EVALUATION OF THE EFFECTIVENESS OF AUTOMATIC SPRINKLING SYSTEM FOR SHALLOT CULTIVATION IN VINH CHAU DISTRICT, SOC TRANG PROVINCE

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ABSTRACT

Shallot is one of the main crops in Vinh Chau district, Soc Trang province where farming techniques are still simply and mainly based on traditional irrigation types. In the district, groundwater is the main water source for daily uses of the local and farming activities. However, this water source increasingly becomes scarity due to over-exploitations. Therefore, this study aims to save water in agricultural production by applying automatic sprinkling irrigation model (Sprinklers system) in shallot farming and Vinh Chau district is selected as the research site. In this study, the amount of irrigation water for Shallot will be determined by CropWat model and the irrigation time will be measured by a soil moisture device (Takemura DM -15). The results show that the automatic sprinkling system model has saved by 43 - 59 % water amount and 85-91 % time of irrigation per 1000 m^2 compared to traditional irrigation methods. The input costs of automatic sprinkling system are estimated at about 8 million VND/1000 m^2 and it can be applied for many types of plants with its span of 4 years (depending on users' uses). In conclusion, the automatic sprinkling irrigation model can alter traditional methods of famers in order to improve productivity, reduce negative impacts on groundwater source, and to adapt to water shortage due to climate change impacts.

Keywords: climate change, water-saving, CropWat model, automatic irrigation system.

1. INTRODUCTION

Shallot crop, science name is *Allium cepa var ascalonicum*, is a high economic value crop in the plant structure of Vinh Chau district, Soc Trang province [1]. According to the Arigculture Report of the People's Council (2014), the agricultural area is about 10,500 ha in total, of which, the shallot area is about 6,500 ha which occupies 62 % of the total. In recent years, shallot farming has showed the signs of decrease in many aspects such as unstable productivity, low quality and hard to preservate after havesting. There are many reasons to explain for these consequences. Some of the main causes are: intentively unplanned growing expansion and fertilizers and pesticide over-uses [2]. Besides that, water plays an important role in Shallot farming. Its irrigation method is determined by the natural conditions of the local and crop characteristics. FAO (2001) identified that there were three main irrigation methods such as Surface irrigation, Sprinkling irrigation and Drip Irrigation. More specifically, there were more than 30 irrigation method have been studied and applied on many kinds of crops around the world [3]. For plants, supplying the right amount of water and nutrients during the farming process is very important; excess, shortage or unsuitable time have negative impacts on the growth [4 - 7]. Besides that, water and soil quality also influence significantly in the cultivation process; if water and and soil contain many micronutrients, it will reduce the fertility supplying for crop growth [8 - 10].

In developed countries (e.g the US, Australia, Holand, Isreal), they are applying irrigation hi-tech in agricultural production in order to use water source effectively, enhance productivity and to reduce negative impacts on the environment, especially to save fresh water in the water deficit areas such as coastal, desert and semi-desert [11, 12]. In Vietnam, the water-saving irrigation method was studied and applied in 1993 but still at the experimental stage with low technology and simple systems. However, it still helped to save water for agricultural irrigation significantly [13]. This attracted attention of governments and scientists to assess its suitability to apply in vulnerable areas, coastal areas especially.

There are many studies conducted on saving irrigation water for agricultural production such as the model of water-saving irrigation for pineapple in Boi river, Hoa Binh province [14]. Researchers designed automatic sprinkling irrigation model based on the local natural conditions. Similarly, [15] also found out mulching solutions using soil moisture to reduce water supply. The results show that this method can increase soil moisture and blossom rate of plants, especially increase its yields up to 17.3 % and decrease the amount of irrigation water compared to the unmulching method; The drip irrigation model combining with mulching method on tomato has saved 50 % water amount in comparison with traditional irrigation methods [16]. In this research, the cooperation between the Mekong Delta Institute – CTU and the Research Center of Wagenenegent, Netherlands (2011–2014) has given more effectiveness on saving irrigation water agricultural production for the Vietnamese Mekong Delta (VMD) in the dry season. However, these irrigation projects were mainly applied for crops in alluvial lands while the deficit status of water is the big problem of the coastal areas of VMD which still has very few researchs. Currently, groundwater is being extremely degraded by over-exploition for agricultural production in the VMD, especially in coastal areas. It is reported that the groundwater table has slumped by 4–9 m in dry season in Tra Vinh and Soc Trang province [17 - 19]. Therefore, the project of "Evaluation of the effectiveness of automatic sprinkling system for Shallot cultivation in Vinh Chau district, Soc Trang province" is being implemented to save water for irrigation in agricultural producion. In addition, the aims of project are to enhance economic efficiency, to decrease negative impacts on groundwater, and to be adaptable to water shortage due to climate change in the future.

2. RESEARCH METHODOLOGY

2.1. Input data

The input data include:

+ The data of temperature, precipitation, win speed, moisture, and evaporation per month from 2010-2014 were collected at Meteorological Monitoring Center Soc Trang.

+ The data of Shallot characteristics (e.g. Height, root, and development state of Shallot) were collected directly at the research area.

+ The data of soil was collected at research area and analysed at College of Agriculture – CTU.

+ The other information (e.g local farmers, irrigation, and agricultural production) were collected at study area through PRA - Participatory Rural Appraisal method.

2.1. Bulding automatic sprinkling system model

2.1.1. Detemining irrigation water for Shallot crop

The water demand for Shallot crop was detemined through CropWat model which was calculated based on water balance combining with weather conditions, local natural conditions, and crop characteristics [20]. In CropWat model, the water demand for crops was calculated mainly basing on Penman Motheith equation (Eq.1 and Eq.2).

$$ET_c = K_c * ET_o \quad (1)$$

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T + 273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (2)$$

where: ET_c: Evapotranspiration of crop (mm/day), K_c: Crop coefficience , ET_o: Reference evapotranspiration (mm/day), R_n: Net radiation at the crop surface (MJ m^{-2} $ngày^{-1}$), G: Soil heat flux density (MJ m^{-2} $ngày^{-1}$), T: Air temperature at 2 m (°C), U_2: Wind speed at 2 m height ($m.s^{-1}$), e_s: saturation vapour pressure (kPa), e_a: Actual vapour pressure (kPa), □: Slope vapour pressure curve (kPa $°C^{-1}$), γ: Psychrometric constant (kPa $°C^{-1}$).

2.1.2. Designing automatic sprinkling system model

The automatic sprinkling irrigation model built in areas of 2000 m^2 with rain nozzles was arranged following triangular of Vietnam standard (TCVN 9170:2012). The distance between nozzles was calculated following TCVN with a = b = 1.75*2.4 ≈ 4 m.

The irrigation time and water were measured basing on soil moisture with moisture coefficiens (WP- Wilting Point) and (FC - Field capacity), it is shown at Eq 3. In cultivation process, soil moisture was measured by moisture device Takemura DM – 15, and the value is WP = 2/3FC [21]. The soil moisture threshold of treatments is showed in Table 1.

$$\mathbf{FC} \geq \mathbf{Q_t} \geq \mathbf{WP} \begin{cases} \mathbf{Q_t} \geq \mathbf{FC} \Rightarrow \text{Stop watering} \\ \mathbf{Q_t} \leq \mathbf{WP} \Rightarrow \text{Start watering} \end{cases} \quad (3)$$

where*:* Q_t: Amount of water supply for crop at t (m^3/ha); FC: Field capacity (changed to m^3/ha) that at which stop watering; WP: Wilting point (changed to m^3/ha) that at which start watering.

The study area was built three irrigation treatments (Figure 1) including: (1) CropWat treatment (300 m^2); (2) CropWat Adjust treatment (700 m^2); and (3) Farmer treatment (1000 m^2). Each of treatment was divided more replace beds to observe development and to compare efficiency with actual model in the study area.

Table 1. The soil moisture threshold for irrigation treatment.

Treatments	WP	FC
CropWat	≈ 35 %	≈ 45 %
CropWat Adjust	≈ 40 %	≈ 60 %
Framer	Follow Farmers	Follow Farmers

3. RESULTS AND DISCUSSION

3.1. The results of automatic sprinkling irrigation model

3.1.1. The average soil moisture berfor and after irrigation between treatments

The results in Figure 2 showed that the average moisture of soil before and after irrigation of Farmer treatment was higher than CropWat and CropWat Adjust treatment. For CropWat and CropWat Adjust treatment, the average moisture before and after irrigation from 38 % to 47 % and from 41 % to 56 % respectively that equal to initial assumptions. The average soil moisture of Farmer treatment before and after irrigation was from 45 % to 64 % which is significantly higher than the other two treatments. This will relate to water supply for irrigation, time and water pumping costs. It can be concluded that the local farmers have used too much water for Shallot irrigation during cultivation process.

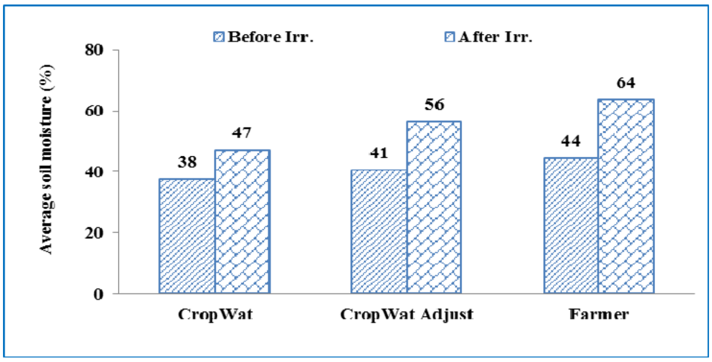

Figure 2. Comparing the average soil moisture before and affer between treatments.

3.1.2. The time and water irrigation per 1000 m^2 between treatments

The automatic sprinkle irrigation modelhas saved 85 - 91 % irrigation time compared to farmaer's technology (Table 2). For CropWat Adjust treatment, the irrigation time is longer than CropWat treatment due to soil moisture higher. However, the irrigation time of automatic sprinkle irrigation modelis much less than Farmer treatment. The Farmer treatment has spend 89.4 minutes to irrigate while the automatic sprinkle irrigation modelwas spend no exceed 15 minutes to irrigated on area 1000 m^2 (Table 2). Therefore, the saving irrigation time has significant important on decreasing energy cost, labour lent cost, saving water, and improving production efficiency.

According to automatic irrigation model, the irrigation water amount for Shallot crop is significantly lower than traditional irrigation methods. The average irrigation water amount from CropWat treatment is about 3.2 m^3/time per 1000 m^2 and CropWat Adjust is about 4.4 m^3/time per 1000 m^2 while the average irrigation water is far higher than that of the automatic irrigation treatments (7.4 m^3/time per 1000 m^2). In concluction, the automatic sprinkling irrigation model can save 43 – 59 % water for irrigation in comparison with irrigation methods of the local farmers.

Table 2. Time and amount of irrigation water for Shallot crop per 1000 m^2.

Treatments	CropWat	CropWat Adjust	Farmer
Irri. Time (minutes)	8.3	13.2	89.4
Irri. Water (m^3)	3.2	4.4	7.4

3.1.3. The yield of Shallot crop between treatments

The yield is one of important factors to assess efficiency of water-saving irrigation model. The results show that the yield of CropWat Adjust treatment was equal to that of Farmer treatment whereas the yield of CropWat treatment is the lowest (Figure 3). The yield of dried Shallot from CropWat Adjust treatment was 1.73 ton/1000 m^2, Farmer treatment was 1.79 ton/1000 m^2, and CropWat treatment was 1.49 ton/1000 m^2. Consequently, water demand to reachive stable soil moisture is very important to the growth of Shallot. If water supply is not enough, it will affect considerably the growth and development of Shallot. In contrast, if the supply exceeds, it will lead to over irrigation for crop and effects to economics for culitvation. It is demonstrated through two treatments CropWat and Farmer.

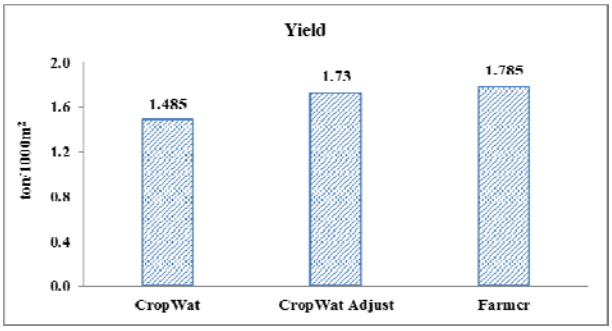

Figure 3. The yield (dry weight) of shallot between treatments.

3.2. The input costs and economical efficiency of automatic sprinkling irrigation model

The input costs for an automatic sprinkling irrigation system for 1000 m^2 is about 8 billion VND and it can be used for 4 years depending on the quality of materials and users' use. The depreciation of system is about 2 billion/year which can lower labour cost for farmers. In addition, the automatic sprinkling irrigation model can save irrigation water, irrigation time and pumping costs without any negative impact on Shallot productivity. Moreover, when applying in a large area, the efficiency of automatic sprinkling irrigation model will develop significantly in comparsion with traditional cultivation methods. As for economical efficiency, irrigation treatments show that the automatic sprinkle irrigation model can increase by 20 % income for farmers. Consequently, the automatic sprinkling irrigation model has brought more benifits on economic aspect and saving water significantly for farmers' irrigation.

4. CONCLUSION

The technology in farming activities of the local farmers is still simple. Their agricultural production is largely based on trational methods which consumes a large amount of irrigation water. Groundwater is the main source for agricultural production but in recent years it has showed the signs of degradation in Vinh Chau district, Soc Trang province.

The automatic sprinkling irrigation technique for Shallot crop has help farmers save 43-59 % irrigation water and 85-91 % irrigation time per 1000 m^2 compared to traditional irrigation methods. The input costs of an automatic sprinklers system are estimated at about 8 million VND/1000 m^2 and it can be used for various plants up to 4 years depending on users' uses. Especially, the sprinkling model can not only encrease income for farmers by 20 % but it also bring great economical efficiency if the model is applied in a large area.

In summary, the spinkling irrigation model can alter traditional irrigation methods of the local farmers and can be applied for other plants such as pepper chilly, corn and radish not only in Vinh Chau district but also in other areas. Noticeably, when setting up spinkling irrigation system, the combination of win speed and threshold of soil moisture (WP and FC) may prevent water loss and supply water most efficiency for cultivating.

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