World Journal of Innovative Research (WJIR)
ISSN: 2454-8236, Volume-4, Issue-2, February 2018 Pages 01-04

Water Use in Sprinkler-Irrigated Carrot Plant in Semi-Arid Konya-Kasınhanı Province of Turkey

Omid Ahmed Jalal Jalal, Bilal Acar

***Abstract*—This study was performed to evaluate water use for sprinkler-irrigated carrot plant at Konya-Kasınhanı Province of Turkey in 2017 vegetation period. In research, current crop patterns, irrigation number, carrot root yield, electricity consumption and common irrigation problems were analyzed. The data were obtained from 19 farms by field observations or face-to-face survey techniques. In examined farms, the maximum crop pattern with a share of 68% was carrot production. Second rank in crop pattern is other vegetables such lettuce, radish, tomato, pepper and cabbage. Including carrot farming, vegetables had 85% of crop pattern in research farms. Seasonal irrigation number was found as about 20 with total applied water of 1500-2000 mm by using sprinkler irrigation system. Depending on cultivars and management activities, carrot root yield varied from 60 to 100 t/ha. Electricity consumptions were determined as about 5338 kwh/ha. In research date of 2017, energy cost of such pump was about 1815 TL/ ha or 485 USD/ha. The most important problems were energy and irrigation labor costs. Carrot production is backbone of the farming activity in region. It has the highest water-consuming crop in region. Therefore, future studies in most should be focused on the efficient water use strategies.**

***Index Terms*—Carrot, Crop Pattern, Energy Use, Sprinkler Irrigation**

I. INTRODUCTION

Agriculture is the single maximum fresh water user sector for worldwide. Water saving irrigation techniques in agriculture is strongly needed in water shortage environments. In those days, depending on the region about 70 % of the fresh water resources is used in agriculture. To minimize such ratio, efforts should base on correct irrigation program in agriculture especially in those water scant environments [1-3].

The main target in each irrigation method is to apply the water to the crops as uniform as possible. Pressurized irrigation methods, sprinkler or drip system, have number of advantages such as less labor requirement, easy control of applied water, more uniform water application to the crops over other irrigation techniques. The possibly the most important advantage is resulting high or qualified yield under well management.

Omid Ahmed Jalal Jalal, Department of Farm Buildings & Irrigation, Faculty of Agriculture, University of Selçuk, Konya, Turkey
Bilal Acar, Corresponding Author, Department of Farm Buildings & Irrigation, Faculty of Agriculture, University of Selçuk, Konya, Turkey

In the study region, KonyaKasınhanı province,field crops such as cereal, sugar beet, corn, dry bean, sunflower and vegetables such as carrot are the main crops. The region has characterized as 3% of fresh water resources and 11% of the cultivated lands of Turkey. All summer crops even including cereals are not growth without irrigation [4].

Carrot production having about 65% of total production of Turkey is mostly dominated in region. It is the most important vitamin A source. Carrot root are used for multi-purposes such carrot juice, salad material. The production has exported to the Middle-East Countries in most. Carrot plants are growth under sprinkler irrigation system. Sprinkler irrigation has more advantages in carrot irrigation over other irrigation methods [5] and can be is good choice for carrot irrigation and under well management, maximum or qualified yield is obtained [6].

Ground water source is used more in irrigation by comparison to the surface water in Konya plain. To meet the increasing irrigation demand, number wells have constructed. Those wells are main reason of increasing demand for electricity [7].

Over water extractions from the groundwater reservoir are the main environmental problems due to the absence of surface water resources in vegetation periods in Konya plain of Turkey. In that regard, agro-research programs based on the water savings are the necessarily prerequisites in such region since more than 75% of the total water use is resulted from the agro-activities [8]. Correct system design, installation of those systems onto the field and well management of the systems are necessarily prerequisites for uniform water application to the crops. Proper design of the irrigation systems and managerial status has great effect on water distribution uniformity. For instance, greater the sprinkler spacing decreased the water distribution uniformity [9] and even deep percolation losses and nitrate leaching are resulted from the uniformity of irrigation water [10].

Fortunately, farmers in region have great experiences about the management of sprinkler irrigation systems. They have used those systems in many field crops such as cereals, dry bean, sugar beet and all vegetables such as carrot, lettuce, cabbage and radish crops.

Sprinkler irrigation system design, working pressure, irrigation time, irrigation number and seasonal applied water were examined in carrot irrigation at Konya-Çumra province of Turkey [11]. The researcher found the followings; lateral diameter of 75 mm, sprinkler spacing of 12mx12m, nozzle diameter of 4.5/4.8 mm, average working pressure of 2.38 atm., irrigation duration in one set of 4.5-6 h, and irrigation number of 19-20. In region, applied water was about 2000 mm that is equal to 20 000 m^3/ha.

One of the most important production costs in carrot production is energy cost in region. Electricity consumption and flow rate and electricity consumption for applying per volume water for different pump systems under sprinkler-irrigated carrot plants at Konya plain of Turkey was evaluated [12]. They found those as 33.87 kwh/h and 37.32 kwh/h; 110.91 and 119.07 m^3/h; and 0.305 and 0.313 kwh/m^3, respectively for both line shaft vertical pump system induced by power takeoff and electrical motor-submersible pump system.

Almost little study was carried out to analyze the water use by sprinkler irrigation systems under carrot production areas in the region. This study was, therefore, performed to determine water use in sprinkler-irrigated carrot plants.

II. MATERIALS AND METHODS

The study was performed at Konya-Kasınhanı province of Turkey. It is about 22 km far from the Konya city center with 1018 m above the sea level. It has the semi-arid climate; dry or hot summers with cold and rainy or sometimes snowy in winters. It is the top with about 65% of the total carrot productionin Turkey. The study region has the least rainfall area of Turkey so irrigation is vital important for summer crops even for cereals. The total annual rainfall is about 323 mm and about 80 mm of that is recorded within the carrot vegetation period. However, total annual evaporation is about 1300 mm.

In general, seeds were sown using planting machine in region at early May 2017 and machinery harvest was performed on 5 September 2017. The number of seeds in sowing was about 220 /m^2 and about 150-170 carrot seeds were germinated successfully. Fertilizer program is also very important for high and qualified carrot root yield. Following fertilizer applications were considered in study: 400-500 kg/ha Diammonium Phosphate, $(NH_4)_2HPO_4$, as a base fertilizer; 40-80 kg/ha Urea, CH_4N_2O, when the crops having two leaves; 250 kg/ha Ammonium Sulfate, $(NH_4)_2SO_4$, after 40 days from the fully germination; 100 kg/ha calcium sulfate, $CaSO_4$, after 80 days from the fully germination.

The data in study were obtained from the surveys of 19 farmers, 17 of them had carrot production activity, and field visits. The main objectives of the present study were to analyze the water use in sprinkler irrigated carrot plants at Konya-Kasınhanı province of Turkey. For those purposes, education level with land size of farmers, current crop patterns, irrigation number, carrot root yield, electricity consumption of sprinkler irrigation systems and common irrigation problems were researched.

In calculation of electricity cost for unit size of one hectare cropped land,relevant data were obtained from the previous study at same region [11].

III. RESULTS AND DISCUSSION

Education level and farming experiences

One of the most important factors affecting efficient water use in agriculture is education level as well as irrigation experience of farmers. In examined farms, 58%, 32%, 5% and 5% of the surveyed farmers were found as primary, secondary, high and university graduation, respectively. In result, most farmers were primary school education. The satisfactory situation is that there is gradual improvement in education level of farmers in recent years.In near future, it is expected that education level will increase more in the farming so that carrot production as well as export of that crop under well-managed irrigation water will also increase and the income of farmers will rise a lot.

The farming experience were determined as 0-10, 11-20, 21-30 year for 5%, 58% and 37% of surveyed farmers, respectively. According to the finding, most farmers performing carrot production in research area had 11-20 year farming experience. Therefore, all farmers were very specialized in carrot or other common vegetable plants such as lettuce and cabbage.

Land size

In general, soil is clay textured with low organic matter and high lime content in most parts of Konya province.

The study region is the carrot production center with about 65% of the carrot production in Turkey. In examined 19 farms, 17 farmers or farms is actively carrot producer. Land size distributions of study farms were presented in Table 1.

The maximum share of the land size with 42% was about in the range of 20-30 ha. Those areas are greater than the average of Turkey since the region is one of the maximum land sizes of Turkey. In that regard, farming is performed almost professional standard and is the backbone of the income source of the people in region. As the land size increase, modern agricultural activities such as using modern irrigation systems are performed easily. That situation has resulted high and qualified agro-production.

Table 1. Land size distribution of examine farms

Land Size, ha	Ratio, %
0-9.9	6.0
10.0-19.9	5.3
20.0-29.9	**42.0**
30.0-39.9	5.3
40.0-49.9	5.3
50.0-59.9	5.3
> 60.0	21.0
Total	**100**

Crop Pattern

In research area, some vegetables such as carrot, cabbage, lettuce, radish, potato, eggplant pepper and field crops such as corn, cereals, sugar beet, sunflower, dry bean

were growth. The crop patterns of the surveyed-farms were listed in Table 2. In such table, the highest land size with 68% was carrot production area. In accordance of the result, carrot is the most important commercial vegetable crop for region or even for Turkey. The main reasons are that soils as well as environmental conditions are best suited and farmers have great experience about carrot farming.

In Table 2, second rank in crop pattern is other vegetables such lettuce, radish and cabbage. Including carrot farming, vegetables had 85% of crop pattern in examined farms. In that regard, vegetables are the main agricultural activity in research region.

However, the crop pattern of cereals was found as 8% in examined farms. The reasons behind the low production area of cereals are farmers think vegetable production is profitable andthey have not reliable income from cereal production. Cereals are low irrigation water requirement so are very important crops for sustainable use of water resources in region.Cropped lands of cereals thus should be increased.

In study region, corn production is getting increase since the region is first rank in animal breeding of Turkey. The problem is that corn is high water consuming crop so it should be cultivated more in water rich parts of Turkey. Increasing land size for corn production will result depletion of water level in wells. If that trend continues, sustainable use of groundwater will be under risk.

In briefly, crop patterns are not suitable in accordance of current water resources in study region. Carrot, corn, sugar beet are high water consuming crops. Therefore, crop pattern should be organized in accordance of current water supply of region. In that regard, some low water consuming crops such as lentil, chickpea and squash may be added to the crop pattern.

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Table 2. Crop patterns of farms

Farm No.	Land Size (ha)	Crop pattern, %							
					Corn			Other	
		Carrot	Cereal	Sugar Beet	Grain	Silage	Alfalfa	Vegetables	Fruit Plant
1	30	57	-	-	20	-	-	23	-
2	68	37	15	15	17	-	3	13	-
3	28	-	45	-	22	21	9	3	-
4	61	25	16	4	-	7	-	48	-
5	30	100	-	-	-	-	-	-	-
6	44.5	57	17	22	-	-	-	4	-
7	15	87	-	-	-	-	-	13	-
8	250	80	-	-	-	-	-	20	-
9	7.5	76	-	13	-		-	11	-
10	2.0	-	-	-	-	-	-	100	-
11	8.0	63	-	-	-	-	-	37	-
12	25	100	-	-	-	-	-	-	-
13	20	85	-	-	15	-	-	-	-
14	25	100	-	-	-	-	-	-	-
15	25	100	-	-	-	-	-	-	-
16	50	80	20	-	-	-	-	-	-
17	21.2	100	-	-	-	-	-	-	-
18	225.5	44	44	8	-	1	-	-	3
19	250	100	-	-	-	-	-	-	-
Total	960.7	**67.5**	**8.0**	3.4	**6.5**		0.6	**14.0**	3

Number of Irrigation, Irrigation Interval and Root Yield

Evapotranspiration or crop water use is direct related to the crop cultivar, growth stages and some atmospheric conditions such as wind speed, relative humidity and geographic position of farms. In region, due to the geographical characteristic, all summer crops or even winter cereal is not growth without irrigation.

Sprinkler irrigation systems are well adapted to carrot irrigation. In study region, sprinkler designs of 12x12 m were common in carrot irrigation. Sprinkler flow rates were 0,8-1.0 t/ h or 1.6-2.5 t/h. Similar result, 2.57 t/h sprinkler having flow rate at 2.38 atm. pressure with 4.5/4.8 mm nozzle diameter was also mentioned elsewhere [11] in same region.

In research region, carrot seeds are sown on 5 th May 2017 and first harvest was made by machinery on 5 thSeptember 2017. In first 15-18 days of germination period, water is applied on the soil by sprinkler irrigation system for 1.5-2 hours. After the crop full cover, irrigation interval was 7 days for sprinkler-irrigated carrot plants. Durations for using sprinklers with 0.8-1.0 t/h and 1.5-2.5 t/h flow rates were 9-10 h and 5-6 h. Number of irrigation in season was found as about 20 with total applied water of 1500-2000 mm or 15 000- 20 000 m^3/ha by using local sprinkler irrigation system. Our findings are inline with [11].

Yield or quality of carrot root is highly affected by carrot cultivar, fertilizer management; cultural practices in vegetation period and correct selection or management of irrigation system. In our study, carrot root yield was in the range between 60 and 100 t/ha. It was reported as 48-104 t/ha in a study [13] and is conformity with the finding of our present study.

Irrigation water was obtained from the ground water source in research region.By considering the sprinkler flow rates, seasonal irrigation number and irrigation time, seasonal average applied water for carrot irrigation was estimated as about 1750 mm or 17500 m^3/ha. The pump unit was worked

by electricity in all examined farms. Under those conditions, average electricity consumption for pumping unit volume of water and seasonal electricity consumption were determined as about 0.305 kwh/m^3 and 5338 kwh/ha (17500x0.305), respectively [11].

In research date of 2017, energy consumption of such pump was about 0.340 TL / kwh. It was calculated as 1815 TL/ ha or 485 USD/ha. Similar energy costs were mentioned elsewhere [11] about energy use of carrot in same region.

Common Irrigation Problems

The most important problem is that carrot is a high water consuming plant. Depending on the production sites, seasonal applied water is about 1500-2000 mm and is about four fold of irrigation water of cereals. Therefore, carrot production should be performed at only research province.

The other environmental problem is growing some other high water consuming field crops such as sugar beet and corn crops. Especially corn production area increases without control. The main reason of groundwater depletion is increase of irrigation area by not considering the current available water supplies. The practical solutions may be that less water consuming crops such cereals, chickpea and squash should be growth more. In the other words, crop patterns in region should be organized in accordance of current water supplies. In addition, deficit irrigation could be applied on some crops such as sugar beet. In accordance of our past experiences, 25% deficit irrigation, not resulting significant yield reduction, is very practical to minimize the water use in irrigation.

In general, the maximum cost in carrot farming was energy cost. Fortunately, all pumping plants were worked by electricity. The electricity cost for unit area of one ha was calculated as about 485 USD. It is very expensive and government should subsidize that cost. Under current situation, carrot production will not be sustainable due to the very little or almost none incomes for farmers.

The other main problem is irrigation labor cost. Carrot production is based on the intense irrigation activities even about 20 irrigations for season. Labor cost of irrigation is also very expensive and all farmers growing carrot plants are not satisfied from those situations.

IV. CONCLUSION

Agro-production mostly is based on the education level as well as farming experiences. Most farmers are primary and secondary school education with great experiences about irrigation.

Agriculture is the single maximum fresh water user sector as 70% worldwide and is more than 75% in Konya plain of Turkey. In such region, it is impossible to grow the crops without irrigation. Therefore, water resources have to be used efficiently. In our region, high water consuming crops such as sugar beet and corn are very common. Production area of corn crops especially has increased dramatically recent years. Therefore, crop patterns should be designated in accordance of water supplies.

The main problem in carrot production is high input costs such as costs of soil cultivation, fertilizer, seed, labor of irrigation, electricity, harvest and packaging. The region has the about 65% of the total carrot root productions of Turkey. Soils are very favorable and environmental conditions are well suited for such farming. Farmers also have great experiences about carrot farming. They know how to obtain maximum yield with best-qualified carrot roots. They also have great experiences about management of modern irrigation systems such as sprinkler irrigation systems with irrigation program of carrot plants. The most important problem in carrot production is obtaining very low income, almost none income in some production year, although farmers have spent maximum efforts during whole production stages. In result, farmers should be subsidized especially in energy cost for sustainable carrot production in region.

ACKNOWLEDGMENT

This paper is a part of thesis for fulfillment of degree of Master of Science of **Omid Ahmed Jalal Jalal**. Particular thanks go to the all farmers in Konya-Kaşınhanı town for support in providing us the opportunity of performing the research.

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