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Design of A Fertilizer System That Can Be Used in The Hose Reel Irrigation Machines

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ABSTRACT

In case the soil cannot supply water and plant nutrients enough for the plant, the actions to be taken are irrigation and fertilization. In this study, the design of a device that allows the fertilizer to apply fertilizer at the same time while irrigation with the Hose Reel Irrigation Machines used in agricultural irrigation was designed. In this design, a dosing unit and a fertilizer tank were added to the irrigation system, allowing a certain amount of fertilizer to be added into the water. The design has been tested both in the laboratory and in field conditions. In the laboratory, it has been observed whether sealing and applying correct amount of fertilizer. In field applications, food coloring was applied instead of fertilizers and the amount of paint on filter papers was evaluated. According to the results obtained, the use of dosing pumps in hose reel irrigation systems gave positive results in order to increase irrigation water use and fertilization efficiency. When the field distribution was analyzed, the coefficient of variation varied between 21-38% and it was stated that this was an acceptable value.

Keywords: Hose Reel, Irrigation, Fertilizer, Dosing, Pump

I. INTRODUCTION

In order to maintain the vital functions of the plants in agricultural production and to obtain high efficiency, the nutrients needed by the plants must be dissolved in roots. Water plays an important role in dissolving the nutrients in the soil and delivering them from the root to the stem, branches and leaves of the plants.

It is the technique of sprinkler irrigation, in which the water is sprayed into the air with a certain angle and pressure, and dropped in the form of fine droplets on the soil and the crop by its own weight. It can be used with the water source with lower flow rate conditions than surface irrigation methods. Due to the fact that the necessary parts can be provided and controlled during application, that method can be widely used in the world.

Among the sprinkler irrigation systems, the hose-reel irrigation machine is a system that provides easy use by reducing the cost with less labor. It is much more economical than other irrigation methods in terms of cost. It can work at low pressures and prevents hardening of the soil and damaging the crops with proper irrigation. It allows irrigation of more than one field area. It is operated under pressure with the help of plastic hoses from water sources.

Today, one of the precautions we can take against the rapid increase of the input costs such as fertilizer, diesel, labor is to increase field efficiency by %20-50 and increasing our profit by producing export quality products. Regarding this, irrigation with methods such as sprinkler irrigation both has advantages and is important in terms of using water resources and water saving, and it should be made more widespread in our country. When the fertilizer applying function is installed on these systems, success will increase even more.

For the sustainable use of water in agriculture, it is necessary to increase the use efficiency of water [1]. To achieve this goal, factors such as irrigation systems that use water efficiently, appropriate irrigation timing, watershed management, drought-resistant plant growing, dry farming, mulch usage, compost and organic farming should be taken into consideration. One of the most important ways is pressure irrigation systems such as drip and sprinkler irrigation. In this way, the root part of the plant can be irrigated directly. Fertigation is the application of plant nutrients, such as liquid or solid fertilizers, together with irrigation systems to soil or plant root zone. It is possible to apply fertilizers with all irrigation systems in fertigation.

Fertilization systems used in agriculture are mostly used in conjunction with the plants planted, fruit trees and drip irrigation systems. In field agriculture, sprinkler irrigation systems are used in the plants planted in many continuous rows, especially cereals. However, fertigation is not applied. Due to the almost constant flow in drip irrigation systems, sufficient amount of fertilizer can be applied at the required time and at the required amount. Thus, the amount of fertilizer, labor and time needed for application are saved and the nutrients needed by the plant during the growth period provided. At the same time, an environmentally friendly application is made by preventing environmentally harmful substances from accumulating in the soil. Miller et al. (1976) and Locascio et al. (1985) stated that the application of water and fertilizer with the drip irrigation is important in terms of increasing the efficiency and quality, as well as increasing the use efficiency of water and fertilizer. Increasing the use efficiency of water and fertilizer is important for human health as well as for protecting the environment and natural resources. Homogeneity is also excellent in fertilizer applications with sprinkler irrigation methods [11].

As can be seen, the main basis of the application is to supply the water and plant nutrients needed for the plant without creating excessive water demand. Loss of nutrients due to surface runoff and

washing from the soil surface can be prevented with this method. Since only the part of the plant is wetted, water and fertilizer saving is provided, while the water and nutrients required by the plant are met during the development period.

Some researchers have reported that the plant yield has increased significantly with the frequent fertigation and fertilizer application in the soil with low nutrient concentrations, and the main reason for this increase in yield is due to regular nutrient intake [21, 27]. In previous studies, it has been determined that plant nutrients and chemicals used in agricultural production can be given frequently, even continuously, with irrigation water in drip systems, and fertilizer and chemical applications efficiency is higher compared to other systems [10].Fertigation enables the application of irrigation water and soluble fertilizers and other chemicals together, uniform (balanced distribution) and more effective [19, 17].

It is stated that traditional fertilizer application methods (spreading or band application) are not as effective as fertigation, and fertigation provides both an effective and cheap way in providing water and nutrients to plants [8, 9]. In general, plants react better to fertigation than band and spreading applications. Fertigation can be advantageous in the application of fungicides and microelements in a mixture for a clean environment. by eliminating the use of these chemicals separately and they can provide osmotic pressure [14]. Similarly, Brian (1995) reported in his study on grapefruit that he achieved higher fertilizer use efficiency compared to traditional fertilization with fertigation application.

Solaimalai et al. (2005), Darwish et al. (2002), in their study on potatoes, report that fertigation provides higher water and nutrient use efficiency compared to traditional fertilization method.

A couple of investigators have demonstrated that the efficacy of nutrient uptake in fertilization of cotton (Gossypium spp), tomato (Lycopersicon esculentum Mill), sugarcane (Saccharum officinarum L.), strawberry (Fragaria ananassa Duch) and broccoli (Brassica oleracea L.) plants increased by 15–50%. and reported that they increased the yield by 7–49% [3, 7, 12, 26, 27]..

The aim of this study is to develop a system that will reduce excess water consumption in agricultural irrigation for the hose-reel irrigation machines. For this purpose, a system including dosing pump, fertilizer tank and fittings has been designed. Later on, this system was evaluated by examining the spray distribution in the field conditions.

II. MATHERYAL AND METHODS

Theoretical studies have been carried out within TekirdağNamık Kemal University Department of Biosystem Engineering. Assembly and experiments are carried out in IrtemTarimMakine Co.,Hayrabolu,Tekirdag,Turkey and the trial fields of the company. The water used for irrigation of the trial parcel was supplied from the deep well with a flow rate of 120 m3/h, located on the border of the trial field.

Fertilizer system consists of a tank, dosing pump, pipes and connections. While taking the water from the source and pumping it into the system, the pressurized liquid enters the fertilizer tank with the help

of a pipe and from there, with the help of the dosing unit, the specified amount is transferred back to the system together with the fertilizer.

When planning all system components, the necessary fertilizer norm was taken into consideration and the dosing pump was selected. Since the hose reel irrigation machines are used for irrigation of plants such as clover, corn, beet, 30 kg / da fertilizer norm, which is the maximum amount applied for those crops was used in these calculations. The suitability of the pump was decided by comparing the pump characteristics and literature information to be used in the system. Using these data, a pump with a flow rate of 2.5 m3 / h (dosing rate: 1: 500) was selected, which can operate between 0.2-8 bar. Then the components were assembled. Mixrite dosing pump with a flow rate of 20-2500 L/h produced by TEFEN Co. has been selected.The pump is connected to the irrigation pipe in the upstream and downstream directions.

The rate of fertilizer to be added on the pump can be adjusted. In addition, the plastic pipe is attached to the suction line of the dosing pump to suck the fertilizer inside the tank. It is attached to the system externally by a pipe. A ball valve is placed between the entry and exit points. Before the inlet and outlet, 2 manometers are connected to control the pressure. Valves are also assembled inlet and outlet of the pump.

A plastic tank is prepared so that the dosing pump can take fertilizer and store the fertilizer. The tank is 100 liters and 40 x 77 cm in size, and the cover can be clamped with a clamp (Fig. 1).

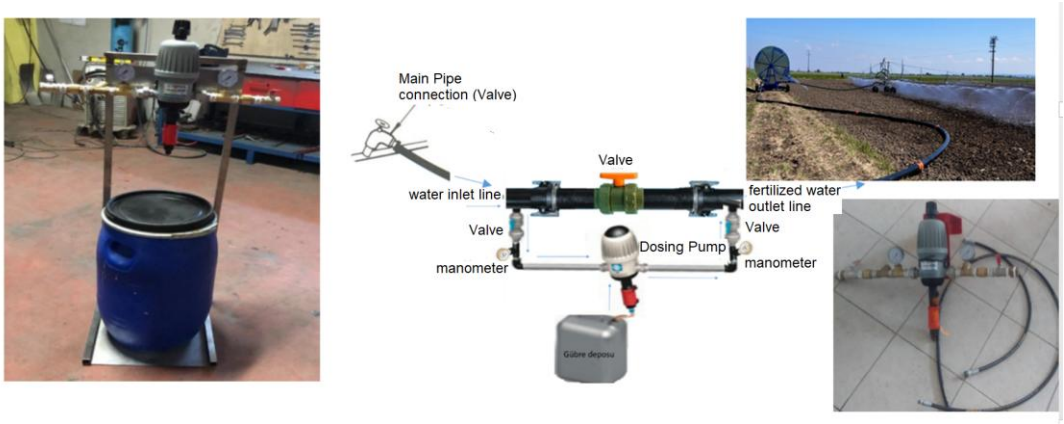

Fig. 1. System installation

The system is operated in different dosages, workshop conditions (0.5-1.0-4.0-6.0-8.0 bar), and its sealing and success have been tested. The performance of water suction, injection, taking fertilizer liquid from the fertilizer tank at the desired rate and injecting this ratio to the system were checked. Then, it was decided to start field trials by connecting to the hose reel irrigation machine system.

The hose reel irrigation machine used in tests produced by Irtem Tarim Makine Co. (Fig 2). It can be used with boom or guns. In general, it consists of the hose reel chassis, gearbox group, axle group, main chassis, lifting piston, tires, hose, water turbine, irrigation gun, boom chassis and boom carrying cart. The main dimensions of the irrigation machine with the hose reel (width x length x height) is 2310 x 3000 x 2250 mm. 300 m of Polyethylene pipe that can be wrapped in a hose reel with a diameter of 90 mm and a thickness of 8 mm is used. The hose reel irrigation machine has a boom width of 45 m

and 30 spray nozzles on it. Each spray nozzle has a diameter of 6 mm. There is also a watering gun at the ends. In this way, it makes irrigation up to 60 m. The boom height can be adjusted between 80-220 cm. 1,8 hectares of land can be irrigated at one time. The speed of self recovery after the machine is turned on is 10-100 m / h.

Fig. 2. The hose reel machine

The field in which the field trial will be carried out was plowed in autumn, it was leveled by curing equipment. Residue distribution test was carried out to determine whether correct fertilization was done. In order to test the homogeneity of the spray, filter papers were placed at certain points in the test area at 5 m intervals. Tartrazine (20 g / L), a water-soluble food coloring, was used as a tracer in the spray liquid. Tartrazine is thought to be suitable for deposit evaluation due to its high recovery rate [20]. In the trials, trace substance norm was used as 4000 g / ha.

In the experiments, filter papers (Schlicher&Schuell 589) with a quarter circle slice with an area of 10x20 cm2 were used as the sample surface. Painted liquid discarded by irrigation was sprayed on filter papers. These papers were kept in water after the application and it was ensured that Tartrazine paint passed to water at a high rate. It is perpendicular to the direction of progress in the trial area and the filter papers are placed under the boom wings (right and left) for 3 repetitions at 5 m intervals. Considering the number of spray nozzles and gun wetting area, 34 filter papers were placed. A total of 102 filter papers were used. In this study, colorimetric method was used to measure the dye concentration in filter papers in the laboratory [2].After fertigation, the researchers waited 15 minutes for the filter papers to absorb the paint well. Then it was wrapped in aluminum foils and stored.

A hand-held anemometer (extech instruments an100-) were used to measure wind and temperature. It has a digital display and can measure by keeping the max-min values in its memory. It gives average values by making 20 measurements.

Pandas 0.23.0, the libraries of the Python 3.0 programming language, were used to evaluate the data, Matplotlib 2.2.2 and Seaborn 0.8.1 were used to draw the graphs of the data. Scipy 1.0.0 is used for statistical tests.

III. Results and Discussion

The designed system was operated at different pressures in the laboratory. In these conditions, the sealing of the system was observed and no problems were encountered. In addition to that, it was

confirmed that the paint mixture (as fertilizer) that the system received from the tank was given to the main pipeline at the desired rates. Then it was assembled in the hose reel irrigation system in the test area.

As stated in the method, filter papers are placed in the test area. The irrigation machine completed irrigation (100 m) in 68 minutes. In the experiments, the measurement groups were collected as 4 groups (4 repetitions) including 30 sample surfaces. These groups are named as A, B, C and D, respectively.

Descriptive statistics table of the values collected from the measurement surfaces are given in Table 1. The highest residue amount was obtained in group B with an average of 2.13 mg / cm2. Group A has the highest standard deviation with 0.68 mg / cm2 standard deviation. The median values of the measurement groups ranged from 0.50 mg / cm2 to 2.09 mg / cm2. Maximum residue amount was obtained from the B group with 3,48 mg / cm2. The coefficient of variation between the residue amounts on the filter papers varied between 21-38%.

The residual amounts obtained in the measurement groups can be seen in Fig. 3. Groups A, B and C show an intersecting distribution. It is seen that the D group has less residue than the other 3 groups. The reason for this is considered that the filter papers used in the D group are used on a sloping land.

TABLE 1. DESCRIPTIVE STATISTICS TABLE OF VALUES COLLECTED FROM MEASUREMENT SURFACES

(mg/cm2)	A	B	C	D
Number	30.000000	30.000000	30.000000	30.000000
Mean	1.783355	2.131660	1.709819	0.574196
Std.Dev	0.682431	0.626689	0.363178	0.429986
Min	0.330251	1.149273	1.030383	0.026420
25%	1.426684	1.694188	1.393659	0.254293
50%	1.750330	2.093791	1.803170	0.501982
75%	2.229194	2.513210	1.862616	0.713342
Max.	2.932629	3.487450	2.536328	1.730515

After analyzing the descriptive statistics values of the measurement groups, it was tried to express whether the residual values obtained in each measurement group showed normal distribution or not with histogram graphs (Fig 4). When histogram graphs of residue measurements were examined, results close to normal distribution were detected in the measurements taken in A, B and C groups. In the D group, although the results are close to the normal distribution, it was determined that the average value was collected towards the left of the axis.

The normality test of the measurement values was done using the D'Agostino and Pearson method [4, 5].For A, B, C and D measurement groups, 0.65, 0.53, 0.75 and 0.09 p-values were obtained,

respectively. Since all of these p-values obtained are greater than 0.05, these values are evaluated to have normal distribution.

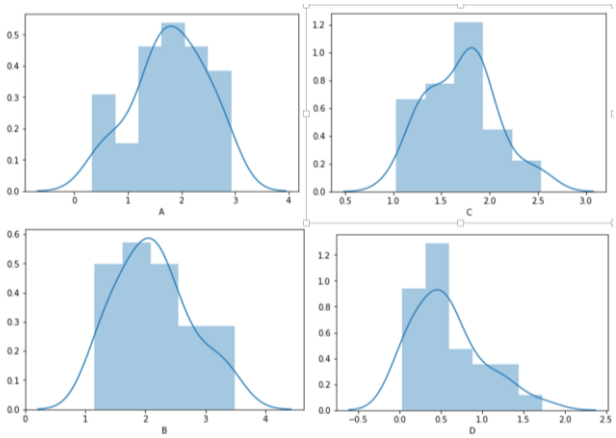

Fig. 3. Residual distribution histograms of measurement groups

After the normality test, whether there is a correlation between the measurement groups was examined by using Pearson correlation method. The results of the correlation test can be seen in Fig. 5. When the correlation values between the measurement groups were compared, the highest correlation (0.270) was found between the measurement groups B and D in a positive direction. The lowest correlation was found between 0.062 and A and B groups.

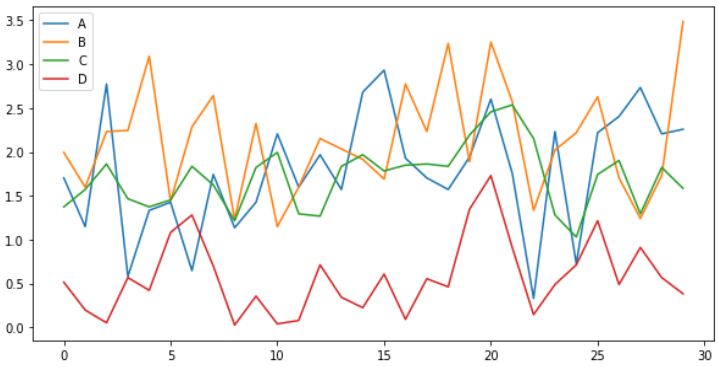

Fig. 4. Distribution of the amount of residue obtained in the measurement groups

Whether there is a statistically significant difference between the groups was analyzed using the Friedman Chi Square test. Analysis p-value was found to be 0.07. Since this value was greater than 0.05, the result of all measurement groups coming from the same distribution was evaluated.

Studies have shown that fertilization with irrigation is successful and necessary. Especially its success in drip irrigation systems has been shown by increasing efficiency and reducing chemical consumption [23, 24, 25]. This method is needed for applications with the hose reel irrigation machines.

IV. Conclusion

In field agriculture, sprinkler irrigation systems are used in plants such as cereals, but fertilization is not observed. Fertilization systems used in agriculture are mostly used in conjunction with the plants

planted, fruit trees and drip irrigation systems. For this reason, the development of a system that will reduce the excess water consumption in agricultural irrigation and give fertilizer disposal for the hose reel irrigation machines has been the subject of this study. For this purpose, a system including dosing pump, fertilizer tank and fittings has been designed. Then this system was examined in field and laboratory trials.

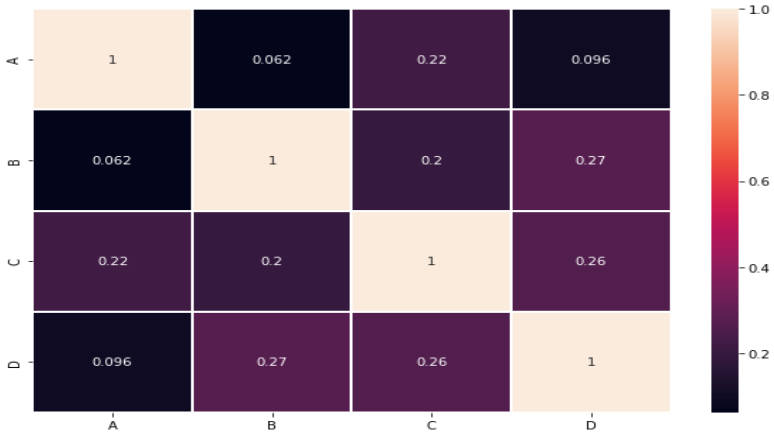

Fig. 5. Correlation values of measurement groups

According to the results obtained, the use of dosing pumps in drum irrigation systems gave positive results in order to increase irrigation water use and fertilization efficiency. The coefficient of variation for the homogeneous distribution varied between 21-38%. In this regard, fertilization efficiency and biological efficiency can be evaluated by using real fertilizer as the next step.

There is the potential to cause serious environmental problems, such as contaminating groundwater, when the chemical is not properly dosed and applied. A suitable system and components are needed for the effective and safe application of chemicals with water. This system generally consists of irrigation water pumping station, chemical injection pump, a storage unit for chemical, system calibration device, backflow preventing system and system safety equipment. For this purpose, a dosing system has been designed that can be used with the hose reel irrigation systems.

The hose reel irrigation machines, which are much more economical and useful compared to other irrigation methods in terms of economic life and usage cost, saving water in hot weather and are environmentally friendly. The hose reel irrigation machines, which can operate even at low pressures, have shown that they can prevent soil hardening and damage to crops with effective irrigation during agricultural production. Labor costs are low as irrigation can be done alone. Finally, it can be said that it also reduces field traffic. When the success of the system designed in this study is added to these benefits, the use of these machines will be more attractive for farmers.

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