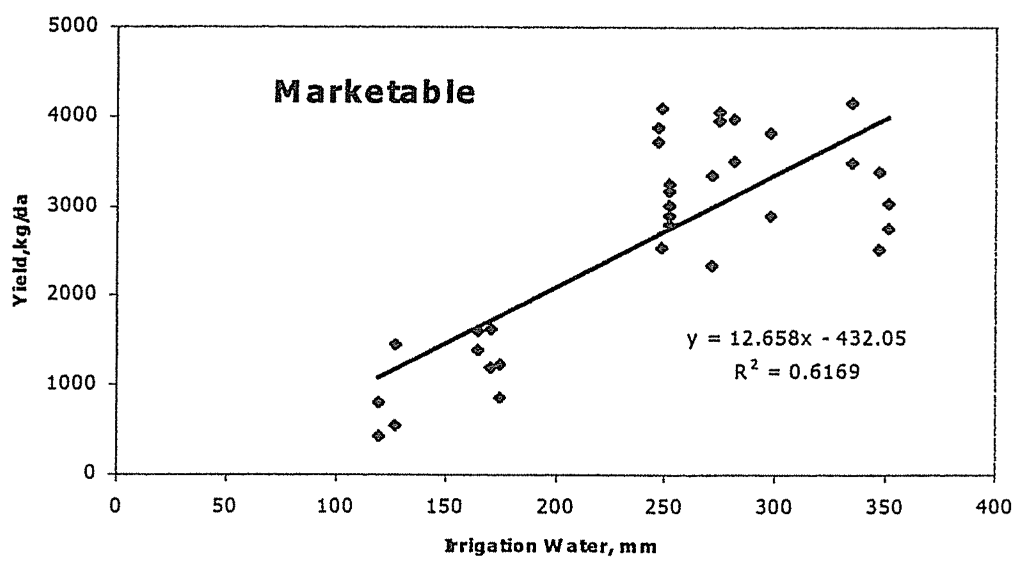


Figure 3.1 Relationships between irrigation water and yields (total and marketable)

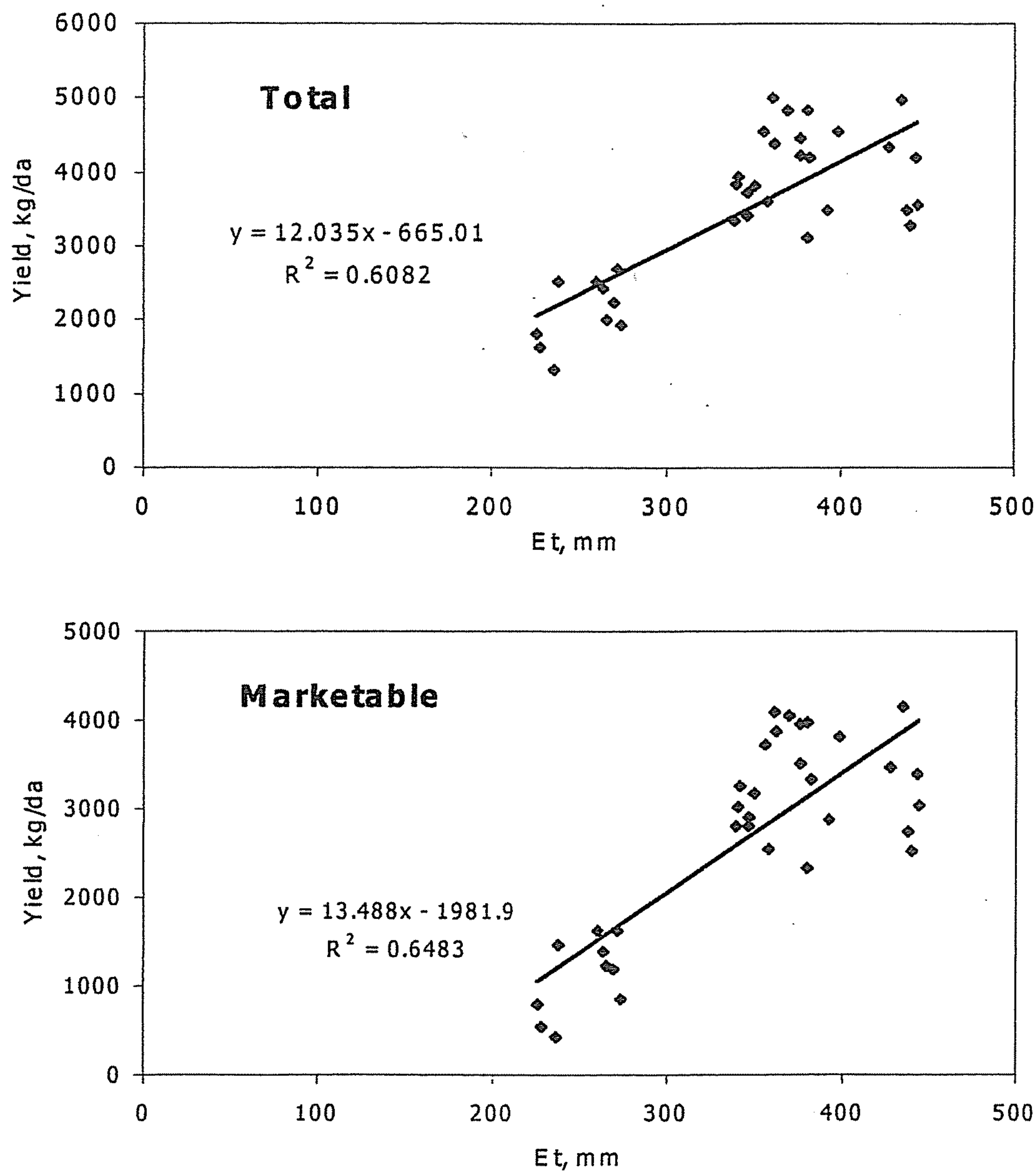


Figure 3.2 Relationships between ET and yields (total and marketable)

As shown in Figure 3.2, there also was a statistically significant linear relationship between yields and ET at 1% confidence level. From this reson, it can be concluded that watermelon yields increased with irrigation water and ET increased.

Relationship between in relative ET deficit and relative yield decreased were shown in Figure 3.3. From the Figure 3.3, it can be seen that the yield response factor (Ky) for total yield was 1.07 and Ky for marketable yield was 1.49. As known, yield response factor shows yield reduction with respect to reduction in the water amount.

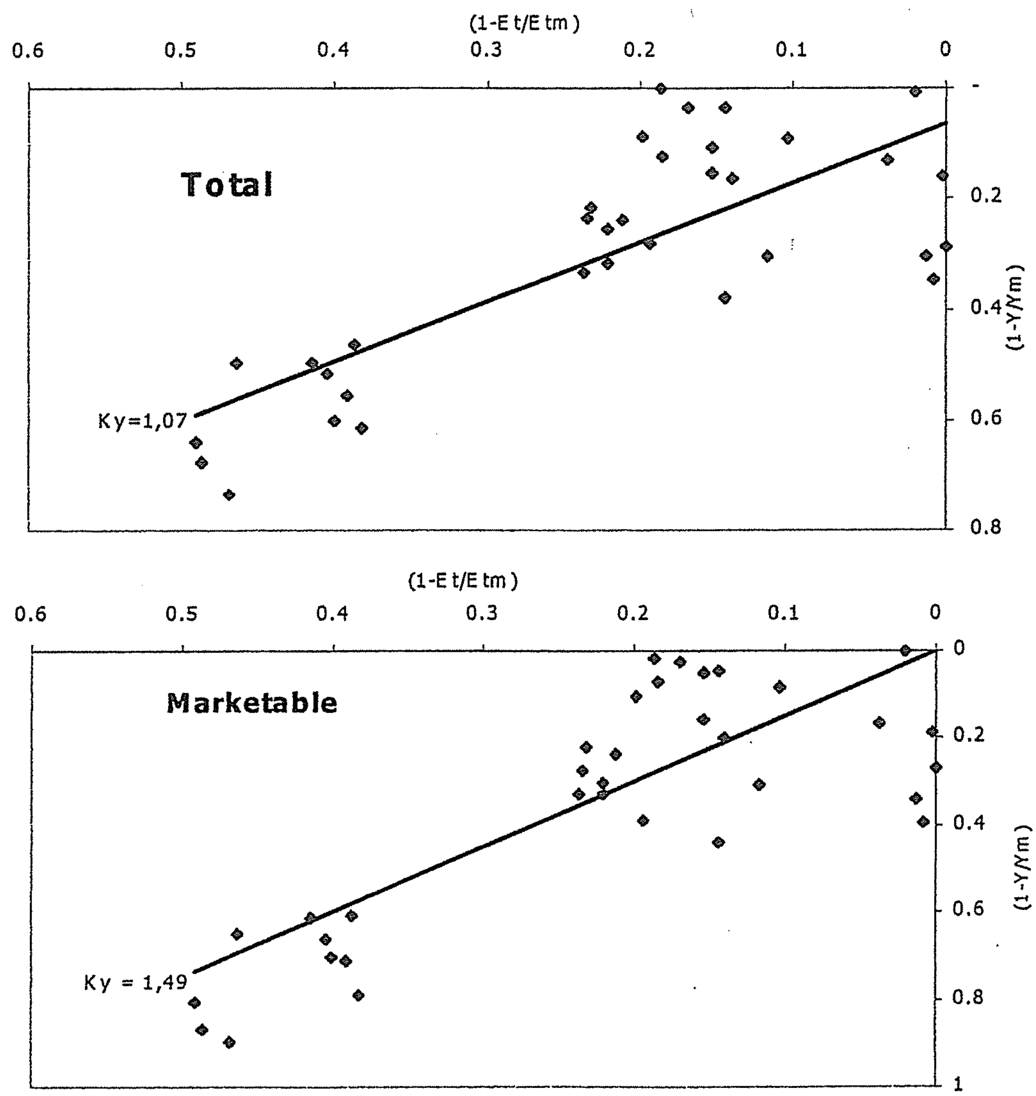


Figure 3.3 Relationships between relative ET deficit and relative yield decrease

From the results, marketable yield was more effected by water deficit. Yield decreased by 1.5 unit in marketable yield and by 1.07 unit in total yield with a unit decrease in water. It can be concluded that to obtain high marketable yield, plant should not undergo water deficient.

(ii) Nitrogen-Yield Functions

Parabolic and statistically significant relationships were calculated between the nitrogen amounts and yields (total and marketable) at 5% confidence level (Figure 3.4).

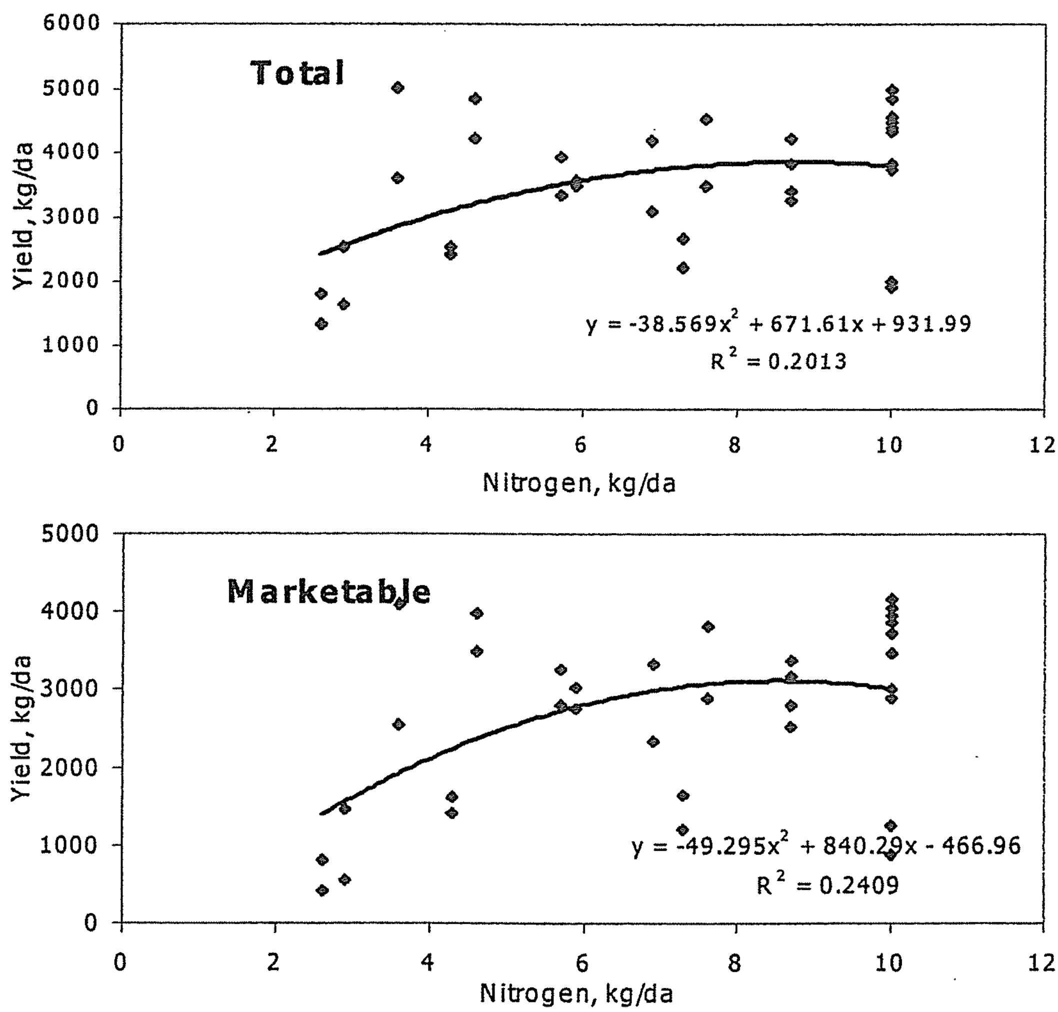


Figure 3.4 Relationships between nitrogen levels and yield (total and marketable)

Data from all the treatments (varieties and irrigation methods) were used together to produce the relationships. These relationships indicated that to obtain maximum total yield, a nitrogen amount of 8.7 kg/da is required while a nitrogen amount of 8.5 kg/da to obtain maximum marketable yield in watermelon. The result agreed with finding of DOORENBOS and KASSAM (1979); EYLEN and TOK (1988). These nitrogen amounts should be provided from a liquid source and it is necessary to apply through irrigation water during the irrigation season.

4.4.4 Quality Properties

Some parameters related to quality properties of treatments were given in Appendix 3, 4, 6, 7 and 9 and average values were given in Table 3.10. Results of variance analyses on the parameters were shown in Appendix 5, 8, 10. These parameters contain second quality yield, fruit diameter and length, fruit weight and total solublesolids (SRINIVAS et al., 1989b; SEZGIN et al., 1997).

Generally, statistically significant differences were not found between treatments. Some quality properties were not influenced by the irrigation methods and nitrogen levels, except fruit diameter and fruit length.

Fruit diameter was found different at 5% confidence level in varieties ($S\bar{x}$=3.80). Fruit diameter of Madera was higher than Paladin's at 95% confidence level. In the same way, variety-nitrogen-irrigation interaction influenced on fruit length ($S\bar{x}$=0.12). Therefore, treatments were constituted 7 groups that were different from each other. It can be concluded that the longest fruit length was measured in Paladin-DL treatment. It is followed by SL and DG treatments in the same variety. In addition, fruit length was increased under drip irrigation in Paladin variety.

Table 3.10 Some Quality Properties of the Treatments*

Variety	Treatm.	Sec. Qual. Yield, kg/da	Fruit Diameter, cm	Fruit Length, cm	T.S.S.W. %	Fruit Weight, g
P	SG	941^{ns}	19.4 b	25.5 b	9.0^{ns}	5020^{ns}
	SGL	890^{ns}	19.3 b	25.0 bc	8.5^{ns}	4969^{ns}
	SL	897^{ns}	18.9 b	25.6 ab	8.8^{ns}	5055^{ns}
	DG	822^{ns}	18.5 b	25.8 ab	10.4^{ns}	4687^{ns}
	DGL	619^{ns}	18.2 b	23.4 c	10.0^{ns}	4099^{ns}
	DL	547^{ns}	18.8 b	26.2 a	9.6^{ns}	5107^{ns}
M	SG	790^{ns}	21.1 a	22.5 cd	8.6^{ns}	5030^{ns}
	SGL	806^{ns}	20.2 a	21.5 e	8.8^{ns}	4835^{ns}
	SL	919^{ns}	21.2 a	21.4 e	9.0^{ns}	4921^{ns}
	DG	839^{ns}	20.7 a	22.6 cd	10.6^{ns}	4996^{ns}
	DGL	649^{ns}	21.1 a	22.4 cd	10.5^{ns}	5236^{ns}
	DL	681^{ns}	20.8 a	22.5 cd	9.4^{ns}	5212^{ns}

* Treatments shown with same letters are in same yield class at the 5% confidence level.

4. CONCLUSIONS

In the study, different watermelon varieties, irrigation methods and nitrogen levels with forms were investigated under Cukurova conditions. Results obtained were summarized under in this section.

No statistically difference between yield of two watermelon varieties. Varieties gave similar results under all conditions such as irrigation method and nitrogen level. However, it can be concluded that yield of Madera variety was greater than Paladin's in some applications. These results could be coincidence since they were not proved statistically. Therefore, further studies are needed for better understanding.

Sprinkler irrigation method seemed to be safer method to irrigate watermelon. Especially, in Madera variety, higher yield was obtained from this method.

There is no statistically significant difference between nitrogen amounts and application types. However, yield of watermelon was increased by nitrogen applied through irrigation water. Same yields were obtained from liquid nitrogen that has about the half of granule nitrogen applied. Important finding, which is related to applying nitrogen through irrigation system at each irrigation were obtained.

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Appendix 1. Total Yields of the Treatments

TOTAL YIELD, kg/da						
YEAR	VARIETY	TREATMENT	I	II	III	AVERAGE
1996	P	SG	2149	1678	1958	**1928**
		SGL	1819	2646	2233	**2233**
		SL1	2002	2272	3013	**2429**
		SL2	1123	1976	1791	**1630**
		SL3	1141	824	2011	**1325**
	M	SG	1879	1809	2324	**2003**
		SGL	3322	2042	2683	**2682**
		SL1	2451	2417	2722	**2530**
		SL2	2064	3000	2526	**2530**
		SL3	2836	1314	2284	**1811**
1997	P	SG1	4343	4352	4321	**4352**
		SG2	4054	4829	5613	**4832**
		SG3	4340	4566	4792	**4566**
		SGL1	4115	2928	2806	**3280**
		SGL2	3204	3620	3631	**3485**
		SGL3	3625	3034	2626	**3108**
		SL1	3152	3567	3982	**3567**
		SL2	3073	4236	5399	**4236**
		SL3	3056	3611	4166	**3611**
		DG	3599	3840	4081	**3840**
		DGL	2004	3421	4837	**3421**
		DL	2776	3343	3909	**3343**
	M	SG1	5578	4961	4403	**4981**
		SG2	4034	4367	4998	**4466**
		SG3	5296	3356	4507	**4386**
		SGL1	5130	3522	3391	**4214**
		SGL2	4759	5211	3676	**4549**
		SGL3	4397	4761	3440	**4199**
		SL1	4209	3125	3122	**3485**
		SL2	4397	5310	4789	**4832**
		SL3	4914	5013	5112	**5013**
		DG	4674	3343	3194	**3737**
		DGL	3776	3865	3834	**3822**
		DL	4220	4036	3546	**3934**

Appendix 2. Marketable Yields of the Treatments

MARKETABLE YIELD, kg/da						
YEAR	VARIETY	TREATMENT	I	II	III	AVERAGE
1996	P	SG	749	748	1110	**869**
		SGL	1179	1401	1036	**1205**
		SL1	932	1425	1850	**1402**
		SL2	197	604	851	**551**
		SL3	115	425	735	**425**
	M	SG	1234	958	1539	**1244**
		SGL	2519	1151	1230	**1633**
		SL1	1430	1759	1672	**1622**
		SL2	874	1740	1782	**1465**
		SL3	689	235	1494	**806**
1997	P	SG1	3661	3370	3395	**3475**
		SG2	3542	4056	4569	**4056**
		SG3	3528	3724	3909	**3724**
		SGL1	3105	2410	2069	**2528**
		SGL2	2847	3103	2701	**2884**
		SGL3	2819	2248	1955	**2341**
		SL1	2807	3040	3273	**3040**
		SL2	2555	3505	4455	**3505**
		SL3	1866	2546	3226	**2546**
		DG	2856	3018	3180	**3018**
		DGL	1361	2801	4241	**2801**
		DL	2282	2796	3310	**2796**
	M	SG1	4779	4367	3333	**4160**
		SG2	3698	3911	4245	**3953**
		SG3	4937	2974	3718	**3876**
		SGL1	4345	2703	3103	**3384**
		SGL2	4345	4314	2787	**3815**
		SGL3	3466	4086	2466	**3339**
		SL1	3463	2555	2245	**2754**
		SL2	3776	4131	4008	**3972**
		SL3	3931	4091	4250	**4090**
		DG	4286	2621	2785	**2897**
		DGL	3391	2730	3400	**3174**
		DL	3708	2794	3257	**3253**

Appendix 3. Second Quality Yields of the Treatments

SECOND QUALITY YIELD, kg/da						
YEAR	**VARIETY**	**TREATMENT**	**I**	**II**	**III**	**AVERAGE**
1996	P	SG	1400	930	848	**1059**
		SGL	640	1246	1197	**1028**
		SL1	1070	848	1163	**1027**
		SL2	926	1371	940	**1079**
		SL3	1026	824	1276	**1042**
	M	SG	642	851	785	759
		SGL	803	892	647	**781**
		SL1	1021	658	1043	**907**
		SL2	1189	1260	844	**1098**
		SL3	1147	1078	790	**1005**
1997	P	SG1	722	824	926	**824**
		SG2	512	778	1044	**778**
		SG3	802	843	883	**843**
		SGL1	1010	508	737	**752**
		SGL2	357	517	930	**601**
		SGL3	806	786	709	**767**
		SL1	345	527	709	**527**
		SL2	518	731	944	**731**
		SL3	1190	1065	940	**1065**
		DG	743	822	901	**822**
		DGL	643	619	596	**619**
		DL	494	597	599	**547**
	M	SG1	799	594	1070	**821**
		SG2	336	456	745	**514**
		SG3	359	382	785	**510**
		SGL1	785	819	888	**831**
		SGL2	414	897	889	**733**
		SGL3	931	675	974	**860**
		SL1	746	570	877	**731**
		SL2	621	1175	781	**860**
		SL3	983	923	862	**923**
		DG	388	722	1409	**839**
		DGL	375	1135	434	**648**
		DL	512	1242	289	**681**

Appendix 4. Fruit Diameter of the Treatments

FRUIT DIAMETER, cm						
YEAR	VARIETY	TREATMENT	I	II	III	AVERAGE
1996	P	SG	20,0	22,0	18,7	**20,2**
		SGL	20,7	20,2	20,4	**20,5**
		SL1	19,8	19,2	18,5	**19,1**
		SL2	19,7	20,2	19,2	**19,5**
		SL3	18,4	18,7	18,5	**18,5**
	M	SG	20,4	21,3	21,0	**20,9**
		SGL	20,5	19,8	20,7	**20,3**
		SL1	20,9	21,1	21,8	**21,3**
		SL2	19,6	20,4	20,4	**20,1**
		SL3	19,3	19,2	19,5	**19,3**
1997	P	SG1	17,9	18,7	19,2	**18,6**
		SG2	18,5	19,5	19,4	**19,1**
		SG3	19,1	18,6	17,7	**18,5**
		SGL1	18,0	17,6	18,3	**18,0**
		SGL2	19,2	19,5	18,2	**19,0**
		SGL3	19,7	18,5	18,3	**18,8**
		SL1	18,0	18,3	19,5	**18,6**
		SL2	18,4	17,8	18,5	**18,2**
		SL3	19,6	18,1	18,1	**18,6**
		DG	19,0	17,9	18,5	**18,5**
		DGL	18,3	17,2	19,1	**18,2**
		DL	19,1	16,7	20,5	**18,8**
	M	SG1	20,7	22,5	20,7	**21,3**
		SG2	20,5	20,8	21,3	**20,9**
		SG3	20,8	20,5	20,8	**20,7**
		SGL1	20,3	20,8	19,1	**20,1**
		SGL2	21,3	20,7	19,0	**20,3**
		SGL3	20,7	21,5	19,3	**20,5**
		SL1	20,5	21,7	20,7	**21,0**
		SL2	23,3	21,3	21,3	**22,0**
		SL3	22,4	21,3	23,3	**22,3**
		DG	20,6	20,6	20,8	**20,7**
		DGL	21,8	20,2	21,3	**21,1**
		DL	21,2	19,9	21,4	**20,8**

Appendix 5. Variance Analyses of the Second Quality Yield and Fruit Diameter

Year			Second Quality Yield		Fruit Diameter	
	Variance Source	DF	Mean Square	F Values	Mean Square	F Values
1996	Repl.	2	2831.56		0.12	
	Variety	1	222289*	396.481	2.76^{ns}	1.7
	Error(1)	2	560.655		1.63	
	Nitrogen	2	7349.69^{ns}	<1	0.08^{ns}	<1
	Error(2)	4	74948.9		0.51	
	Varety-Nitrog.Int.	2	12941.5^{ns}	<1	2.06^{ns}	4.37
	Error (3)	4	74252.7		0.47	
	General	17	50968.4		0.85	
1997	Repl.	2	53259		3.57	
	Variety	1	10268.4^{ns}	<1	43.45*	292.8
	Error(1)	2	55288		0.15	
	Irr. Method	1	163755^{ns}	2.88	0.02^{ns}	<1
	Irr.-Variety Int.	1	79524^{ns}	1.4	0.37^{ns}	<1
	Error(2)	4	56920.6		1.04	
	Nitrogen	2	19757.7^{ns}	<1	0.06^{ns}	<1
	Error(3)	4	114526		1.28	
	Nitrog.-Variety.Int.	2	37965.9^{ns}	<1	0.04^{ns}	<1
	Error(4)	4	63729.8		0.30	
	Nitr.-Irr.Method Int	2	219348^{ns}	1.9	0.03^{ns}	<1
	Var-Nitr-Irr.Meth.Int	2	56627.9^{ns}	<1	0.44^{ns}	<1
	Error(5)	8	116791		1.95	
	General	35	66066.5		1.91	

Appendix 6. Fruit Length of the Treatments

FRUIT LENGTH, cm						
YEAR	**VARIETY**	**TREATMENT**	**I**	**II**	**III**	**AVERAGE**
1996	**P**	SG	23,9	24,6	24,8	**24,4**
		SGL	23,5	23,5	26,1	**24,4**
		SL1	24,2	23,0	24,5	**23,9**
		SL2	22,4	23,5	22,2	**22,4**
		SL3	20,0	23,4	21,4	**21,6**
	M	SG	21,1	23,7	23,0	**22,6**
		SGL	20,1	22,9	21,0	**21,3**
		SL1	21,8	21,8	21,8	**21,8**
		SL2	21,1	21,1	20,5	**20,9**
		SL3	19,5	18,8	20,2	**19,5**
1997	**P**	**SG1**	25,2	26,6	27,9	**26,6**
		SG2	25,8	27	26,7	**26,5**
		SG3	26,9	26,5	26,5	**26,6**
		SGL1	24,8	25,5	26,3	**25,5**
		SGL2	25,5	27,7	24	**25,7**
		SGL3	28	27,2	24,4	**26,5**
		SL1	27,3	24,3	30,2	**27,3**
		SL2	26,3	22,7	28,25	**25,8**
		SL3	26,2	24,5	26,6	**25,8**
		DG	27	24,4	26	**25,8**
		DGL	25,2	22,4	22,7	**23,4**
		DL	26,4	23,7	28,5	**26,2**
	M	**SG1**	22,7	21,7	22,5	**22,3**
		SG2	21,1	21	23,4	**21,8**
		SG3	23,5	22,3	23,5	**23,1**
		SGL1	22,8	21,9	20,5	**21,7**
		SGL2	23,8	23,1	20,7	**22,5**
		SGL3	22,3	24	20,8	**22,4**
		SL1	21,9	20,5	20,5	**21,0**
		SL2	23,3	21,3	21,25	**22,0**
		SL3	22,4	21,3	21,25	**22,0**
		DG	22,3	22,06	23,5	**22,6**
		DGL	24	21,3	22	**22,4**
		DL	22,7	21,5	23,3	**22,5**

Appendix 7. Total solublesolids in Water of the Treatments

T.S.S.W.,%						
YEAR	VARIETY	TREATMENT	I	II	III	AVERAGE
1996	P	SG	9,7	8,4	8,4	**8,8**
		SGL	7,8	9,2	8,0	**8,3**
		SL1	8,5	8,6	8,7	**8,6**
		SL2	9,4	9,3	9,5	**9,4**
		SL3	7,8	8,6	9,4	**8,6**
	M	SG	8,8	7,8	8,2	**8,2**
		SGL	8,0	8,1	8,3	**8,1**
		SL1	8,5	8,6	8,8	**8,6**
		SL2	8,5	9,2	9,2	**9,0**
		SL3	9,3	7,7	8,9	**8,6**
1997	P	SG1	9,3	9,3	8,9	**9,2**
		SG2	11,4	9,6	10,0	**10,3**
		SG3	8,9	8,6	9,5	**9,0**
		SGL1	8,5	7,6	9,8	**8,6**
		SGL2	9,0	9,9	9,0	**9,3**
		SGL3	9,9	9,2	8,4	**9,2**
		SL1	8,8	9,1	8,8	**8,9**
		SL2	10,5	10,3	8,9	**9,9**
		SL3	10,6	9,3	8,2	**9,4**
		DG	9,9	10,4	11,0	**10,4**
		DGL	10,0	9,8	10,1	**10,0**
		DL	9,7	8,6	10,5	**9,6**
	M	SG1	9,6	8,3	8,7	**8,9**
		SG2	9,3	9,2	8,6	**9,0**
		SG3	10,1	10,2	8,3	**9,5**
		SGL1	10,0	7,2	8,9	**9,5**
		SGL2	9,6	9,5	8,4	**9,2**
		SGL3	9,5	9,4	8,0	**9,0**
		SL1	9,5	10,5	8,2	**9,4**
		SL2	10,1	10,1	8,5	**9,6**
		SL3	9,7	8,9	7,9	**8,8**
		DG	10,2	10,4	11,2	**10,6**
		DGL	10,6	10,4	10,6	**10,5**
		DL	9,0	9,3	9,8	**9,4**

Appendix 8. Variance Analyses of the Fruit Length and T.S.S.W.

YEAR			FRUIT LENGTH		T.S.S.W.	
	Variance Source	FD	Mean Square	F Values	Mean Square	F Values
1996	Repl.	2	0.81		0.03	
	Variety	1	11.1^{ns}	8.44	0.30^{ns}	1.99
	Error(1)	2	1.32		0.15	
	Nitrogen	2	6.74^{ns}	3.2	0.25^{ns}	<1
	Error(2)	4	2.1		0.53	
	Varety-Nitrog.Int.	2	0.40^{ns}	<1	0.15^{ns}	1.4
	Error (3)	4	1.37		0.11	
	General	17	2.56		0.23	
1997	Repl.	2	5.27		0.49	
	Variety	1	90.54^{ns}	107.10	0.02^{ns}	<1
	Error(1)	2	0.85		0.44	
	Irr. Method	1	3.48^{ns}	2.35	7.93^{ns}	4.61
	Irr.-Variety Int.	1	2.67^{ns}	1.81	0.12^{ns}	<1
	Error(2)	4	1.48		1.72	
	Nitrogen	2	2.18^{ns}	<1	1.10^{ns}	3.01
	Error(3)	4	4.65		0.36	
	Nitrog.-Variety.Int.	2	0.81^{ns}	2.06	0.44^{ns}	1.22
	Error(4)	4	0.39		0.36	
	Nitr.-Irr.Method Int	2	2.50*	4.59	0.70^{ns}	<1
	Var-Nitr-Irr.Meth.Int	2	4.67*	8.57	1.34^{ns}	<1
	Error(5)	8	0.55		0.09	
	General	35	4.47		0.76	

Appendix 9. Fruit Weights of the Treatments

FRUIT WEIGHT, g						
YEAR	VARIETY	TREATMENT	I	II	III	AVERAGE
1996	P	SG	5112	5187	4739	**5013**
		SGL	5365	5264	5764	**5464**
		SL1	5144	4484	5316	**4981**
		SL2	4500	5071	4214	**4595**
		SL3	3624	4500	3801	**3975**
	M	SG	5211	5507	5496	**5405**
		SGL	4405	5298	4928	**4877**
		SL1	5037	4977	5253	**5089**
		SL2	4498	4461	4494	**4487**
		SL3	3688	3611	4035	**3778**
1997	P	SG1	4612	5150	5320	**5027**
		SG2	5017	5310	5445	**5257**
		SG3	5522	5205	4755	**5161**
		SGL1	4332	4235	4855	**4474**
		SGL2	5142	5405	4755	**5100**
		SGL3	5490	4735	4520	**4915**
		SL1	5130	4350	5905	**5128**
		SL2	4796	3820	5330	**4650**
		SL3	5397	4350	5155	**4967**
		DG	5288	3933	4840	**4687**
		DGL	4674	3500	4123	**4099**
		DL	5201	3786	6333	**5107**
	M	SG1	5272	4900	4925	**5032**
		SG2	4797	4640	5500	**4975**
		SG3	5762	4800	5655	**5406**
		SGL1	5165	5055	4160	**4793**
		SGL2	5795	5260	4090	**5048**
		SGL3	5286	6175	4385	**5282**
		SL1	4795	4805	4655	**4752**
		SL2	4895	4583	4740	**4739**
		SL3	5457	4215	5775	**5149**
		DG	4988	4883	5116	**4996**
		DGL	5958	4656	5093	**5236**
		DL	5446	4566	5623	**5212**

Appendix 10. Variance Analyses of Fruit Weights

Year	Variance Source	FD	Fruit Weight	
			Mean Square	F values
1996	Repl.	2	63640.8	
	Variety	1	4044^{ns}	<1
	Error(1)	2	136695	
	Nitrogen	2	50176.8^{ns}	<1
	Error(2)	4	124574	
	Varety-Nitrog.Int.	2	382369^{ns}	6.36
	Error (3)	4	60101.7	
	General	17	118148	
1997	Repl.	2	2029850	
	Variety	1	1373584^{ns}	9.99
	Error(1)	2	137361	
	Irr. Method	1	595984^{ns}	2.24
	Irr.-Variety Int.	1	143136^{ns}	<1
	Error(2)	4	265565	
	Nitrogen	2	170556^{ns}	<1
	Error(3)	4	798770	
	Nitrog.-Variety.Int.	2	306860^{ns}	2.79
	Error(4)	4	109718	
	Nitr.-Irr.Method Int	2	288992^{ns}	<1
	Var-Nitr-Irr.Meth.Int	2	324857^{ns}	<1
	Error(5)	8	828161	
	General	35	428063	