Effect of irrigation scheduling on productivity and water use efficiency of potato in south-eastern Ethiopia

南東エチオピアにおける灌漑スケジューリングのもたらすジャガイモの生産性および水利用効率への効果

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1. Background and Objective

Almost all of the irrigation schemes of Arsi zone, the southeastern part of Ethiopia, are small scale and traditional. Farmers seem to have awareness about the benefits of irrigation and proven ability to organize themselves to manage small scale irrigation systems. However, it lacks scientific management; they either over or under irrigate their fields. This in turn results in yield reduction and adverse changes on soil chemical properties. For example, the national average productivity of irrigated potato in Ethiopia was only 3.7 t ha^{-1} (CSA, 2015), while the world and Japan average were 16.8 and 31.9 t ha^{-1}, respectively (FAOSTAT, 2008). This could be due to inadequate management of irrigation water by the farmers in addition to other factors of irrigated potato production system. Therefore, the experiment was conducted to determine the appropriate frequency and amount irrigation water for potato crop production in Ethiopia.

2. Materials and Methods

Experiments were conducted at Shelled, Golja and Lemu sites in the south-eastern Ethiopia in 2007 and 2008. There were no well-established weather stations in all sites. For this reason, CLIMWAT, climatic database, was used to generate the required climatic data. FAO Penman-Monteith method was employed to calculate reference evapotranspiration (ETo). ETo was multiplied by potato crop coefficients to calculate crop evapotranspiration values for each site. The trial comprising 4 treatments of irrigation regimes; 3 of them were determined using Cropwat 4 Windows 4.3 computer model developed by FAO (FAO, 1992) depending on alternatives for minimum yield loss and maximum irrigation efficiency while 4^{th} treatment was farmers' practices of each site (table 1). The experiment was laid out in randomized complete block design with 3 replications. Tuber yield, biomass yield and water use efficiency were measured and subjected to analysis of variance using statistical analysis system (SAS) software.

Table 1 Summary of treatment descriptions

Treatment	Shelled	Golja	Lemu
T_1	Traditional	Traditional	Traditional
T_2	13mm every 4 days	11mm every 5 days	15mm every 9 days
T_3	16mm every 5 days	15mm every 7 days	21mm every 12 days
T_4	20mm every 6 days	27mm every 9 days	28mm every 15 days

3. Result and Discussion

Potential Evapotranspiration (ETo)

Computed result for ETo varied from 2.29 mm day^{-1} in July to 3.65 mm day^{-1} in March at Lemu, 2.88 mm day^{-1} in September to 3.83 mm day^{-1} in June at Golja and 3.26 mm day^{-1} in September to 4.39 mm day^{-1} in March at Shelled (Fig. 1). Shelled had the highest ETo and

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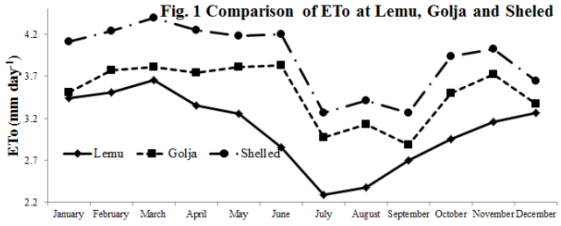
the lowest was observed at Lemu, which belong to the low and highlands, respectively. The value for Golja was intermediate, which belongs to midland.

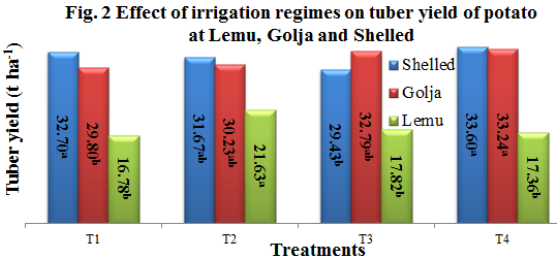
Crop water and irrigation requirements

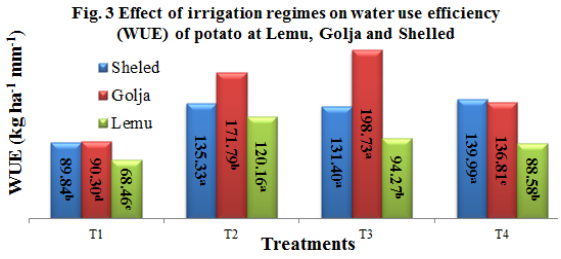
ETc over the whole season amounted to 1118, 1278 and 1426 mm while the corresponding total annual rainfalls were 1203, 699 and 689 mm at Lemu, Golja and Shelled, respectively. However, rainfall was not uniformly distributed through the year; it was concentrated from June to September at Lemu, and July and August at Golja and Shelled indicating deficits of soil moisture; hence, irrigation was important for majority of the months. Seasonal crop evapotranspiration (ETc) were 414, 441 and 501 at Lemu, Golja and Shelled, respectively. Total irrigation input applied on potato ranged from 180–245, 165-330 and 224–364 mm at Lemu, Golja and Shelled, respectively.



Yield and water use efficiency (WUE)

Tuber yield in experimental plots varied from 16.78 to 33.6 t ha^{-1} (Fig. 2) while WUE varied from 68.46 to 198.73 kg ha^{-1} mm^{-1} (Fig.3). Irrigation regimes significantly influenced tuber and biomass yields and WUE of potato at all locations. Values for the three irrigation treatments (T2, T3, and T4) were generally higher as compared with farmers' practices. Especially for WUE, model produced irrigation treatments had significantly higher values as compared with traditional farmer's practice.





Generally, increasing irrigation water amounts produced relatively higher yields at Shelled, which belongs to lowland while increasing irrigation water amounts resulted in relatively reduced yields at Lemu, which belongs to highland attributed to the detrimental effect of continuous wet conditions in the root zone due to relatively low ETo. The values for Golja were intermediate. Results further indicated that the water use efficiency of farmer's practices were inferior at all locations; farmers' practices were wasting irrigation water.

4. Conclusion

Results confirmed that irrigation regimes significantly influenced yield and water use efficiencies of potato. All irrigation treatments determined based on Cropwat 4 Windows 4.3 computer model gave superior yields and water efficiencies of potato compared to farmers' practices at all locations, indicating good irrigation water management strongly required for crop cultivation. Applications of 20 mm irrigation water every 6 days, 15 mm irrigation water every 7 days and 15 mm irrigation water every 9 days have been recommended for Shelled, Golja and Lemu areas, respectively and other similar agroecologies for increasing productivity and water use efficiencies of potato.

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