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# Irrigation and Economic Aspect of Vineyard in the *Gediz basin* of Turkey

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**Abstract:** The objectives of this study are to obtain irrigation scheduling and to determine the gross return values of vineyard in the *Gediz basin* both in adequate and limited water conditions. The irrigation programme for adequate water conditions (100%) and the appropriate limited irrigation programme for 90, 80, 70, 60, 50% limited water. The amount of water applied in adequate water conditions is between 467-656 mm whereas in limited water conditions it is between 232-593 mm in clay loam soil. In the adequate water conditions, the highest gross return values were obtained from average and rainy year conditions in both fresh and raisins. In both irrigation conditions, the highest gross return was obtained from raisins.

**Key words:** Irrigation scheduling, vineyard, limited irrigation, gross return.

## INTRODUCTION

The most suitable climatic zones for viticulture are between latitudes 34 and 49° north and south. Viticulture has an important place in world agriculture because it is possible to use grapes in many different ways (table, wine, drying and for fruit juice). In 1999, 7, 396, 479 hectares were devoted to viticulture and total fresh grape production was 58, 119, 955 tons worldwide. When we compare these values with those of 1997, we see a 9.7% decrease in vineyard area and a 4.2% decrease in grape production[1].

Turkey is in fourth place worldwide in terms of vineyard area and in fifth place in terms of production. Turkey has large vineyard areas and grape production: 541, 000 ha and 3, 600, 000 tons, respectively. The Aegean region is in first place in terms of both vineyard area and grape production with 1, 640, 446 tons on 154, 196 ha, respectively[1].

As in the other countries, in Turkey, despite the lack of irrigation in some parts of the vineyard areas, irrigation is applied in regions where seedless grapes are cultivated. If the area to be irrigated is large and water is expensive, limited irrigation can be applied. In limited irrigation, the amount of water applied can be restricted and some amount of decrease in yield can be allowed. On the other hand, income per unit of water can be increased[2].

Balçin and Güleç[3] have determined the irrigation schedule for tomatoes using IRSIS and CROPWAT computer software and by comparing results for 1994-1996 with field data. They showed that the irrigation statistics and the amount of irrigation water obtained using IRSIS and CROPWAT were similar to the field data.

Kanber *et al.*[4] examined the yield functions for groundnut with different sowing times and regional field characteristics in limited irrigation conditions. They concluded that the effects water limitation on late sowing and in light textured soil were very important.

According to Samanci[5], the irrigation time of vineyard is the time when the grape vine shows insufficient water indications. Following the granule holding in fruit set stage, grape vine needs more water. Hence, water stress appears in this period. There should not be any irrigation scheduled through the last periods of reaping (2-4 weeks before). The irrigation, made in this period, accelerates the development of new shoot.

Şener and İlhan[6] have examined water consumption and irrigation water requirements of round seedless grape in Manisa-Horozköy. They found that the amount of irrigation water given was 110-120 mm and the seasonal water consumption was 535 mm.

The aim of this study is to determine the irrigation scheduling and the gross return values for vineyards in the *Gediz basin* in both adequate and limited water conditions.

## MATERIALS AND METHODS

The *Gediz basin* is located in the Aegean Region of western Turkey. The basin lies between 38°04′ and 39°13′ north latitudes and 26°42′ and 29°45′ east longitudes. The total land area of the *Gediz basin* is 1, 721, 895 ha, or about 2.2% of the total surface area of Turkey.

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The *Gediz basin* has 516, 600 ha area available for agriculture or about 30% of the total basin area[7]. For agriculture areas are suitable for vineyards and olive production. In the basin, Manisa is in the first place in terms of both vineyard area and grape production with 51, 963 ha and 607, 142 tons[8].

The reference evapotranspiration ($ET_0$) values for vineyards were calculated using Penman (FAO Modification) methods. For this purpose, IRSIS computer software was used[9]. First, the solution for adequate water was carried out and the required amount of water (100%) was obtained. Then the 90, 80, 70, 60, 50% of this amount of water was taken in order to calculate the amount of limited irrigation water and to obtain the limited irrigation schedules. In this study seasonal water restriction was applied.

Climatic data for the area were taken from The State Meteorological Works archives. The precipitation values were calculated using RAINBOW computer software; the expected dependable precipitation values of arid, average and rainy periods in a year were obtained[10]. Soil texture was taken as clay loam[6]. Crop field data such as crop coefficient (kc), yield factor (ky), efficient root depth (D), soil water depletion fraction (p) were gathered from available publications[11,12]. The stages followed in the study are given in Fig. 1.

Reducing in which ratio of actual evapotranspiration rate, situation of soil water depleted below p ratio can be calculated depending on maximum evapotranspiration (ETm), irrigation interval, total available water of root zone and p ratio or taken from tables, in any period of crop growth season. In the condition of actual evapotranspiration declined under maximum evapotranspiration, the decrease amount in the yield can be calculated. The equality (1) shows the relation between relative evapotranspiration difference ($1-ET_a / ET_m$) and relative yield decrease ($1- Y_a / Y_m$)[13].

$$(1- Y_a / Y_m)= k_y (1-ET_a / Et_m) \quad (1)$$

In the equality;

$Y_a$ = Actual yield amount (kg/ha)
$Y_m$ = Maximum yield amount (kg/ha)
$k_y$ = Yield factor
$Et_a$ = Actual evapotranspiration (mm)
$Et_m$ = Maximum evapotranspiration (mm), values were given.

Gross return was determined by subtracting the variable costs from gross production value. The variable costs were taken as seed, manure, pesticide, fuel costs, labour costs, water costs, marketing costs, machine rents, product insurance and interest. Variable and fixed costs regarding yield were determined by considering the principles, that maintenance, harvest-threshing, carrying, various input and average expense, given in Koral and Altun[14]. In the study, the gross return values were calculated using year 2000 prices[15-17].

## RESULTS AND DISCUSSION

The results of the schedules obtained for *Gediz basin* in the adequate and limited water conditions are given in Table 1. In the adequate irrigation conditions, amount of water applied for different precipitation ranged from 466 to 656 mm. In these conditions, the ratio of $ET_a$ to $ET_m$ is 1.00, consequently the actual yield (Ya) is equivalent to the maximum yield (Ym). Şener and İlhan[6], determined the seasonal water consumption of grape as 535 mm in Manisa-Horozköy and Menemen. After the optimum results were obtained, the limited irrigation schedules were created by applying the 90, 80, 70, 60 and 50% of the total irrigation water. For reliable results in limited irrigation conditions it was made sure that the amount of irrigation water were equal or near to the 90, 80, 70, 60, 50% of the total irrigation water of optimum conditions. For example, in arid precipitation condition, for the S2Y3 result it was made sure that the irrigation water was equal or near to 656 x 0.90=590 mm. In the treated irrigation programme, totally 593 mm of irrigation water was applied, as it was seen that there was a little difference (under 1%) between 590 mm. Since the plant came across with a kind of water stress, Ya/Ym equals to 95.5%. In the limited irrigation water conditions, the values of Ya/Ym for S2Y3 were 90.4, 84.5, 73.9 and 68.9%.

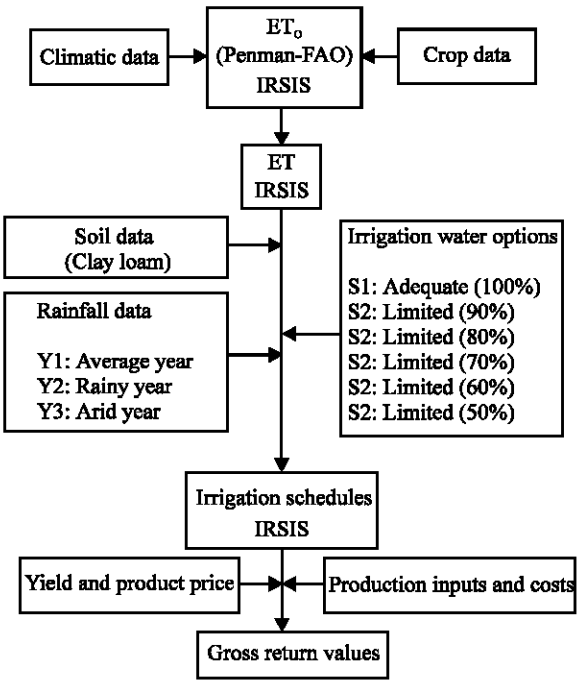


Fig. 1: Flowchart of the study

Table 1: Developed irrigation schedules for vineyard

| | | Results | | |
|---|---|---|---|---|
| Irrigation options | Irrigation treatments | Irrigation number | Total water (mm) | Yield level (%) |
| Adequate (100%) | S1Y1 | 5 | 467 | 100.0 |
| Limited 90% | S2Y1 | 3 | 408 | 93.8 |
| Limited 80% | | 3 | 388 | 93.2 |
| Limited 70 % | | 3 | 330 | 87.4 |
| Limited 60% | | 2 | 290 | 83.3 |
| Limited 50% | | 2 | 232 | 74.7 |
| Adequate (100%) | S1Y2 | 5 | 471 | 100.0 |
| Limited 90% | S2Y2 | 4 | 428 | 97.2 |
| Limited 80% | | 3 | 376 | 95.3 |
| Limited 70% | | 3 | 333 | 92.0 |
| Limited 60% | | 2 | 286 | 88.3 |
| Limited 50% | | 2 | 235 | 81.6 |
| Adequate (100%) | S1Y3 | 7 | 656 | 100.0 |
| Limited 90% | S2Y3 | 5 | 593 | 95.5 |
| Limited 80% | | 5 | 527 | 90.4 |
| Limited 70% | | 3 | 463 | 84.5 |
| Limited 60% | | 2 | 358 | 73.9 |
| Limited 50% | | 2 | 320 | 68.9 |

S1: Adequate irrigation, S2: Limited irrigation, Y1: Average year, Y2: Rainy year, Y3: Arid year

Table 2: Gross return of fresh grape with adequate and limited water in *Gediz basin*

| Irrigation treatments | | Ya/Ym (%) | Ya (kg ha$^{-1}$) | Price ($ kg$^{-1}$) | Gross production value ($ ha$^{-1}$) | Variable costs ($ ha$^{-1}$) | Gross Return ($ ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| S1Y1 | | 100.0 | 14,520 | 0.62 | 9,000 | 3,540 | 5,460 |
| S2Y1 | 90% | 93.8 | 13,620 | 0.62 | 8,445 | 3,455 | 4,990 |
| | 80% | 93.2 | 13,530 | 0.62 | 8,390 | 3,460 | 4,930 |
| | 70% | 87.4 | 12,690 | 0.62 | 7,870 | 3,430 | 4,440 |
| | 60% | 83.3 | 12,090 | 0.62 | 7,500 | 3,400 | 4,100 |
| | 50% | 74.7 | 10,850 | 0.62 | 6,730 | 3,345 | 3,385 |
| S1Y2 | | 100.0 | 14,520 | 0.62 | 9,000 | 3,540 | 5,460 |
| S2Y2 | 90% | 97.2 | 14,110 | 0.62 | 8,750 | 3,500 | 5,250 |
| | 80% | 95.3 | 13,840 | 0.62 | 8,580 | 3,460 | 5,120 |
| | 70% | 92.0 | 13,360 | 0.62 | 8,285 | 3,450 | 4,835 |
| | 60% | 88.3 | 12,820 | 0.62 | 7,950 | 3,400 | 4,550 |
| | 50% | 81.6 | 11,850 | 0.62 | 7,350 | 3,375 | 3,975 |
| S1Y3 | | 100.0 | 14,520 | 0.62 | 9,000 | 3,600 | 5,400 |
| S2Y3 | 90% | 95.5 | 13,870 | 0.62 | 8,600 | 3,520 | 5,080 |
| | 80% | 90.4 | 13,130 | 0.62 | 8,140 | 3,500 | 4,640 |
| | 70% | 84.5 | 12,270 | 0.62 | 7,600 | 3,420 | 4,180 |
| | 60% | 73.9 | 10,730 | 0.62 | 6,660 | 3,385 | 3,275 |
| | 50% | 68.9 | 10,000 | 0.62 | 6,200 | 3,320 | 2,880 |
| Rainfed | | - | 6,340 | 0.62 | 3,950 | 3,380 | 570 |

1 $ = 638,579 Turkish Liras

Table 3: Gross return of raisin with adequate and limited water in Gediz Basin

| Irrigation treatments | | Ya/Ym (%) | Ya (kg ha$^{-1}$) | Price ($ kg$^{-1}$) | Gross production value ($ ha$^{-1}$) | Variable costs ($ ha$^{-1}$) | Gross return ($ ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| S1Y1 | | 100.0 | 11,040 | 1.12 | 12,370 | 3,940 | 8,430 |
| S2Y1 | 90% | 93.8 | 10,360 | 1.12 | 11,600 | 6,030 | 5,570 |
| | 80% | 93.2 | 10,290 | 1.12 | 11,530 | 6,030 | 5,500 |
| | 70% | 87.4 | 9,650 | 1.12 | 10,800 | 6,000 | 4,800 |
| | 60% | 83.3 | 9,200 | 1.12 | 10,300 | 5,960 | 4,340 |
| | 50% | 74.7 | 8,250 | 1.12 | 9,240 | 5,920 | 3,320 |
| S1Y2 | | 100.0 | 11,040 | 1.12 | 12,370 | 3,940 | 8,430 |
| S2Y2 | 90% | 97.2 | 10,730 | 1.12 | 12,020 | 6,080 | 3,940 |
| | 80% | 95.3 | 10,520 | 1.12 | 11,790 | 6,040 | 5,750 |
| | 70% | 92.0 | 10,160 | 1.12 | 11,380 | 6,030 | 5,350 |
| | 60% | 88.3 | 9,750 | 1.12 | 10,920 | 5,980 | 4,940 |
| | 50% | 81.6 | 9,000 | 1.12 | 10,080 | 5,960 | 4,120 |
| S1Y3 | | 100.0 | 11,040 | 1.12 | 12,370 | 4,150 | 8,220 |
| S2Y3 | 90% | 95.5 | 10,540 | 1.12 | 11,800 | 6,100 | 5,700 |
| | 80% | 90.4 | 9,980 | 1.12 | 11,180 | 6,080 | 5,100 |
| | 70% | 84.5 | 9,330 | 1.12 | 10,450 | 6,000 | 4,450 |
| | 60% | 73.9 | 8,160 | 1.12 | 9,150 | 5,960 | 3,190 |
| | 50% | 68.9 | 7,610 | 1.12 | 8,530 | 5,900 | 2,630 |
| Rainfed | | - | 2,760 | 1.12 | 3,100 | 2,690 | 410 |

1 $ = 638,579 Turkish Liras

The gross production and gross return values calculated for fresh grapes in adequate and limited conditions are given in Table 2. The same values for raisins are given in Table 3. In the adequate conditions, the highest gross return value in fresh and raisin was obtained S1Y1 and S1Y2 treatments. Although the variable costs of producing raisins for all irrigation treatments were higher than those for fresh grapes, the high market price of raisins caused a higher gross return value. When we examine Table 3, we can see that as the amount of irrigation water decreases, the gross return value decreases. Higher gross returns are obtained from raisins in limited conditions.

Results of the irrigation programme for the *Gediz basin* show that, to obtain more yield with the same amount of water in limited irrigation conditions, the water-yield relation should be taken into consideration while determining these irrigation schedules. An important yield increase can be obtained by applying the right irrigation at the right time. To use water sources more effectively, greater importance should be given to water-yield and water- income relations in limited irrigation programmes.

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