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FIELD PERFORMANCE OF THE CAPILLARY WICK IRRIGATION (*CAPILLARIGATION*) SYSTEM FOR RICE-BASED CROPS

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ABSTRACT: The Philippines is suffering from the devastating effect of climate change. During extreme drought periods when it is already too risky to plant rice, farmers are advised to plant vegetables and other short duration crops so as to maximize the use of limited water supply and have an alternate source of income. This study evaluated the field performance of a locally developed irrigation system designed to be as efficient as possible so as to maximize the use of the limited supply of water during such conditions and as low cost as possible so that smallholder farmers could afford to use it. The resulting prototype is a do-it-yourself type irrigation system which is almost similar in layout as that of the drip irrigation system, except that, among other things, it makes use of capillary wicks as drippers (hence called as *capillarigation* system) and maximizes the use of local and recycled materials. Results of field tests consistently showed that the *capillarigation* system outperformed the existing farmers' irrigation practices (drip and hose) in terms of water productivity. In a field planted with green pepper (*Capsicum annuum L.*), the system yielded higher water productivity of 36.6 g/L as compared to the drip irrigation system (9.9 g/L). The same trend was observed when tested in another field planted with eggplants (*Solanum melongena esculentum*). Being able to work with unfiltered water, with very low operating pressure (15-20cm) and discharge rate (20-30mL/h), the *capillarigation* system offers advantages when compared with other existing irrigation methods. It however still needs more field tests so as to further evaluate its performance under various crop, field, soil, and water conditions.

Keywords: Capillarigation, Capillary wick irrigation, Climate change, Drip irrigation, Drought

1. INTRODUCTION

The Philippines is suffering from the devastating effect of climate change. Droughts, for instance, have become more intense and frequent, causing significant losses in crop production. These extreme drought events are associated with El Niňo which, as reported by Roberts et al. [1] is affecting the country's rice production both in irrigated and in rainfed areas. The 1998-1999 El Niňo in particular, resulted in a significant reduction in the paddy rice production, leaving most smallholder rice farmers in debt. Another strong El Niňo hit the country in 2015-2016 which, according to the damaged report of the Philippine Department of Agriculture as cited by the Food and Agriculture Organization [2], 'affected 16 of the country's 18 regions and of which the impact was strongest in Mindanao where 27 provinces were affected'. The occurrence of these extreme drought events is expected to continue in the future not only in the Philippines but also in other Southeast Asian countries, basing from the results of the study by the World Resources Institute [3].

To help enhance farmers' resilience to climate change, the Philippine Rice Research Institute (PhilRice) is encouraging the farmers to diversify their farming activities through the *Palayamanan*, a highly diversified and integrated rice-based farming system wherein farmers not only plant rice but also other crops (vegetables, fruit trees, etc.) as well as engage in other farming activities like mushroom production (utilizing the rice straws generated from rice production as by-products), poultry, livestock, and freshwater fish production, among others, so as to maximize the use of farm inputs and agricultural wastes, and provide farmers additional sources of income [4]. During extreme drought conditions, vegetables and other upland crops are usually planted by *Palayamanan* farmers so as to maximize the use of the limited supply of water.

While the commercially available drip irrigation system (DIS) is proven efficient [5, 6], its cost of acquisition is high and beyond the financial capability of these smallholder farmers. Thus, PhilRice developed an irrigation system which was designed to be as low cost and highly efficient as possible. To lower down the cost and make it affordable to smallholder farmers, one of the basic criteria in the design and development of the system is to make the components easy to fabricate and install by the farmers themselves, maximizing the use of recycled materials or those that can easily be sourced out within their locality. This led to the idea of using capillary wicks as a means of dispensing water. The use of capillary wicks in irrigating plants was proven to efficiently work in nurseries, saving water, time and labor in irrigation [7]. However, no advancements had been done yet in making use of the capillary wicks in field crop production [8].

Our initial work proved that the use of capillary wicks can feasibly be used in an irrigation system that is laid out in an almost similar manner as that of the drip irrigation system. In this system, called a *capillarigation* system (CS), capillary wicks serve as the substitute of the drippers following a setup shown in Figure 1. From the tank (made of 200L steel drum), water flows out of the float valve into a container wherein its depth sets the system's operating depth, typically not more than 15 cm. Because water seeks its own level, this level sets the limit in all 'risers' where capillary wicks are placed. Details on the design and construction of the whole system, including the results of the laboratory studies conducted to identify appropriate wick materials and design parameters, was described in our previous publication [9]. This paper presents the results of our follow up studies conducted to evaluate the performance of the CS under actual field conditions, together with the existing irrigation methods/systems.

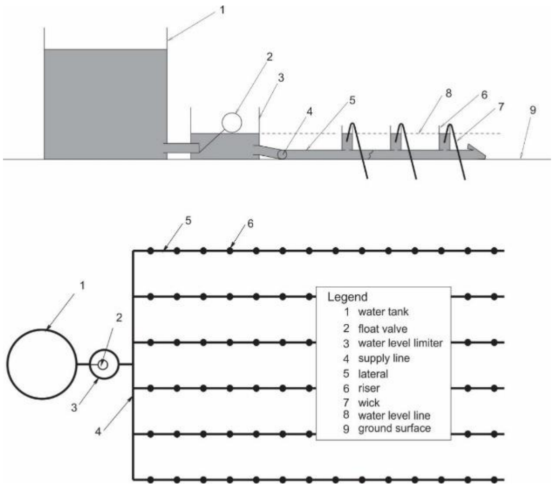

Fig.1 Schematic diagram of the *capillarigation* system showing the various parts [9].

2. MATERIALS AND METHODS

This study was conducted at the Central Experiment Station of the Philippine Rice Research Institute (PhilRice-CES) in Muňoz Science City, Nueva Ecija, Philippines (15.6712° N, 120.8908° E) during the dry season of 2015 and of 2016. The soil at PhilRice-CES, as reported by Javier et. al [10], was classified as Maligaya clay soil, which is typically fine and has a bulk density of 1.33 g cm^{-3}. In the PhilRice Soil Series Information System, this soil is described as 'heavy clay having poor drainage characteristics, high shrink and swell capacity upon wetting and drying, producing wide cracks in the soil, hard when dry, and has very slow permeability'.

Field trials of the prototype CS were established together with two existing irrigation methods: the hose irrigation (HI) which is commonly practiced by smallholder and resource-challenged farmers when growing short duration crops, and the drip irrigation system (DIS) which is used only by advanced and financially stable farmers. The experimental sites were within a 500m radius from the PhilRice's Agrometeorology station. In all of the field test trials conducted, the objective was to compare the performance of the CS with the existing irrigation practices in terms of the test crop's performance (yield and agronomic parameters) and the water productivity. Monitoring of the soil moisture content (MC) was done at different growth stages of the crop, details of which are described in each of the following test setups.

2.1 *Capillarigation* vs. Hose Irrigation (2015 Dry Season)

A 6m x 6.5m field, divided into six parallel 80 cm x 650 cm plots spaced 20cm apart, was prepared for testing the performance of the CS side by side with the farmers' practice of HI using green pepper (*Capsicum annuum L.*) as the test crop. Using garden tools, each plot was tilled up to 15-20 cm depth, pulverized, and applied with rice hull biochar as a soil amendment at 5 kg m^{-2} prior to final leveling. In the setting up of the irrigation treatments, each plot served as one replication. No randomization was done on the assignment of the plots in order to simplify the setting up of the CS. Thus, the first three adjacent plots were used in the CS while the remaining three plots were used in the HI. In the CS, lateral pipes made from commercially available 25mm diameter flexible black Polyvinyl Chloride (PVC) plastic hose was laid out in the middle of each of the three plots. Risers were installed at every 50cm length of the lateral. Each riser was made from the same material (PVC hose) cut to 15cm lengths and provided with a rubber seal at the bottom and a means for water from the lateral to flow into it. Final trimming of the risers was done to maintain a freeboard of 2-3 cm. Two capillary wicks were installed at each riser, providing a means for dispensing water into the soil. Each capillary wick was made from 5mm (average diameter) x 20cm long cotton strands extracted from mop heads normally sold in local groceries or supermarkets. To minimize mold accumulation as well as water loss due to evaporation, plastic drinking straw (6mm dia x

30mm length) were used to cover each individual wick. Once the whole CS was laid out, 2-week old green pepper seedlings were transplanted in two rows for each plot, 60cm apart and 60cm between hills, with the system's lateral pipe in between each pair of row (Fig. 2). Wicks were then directed to each row, maintaining a distance of 10cm from its tip to the nearest plant. The tip of the wick was also positioned 5cm below the ground surface. In the HI plot, the plants were watered twice a day, one in the morning (8-9 AM) and one in the afternoon (4-5 PM), at an application rate of 0.5 liters per plant using a 20mm garden hose, simulating a backyard gardening practice. Following the recommended nutrient management practice [11], a commercially available complete fertilizer (14-14-14) was applied in the second week after transplanting (WAT) at 5g/hill followed by Urea (46-0-0) and Muriate of Potash (0-0-60) each at 4g/hill in the 4th and 6th WAT.

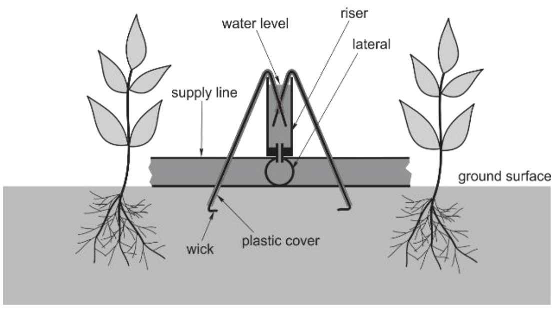

Fig. 2 A typical setup of a *capillarigation* system showing the placement of the lateral and the wicks serving two rows of plants.

To determine the influence of each of the two irrigation methods on soil moisture within the plants' root zone, soil samples were taken using a soil auger at 10 cm distance from the nearest plant and, in the case of the CS, not more than 10cm from the nearest wick. The time of getting of soil samples was referenced from the time water was applied in the HI plot. The first sampling was done one hour before (B) and the second one was six hours after (A) irrigation water was applied in the morning. For the HI plot, the second sampling time (A) was done prior to the application of water in the afternoon. Each set of soil samples were taken at 0, 10, 20, 30, and 40cm depth and were oven-dried following the standard laboratory procedures for soil MC determination. For the whole crop growth duration, three sets of the soil samples were taken, one at the vegetative stage, another at flowering and at fruiting stages of the crop.

To determine if the irrigation treatments have some influence on weed population, occasional weeding was done in all plots to keep them weed-free and the total air-dried weight of all of the removed weeds was determined.

To check the consistency of the wicks to deliver water as time passed by, the water flow rate at the point where the float valve was installed (which represents the sum of all the wicks' flow rates) was monitored weekly.

2.2 *Capillarigation* vs. Drip Irrigation (2016 Dry Season)

The components for the DIS used in the study were locally purchased, comprising of 25mm flexible plastic pipe with built-in emitters (1.2 L h^{-1} discharge rate) spaced at 30cm, cut-off valves, pipe connectors, and water filters. A 1m^3 plastic container was used as water tank which was provided with a platform made from iron angle bars to elevate it 1m from the ground. From the establishment of the tank alone, one can recognize the advantage of the *capillarigation* system since it does require an elevated which is an additional investment on the part of the farmer.

Water application using the DIS was done by opening the valve for a period of two hours daily in the morning (8-9 AM) until harvest, simulating the typical practice of the local users of the technology. In the CS, the lateral which was made of flexible PVC pipe in the previous setup was replaced with tarpaulin sheet that had been cut to 30cm width, folded longitudinally to form a U-shaped cross-section and then folded at the ends so that it resembled a small channel to hold water (Fig. 3). Bamboo sticks anchored on the ground were used as stiffeners so that the sides of the tarpaulin would stay vertical and be able to hold water. With this modification, the installation of individual risers along the length of the lateral was no longer needed, further reducing the cost of the system. Like in the previous setup, the same freeboard of 2-3 cm was maintained.

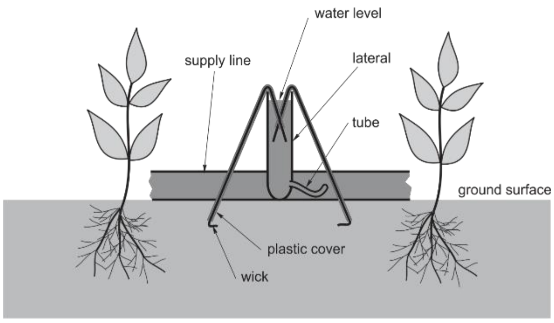

Fig. 3 The improved CS setup which made use of the tarpaulin sheet for the lateral.

Two field setups were established to compare the performance of the CS with that of the DIS. In the first setup, eight 1m x 15m parallel plots were made and planted with the same test crop (green pepper) and management practices as in the 2015 setup (CS vs HI). The first 4 plots were devoted to the CS and the remaining four plots were for the DIS. Soil samples were also collected in a similar manner as in the 2015 setup except for the depth which was only up to 30cm. To measure the total volume of water applied in each irrigation treatment (CS and DIS) throughout the whole period of crop growth, a calibrated mechanical-type flow meter with a resolution of 0.001 m^3 was installed at the main line of each irrigation system.

In the second setup, the test crop used was eggplant (*Solanum melongena esculentum*), transplanted at 14 days old and spaced at 60cm between rows and hills. Urea (46-0-0) solution of 10g per 5L water was applied at a rate of 170 mL $hill^{-1}$ at 3, 5, and 9 WAT. On the other hand, Muriate of Potash (0-0-60) solution (10g per 5L water) was applied at 7 WAT at 170 mL $hill^{-1}$ following Inque and Agres (2017) recommendation [11].

Monitoring of soil MCs at different root zone depths and crop stages were done only in the first set up in the same manner as in the 2015 (CS vs HI) setup. The time of getting of soil samples was referenced from the time water was applied in the DIS, i.e. one hour before drip irrigation was done. Each set of soil samples were taken at 0, 10, 20 and 30cm depth and were oven-dried following standard laboratory procedures for MC determination. For the whole crop growth duration, three sets were taken, one at the vegetative stage, another at flowering and fruiting stages of the crop.

2.3 Data Gathered

Unless otherwise specified, the following data were gathered in all of the field setups established under this study:

2.3.1 Soil MC profile

This was derived from the MC of the set of soil samples taken during the three stages of the test crop's growth (vegetative, flowering, and fruiting). Standard procedure for oven dry method was followed and the MC was expressed in gravimetric dry weight basis.

2.3.2 Average soil MC maintained (aMC)

This parameter was used to evaluate the performance of the irrigation method in terms of supplying water and maintaining soil MC conducive for crop growth. The following formula was used:

$$aMC = \frac{(dMC)+(sMC)}{nd+ns} \quad (1)$$

Where *dMC* = the sum of the MCs taken from the represented soil depths, *sMC* = sum of the MCs taken from the represented crop growth stages, *nd* = number of soil depths represented, and *ns* = number of crop stages represented

2.3.3 Volume of water applied (V)

This was expressed in the per plant and in per unit area basis, using the formula,

$$\boldsymbol{V} = \frac{\boldsymbol{Vt}}{\boldsymbol{n}} \quad (2)$$

Where *Vt* = total accumulated volume of water applied throughout the whole duration of crop growth and *n* = number of plants

2.3.3 Yield

Yield data were taken from five randomly selected inner plants in a selected row of an inner plot. An average was taken to represent the average plant yield in each irrigation treatment.

2.3.4 Water productivity (E_{wu})

This was computed following the standard formula:

$$E_{wu} = \frac{\boldsymbol{Vt}}{\boldsymbol{Y}} \quad (3)$$

Where *Vt* = total accumulated volume of water applied throughout the whole duration of crop growth and *Y* = total crop yield in the area covered

2.3.5 Labor requirement

This refers to the labor needed in the setting up in the field and in the operation of each of the irrigation method.

2.3.6 Cost of irrigation

The cost of irrigation of each irrigation method was computed by taking note of the cost of establishing the irrigation system which includes the cost of the materials as well as the cost of labor during its establishment in the field. Moreover, the cost of operation, like the opening and closing of valves and cleaning of the filter as in the case of the DIS, was also included.

2.4 Statistical Analysis

Whenever applicable, an analysis of variance (ANOVA) was done on the gathered data by considering the irrigation methods as treatments following a Completely Randomized Design.

3. RESULTS AND DISCUSSION

3.1 *Capillarigation* vs. Hose Irrigation

3.1.1 Effect on soil moisture content

Comparing the soil MCs at the two sampling times during the vegetative stage of the crop, it can be observed from Figure 4 that there was an increase in soil MCs from the first soil sampling time (B) to the second sampling time (A) in the hose irrigation method. The difference is more prominent at the ground surface than those beneath. On the other hand, in the CS where water was applied continuously in small amounts, a reverse trend was observed - the soil MC was higher in B than in A, in all depths considered, with the largest difference observed at the ground surface. This could be explained by the fact that the second sampling time occurred in the afternoon (2-3 PM) and the decrease observed in the CS could be due to water evaporation. For the hose irrigation, higher soil MC was observed at the second sampling time (A) since it occurred in the afternoon, just six hours away from its most recent application of water (8-9 AM, same day) while in the first sampling time (B), it occurred 23 hours away from its most recent application of water. At 25 DAT and 35 DAT, there was no remarkable difference observed in the soil MC taken at the ground surface for the two irrigation treatments. One of the reasons is because the ground surface had already been covered by the crop's canopy during this time and water loss due to surface evaporation was therefore minimized. As shown also in Figure 4, the highest soil MC for the CS was observed at 10cm depths particularly during the sampling period of 15 and 25 DAT. This is because the tip of the wicks was buried close to this depth.

As shown in Figure 5, the CS maintains a higher soil MC than the HI in all depths covered. Except for the 10cm depth which is close to where the tip of the wick was buried (5cm), the soil MC in all other points are almost the same (~20%). In the HI, on the other hand, the lowest MC was at the surface which doubles at 10cm and then gradually increased and stabilized at 20 up to 40cm depths. The marked difference in the MC at the first 10cm depth between the CS and the HI can be attributed to the fact that, in the CS, water in very small amount is constantly delivered into the soil throughout the whole duration of crop growth whereas, in the HI, soil dryness happened in between each application of water which was twice a day (morning and afternoon). As far as maintaining the wetness of the soil conducive for plant growth is concerned, Figure 5 suggests that CS is superior over the HS.

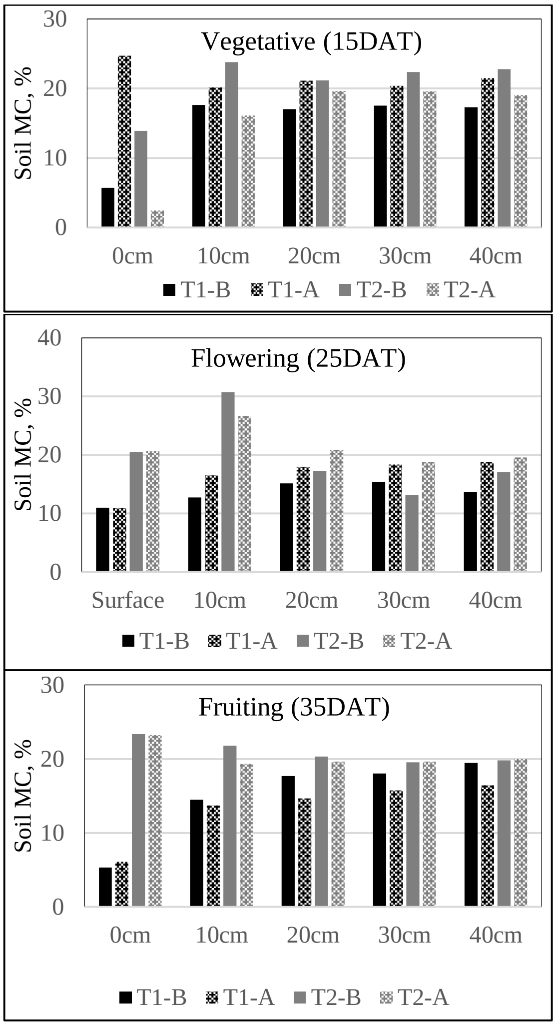

Fig. 4 A comparison of the soil MCs at different soil depths between the hose irrigation (T1) and the *capillarigation* system (T2) taken at two sampling times (B=1h before and A= 6h after water was applied in T1), during three stages of green pepper growth.

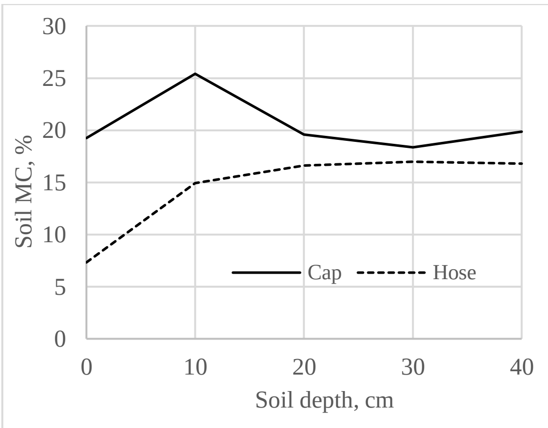

Fig. 5 Soil moisture content profiles of the *capillarigation* and the hose irrigation.

3.1.2 Effect on crop performance and water use

As presented in Table 1, the CS maintained a significantly higher average soil MC (20.49%) than the HI (14.54%) throughout the whole duration of crop (green pepper) growth. Although their yields did not vary statistically, the yield difference is remarkable which may merit deeper analysis. One possible reason could be the assigning of the plots which were not randomized, resulting in a high coefficient of variance. Another could be the fact that in the CS-irrigated plants, the soil MC was always maintained at field capacity while in the HI, the soil underwent alternate drying and rewetting which may have some beneficial effects. In spite of this, however, the CS utilized water more efficiently than the HI.

Table 1 A comparison of the average soil moisture maintained, the total amount of water applied and water use efficiency of the two irrigation treatments.

Treatment	Average soil MC maintained*	Yield per plant (g)	Water applied (L plant^{-1})	Water productivity (g/L)
Capillar i-gation	20.49	68.67	29.07	1.61
Hose Irrigation	14.54	86.00	51.00	1.25
ANOVA	*	ns	s	s
CV	8.51	41.87	2.69	7.8

3.2. *Capillarigation* vs. Drip Irrigation

Figure 6 shows the field setup of the CS and the DIS wherein in the CS, tarpaulin sheets were used as laterals, replacing the PVC hose. With this modification, the labor requirement in the installation of the laterals and the wicks had been reduced as compared to that in the previous setup which made use of the PVC hose as laterals and risers.

3.2.1 Effect on soil moisture content

As shown in Figure 7, the CS maintained a significantly higher soil MC than the DIS especially in the first 10cm of the root depth, in all stages of the test crop's growth. The reason for the low soil MC in the DIS, especially at the soil surface, is because sampling was done prior to the application of water, or 23 h from the most recent application of water. Thus, prior to sampling, the soil surface had been exposed to the hottest period of the day. In the CS, on the other hand, water was applied continuously in small amounts throughout the whole period of crop growth.

Fig. 6 The field setup of the *capillarigation* system making use of tarpaulin sheets as laterals.

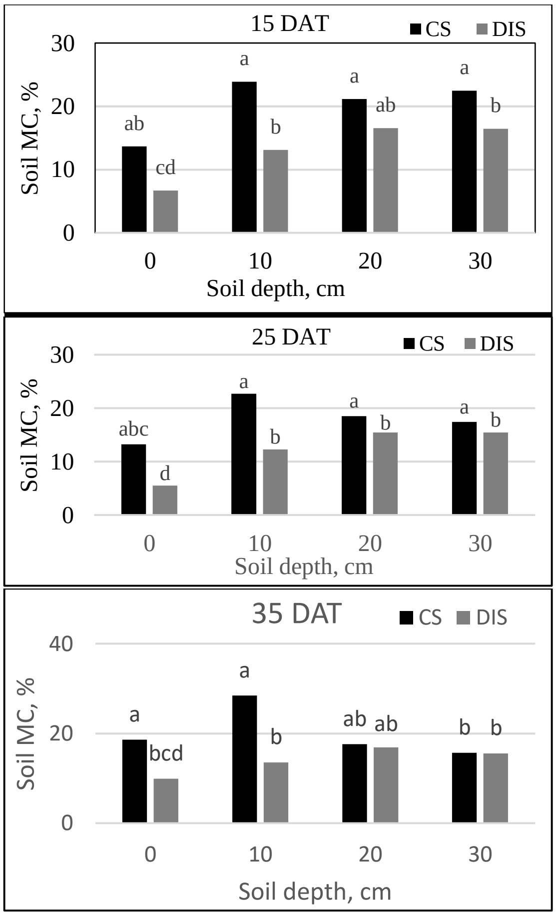

Fig. 7 Moisture content (%) profile of the soil taken during three stages of the crop (green pepper) growth and 24h after water was applied in the drip-irrigated plants. Means with the same letter do not vary significantly

On the average, combining all the soil samples taken at different crop stages, the soil MC in CS followed the same trend as that in the previous trial (CS vs HI) where the highest soil MC was at 10 cm depth and slightly decreased at 30-40cm depths. On the other hand, the soil MC in the DIS was lowest at the ground surface and increases at increasing soil depths and stabilizes at 20-30cm (Fig. 8).

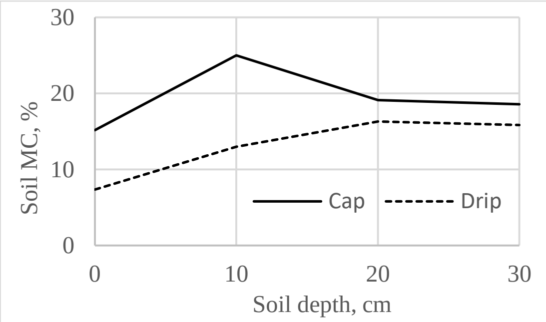

Figure 8. Soil moisture content profiles under the two irrigation methods, the *capillarigation*, and the drip irrigation system.

3.2.2 Effect on crop performance and water use

There was no significant difference between the two irrigation methods in terms of the number of days from transplanting to flowering (22 DAT) and fruiting (30 DAT). In terms of yield, however, plots irrigated with the DIS yielded a significantly higher harvest than that in the CS (Table 2). However, like in the previous trials, the CS outperformed the DIS in terms of water productivity.

Table 2 Performance of the CS as compared to the DIS (2016 trial).

	Capillary	Drip	ANOVA	CV
Setup No. 1 (green pepper, 60m^2)				
Yield (g plant^{-1})	433.1	599.8	ns	15.8
Water consumption (L plant^{-1})	11.8	60.6	s	10.7
Water productivity (g L^{-1})	36.6	9.9	s	29.6
Weed density (g m^{-2})	29.2	32.2	ns	28.8
Setup No. 2 (eggplant, 100 m^2)				
Yield (g/plant)	330.0	352.0	ns	4.5
Water consumption (L/plant)	104.8	237.9	s	11.7
Water productivity (g/L)	3.1	1.5	s	8.48

3.3 Labor Requirement

The CS requires labor in setting up its various components which are significantly higher than that of the DIS (Table 3). In the DIS, all the parts are already available hence only the labor of setting up the whole system in the field was required. For the CS, on the other hand, around 70% of the labor is spent in the preparation (fabrication) of its various components, particularly the preparation of the capillary wicks and in the manner, they are installed in the field. Efforts are continuously being done in improving the whole system so that its labor requirement of setting up in the field could be further reduced. Once the CS had been established in the field, however, no effort is no longer needed with regards to applying water to the crops. In the case of the DIS, on the other hand, there are cut-off valves to open and close regularly so as to ensure that the water is applied just at the right amount. Moreover, additional labor is needed to regularly check the filter and the mold accumulation in the tank so additional labor for cleaning these two components is needed. With regards to the hose irrigation, 100% of the labor needed was in the application of water to the plants for the whole duration (68 days) totaled to 22 labor-h for the 19.5 m^2 area or an average of 1.13 labor-h per m^2.

Table 3 Labor requirement in the setting up establishment of the two irrigation systems.

Irrigation system	Labor required in the establishment (labor-h)		Average labor requirement (labor-h m^{-2})
	60 m^2	100 m^2	
Capillarigation	9	15.5	0.153
Drip irrigation	1.5	2	0.022

3.4. Material Cost

As shown in Table 4, the cost of materials needed in establishing the CS is computed at Php 14.58 m^{-2} while that of the DIS is Php 74.03 m^{-2}, a reduction of 80.31%. Among the reasons that contributed to the reduced cost of materials in the CS is its operating pressure that is much lower than that of the DIS. In the DIS, the water tank needs to be elevated to at least 1m (additional cost on the platform) so as to ensure a more or less uniform flow at each dripper/emitter. On the other hand, the CS operating head, in the case of this study, did not exceed 20 cm thus the tank can be directly put on top of the ground. Another reason is the fact that in the CS, a water filter is no longer necessary since water is discharged through the capillary wicks which do not necessarily require clean or filtered water.

Table 4 Comparison between the materials used for, and cost of components of, the two irrigation systems for a 100m^2 irrigated area.

Major Component	Material Used		Cost of Component (Php)*	
	Drip	*Capillarigation*	Drip	*Capillarigation*
Water supply tank	1 m^3 plastic tank	200L steel drum	4,000	900
Water tank stand	Structure made from a 4mm thick x 38mm x 38mm steel angle bar holding the tank 1m above the ground	no stand needed; the steel drum was directly placed on the ground	1,500	-
Water filter and other accessories prior to delivery of water	Superflow screen filter, 3m^3/hour, 3/4" diameter, 1 pc @ Php 475/pc	No filter needed	475	-
		1 pc plastic pail (10L)		20
		1 pc plastic faucet		8
Supply line	¾" dia flexible PVC hose, 6m @ Php 8/m	¾" dia flexible PVC hose, 3m at Php 18/m	48	54
Lateral and components for dispensing water	Dripline, 11.8mm ID, 12.3mm OD with emitters (1.2 Lh^{-1} discharge) spaced 30 cm apart, 160m long at Php7/m	Flexible PVC hose, 12.5mm dia, 25m at Php 13/m	1,120	325
		Cotton twine (from mop heads), 5mm dia x 100mm, 42 pcs at Php2.33/pc	-	97.86
		Plastic drinking straw, 60 pcs at Php 0.13/pc	-	7.8
Fittings	Quick start fitting, 48mm x 20mm, 8pcs @ Php15/pc	PVC elbow, ½ x ¾", 2 pcs at Php 15/pc	120	30
	PVC tee, ¾", 1 pc @Php30/pc	PVC tee 3/4" x 1/2" x 3/4", 1 pc at Php 15/pc	30	15
	poly reducing tee, 16mm x 12mm x 16mm, 4 pcs at Php15/pc	-	60	-
	Tee, 16mm x 16mm x 16mm, 1 pc at Php20/pc	-	20	-
	Elbow, 12mm x 16mm, 2 pcs at Php15/pc	-	30	-
Total cost			7,403	1,458
Cost per m^2			74.03	14.58
% Reduction			80.31	

4. SUMMARY AND CONCLUSION

With the advent of climate change, drought has become more frequent and intense. Hence, it is important to consider how water is applied to the plants especially during the time when its supply is very scarce. Drip irrigation systems which are already commercially available had been proven to be effective, however, for smallholder farmers especially in developing countries like the Philippines, it is not widely used simply because of its high cost of acquisition. This study presented the field test results of the developed *capillarigation* system which is a low-cost variant of the drip irrigation system that makes use of capillary wicks instead of the conventional drippers. From the results of the study, the following conclusions are drawn:

a. The use of capillary wicks is not only applicable in nurseries but also in field crops following a setup that is patterned from the drip irrigation system. In this system (*capillarigation* system), the capillary wicks replace the emitters in drip irrigation systems as means for dispensing water to the plants and some parts had been added to lower down the system's operating pressure and provide some means to put up the individual wicks;
b. In all the field trials conducted, the *capillarigation* system yielded the highest water productivity when compared to the other irrigation systems/practices tested;
c. The material cost of the *capillarigation* system is lower by up to 80% as compared to the drip irrigation system.

More field tests, however, are still to be done to verify these results and to further evaluate the performance of the system in wider areas and various field and crop conditions. In particular, there is a need to further investigate the reason why, in some trials, the yield of the wick-irrigated crops is lower than those in the drip-irrigated crops.

5. ACKNOWLEDGMENTS

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Rice Engineering and Mechanization Division, PhilRice, during the conduct of the study.

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