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Multi-Objective Drainage Requirement of Harran Plain

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Abstract: While the main objective of drainage requirement in the semi-arid region such as south-eastern Anatolia is generally salinity control, other objectives may also be important. Because of irrigation, salinity problems have occurred in many areas in Harran Plain. There is no subsoil drainage system in the plain. In this study, proper drain depth, drain diameter and drain spacing are determined and evaluated depending on soil and plant features of the plain. In the plain, drain depth, drain diameter and drain spacing are proposed as 1.8–2.0 m, 100 mm and 21.3 m, respectively.

Key words: Harran Plain, drainage, salinity, subsoil drainage, drainage project

INTRODUCTION

While the standard design approach almost exclusively focused on salinity control, recent experiences indicate that other drainage requirement objectives may also be important. With advances of research and the development of new drainage projects, conditions in the semi-arid regions are found to be more variable than hitherto perceived. In projects in the northern part of Indian sub-continent, in the central-eastern part of main land China and in the Mediterranean part of Turkey, it was found that in the design of groundwater drainage systems, besides salinity control, aeration control and subirrigation potentials also had to be considered (Smedema, 1990).

Christen *et al*. (2001) evaluated subsurface drainage design and management in irrigated areas of Australia in terms of long-term sustainability of irrigated agriculture. The long-term sustainability of irrigated agriculture depends upon controlling the salinity levels in the crop root zone and maintaining the ability to dispose of drainage water. This requires that subsurface drainage systems are efficient in terms of removing the minimum amount of water with the lowest salinity possible, given the existing conditions, while still maintaining crop productivity.

The sustainability of irrigated agriculture in India is threatened by waterlogging, soil salinity and alkalinity. To reverse declining agricultural productivity, a combination of surface and subsurface drainage, supplemented by improved irrigation management, has been identified as the most appropriate strategy. But subsurface drainage for salinity control is costly. Therefore, its benefits in terms of sustained agricultural production must be thoroughly investigated to establish its techno-economic feasibility. In the study the results show that, gains from drainage are helping to increase land productivity, gainful employment of the farmers and, hence, farm income. The financial and economic feasibility of drainage in waterlogged and saline areas looks favorable, provided that sufficient water is available for leaching and irrigation and that a sustainable solution for the disposal of the low-quality drainage effluent is found (Datta *et al*., 2000).

All available data on saline and/or waterlogged soils indicated that the cause of salinity in Turkey is related to climate, drainage, farming practices and soil characteristics. When considering the effects of these factors on the present state of salinity in Turkey it is difficult to differentiate between the importance of each. Except north-eastern Black sea coast of Turkey, the country can be considered to be in arid and semi-arid zone. In arid and semi-arid regions in the country the natural drainage channels are not adequate. On the coastal plains the average elevation is in the range of 2 to 20 m above sea level. The inland plateaus do not have adequate drainage outlets (Anonymous, 1973).

Compared to similar projects worldwide, the Southeastern Anatolia Project (GAP) is rather ambitious in terms of its geographical area, physical magnitudes and targets. It is a multi-sector, integrated regional development project launched in the region of Southeastern Anatolia. GAP is a multi-sector and integrated regional development effort approached in the context of sustainable development. Its basic objectives

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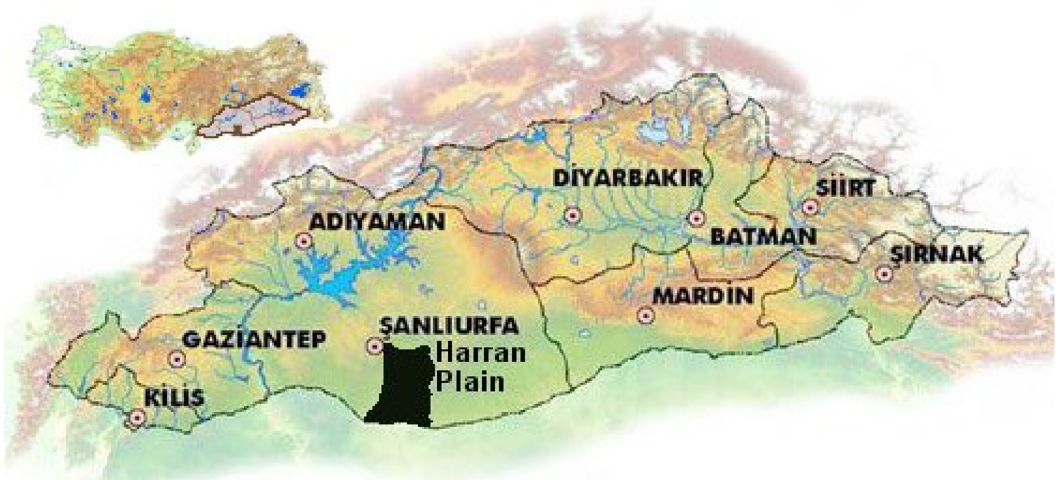

Fig. 1: Gap project area and harran plain

Table 1: Land Resources for Turkey and GAP Region

Land resource and use	Turkey		GAP		Ratio of GAP in Turkey
	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Oran (%)
Agricultural land	28 059 397	36.0	3 290 575	43.6	11.7
Pasture	21 506 028	27.6	2 214 473	29.4	10.3
Forest	23 248 297	29.8	1 451 185	19.2	6.2
Aquatic environment	1 159 207	1.5	96 672	1.3	8.3
Others	3 972 271	5.1	488 095	6.5	12.3
Total	77 945 200	100.0	7 541 000	100.0	9.7

include the improvement of living standards and income levels of people so as to eliminate regional development disparities and contributing to such national goals as social stability and economic growth by enhancing productivity and employment opportunities in the rural sector. The project area covers 9 administrative provinces (Adiyaman, Batman, Diyarbakir, Gaziantep, Kilis, Mardin, Siirt, Sanliurfa and Sirnak) in the basins of the Euphrates and Tigris and in Upper Mesopotamia (Fig. 1).

Southeastern Anatolia Project (GAP) is located in the region with the richest source potential per person. Approximately 9% of the country population lives in GAP project area, allocating almost 10% of the country total land area. On the other hand, based on the natural resources, ¼ of total arable land area, ¼ of above and underground water potential, ¼ of hydroelectric power potential, almost all of the oil and phosphate reserves are located in this region (Balaban, 1995).

GAP area has a significant share in Turkey with its land area. GAP project area land resources are given in Table 1 in comparison with country total land resources (Karli, 1999).

Dry land areas are continuously opened for irrigation and production is increased toward a better utility of potential water and land resources. However, these new areas are losing their agricultural value via salinity and aridity problems since the necessary measures are not taken sufficiently (Celik *et al*., 1999).

Harran Plain already has salinity and drainage problems due to irrigation practices with underground water in Akcakale. Salinity and high ground water level problems has arisen and land areas with these problems are extended in Harran Plain, which was opened for irrigation via Urfa Tunnel. Based on the researches carried out in the plain, 20 000 ha land area has salinity and high ground water level problems. It is certain that these areas will increase in case the necessary measures were taken (Anonymous, 1998).

Current drainage system in Harran Plain is surface drainage except a small area. Most of them are secondary and main discharges. Current system is enough for remove the surface water but not enough for the problems arisen from high ground water levels.

In this study, information was given about the measures to control the ground water levels in semi-arid GAP region and drainage coefficient for current cropping pattern was determined. Based the resultant value, subsurface drainage criteria for groundwater level and salinity control measures were determined.

MATERIALS AND METHODS

This study was carried out by considering Harran Plain which was opened for irrigation first to represent the GAP region and based on the available data for Sakca, Meydankapi, Kisas, Koruklu, Harran, Cinpolat and Akcakale where there were several studies carried out.

Soils of Harran Plain are 70% clay, 12% clay-loam, 8% silty clay, 5% silty clay loam, 3% silty loam and 2% loam (Erozel, 1988; Dinc *et al.*, 1986). Permeability varies from one region to another. Although the soils are heavy textured soils, high permeabilities can be seen due to high lime content. Salinity usually occurred in base lands with high ground water levels and impermeable layer depth is about 5 meters in these lands.

There are two water bearing aquifer in Harran Plain and the upper aquifer has significantly saline water. Electrical conductivity of water samples from some pump wells is around 13.5 dS m^{-1}. Electrical conductivities of drainage canal water were also found to be high (Cullu, 1999).

Leaching is needed to prevent salinity in several locations in the plain. On the other hand, an efficient inland drainage system is needed to prevent salinity by leaching. However, most of the lands opened for irrigation do not have a drainage system and need for drainage is getting increasing day by day.

Akcakale irrigation can be given as an example for the locations with the highest salinity problem. In Akcakale, which never had a ground water level problem in its history, ground water level is varies between 0-1 meter in 21-26% of irrigated area and between 1.0-2.0 meter in 26-37% of irrigated land area (Tekinel *et al.*, 2001). Ground water salinity has increased the severity of the problem. Based on 1999 data, 68.3% of ground water has a salinity of 0-2.5 dS m^{-1}, 0.3% has 2.5-3 dS m^{-1}, 8.9% has 5-7.5 dS m^{-1}, 16% has 7.5-10 dS m^{-1} and 6.4% has salinity levels greater than 10 dS m^{-1}.

There are also some locations other than Akcakale in Harran Plain with a ground water level above 1 meter and salinity levels between 5-10 dS m^{-1}. This reminds us about the urgent need for salinity and drainage measures.

Drainage need in harran plain for alternative cropping pattern: Considering the current cropping pattern and based on salinity control and leaching need, average drainage needs were determined. Necessary leaching needs were calculated by the following equation:

$$LR = (E - P)\frac{ECi}{e(\frac{DY}{TK}ECe) - Eci} \quad \text{(Van Der Molen, 1973).}$$

Considering the plant water consumptions, amount of water to be applied and total seepages were determined. Drainage coefficients were determined considering the water application performances (Kizilkaya, 1988) and leaching needs (Erozel *et al.*, 1994).

Determination of drainage components for the plain: Average root depth based on alternative cropping pattern and drain depth based on soil properties were determined. Drain spacing was determined by using Hoog-houdt formula and Kirkham tables.

Drain diameters for alternative values were determined based on the principles defined by Eggelsmann (1973).

RESULTS AND DISCUSSION

To determine the amount of irrigation water which was used to determine the drainage criteria, cropping pattern of the year 2001 of Harran Plain with 116 000 ha irrigated land area and supplied by GAP regional development administration was used (Table 2).

Based on the cropping pattern, amounts of net irrigation water for the critical month, July, were determined and amount of irrigation water and seepage loses were determined based on water loses and water application performances defined by Kizilkaya (1988) (Table 3).

Table 2: Year 2001 cropping pattern for sanliurfa harran plain

Crops	Plantation ratio (%)	Plantation area (ha)	Yield (kg ha^{-1})	Production (ton)
Wheat	12.50	14500.00	5000	72500.00
Barley	2.30	2668.00	4000	10672.00
Cotton	84.50	98020.00	4000	392080.00
Corn (II)	0.87	1009.20	8500	8578.20
Fruit	0.12	139.20	225	31.32
Sesame (II)	0.01	11.60	850	9.86
Vegetable	1.60	1856.00	34000	63104.00
Cotton (II)	1.10	1276.00	3500	4466.00
Total	103.00	119480.00		551441.38

Drainage coefficient: Additional leaching water needs in Table 3 express the amount of additional leaching water for the plants not to be effected from the salinity based on their salt tolerances and for the soil not to get saline. Salinity limit was taken as 4 dS m^{-1} for the plants with salt tolerance greater than 4 dS m^{-1}. Even a plant with resistance to salinity levels more than this value will not be affected from salinity, the soil will get saline. That is why, salinity limit was taken as 4 dS m^{-1}. Drainage needs were determined for each plant type by adding seepage and additional leaching water and then this value was corrected with the plantation ratio, finally the monthly rational drainage need was found to be 85.6 mm $month^{-1}$. Based this rational drainage need, the drainage coefficient is 2.76 mm day^{-1}. Since the irrigation interval based on plants is taken as 10 days, total seepage in per irrigation will be 27.6 mm $irrigation^{-1}$. When the plants were evaluated separately, seepage values per irrigation were 30.6 for cotton, 44.1 for corn II, 29.2 for fruit, 43.7 for sesame and 32.1 mm $irrigation^{-1}$ for vegetable. Irrigation

Table 3: Harran plain rational drainage need based on cropping pattern

Crops	Plantation ratio (%)	Critical month water consumption (mm)	Amount of irrigation water (mm)	Deep percolation (% 15)	Additional leaching water	Drainage requirement (mm month^{-1})	Rational drainage requirement(mmmonth^{-1})
Wheat	12.50	-	-	-	-	-	-
Barley	2.30	-	-	-	-	-	-
Cotton	84.50	330.7	509	76.4	18.4	94.8	80.1
Corn (II)	0.87	230.5	355	53.3	83.3	136.6	1.2
Fruit	0.12	294.8	454	68.1	22.5	90.6	0.1
Sesame (II)	0.01	240.0	369	55.4	80.0	135.4	0.0
Vegetable	1.60	297.2	457	68.6	130.5	199.1	3.2
Cotton (II)	1.10	330.7	509	76.4	18.4	94.8	1.0
Total	103.00						85.6

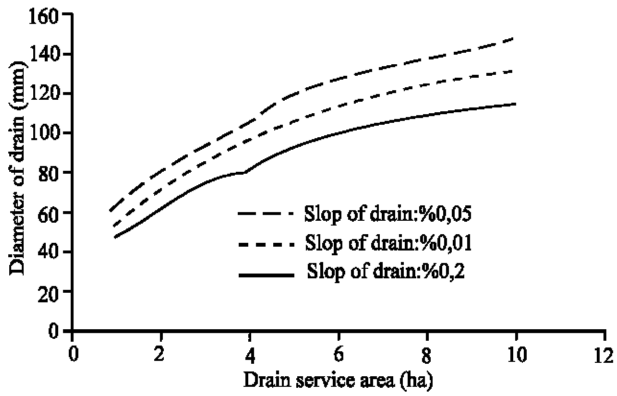

Fig. 2: Drain diameter determination for Harran Plain

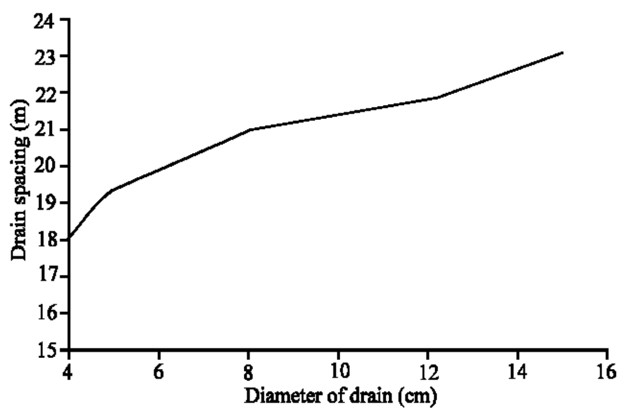

Fig. 3: Drain diameter and drain spacing relation for Harran Plain

interval for vegetable was taken as 5 days since it exhibit more often irrigation need.

Drain depth: Effective porosity of plain soils, most of which have heavy structures, was found to be around 3% (Gemalmaz, 1983).

As an average value, the drain depth for plain can be determined as follows:

$$H = \frac{q}{f} \rightarrow H = \frac{27.6}{0.03} = 920\text{mm} = 92\text{cm}$$

$$Dd = H + Dt = 92 + 90 = 182\text{cm}$$

Here;

H: Amount of ground water level increase per irrigation
q: seepage water per irrigation
f: effective porosity
Dd: Drain depth
Dt: Plant effective root depth

Since the plant dependent drainage coefficients and plant effective root depths are different from each other, drain depths will also exhibit a difference. For the plants in cropping pattern, drain depths will be 192 cm for cotton, 207 cm for corn II, 217 cm for fruit, 205 cm for sesame II and 167 cm for vegetable.

Based on these results, drain depth for the plain for an effective drainage should be high in heavy textures locations and lower in light textured location and it will be appropriate to select it between 1.80-2.00 m.

Drain diameters and spacing: Since a drain line serves for 4-5 ha land area of the plain and drains are placed with 0.1% slope, drain diameter was found as 0.1 m. Using this diameter value and Kirkham tables developed for locations without impermeable barrier layer, drain spacing was found to be 21.2 m. This value is in complete accordance with 22 m spacing found by Erozel (1988). Erozel also defined that a 1.5 m. drain depth would be sufficient. However, considering the current salinity problems, it can be said that 1.80-2.00 m. drain depths, determined in this study, would be more appropriate.

When the drainage coefficient is taken as constant, drain diameter changes with drain service area and drain placement slope. For this purpose, a figure was developed based on drain slope and service area to help in determination of drain diameter in Harran Plain (Fig. 2). Determination of proper drain diameter for a tertiary line with a service area of 4 ha and slope of 0.1% was demonstrated on the figure. For these values, the drain diameter was selected as 95 mm from the figure and the closest commercially available diameter (100 mm) will be selected for application.

Keeping the all other parameters effecting drain spacing constant, another figure was developed for

Harran Plain based on drain diameter and drain spacing relationship (Fig. 3). The diameter selected from Fig. 2 can be used in Fig. 3 to determine the proper drain spacing.

For 100 mm drain diameter with 4-5 ha service area recommended for the plain can be used in Fig. 3 and drain spacing can easily be determined.

As a result, since the salinity problem exists in Harran Plain, drain depth should be at least 1.80 m, this value can be increased up to 2 m in heavy soil textures. Since a tertiary drain serves for 4-5 ha land area, selecting a drain diameter of 100 mm and a drain spacing of 21.3 m will be appropriate.

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