

Journal of Horticulture and Forestry

Volume 9 Number 1 January 2017

ISSN 2006-9782



*Academic
Journals*

ABOUT JHF

The **Journal of Horticulture and Forestry (JHF)** is published monthly (one volume per year) by Academic Journals.

Journal of Horticulture and Forestry (JHF) is an open access journal that provides rapid publication (monthly) of articles in all areas of the subject such as Arboriculture, Plant growth by hydroponic methods on straw bales, Postharvest physiology of crops, Permaculture etc.

The Journal welcomes the submission of manuscripts that meet the general criteria of significance and scientific excellence. Papers will be published shortly after acceptance. All articles published in JHF are peer-reviewed.

Contact Us

Editorial Office: jhf@academicjournals.org

Help Desk: helpdesk@academicjournals.org

Website: <http://www.academicjournals.org/journal/JHF>

Submit manuscript online <http://ms.academicjournals.me/>

Editors

Dr. Amanullah Khan

Khyber Pakhtunkhwa Agricultural University,
Department of Agronomy, Faculty of Crop
Production Sciences, Peshawar-25130, Pakistan.

Prof. Paul K. Baiyeri

Department of Crop Science,
Faculty of Agriculture,
University of Nigeria, Nsukka,
Nigeria

Dr. Fahrettin Tilki

Artvin Coruh University
Faculty of Forestry
08000-Artvin,
Turkey

Dr. Peter Fredenburg

Freewheel Media
2D Samtoh Building
386 Queens Road West
Sai Ying Pun,
Hong Kong

Dr. Deepu Mathew

Kerala Agricultural University
Tavanur - 679 573,
India

Dr. Süleyman Korkut

Strategic Objective 2 - Sustainable Agricultural
Production Systems (SO2)
Food and Agriculture Organization of the United
Nations (FAO)
Viale delle Terme di Caracalla,
Rome,
Italy.

Dr. Süleyman Korkut

Düzce University, Faculty of Forestry
Department of Forest Industrial Engineering
81620 Beciyorukler Campus, Duzce
Turkey

Dr. Geoff Sellers

Research Fellow Agronomy Institute
UHI Orkney College Kirkwall
Orkney KW15 1LX

Dr. Xianmin Chang

Agronomy Institute, Orkney College
University of Highlands and Islands
East Road, Kirkwall, Orkney
UK

Dr. Alireza Iranbakhsh

Islamic Azad Univeristy,
Aliabad Katoul Branch, Aliabad Katoul,
Golestan
Iran

Editorial Board

Dr. Gecele Matos Paggi

Federal University of Mato Grosso do Sul
Brazil

Dr. Mekou Youssoufa Bele

Center for International Forestry Research (CIFOR)
Central Africa Regional Office (CARO)
P.O.Box 2008, Messa.
Yaounde - CAMEROON

Dr Ugur Cakilcioglu

Firat University,
Faculty of Science and Arts,
Department of Biology
TURKEY

Dr Hare Krishna

Central Institute of Temperate Horticulture-Regional
Station,
Mukteshwar-263 138, District- Nainital, Uttarakhand,
India

Dr. Zhonglian('Julie') Huang

Donald Danforth Plant Science Center
975 North Warson Road
St.Louis, MO 63132
USA

Dr. Gholamreza Sharifisirchi

Reza Sharifi-Sirchi
Biotechnology Department, Agriculture college,
Shahid Bahonar University-Kerman
Iran

Dr Ashwani Tapwal

Scientist
Rain Forest Research Institute (RFRI),
Ministry of Environment & Forests (GOI)
P.O. Box -136, Deovan, Jorhat-785 001,
Assam, Tanzania

Dr. Karim Hosni

School of Agriculture, Mograne,
Department of Agricultural Production, 1121, Zaghouan,
Tunisia

Dr. Jasper Abowei

Department of Biological Sciences,
Faculty of Science,
Niger Delta University, Wilberforce Island,
Bayelsa State
Nigeria

Dr. Hasan Turkez

Faculty of Science, Molecular Biology and Genetics
Department,
Erzurum Technical University,
Erzurum, Turkey

Dr. Ricardo Aroca

Department of Soil Microbiology
Zaidín Experimental Station (CSIC)
Professor Albareda 1
18008 Granada
Spain

Dr. Maarit Kallio

Finnish Forest Research Institute
Vantaa Unit,
POB 18,
FI-01301 VANTAA
Finland

Dr. Iulian Costache

University of Craiova
Faculty of Agriculture and Horticulture
Department of Biology and Environmental Engineering
13 A. I. Cuza Street, 200583 Craiova,
Romania

Dr. Rajesh Kumar

Scientist C
Forest Protection Division
Rain Forest Research Institute (RFRI),
P.O. Box -136, Deovan, Jorhat-785 001,
Assam, India

Bharat Sharma Acharya

Ratnanagar 01, Chitwan, Nepal
Nepali

Dr. Subhasis Panda

Taxonomy & Biosystematics Laboratory
Post-Graduate Department of Botany
Darjeeling Govt. College
Darjeeling-734101
India

Dr. Kadiriye URUÇ PARLAK

Agri Ibrahim Cecen University
Science and Arts Faculty
Department of Biology
04100 Agri/TURKEY

Journal of Horticulture and Forestry

Table of Contents: Volume 9 Number 1 January 2017

ARTICLE

Effect of nitrogen and potassium application rates on nitrogen use efficiency and tuber minerals content in central high lands of *Ethiopia*

1

Egata Shunka, Abebe Chindi, Gebremedhin W/giorgis, Ebrahim Seid and Lemma Tessema

Full Length Research Paper

Effect of nitrogen and potassium application rates on nitrogen use efficiency and tuber minerals content in central high lands of *Ethiopia*

Egata Shunka*, Abebe Chindi, Gebremedhin W/giorgis, Ebrahim Seid and Lemma Tessema

Ethiopian Institute of Agricultural Research (EIAR), Holetta Agricultural Research Center, P. O. Box: 2003, Addis Ababa, Ethiopia.

Received 20 October, 2016; Accepted 9 January, 2017

An experiment was conducted on a Nitisol of Holetta agricultural research and Jeldu Sub-center using three factors such as potato varieties (Belete, Jalenie and Gudanie), nitrogen rates (87, 110 and 133 kg/ha) and potassium oxide rates (0, 34.5, 69 and 103 kg/ha) that were arranged on randomized complete block design with three replications. The data were subjected to Proc GLM model of SAS software version 9.2. Higher tuber nitrogen content, uptake and utilization was obtained from Holetta location than Jeldu. Increasing nitrogen fertilizer from 87 to 133 kg/ha reduced the tuber nitrogen uptake and utilization efficiency by 75.56 and 75.49%, respectively. The interaction between variety and location also highly significantly affected tuber nitrogen content and nitrogen utilization efficiency. The interaction between nitrogen and variety affected tuber nitrogen in percent and protein content highly significantly. The highest tuber nitrogen and protein content was obtained from Belete and Gudenie varieties at a rate of 110 kg/ha nitrogen. From these results, it can be concluded that, the interaction between nitrogen and potassium rates did not affect significantly any parameter measured in this experiment, while nitrogen, varieties, interaction of location with variety showed significantly different nitrogen use efficiencies and tuber minerals content.

Key words: Gudenie, Belete, Jalene, potassium, nitrogen rates.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is temperate crop (Onder et al., 2005) that satisfactorily grows and yields well in cool and humid climates. 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 (Yilma, 1991). As potato is a source of both food and income in the growing countries of the world, it can change greatly the food security ensuring capacity of countries as result of high productivity per unit area and time in relation to other crops. In addition, high prospects for growth of the market for fresh potatoes (Scott et al.,

*Corresponding author. E-mail: egata.shunka2007@yahoo.com. Tel: +251112370295, 0931796885.

2000); make the commodity fundamental for rural development particularly in countries where food security is a major problem.

Soil fertility decline is one of the major environmental problems threatening the livelihoods of millions of farm households in rural Ethiopia (Mitiku et al., 2007). Stoorvogel et al. (1993) estimated that about 41 kg of N, 6 kg of P and 26 kg of K is lost per hectare per year from Ethiopian highlands which was valued in to \$24 to 193 per ha per year (Ekossa et al., 2015). On top of this, approximately 41% of the total farmland of the country is acidic, of which nearly one-third faces the problem of aluminum toxicity (EATA, 2013). Strong soil acidity is associated with Al, H, iron (Fe), and manganese (Mn) toxicities to plant roots in the solution and corresponding deficiencies of the available phosphorus (P), molybdenum (Mo), calcium (Ca), magnesium (Mg) and potassium (K) (Jorge and Arrunda, 1997). The problem is exceptionally severe in the highlands of the country where the majority of the human and livestock population is concentrated (Teklu, 2005). Plants grown on acidic soils may be limited by deficiencies of N, P, K, Ca, Mg, or Mo; toxicity of Al or Mn; reduced nutrient cycling; and reduced uptake of nutrients by plant roots and inhibition of root growth (Marschner, 2011). Soil acidity adversely affects morphological, physiological and biochemical processes in plants and thus N uptake and use efficiency (Fageria and Baligar, 2005; Marschner, 2011). Plant nutrition is the practice of providing to the plant the right nutrient, in the right amount, in the right place, at the right time.

Potatoes productions require relatively high amounts of fertilizer (Munoz et al., 2005; Pack et al., 2006). Because of its shallow root system and short crop duration, the nutrient requirement of potato is very high (Dechassa and Schenk, 2004). Love et al. (2003) also described that, potato has shallow root system and relatively poor nutrient and water use efficiency. Depending on the soil type, variety, crop rotation, moisture supply and management practices a normal potato crop may remove an estimated 90 to 120 kg ha⁻¹ of N, 13.8 to 25.8 kg ha⁻¹ of P and 150 to 250 kg ha⁻¹ of K from the soil (Sikka, 1982). As reported by Getu (1998), tubers account for more than 70% of the nutrient removed from the soil. N and K are found in largest amounts in a potato plant followed by Ca and Mg. Most of the phloem mobile nutrients will be in the tubers at harvest while the immobile nutrients will be in the residual vegetative portion of the plants (Westermann, 2005). The consequence of poor efficiency and high water/fertilizer rates requirement in potato is the potential for significant N acidification to soil as well as surface (Honisch et al., 2002) and groundwater (Madramootoo et al., 1992). Unless it is checked, the environmental pollution due to these effects is hazardous for future life sustenance. In potato production N is applied more frequently and in greater amounts than any other nutrient. An adequate amount of

N increases root and shoot number and size of tubers. It is also the nutrient that most often limits yield (Tisdale et al., 1995), they reported that, N responses varies with the soil type, varieties, length of the growing season, organic manures, kind of fertilizers, time and method of application, moisture supply and nutrient interaction. Nitrogen and potassium rates determination for varieties relating with the nitrogen use efficiency is very important to alleviate these problems and maximize farm profit by declining resources wastage or cost of production, and increasing regulations to reduce environmental pollution (Powell et al., 2010). Low potassium nutrient availability is one of the limiting factors for plants growth which commonly found in acid soils including inceptisols (Amisnaipa et al., 2016).

Efficient use of available resources, especially water and nutrients, is one of the most important objectives in the sustainable management of cropping systems. Nitrogen use efficiency (NUE) in plants is a complex phenomenon that depends on a number of internal and external factors. According to Ravi et al. (2008), it basically depends on soil nitrogen availability, its uptake and assimilation, photosynthetic carbon and reluctant supply, carbon-nitrogen flux, nitrate signaling and regulation by light and hormones. Nitrogen use efficiency is a yield determining parameter that can be computed either by use of taken up nitrogen or utilized portion of nitrogen for formation of tubers. NUE can also be expressed based on apparent nitrogen recovery using physiological and agronomic parameters (Ravi et al., 2008). The most suitable way to estimate NUE depends on the crop, its harvest product and the processes involved in it.

Though potato has been under cultivation for 154 years in Ethiopia with high production potential, its national average yield is very low (7.9 t ha⁻¹) (Peter et al., 2009), compared to the world average (16.4 t ha⁻¹) (FAO, 2004). Among factors contributing to low average yield, poor agronomic practice and inefficient resource management are very important ones. Therefore, the present research was conducted in Holetta and Jeldu location to quantify and compare the nitrogen use efficiencies of three potato varieties (Jalanie, Gudenie and Belete) and also to determine the interaction effect of rates of nitrogen and potassium on nitrogen use efficiency (NUE) and tuber minerals content of the Jalanie, Gudenie and Belete potato varieties.

MATERIALS AND METHODS

A field experiment was conducted in 2014 and 2015 at Holetta Agricultural Research and Jeldu sub-center including three factors, potato varieties (Jalanie, Gudenie and Belete), nitrogen at rates 87, 110 and 133 kg/ha and potassium at rates 0, 34.5, 69 and 103.5 kg/ha, respectively. The experiments were laid out using completely randomized block design with three replications. The fertilizers source used were urea (CO ([NH₂]₂) (46% N) and 90 kg/ha of diammonium phosphate (DAP) (46% P₂O₅) and

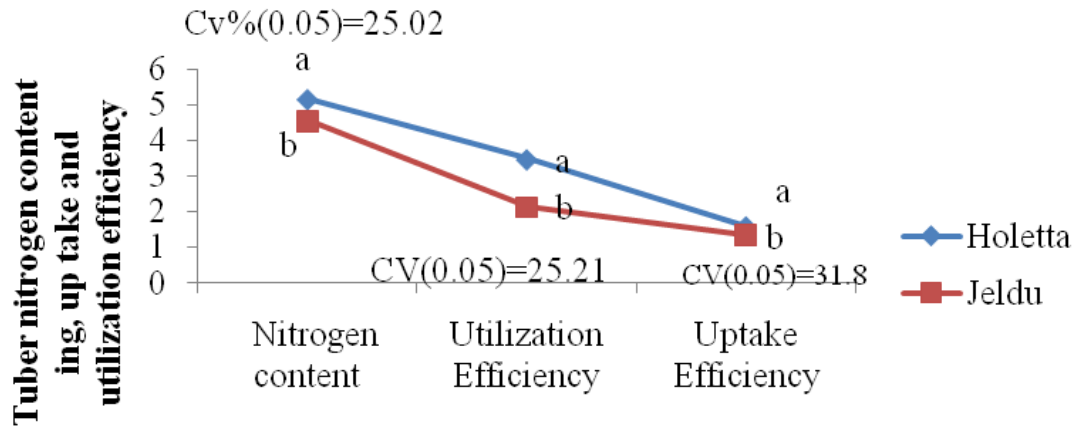


Figure 1. Effect of growing year on tuber up take and nitrogen efficiency.

potassium nitrate ($\text{KNO}_3=13\%\text{N}$ and $46\%\text{K}_2\text{O}$). The land was prepared well in similar ways of land preparation rule for potato fields in Holleta research center and potato tubers used for planting were similar in size for the three varieties. Planting was carried out using sprouted tubers in 10 cm depth with 75 cm distance between rows and 30 cm between plants on 3 m x 3 m plot size. The nitrogen fertilizer was applied in two split: Half as basal at planting and half at 45 days after planting (Girma and Ravishanker, 2008) at 5 cm around the root zones as reported in Teriessa (1997). Phosphorus at a rate of 195 kg/ha in the form of DAP and potassium fertilizer was applied during planting. A fungicide, Ridomil MZ 68% WP at the rate of 2 kg/ha was applied to control late blight following incidence of 24 to 36 h. Others cultural practices were done in the same practice as Holetta Research Center recommended practice for potato production. tuber harvesting was done once at proper physiological maturity (70% leaves withering). Tuber fresh weight and dry mass was measured after drying sample biomass in oven dry at 65°C until constant weight was achieved. Tuber dry weight (dried at 65°C until constant weight) was grinded in to flour and total nitrogen in dry matter was determined by micro-kjeldahl method using the following formula.

$$\text{Absorption or uptake efficiency} = \frac{\text{Total plant uptake (g)}}{\text{Nitrogen supply (g)}}$$

$$\text{Utilization efficiency} = \frac{\text{Average tuber fresh weight (g)}}{\text{Nitrogen supply (g)}}$$

Where = total plant nitrogen uptake at maturity (tuber + haulm), average tuber fresh weight (g) at maturity and Nitrogen Supply (g) = applied N + Soil N.

Data was subjected to analysis of variance using proc GLM (general linear model) procedure of SAS 9.2 software (SAS Institute Inc. 2009). The means was compared with Duncan's multiple range test at 5% significance level.

RESULTS AND DISCUSSION

The growing locations affected the tuber nitrogen content (g/m^2), uptake and utilization efficiency highly

significantly (Figure 1). It also affected percent phosphorus, potassium, and total available nitrogen as well as organic matter content of tuber highly significantly (Table 1). Higher tuber nitrogen content (g/m^2), uptake and utilization was obtained from Holetta location than Jeldu. The effect of potassium rates on tuber nitrogen content (g/m^2), up take and utilization efficiency was not significant (Table 2). The higher tuber phosphorus and organic matter was recorded from Jeldu while the higher potassium and total available nitrogen was recorded from Holetta location.

The nitrogen rates were highly significantly affected uptake and utilization efficiency (Table 3). The highest nitrogen uptake and utilization efficiency was produced at a rate of 87 kg/ha, while the lowest was obtained at a rate of 133 kg/ha (Table 3). Increasing nitrogen rates decreased the efficiencies of nitrogen fertilizer. Increasing nitrogen fertilizer from 87 to 133 kg/ha reduced the tuber nitrogen uptake and utilization efficiency by 75.56 and 75.49%, respectively.

The potato varieties produced significantly different uptake and utilization efficiency and highly significantly different tuber dry matter nitrogen percentage and gram nitrogen (Table 4). The higher tuber nitrogen percentage was produced from potato variety Gudenie, while two remaining varieties provided statistically not different lower values. The highest gram nitrogen content and uptake efficiency was obtained from Gudenie variety though the value is not significantly different from Belete. The maximum utilization efficiency was recorded from Belete even though the value is not statistically different from Gudenie.

The interaction between location and nitrogen rates was highly significant (Table 5). The highest utilization efficiency was produced from Holetta location at a rate of 87 kg/ha nitrogen, while lowest was obtained from Jeldu location at a rate of 133 kg/ha nitrogen. The tuber nitrogen content in gram from dry matter and uptake efficiency was not significantly affected by the interaction

Table 1. Effect of growing location on tuber content.

Location	P (%)	K (%)	OM (%)	TN (%)
Jeldu	0.22 ^{a**}	0.73 ^{b**}	96.23 ^{a**}	0.93 ^{b**}
Holetta	0.17 ^{b**}	1.17 ^{a**}	95.37 ^{b**}	1.18 ^{a**}
CV(0.05)	13.35	17.83	0.52	16.38

Means followed by same letter(s) are not significantly different from each other at $p \leq 0.05$. ** - indicate means which are significantly different at 1% level of probability. CV%, Coefficient of variance.

Table 2. Effect of potassium rates on tuber up take and nitrogen efficiency.

K ₂ O kg/ha	Tuber nitrogen (g)	Uptake efficiency	Utilization efficiency
0	4.85 ^{ns}	1.44 ^{ns}	2.6 ^{ns}
34.5	4.79 ^{ns}	1.45 ^{ns}	2.78 ^{ns}
69	4.92 ^{ns}	1.49 ^{ns}	2.86 ^{ns}
103.5	4.88 ^{ns}	1.44 ^{ns}	2.96 ^{ns}
CV%(0.05)	25.02	31.78	25.21

CV%, Coefficient of variance. Ns, Means which are not significantly different at $p \leq 0.05$.

Table 3. Effect of nitrogen rates on tuber up take and nitrogen efficiency.

Nitrogen (kg/ha)	Tuber nitrogen (g)	Uptake efficiency	Utilization efficiency
87	4.76 ^{ns}	2.66 ^{a**}	5.14 ^{a**}
110	4.92 ^{ns}	1.05 ^{b**}	2.0 ^{b**}
133	4.89 ^{ns}	0.65 ^{c**}	1.26 ^{c**}
CV%(0.05)	25.02	31.78	25.21

Means followed by same letter(s) are not significantly different from each other at $p \leq 0.05$. **Indicate means which are significantly different at 1% level of probability. CV%, Coefficient of variance. Ns, means which are not significantly different at $p \leq 0.05$.

Table 4. Effect of variety on tuber up take and nitrogen efficiency.

Variety	Tuber nitrogen (g)	Total nitrogen (%)	Up take efficiency	Utilization efficiency
Belete	5.03 ^{ab**}	1.036 ^{b**}	1.45 ^{ab*}	2.92 ^{a*}
Gudenie	5.09 ^{a**}	1.098 ^{a**}	1.54 ^{a*}	2.81 ^{ab*}
Jalenie	4.46 ^{c**}	1.022 ^{b**}	1.33 ^{c*}	2.67 ^{b*}
CV%(0.05)	25.02		31.78	25.21

Means followed by same letter(s) are not significantly different from each other at $p \leq 0.05$. ** - indicate means which are significantly different at 1% level of probability. CV%, Coefficient of variance.

Table 5. Effect of location and nitrogen rates on tuber up take and nitrogen efficiency.

Nitrogen (kg/ha)	Tuber nitrogen (g)		Uptake efficiency		Utilization efficiency	
	Holetta	Jeldu	Holetta	Jeldu	Holetta	Jeldu
87	5.09 ^{ns}	4.44 ^{ns}	2.86 ^{ns}	2.46 ^{ns}	6.37 ^{a**}	3.92 ^{b**}
110	5.3 ^{ns}	4.54 ^{ns}	1.14 ^{ns}	0.97 ^{ns}	2.47 ^{c**}	1.54 ^{d**}
133	5.09 ^{ns}	4.7n ^s	0.69 ^{ns}	0.62 ^{ns}	1.55 ^{d**}	0.97 ^{e**}
CV%(0.05)	25.02		31.78		25.21	

Means followed by same letter(s) are not significantly different from each other at $p \leq 0.05$. **, means which are significantly different at 1% level of probability. CV%, Coefficient of variance. Ns, Means which are not significantly different at $p \leq 0.05$.

Table 6. Effect of growing location and variety on tuber up take and nitrogen efficiency.

Variety	Tuber nitrogen (g)		Uptake efficiency		Utilization efficiency	
	Holetta	Jeldu	Holetta	Jeldu	Holetta	Jeldu
Belete	5.08b**	4.98b**	1.52 ^{ns}	1.48 ^{ns}	3.62 ^{a*}	2.23 ^{b*}
Gudenie	5.76a**	4.42c**	1.73 ^{ns}	1.35 ^{ns}	3.45 ^{a*}	2.17 ^{b*}
Jalenie	4.63bc**	4.28c**	1.44 ^{ns}	1.23 ^{ns}	3.31 ^{a*}	2.03 ^{b*}
CV% _(0.05)	25.02		31.78		25.21	

Means followed by same letter(s) are not significantly different from each other at $p \leq 0.05$. **- indicate means which are significantly different at 1% level of probability. CV%, Coefficient of variance. Ns, Means which are not significantly different at $p \leq 0.05$.

Table 7. Interaction between N and variety on nitrogen and protein content.

Nitrogen rates (kg/ha)	Varieties					
	Available nitrogen (%)			Protein content		
	Belete	Gudenie	Jalenie	Belete	Gudenie	Jalenie
87	0.99 ^{c*}	1.11 ^{ab*}	0.99 ^{c*}	6.16 ^{c*}	6.94 ^{ab*}	6.21 ^{c*}
110	1.114 ^{a*}	1.12 ^{a*}	0.99 ^{c*}	6.96 ^{a*}	6.99 ^{a*}	6.17 ^{c*}
133	1.01 ^{bc*}	1.07 ^{abc*}	1.09 ^{abc*}	6.31 ^{bc*}	6.66 ^{abc*}	6.78 ^{abc*}
CV%(0.05)	16.38			16.37		

Means followed by same letter(s) are not significantly different from each other at $p \leq 0.05$. *, indicate means which are significantly different at 5% level of probability. CV%, Coefficient of variance. Ns, means which are not significantly different at $p \leq 0.05$.

between nitrogen and growing location. The interaction between variety and location also highly significantly affected tuber nitrogen content and nitrogen utilization efficiency (Table 6). The highest tuber nitrogen content (g) was obtained from Gudenie variety grown at Holetta location and the lowest was produced from Jalenie and Gudenie grown at Jeldu location. In addition, higher utilization efficiency was obtained from Belete variety even though it was not significantly different from nitrogen utilization efficiency of Gudenie and Jalenie at same location. The lowest was obtained from Jalenie at Jeldu location, while it was not statistically different from both Gudenie and Belete utilization efficiency of Jeldu location.

The interaction between location and variety significantly affected tuber potassium content (Figure 2). The highest tuber potassium was recorded from Gudenie produced at Holetta location however, on par with Jalenie value produced from same location. The lowest tuber potassium content was obtained from Gudenie grown at Jeldu location even though on par with Belete content at same location. The interaction between nitrogen and variety affected tuber nitrogen in percent and protein content is highly significant (Table 7). The highest tuber nitrogen in percent and protein content was obtained from Belete and Gudenie varieties at a rate of 110 kg/ha nitrogen however, the values were on par with Gudenie at a rate of 87 kg/ha nitrogen, and Gudenie and Jalenie at 133 kg/ha nitrogen rate.

Uptake efficiency was affected by the factors; 65% as

R^2 for regression indicated at 0.65. The model for regression analysis was uptake efficiency = $3.61 + 0.1 \text{ k-N-variety}$. Nitrogen was affected the parameter significantly even at p -value $< .0001$ while the direction is inverse. Potassium affected the nitrogen uptake efficiency non significantly by 10% that means a unit change in potassium application cause 0.1 increase in up take efficiency.

According to David et al. (2016) there were varietal variability in their nitrogen use efficiencies and the maximum efficiency was recorded at low nitrogen level which makes this experiment and present finding similar. Increasing nitrogen rates from 0 to 250 kg/ha increased tuber nitrogen concentration from 0.68-0.81 to 1.27-1.49% DM (Millard, 1986). It was also mentioned that increment of amount of each amino acid contained in a unit weight of fresh tuber increased with increasing nitrogen supply. According to Ochi-e-Ardabili et al. (2010) there is a significant effect of nitrogen rates on tuber nitrogen content. They also described the interaction between nitrogen rates and spacing had imposed significant impact on protein and potassium content. Increasing nitrogen increased tuber potassium content (Mahmoodi and Hakimian, 2005). Again, these results are in agreement with the finding of Kakuhenzire et al. (2005) in which higher nitrogen uptake efficiency was reported from lower rate of nitrogen applied (0-40 kg/ha) than higher rate (40-80 kg/ha). Similar results were reported by Beukema and van der Zaag (1990). According to Singh and Lal (2012) there was significant

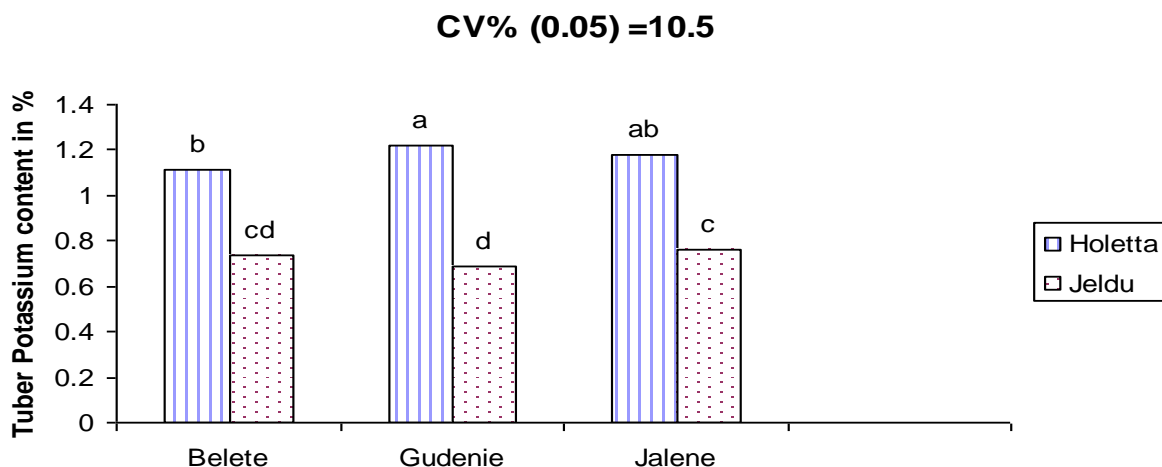


Figure 2. Interaction effect between location and variety on potassium content.

positive interaction between N and K. At each level of N, increasing levels of K application increased the tuber yield, N and K uptake by potato at harvest (Singh and Lal, 2012). Optimal N-K ratios favored crop growth and enhanced K and N use efficiency (Regmi et al., 2002). Higher nutrient content at higher level of fertilizer application together with higher dry matter production resulted in higher nutrient uptake (Chettri and Thapa, 2002). Potassium enhances N uptake and protein synthesis there by increasing the N uptake (Marschner, 1995). Increasing nitrogen increased leaf petiole N significantly and the interaction between nitrogen and potassium significant affected N content (Abu-Zinada, 2009), they also reported that petiole K significantly increased as K increased, whereas nitrogen was of insignificant effect on K, but the interaction between N and K imposed significant influence on K content. Also, Bertrand et al. (2011) indicated increasing mechanisms of controlling plant N economy is essential for improving NUE and for reducing excessive input of fertilizers, while maintaining an acceptable yield and sufficient profit margin for the farmers. It also further explained its combination with gene, protein and metabolite profiling to build up a comprehensive picture depicting the different steps of N uptake, assimilation and recycling to produce either biomass in vegetative organs or proteins in storage organs. Who, also indicated higher NUE at lower level nitrogen input use which are in agreement with the present findings. The genetic variability for both N absorption efficiency and for N utilization efficiency for most crops was showed in Hirel et al. (2007). Not only NUE but also each step of it (N uptake, transport, assimilation, and remobilization) is variable based on both genetic and environmental factors (Xu et al., 2012). In most intensive agricultural production systems nitrogen leaching may reach up to 50 to 75% from N applied to environment (Asghari and Cavagnaro, 2011) which can be a serious risk for human health due to contaminating

water (Umar and Iqbal, 2007). According to Sutton et al. (2011) energy crops have a large capacity to produce higher biomass with the minimal amount of N fertilizer while at the same time protecting the environment. Others strategies to improve NUE are to use genetic modification or to breed for new varieties that take up more organic or inorganic N from the soil N and utilize the absorbed N more efficiently (Hirel et al., 2007). According to Hirel et al. (2007), N uptake and utilization efficiencies (NUE) are species-specific. Genotypic and environment interactions also have considerable impact on varieties NUE (Ludewig et al., 2007). Species and cultivars are expected to play a primary role in determining NUE as it affects both the N uptake and the use of absorbed N (Schenk, 2006). Furthermore, the same genotype can show different NUE response to different levels of N available (Burns, 2006).

CONCLUSION AND RECOMMENDATION

Similar to other finding done on nitrogen use efficiency, this experiments result indicated that, there were location variation in their tuber phosphorus, potassium, organic matter and nitrogen content. There was also growing year highly significant impact on nitrogen use efficiencies and tuber nitrogen content. The nitrogen also affected highly significantly the nitrogen use efficiencies, while the variety showed highly significant variation in their tuber nitrogen content and significantly different response in their nitrogen use efficiencies. The interaction between nitrogen and variety also significantly affected the tuber nitrogen and protein content. The interaction between location and nitrogen affected nitrogen utilization efficiency highly significantly, while variety and location interaction affected significantly the tuber nitrogen content and nitrogen use efficacies' as well as tuber potassium content highly significantly. The higher nitrogen use

efficiency was attained at a rate of 87 kg/ha nitrogen, while the potassium rate not significantly affected nitrogen use efficiency and tuber nitrogen content. Gudenie variety was the most nitrogen use efficient followed by Belete while Jalene is the least in its nitrogen use efficiency.

Conflicts of Interests

The authors have not declared any conflict of interests.

REFERENCES

- Abu-Zinada IA (2009). Potato response to potassium and nitrogen fertilization under gaza strip conditions. *J. Al Azhar University-Gaza (Nat. Sciences)*, 11:15-30.
- Amisnaipa A, Susila D, Dedi N, Wasgito Purnomo D (2016). Determination of potassium (K) fertilizer requirement for pepper (*Capsicum annuum L.*) on inceptisols soil. *J. Agron.* 15:165-172.
- Asghari HR, Cavagnaro TR (2011). Arbuscular mycorrhizas enhance plant interception of leached nutrients. *Funct. Plant Biol.* 38:219-226.
- Bertrand H, Thierry T, Peter JL, Frédéric D (2011). Improving Nitrogen Use Efficiency in Crops for Sustainable Agriculture. *J. Sustain.* 3:1452-1485.
- Beukema HP, Van der Zaag DE (1990). Introduction to Potato roduction. Pudoc.Wagenignen.
- Burns IG (2006). Assessing N fertilizer requirements and the reliability of different recommendation systems. *Acta Hort.* pp. 35-48.
- Chettri M, Thapa U (2002). Response of potato to different sources of potassium with or without farm yard manure in new alluvial zone of West Bengal Haryana. *J. Hort. Sci.* 31(3/4):253-55.
- David S, Evelyn R, Farfán V, Raymundo G, Felipe De M, Roland S, Merideth B, Awais MK (2016). Yield and Physiological Response of Potatoes Indicate Different Strategies to Cope with Drought Stress and Nitrogen Fertilization. *Am. J. Potato Res.* 93:288-295.
- Dechassa N, Schenk MK (2004). Exudation of organic anions by roots of cabbage, carrot and potato as influenced by environmental factors and plant age. *J. Plant Nutr. Soil Sci.* 167:623-629.
- EATA (Ethiopian Agricultural Transformation Agency) (2013). Status of soil resources in Ethiopia and priorities for sustainable management. GSP for Eastern and Southern Africa, 25-27 March 2013, Nairobi, Kenya.
- Ekossa T, Wudneh A, Desalegn B, Taye G (2015). Linking soil erosion to on-site financial cost: Lessons from watersheds in the Blue Nile basin. *Solid Earth* 6(2):765-774.
- Fageria NK, Baligar VC (2005). Enhancing nitrogen use efficiency in crop plants. *Adv. Agron.* 88:97-185.
- FAO (2004). FAOSTAT Agricultural data. Provisional 2003 Production and Production Indices Data. Crop primary. (<http://apps.fao.org/d/efault.jsp>).
- Getu B (1998). Yield, quality and nitrogen uptake of potato (*Solanum tuberosum L.*) as influenced by rate and time of nitrogen application. MSc. Thesis Presented to the School of Graduate Studies of Alemaya University.102 p.
- Girma A, Ravishanker H (2008). The nutritive value of Potato tuber and N and P Effect on its Crude protein and Dry Matter Production. *Ethiop. J. Crop Sci.* 1(1):28-37.
- Hirel B, Le Gouis J, Ney B, Gallais A (2007). The challenge of improving nitrogen use efficiency in crop plants: Towards a more central role for genetic variability and quantitative genetics within integrated approaches. *J. Exp. Bot.* 58:2369-2387.
- Honisch M, Hellmeier C, Weiss K (2002). Response of surface and sub-surface water quality to land use changes. *Geoderma* 105:277-298.
- Jorge RA, Arrunda P (1997). Aluminum induced organic acids exudation by roots of aluminum tolerant maize. *Photochemistry* 45(4):675-681.
- Kakuhenzire R, Hakiza JJ, Berga L, Adipala E, Olanya M, Wagoire W, Kashajia I (2005). Response of four selected potato cultivars to fungicide and fertilizer application. *African Crop Science Conference Proceedings*, 6:69-75.
- Love SL, Novy R, Corsini DL, Bain P (2003). Variety selection and management. Pages 21-47 in: *Potato Production Systems*. Stark JC, Love SL eds. Agric. Commun. Univ. of Idaho, Moscow.
- Ludewig U, Neuhäuser B, Dynowski M (2007). Molecular mechanisms of ammonium transport and accumulation in plants. *FEBS Lett.* 581:2301-2308.
- Madramootoo CA, Wayo KA, Enright P (1992). Nutrient losses through tile drains from potato fields. *Appl. Eng. Agric.* 8:639-646.
- Mahmoodi SH, Hakimian M (2005). Principle of Soil Science (Translation). Tehran University press, Iran. P 650.
- Marschner H (1995). Mineral nutrition of higher plant. Second edition. Academic Press, London: 234 p.
- Marschner H (2011). Marschner's mineral nutrition of higher plants. Third edition. Academic press. German: 672p.
- Millard P (1986). The nitrogen content of potato (*Solanum tuberosum L.*) tubers in relation to nitrogen application the effect on amino acid composition and yields. *J. Sci. Food Agric.* 37:107-114.
- Mitiku H, Herweg K, Stillhardt B (2007). Sustainable land management: a new approach to soil and water conservation in Ethiopia. Land Resources Management and Environmental Protection Department of Mekelle University, and Centre for Development and Environment, Swiss National Centre of Competence in Research (NCCR): North-South University of Bern.
- Munoz F, Mylavarapu RS, Hutchinson CM (2005). Environmentally responsible potato production systems: A review. *J. Plant Nutr.* 28:1287-1309.
- Ochi-e-Ardabili M, Jamaati-e-Somarin S, Abbasi A, Hedayat S, Hassanzadeh M, Zabihi-e-Mahmoodabad R (2010). Effects of nitrogen fertilizer and plant density on NPK uptake by potato tuber. *World Appl. Sci. J.* 8(3):382-386.
- Onder S, Caliskan ME, Onder D, Caliskan S (2005). Different irrigation methods and water stress effects on potato yield and yield components. *Agric. Water Manage.* 73:73-86.
- Pack JE, Hutchinson CM, Simonne EH (2006). Evaluation of controlled-release fertilizers for northeast Florida chip potato production. *J. Plant Nutr.* 29:1301-1313.
- Peter RG, Wachira K, Oscar O, Agajie T, Gebremedhin W, William WW, Rogers K, Peter MK, Moses N, Paul CS, Cees L (2009). Improving Potato Production in Kenya, Uganda and Ethiopia. *Potato Res.* 52:173-205.
- Powell JM, Gourley CJP, Rotz CA, Weaver DM (2010). Nitrogen use efficiency: A potential performance indicator and policy tool for dairy farms. *Environ. Sci. Policy* 13:217-228.
- Ravi RP, Sunila L, Nandula R, Altaf A (2008). Molecular physiology of plant nitrogen use efficiency and biotechnological options for its enhancement, recommendation systems. *Acta Hort.* 700:35-48.
- Regmi AP, Ladha JK, Pasuquin E, Pathak H, Hobbs PR, Shrestha LL, Gharti DB, Duveiller E (2002). The role of potassium in sustaining yields in a long-term rice-wheat experiment in the Indo-Gangetic Plains. *Biol. Fert. Soils* 36:240-247.
- SAS Institute Inc (2009). SAS 9.2 stored processes developer's guide .Carry. SAS. Institute Inc.2009. Cary, NC, USA.
- Schenk MK (2006). Nutrient efficiency of vegetable crops. *Acta Hort.* 700:25-38.
- Scott GJ, Rosegrant MW, Ringler C (2000). Global projections for root and tuber crops to the year 2020. *Food Policy* 25:561-597.
- Sikka L (1982). Fertilizer and manure requirements of the potato. In: *Potato seed production for tropical Africa*. (S. Nganga and F., Shideler, Eds.), CIP, Lima, Peru.
- Singh SK, Lal SS (2012). Effect of potassium levels and its uptake on correlation between tuber yield and yield attributing characters in potato (*Solanum tuberosum L.*) var. Kufri Pukhraj. *Asian J. Hort.* 7(2):392-396.
- Stoorvogel J, Smaling E, Janssen B (1993). Calculating soil nutrient balances in Africa at different scales. *Fertilizer Res.* 35(3):227-235.
- Sutton M, Howard CM, Erisman JW, Billen G, Bleeker A, Grennfelt P, van Grinsven H, Grizetti B (2011). Assessing our nitrogen inheritance. In *The European Nitrogen Assessment. Sources, Effects and Policy Perspectives*; Sutton MA, Howard CM, Erisman JW, Billen

- G, Bleeker A, Grennfelt P, van Grinsven H, Grizzetti B Eds. Cambridge University Press: Cambridge UK, 2011 pp. 1-6.
- Teklu E (2005). Land preparation methods and soil quality of vertisol area in the central highlands of Ethiopia. Stuttgart: Universitat Hohenheim (310):D-70593.
- Teriessa J (1997). A simple guide to potato production in Eastern Ethiopia. Alemaya University of Agriculture P 50.
- Tisdale SL, Nelson WL, James DB, John LH (1995). Soil fertility and fertilizers (5th Ed.). Macmillan publishing Co, Inc. New York pp. 109-229.
- Umar AS, Iqbal M (2007). Nitrate accumulation in plants, factors affecting the process, and human health implications. A review. *Agron. Sustain. Dev.* 27:45-57.
- Westermann DT (2005). Nutritional requirement of potatoes. *Am. J. Potato Res.* 82:301-307.
- Xu G, Fan X, Miller AJ (2012). Plant nitrogen assimilation and use efficiency. *Ann. Rev. Plant Biol.* 63:153-182.
- Yilma S (1991). The potential of true potato seed in potato production in Ethiopia. *Actae Horticulturae* 270:389-394.



Journal of Horticulture and Forestry

Related Journals Published by Academic Journals

- *Journal of Plant Breeding and Crop Science*
- *African Journal of Agricultural Research*
- *Journal of Horticulture and Forestry*
- *International Journal of Livestock Production*
- *International Journal of Fisheries and Aquaculture*
- *Journal of Cereals and Oilseeds*
- *Journal of Soil Science and Environmental Management*
- *Journal of Stored Products and Postharvest Research*

academicJournals