沙漠研究 **19**-1, 245- 248 (2009 ) "Desert Technology IX "
Journal of Arid Land Studies Refereed Paper

# Trial on Water Saving Irrigation Farming Technology in Semi-Arid Area of Ethiopia

Kozo INADA[1], Girma LEMMA[2], Tetsuji OYA[3], Birhanu KEBEBEW[4], Shinji SUZUKI[5], Satoru TAKAHASHI[5]

**Abstract:** A verification experiment was carried out in the field located in Zway, Oromia Region to examine suitable irrigation type and optimum irrigation amount that can be easily applicable by farmers. It is considered that approximately 5 mm/day/m$^2$ of irrigation amount is optimum for tomato and cabbage with regard to quality and quantity with basin and furrow irrigation in dry season in this area. Water saving with watering can and drip irrigation might be achieved not by longer irrigation interval but by smaller amount of irrigation amount with frequent application.

**Key words:** Crop yield, Irrigation interval, Irrigation type, Soil moisture, Water use efficiency

## 1. Introduction

Ethiopia has great agricultural potential based on its vast areas of fertile land, diverse climate, generally adequate rainfall, and large labor pool. Despite this potential, however, Ethiopian agriculture has remained underdeveloped. The agricultural sector suffers from frequent drought and poor cultivation practices. Some of the very precious rainfall in the dry lands is wasted through evaporation and runoff. Insufficient and unreliable rainfall, drought, and low diversification of crops have resulted in natural resources degradation, low production, and low water use efficiency. Improving water use efficiency through the implementation of appropriate technologies may lead to poverty mitigation through the increased crop productivity. Although this can be achieved through different agronomic practices, irrigation development has a great and decisive role to play.

Based on this background, after conducting several development studies, Japan International Cooperation Agency (JICA) started "The project for irrigation farming improvement" since September 2005. Its objective was that Water utilization technology is improved by the farmers in the project target area, which will make small holder farmers to increase their production using the available moisture in those areas.

Some cropping plans for irrigation farming in semi-arid area are made based on FAO data that suggests water requirement for crops (FAO, 1998), however, some examples will be necessary for actual application for small holder farmers. Therefore, a verification experiment was carried out in the field located in Zway, Oromia Region to examine suitable irrigation type and optimum irrigation amount that can be easily applicable by farmers.

Change of soil moisture content at different depths according to time after irrigation will be utilized for Recommendation of irrigation amount and interval based on soil moisture. Response of crops to the irrigation will be utilized for recommendation of irrigation amount and interval based on crop yield, and for information of the effect of excess or deficit irrigation on crop yield. Difference of application efficiency among the irrigation types with different application time, duration, and area will be recognized.

## 2. Materials and Methods

Experiment was carried out during dry season without any rainfall in Zway (N08˚01', E38˚43', 1622 masl.). Cabbage (Variety: Copenhagen) and tomato (Variety: RomaVF) were sown after seed treatment on 15 November 2007, and transplanted to the experimental field (Farmer Training Center demonstration field) on around 1 January 2008. Daily air temperature during experimental period ranged from 25.4 (Dec.) to 28.2 ˚C (Apr., max) and from 9.8 (Dec.) to 12.2 ˚C (Apr., min). Evapotranspiration ranged from 3.6 (Dec.) to 4.4 mm/d (Apr.) according to CROPWAT (FAO, 1992). Planting density was 40 × 60 cm for cabbage and 40 × 75 cm for tomato. Soil type was sandy loam. Ten and twenty g/m$^2$ of diammonium

[1] Japan International Cooperation Agency (JICA), Addis Ababa, Ethiopia, E-mail: kmtskinada@yahoo.co.jp
[2] Oromia Rural and Agricultural Development Bureau, Addis Ababa, Ethiopia, E-mail: gimartha@yahoo.com
[3] Japan International Research Center for Agricultural Sciences (JIRCAS), Tsukuba, Japan, E-mail: oyatet@affrc.go.jp
[4] Oromia Water Resources Bureau, Addis Ababa, Ethiopia, E-mail: kebebew_birhanu@yahoo.com
[5] Tokyo University of Agriculture, Setagaya, Tokyo, Japan, E-mail: s4suzuki@nodai.ac.jp,satoru@nodai.ac.jp

phosphate was applied to cabbage and tomato, respectively, on the day of transplanting. Twenty g/m$^2$ of urea was applied on the day of the initiation of irrigation treatment. Weeding was made manually as needed. Fungicide and insecticide were applied once during vegetative stage.

Irrigation treatment was applied from 26 days after transplanting until harvest. Four irrigation types such as Basin, Furrow, Watering Can, and Drip were used. Two hundred liter of water (with 200 liter barrel) was applied for one irrigation to each plot with area of nine square meters (3m × 3m). Water was drawn from the lake by pump to two pits of 6 m$^3$ volume dug in the field. Treadle pump was used to fill water into the barrels from the pit and hose was used to irrigate a plot from the bottom of the barrel with a tap. Due to this process, irrigated water was not so clear with some silt and its pH was around 8. Irrigation intervals as treatment were 2, 4, 6, 8 days (Irrigation amount per day were 11, 5.5, 3.7, 2.8 mm/day/m$^2$, respectively). There were two replications, therefore, 64 plots in total in 25 m × 40 m area. Basin and Furrow plots were located closely and the others were located in the rest of the field. Drip system obtained from Bruh Tesfa Modern Irrigation Design and Installation Department is called Family Drip System because it is very simple, cost effective, and can be managed by the family level of the farmers as well as small land holders.

Soil moisture content at 10, 20, 30 cm depth, 10 cm apart from the plant grown center of the plot was measured with soil moisture sensor (Profile probe, PR2/4, Delta-T) during 7 to 9 a.m. every day before irrigation. Due to the limitation in number, the tubes for measurement were installed in all the plots for cabbage with one replication and 2, 8 day interval plots for tomato with one replication. For yield analysis of cabbage, five average plants were harvested from mid area of each plot in late March to determine mean fresh weight. For tomato, the whole products during harvesting period (from 28 March to 16 April) were taken from each plot for yield analysis.

## 3. Results and Discussion

Cabbage yield was reduced with longer irrigation interval (**Fig. 1**). This reduction was sharp in Watering Can and Drip irrigation plots, but fairly gentle in Basin and Furrow irrigation. This fact showed that water application to smaller area such as Watering Can and Drip irrigation had disadvantage in case of longer irrigation interval. Tomato showed similar tendency with Watering Can and Drip irrigation, however, with Basin and Furrow irrigation 4 day interval irrigation brought maximum yield, which suggested that 2 day interval irrigation might be over irrigation (**Fig. 2**). These results suggested that cabbage requires more water than tomato and therefore Basin and Furrow irrigation shows advantage compared to Watering Can and Drip irrigation especially with longer irrigation interval.

Considering irrigation efficiency or water use efficiency of cabbage evaluated by the slope of **Fig. 3**, Drip irrigation showed highest efficiency, followed by Furrow irrigation within the range from 3.7 to 11 mm/m$^2$/d. In the case of tomato (**Fig. 4**), since yield reduction was observed with 11 mm/m$^2$/d, analysis was not carried out. This more sensitive response of Drip and Furrow to the irrigation amount compared to Basin and Watering Can will be useful for farmer to prevent over irrigation. This fact is consistent with

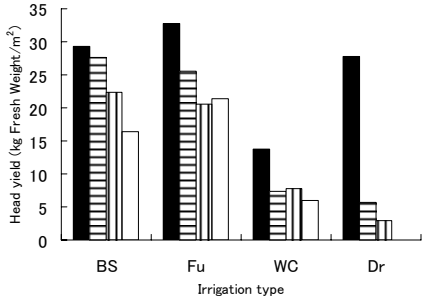


**Fig. 1. Change in cabbage yield according to different irrigation type and interval.**
(BS:Basin, Fu:Furrow, WC:Watering Can, Dr:Drip, ■:2day, ▤:4day, ▥:6day, □:8day interval)
Data are shown as means of two replications.

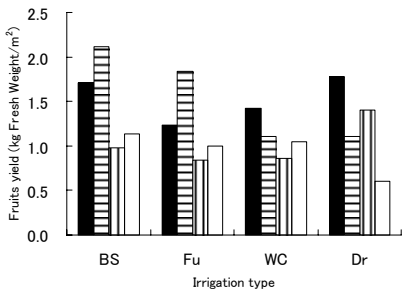


**Fig. 2. Change in tomato yield according to different irrigation type and interval.**

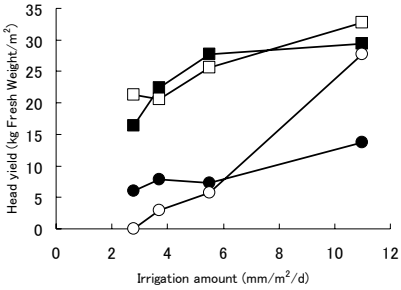


**Fig. 3. Cabbage yield in response to irrigation amount.**
(■:Basin,□:Furrow, ●:Watering Can,○:Drip)
Data are shown as means of two replications.

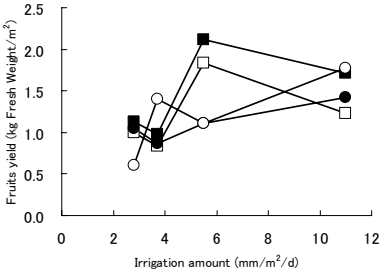


**Fig. 4. Tomato yield in response to irrigation amount.**

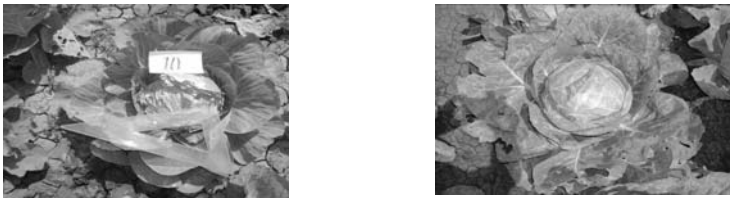

**Fig. 5. Effect of irrigation interval on cabbage products quality.**
(Left: 2day interval, cracked, Right: 4 day interval, well compacted)

Nishimaki *et al*. (2006a, 2006b) who recommended that the furrow irrigation is useful system as a substitute of basin irrigation in tropical arid Africa in terms of crop growing as well as soil hardening and evaporation from soil surface.

Product quality was also affected by irrigation interval. Some cabbage heads of Watering Can plots cracked by 2 day interval (**Fig. 5**). Tomato fruits became more waterish by 2 day interval and changed their color into whitish by 8 day interval.

Soil moisture content was maintained almost constant with 2 day interval irrigation, but with other intervals it declined at the constant rate and was recovered by application of irrigation (**Fig. 6**). Soil moisture content at 10 cm depth tended to increase slightly as the crop grew, but those at 20 and 30 cm depths tended to decrease, which suggested that root zone with active water absorption would deepen as the crop grew (**Fig. 6**). This tendency was more remarkable in cabbage (data not shown for tomato). Maynard (1997) reported that effective rooting depth is deeper in tomato than in cabbage. This may explain why response of cabbage was more obvious in the soil layer above 30 cm in this experiment. Soil moisture content in 4 day plots with Watering Can and Drip irrigation were lower at the initiation of the treatment compared to the plots with the other irrigation intervals (**Fig. 6**). This might be one cause of large reduction of cabbage yield from 2 day to 4 day plots in those irrigation types.

In this experiment, 11 mm/day/m$^2$ was shown an excess application to tomato with furrow irrigation. Yusuf and Muluken (2008) demonstrated more yield of tomato and onion with less water amount of furrow irrigation by changing farmers' practice near this experimental field, which suggested that farmers around there tended to apply excess water to the crops.

## 4. Conclusion and Recommendations

It is considered that approximately 5 mm/day/m$^2$ of irrigation amount is optimum for tomato and cabbage with regard to quality and quantity with Basin and Furrow irrigation in dry season in this area. There are some recommendations that Drip irrigated tomato of 3 mm/day/m$^2$ is preferable for healthy production and water saving advantage in the area. However, water saving with Watering Can and Drip irrigation might be achieved not by longer irrigation interval but by smaller irrigation amount with frequent application. Relationship between crop growth and soil moisture content will be examined to determine effective method of supplemental irrigation on crop yield increase. In the future the importance of

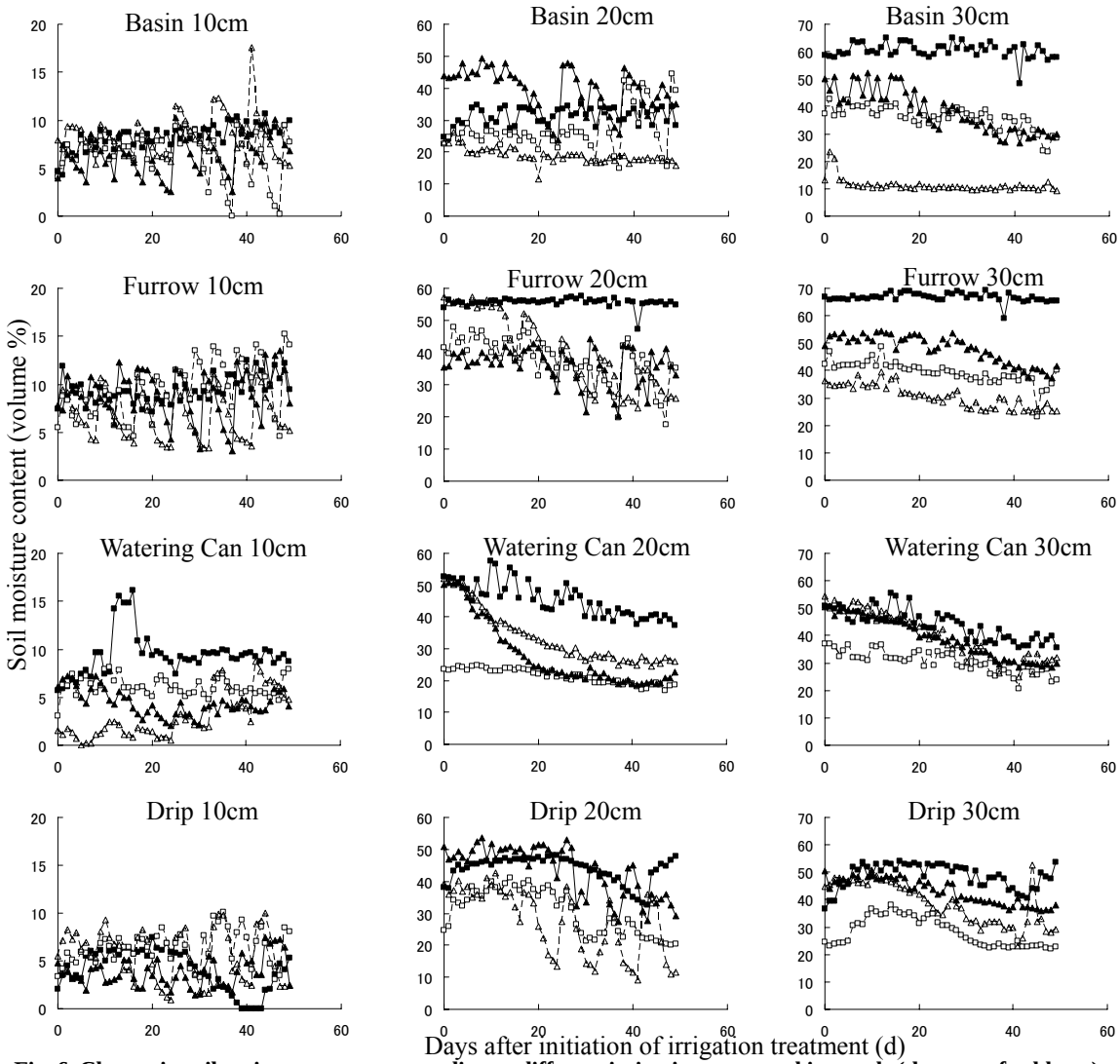


**Fig. 6. Change in soil moisture content according to different irrigation types and intervals (the case of cabbage).**
(■:2 day, □:4 day, ▲:6 day, □:8day- Irrigation Interval)

supplemental irrigation in rainy season also should be examined based on the results from the dry season experiment. Besides, a trial should be done further on farmers' field with their management as a process of extension like Yusuf and Muluken (2008) to make them more confident of its practical applicability.

## References

FAO (1992): *CROPWAT - A Computer Program for Irrigation Planning and Management. FAO Irrigation and Drainage Paper No. 46*. Food and Agriculture Organization of the United Nations, Rome.

FAO (1998): *Crop evapotranspiration - Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper No. 56*. Food and Agriculture Organization of the United Nations, Rome.

Maynard, D.N. (1997): *Knott's handbook for vegetable production. 4th ed*. John Wiley & Sons, New York.

Nishimaki R., Okada Y., Shiwachi H., Takahashi H., Takahashi S. (2006a): Comparison between basin and furrow irrigation in terms of crop growth. *Journal of Arid Land Studies*, **15**: 333-337.

Nishimaki R., Okada Y., Toyoda H., Shimada S., Takahashi S. (2006b): Comparison between basin and furrow irrigation in terms of appropriate water use. *Journal of Arid Land Studies*, **15**: 329-332.

Yusuf K., Muluken P. (2008): *Scaling out of improved irrigation water management technologies through demonstration on farmers' field of FRG members. FRG Completed Research Reports 2007*, 65-76. Melkassa Agriculture Research Centre, Ethiopia.