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Effect of Nitrogen Rates and Irrigation Regimes on Water Use Efficiency of Selected Potato Varieties in Jimma Zone, West Ethiopia

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K **:** Variety; WUE (water use e ciency); Irrigation regimes; Nitrogen rates

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Potato (*Solanum tuberosum* L.) ranks fourth among the world's crop production in volume a er wheat, rice and corn [1]. But it is rst from Root and Tuber crops followed by cassava, sweet potato and yam [2]. Potato has got production potential of about 327 million tons and 18.6 million hectares worldwide [3]. Potato was introduced to Ethiopia in 1858 (19th century) by a German Botanist Schimper [4]. Since then, farmers in Ethiopian high lands began cultivating the potato tuber as compensation when other crops failed. In Ethiopia, the estimated land under potato cultivation each year is over 160,000 hectares [5]. Based on FAO data, potato production in Ethiopia has increased from 280, 000 tons in 1993 to around 525, 000 tons in 2007 [6].

Potato is temperate crop that satisfactorily grows and yields well in cool and humid climates [7]. It is a major food crop in many countries being grown from the tropics to the sub-polar. Among African countries, Ethiopia has possibly the greatest potential for potato production as 70% of its arable land mainly in highland areas with altitude greater than 1,500 m above sea level is considered suitable for potato [8]. Since the highlands are also home to higher percent of Ethiopia's population, the potato can play a key role in ensuring national food security if production potentials are exploited well [6].

e ideal growth requirements for potato include high and nearly constant soil matric potential, high soil oxygen di usion rate, adequate incoming radiation and optimal soil nutrients [9]. Among other environmental conditions, temperature and photoperiod are known to a ect the various physiological processes of the potato plant [10]. Optimum temperatures for foliage growth and net photosynthesis are 15-25°C and 20°C for tuberization. At temperature above 29°C tuberization is inhibited, foliage growth is promoted and net photosynthesis and assimilate partitioning to the tubers are reduced [11]. In natural environment plants are subjected to many stresses that have a great impact on growth, development and nally yield of crops. ese factors can be biotic and abiotic. Among these factors, drought and nutrients suboptimal use are major abiotic factors that limit crop production [12].

Early studies have shown that water is the most important limiting factor for potato production and it is possible to increase production levels by well-scheduled irrigation programs throughout the growing season for e cient use of water [13]. Most researchers reporting the in uence of water stress on potato yield in terms of its e ect on aerial parts [14]. In course of improving water and nitrogen use e ciency researchers indicated use of drip irrigation for most crop commodities; mainly for vegetables and fruits [15]. For e cient use of water, supplementing rainfall by irrigation water to satisfy the needs of the crop at each growth stages is important to attain the required yields, especially in periods of limited rainfall. is is a key operation to avoid water shortage and over-irrigation which can reduce yields through

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upper diameter. The experiment was 3 × 3 × 3 factorial with three replications laid down in a Block Design. Interaction of variety and irrigation signifcantly affected water use effciency recorded the highest WUE at 80% irrigation, but was on par with Guassa varieties at 100% irri was obtained from Degemegn variety at 100% irrigation even though there was no signifca three irrigations. From the results, it can be concluded that irrigation regimes and variety we water use effciency of the potato varieties while the nitrogen rates and interaction between c nitrogen combination were not influenced the water use effciency of the potato varieties signi of greenhouse condition, open feld experiment is suggested to be carried out to come up w

because of high nutrient demand and a shallow, as well as ine cient rooting system [18,19]. In addition to shallow rooting, many potato cultivars have relatively ine cient nutrient and water use e ciency systems [20]. e consequence of poor e ciency and high water/fertilizer rates in potato is the potential for signi cant N contamination to surface and groundwater [21,22]. Although not studied as extensively as N in potatoes, high soil P is a potential environmental problem as well [23]. Understanding nitrogen application rates and irrigation regimes that enhance the e cient use of both water and nitrogen, and developing wisdom of e cient use of resource management practices could minimize the potential N losses thereby reducing production cost and increasing farm pro t.

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e fertilizers used were Urea (CO ($[NH_2]_2$) (46% N) and 90 kg/ha of DAP (46% P_2O_5)) e amount of ertilizers used in this study was applied using band method. Nitrogen fertilizer was applied in two splits. Half of the nitrogen fertilizers and entire phosphorus requirement was applied as basal while the remaining amount was applied at 45 days a er planting [32]. e amount of phosphorus requirement was 90 kg/ha. All of the other cultural practices used throughout the growing season were similar to those that were practiced by regular farmers.

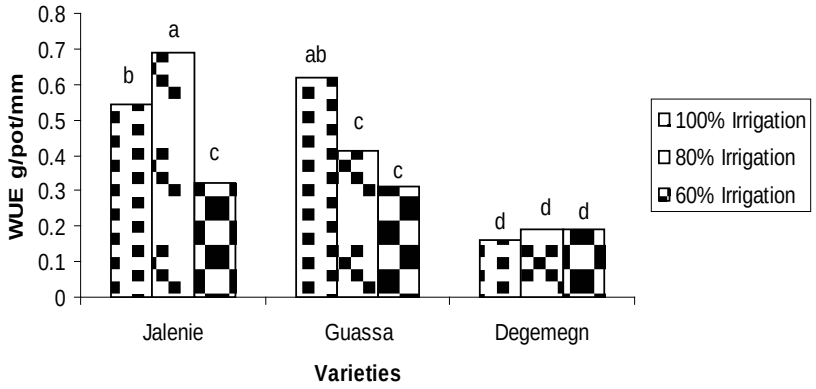

Figure 1: Variety and irrigation interaction effect on water use efficiency of potato.

Treatment	Water amount(mm)	Average tuber weight (g)	WUE (g tuber/pot/mm)	WUE (g above ground fresh weight/pot/mm)
Irrigation				
100%=I1	573.68a**	253.25a**	0.44133a**	0.53741b**
80%=I2	458.95b **	195.81a*	0.42885a**	0.55924b**
60%=I3	339.5c**	94.21b**	0.27500b**	0.61159a**
Variety				
Jalenie	457.6ns	245.51a **	0.51822a**	0.59599a**
Guassa	457.6ns	216.47a**	0.44704a**	0.57158ab**
Degemeng	457.6ns	81.18b**	0.17993b**	0.54068b**
Nitrogen				
130 kg/ha	457.6ns	170.33ns	0.35730ns	0.56551ns
110 kg/ha	457.6ns	195.03ns	0.40137ns	0.56396ns
90 kg/ha	457.6ns	177.91ns	0.38652ns	0.57878ns
LSD	20	59.371	0.1274	0.0462
C% at α=5%	2.825085	14.25899	19.40995	14.84519

**- means of the same factor followed by the same letter with in the column are not significantly different at 1% level of probability, LSD-Least Significant Difference, CV% - Coefficient of Variance. Ns=none significantly difference at 5% level of probability.

Table 1: Effect of irrigation, variety and nitrogen rates on WUE of potato.

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Water Use E ciency (WUE) g/mm: Variety and irrigation interaction signi cantly a ected the WUE calculated from ratio of fresh tuber weight to irrigated water in mm (Figure 1). Jalenie recorded the highest WUE at 80% irrigation, but was not signi cantly di erent from Guassa at 100% irrigation. e lowest WUE was obtained from Degemegn at 100% irrigation. However, it was not statistically di erent from WUE of the same varieties at 80 and 60%. Decreasing the irrigation water by 20% increased the WUE by 14.4% further decreasing to 40% reduced the WUE by 40.33% in Jalenie variety while decreasing the irrigation water by 20% and 40% decreased the WUE of Guassa by 33.6 and 49.6% respectively. In Degemegn variety, decreasing the irrigation water by 20% and 40% had no signi cant e ect on WUE.

Water use e ciency of above ground fresh weight was signi cantly a ected by variety and irrigation (Table 1). Jalenie variety recorded signi cantly high WUE but was not signi cantly di erent from Guassa variety. However, the WUE of Guassa was not signi cantly di erent from that of Degemegn variety. Nitrogen rates and interactions holding nitrogen did not a ect water use e ciency of above ground fresh weight.

WUE of tuber was increasing with increasing irrigation water from 60-100% (Table 1). A signi cantly positive correlation coe cient (r=0.225) was observed between WUE and irrigation water amount (Table 2). is may be because when the amount of water irrigated increased to the eld capacity, the potato varieties get better supply that satisfy their needs for better tuber formation that directly involved in increment of the WUE. Signi cantly strong positive association was also found between WUE and Harvesting index, tuber to shoot ratio, total dry weight, tuber number, tuber fresh and dry weigh (Table 2).

e WUE of tuber in this study was variable with varieties and increased with increased irrigation water amount. ese results agree with ndings of Darwish et al. [39] which obtained the lowest WUE from 60% of full irrigation while 80%, 100% and 120% irrigation provided maximum WUE, respectively. Steyn et al. [40] reported similar results in similar experiment with irrigation regimes of 100, 80 and 60%. On the other hand, Kirda [41] found a contradictory result from drip irrigation. Onder et al. [7] also reported decreasing WUE with increasing water supply. Similar reports were presented in Kashyap and Panda [42] and Yuan et al. [9]. According to Badr et al. [43] nding, fully irrigated potato increased N uptake and tuber yield which implies that better water use e ciency than water stressed treatment. 80% irrigation was reduced nitrogen losses by 58 to 81% compared to 20% irrigation regime [44], indicating that better watering to the eld capacity encourages better utilization of not only water but also other nutrients. David et al. [45] showed di erent response of potato varieties to fully irrigate and stressed treatments which correlate the two ndings as varieties recorded signi cantly di erent water use e ciencies resulted in due to di erent yield development of the varieties under same and di erent irrigation regimes. Finding

of Ahmadi et al. [46] indicated non-signi cant di erent water use e ciencies between potato varieties subjected to di erent irrigation water amounts in contrary to this experiment which may be due to growing condition and managements other than irrigation. Decreased water use e ciency was reported with increasing water supply [47]. Maximum potato performance was recorded at full irrigation [48].

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Many researchers had reported Variability of WUE with variable

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