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Effects of Plant Growth Regulators on Tuber Dormancy and Sprouting of Potato (Solanum tuberosum L.) Varieties at Kulumsa, Southeast Ethiopia

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Abstract
Potato production is constrained by shortage of seed tubers for different reasons among which extended potato tuber dormancy plays a significant role. The present study was conducted to evaluate the effects of plant growth regulators (PGRs) on dormancy and sprouting of seed tubers on potato varieties. Three PGRs viz. Gibberrelic Acid (GA_3), Benzyl adenine (BA) and Benzyl amino purine (BAP) each at two concentrations (0.1 and 0.2 mM) with distilled water (DW) as a control treatment were evaluated on tubers of two dominantly grown potato varieties (Jalenie and Belete) in Ethiopia. The treatments were laid out in a factorial experiment using Complete Randomized Design (CRD), with three replications. Thirty medium sized freshly harvested tubers of the two varieties per treatment were cleaned and soaked for 24 hrs in solutions of the three plant hormones at 0.1 mM and 0.2 mM. Likewise, tubers for the control treatment were soaked in distilled water for 24 hrs. The treated tubers were placed in separate plastic boxes, labeled and stored in a diffused light store (DLS). During the storage period, data were recorded every 10 days until 80% of the tubers showed visible sprouting (~2mm). The results showed all the PGRs significantly ($p<0.05$) affected tubers' dormancy and sprouting at different concentrations compared to the un-treated control (DW). Compared to BAP and BA, GA_3 at low concentration (0.1mM) highly shortened tubers' dormancy period of both varieties while Jalenie sprouted earlier than Belete. In addition to tuber's dormancy, GA_3 significantly ($p<0.05$) increased the number of sprouts per tuber, length of apical dominance, length of lateral branching of sprout, and fresh and dry weight of tubers' sprouts. The highest increment of the aforementioned measurements was recorded at 0.1 mM GA_3 although differences were observed between the two varieties. Therefore, GA_3 at 0.1 mM could be recommended as the best PGR to shorten tubers' dormancy of both varieties after harvest. Using GA_3 treatment as a pre-sprouting hormone could double/ or triple the number of seed tuber production cycle per season with supplementary irrigation depending up on the need. Nevertheless, for conclusive recommendation, additional study is needed to know the profit margin of using GA_3 at the optimum concentration for large scale seed production.
Keywords: Plant Growth Regulators, Potato, Seed potato store, Tuber dormancy
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1. Introduction

Potatoes are the fourth most important food crop in the world (NAAS, 2018) which consists of adequate amount of protein, starch, carbohydrates, essential amino acids, vitamins and minerals which are important in human nutrition (Akhavan et al., 2007). Potato plays an important role in the economy of Ethiopian Agriculture which contributes towards earning foreign exchange through exporting potatoes to other countries and used as a food as well as a cash crop in the farming community (Ahmed, 1999; Pervez et al., 2000). Globally, potato ranks fourth among the most cultivated food crops after wheat, rice, and maize, and followed by cassava, sweet potato, and yam (FAO, 2010). The total world potato production is estimated to be about 368 metric tons harvested from 17 million hectares of land. In the same year about 743 thousand tons of potatoes were harvested from an area of 67 thousand hectares in Ethiopia (http://www.fao.org/faostat, accessed on 12 September 2020). In Ethiopia, potato ranks first among root and tuber crops in volume produced and consumed followed by sweet potato, enset, yam and taro (Olango, 2008).

At harvest, potato tubers will not sprout even if placed in suitable environmental conditions for growth (Delaplace et al., 2008). Failure of tubers to sprout and grow is due to extended dormancy period caused by changes in concentrations of phytohormones at the beginning of potato tuber dormancy (Fernie and Willmitzer, 2001; Weiner et al., 2010). Specifically, the entry into dormancy is associated with increased concentrations of abscisic acid (ABA) and a decrease in gibberellins. The long dormancy period of tubers is a major problem in areas where two or more potato production per year is experienced. The problem of obtaining quality potato seed with good sprouting associated with tubers dormancy delays planting, which leads to poor crop emergence and

vigor (Wiersema, 1985) and this can adversely affect the expansion of potato production in many developing countries (Crissman et al.,1993). Hence, timely availability of well-sprouted seed potato tubers at the on-set of rain is a pre-requisite for attaining high yields in rain fed producing areas.

In developing countries farmers usually sprouts potato tubers under pits as it is cheaper to construct and maintain. Under pit conditions, tuber sprouting occurs quite fast within three weeks possibly due to the heat buildup or modified air conditions created (Hunt, 1982; Bencini, 1991). Potato seeds sprouted in pits are, however, of poor quality due to apical dominance, rotting and shoot etiolating caused by the dark conditions. However, a better alternative, if not commonly practiced in Ethiopia, is available — use of plant growth regulators (PGRs) or hormones to speed up sprouting of seed tubers by breaking the dormancy. PGRs whether separately or in combination have been studied internationally on pre-plant dormancy breaking of seed tubers in seed potato production (Struik and Wiersema, 1999). In Ethiopia, where potatoes are produced twice per year, pre-sprouting of the seed tubers prior to planting, by application of plant growth hormones, could lead to double the yields and help the ever growing seed demand in the country. However, the responses of commonly grown potato varieties in the country to commercially available PGRs are not well known and documented for users. Therefore, this study was carried out to assess the effects of some plant growth regulators on dormancy period and sprouting of tubers of potato varieties.

2. Materials and Methods

2.1 Description of the Study Area

The study was conducted at Kulumsa Agricultural Research Center (KARC) which is located at 8º00'-8º02'N latitude and 39º07'-39º10'E longitude at an elevation of 2210 m.a.s.l. in Arsi Administrative Zone of the Oromia Regional State, 167 km southeast of Addis Ababa. The agro climatic condition of the area is wet with 811 mm mean annual rain fall and it is a uni-modal rainfall pattern with extended rainy season from March to September. However, the peak season is from July to August. The mean annual maximum and minimum temperatures are 23.1 and 9.9ºC, respectively. The coldest month is December whereas March and May are the hottest months.

The soils at KARC have several physical and chemical properties that have different textural classes from heavy clay, clay, silt clay, clay loam and sandy clay loam, sub angular structure, low to medium organic matter content (0 to 30 cm) ranging between 0.31 to 4.8%, high total nitrogen content (greater than 0.15%) and 3 and 12 ppm available phosphorous (Abayneh et al., 2003).

Table 1. Description of potato varieties used in the present study

Varieties	Release		Altitude (m.a.s.l)	Rainfall (mm)	Maturity (days)	Dormancy in DLS (months)	Yield(tha-1)	
	Year	Research Center					On research station	On farm
Jalenie	2002	Holeta	1600-2800	750-1000	110-120	> 4	35	20
Belete	2009	Holeta	1600-2800	750-1000	110-120	> 4	47	28

Source: Ministry of Agriculture and Natural Resource (MoANR), Crop Variety Register (2002 & 2009), DLS=Diffused Light Store.

2.2 Experimental Materials and Working Samples

Medium sized (35-45mm in diameter) and undamaged tubers of two commonly known potato varieties (Jalenie and Belete) were obtained immediately after harvest from Holetta seed tuber multiplication field, West Shoa, Ethiopia (Table 1). Three PGRs viz Gibberellic acid (GA_3), Benzyl amino purine (BAP) and Benzyl adenine (BA) were obtained from chemical suppliers. Depending on the physicochemical properties of the three PGRs, 1000mg GA_3 was dissolved in 50ml ethanol; while 1000mgBAP and 1000mgBA were dissolved in 50ml NaOH each. BAP and BA were slightly warmed to increase the activity of the effectiveness. The final volume was made up to 100ml with distilled water (DW). In order to ensure complete dissolving of the PGRs, an Erlenmeyer flask was filled with 1000ml of distilled water placed on shaker. Working solutions were prepared by diluting appropriate amount of the stock solution with distilled water. Two concentrations of 0.1 and 0.2 mM of GA_3, BAP, BA and the control (DW), which is 0 mM were prepared for the treatment applications based on Alexopoulos et al. (2007) with modifications.

2.3 Experiment Layout and Treatment Applications

Factorial combinations of the three PGRs (GA_3, BAP and BA) in three concentrations (0mM, 0.1mM and 0.2mM) including the control (Distilled Water-DW) and tubers of the two potato varieties (Jalenie and Belete) were laid out in a Complete Randomized Design(CRD), with three replications. Thirty medium sized freshly harvested tubers of the two varieties per treatment were washed with tap water to remove the soil and foreign material

adhered to the skin.

The water from the surface of the tubers was dried off and then soaked for 24 hrs in the three plant hormone solutions of different concentrations (0.1mM and 0.2mM), while tubers for the control treatment were soaked in distilled water. The treated tubers were placed in separate plastic boxes, labeled and stored in the DLS. During the storage period, data were recorded every 10 days until 80% of the tubers showed visible sprouting (~2mm).

2.4 Data Collection and Measurements

Dormancy breaking period (DBP) was counted as number of days from haulm cutting to sprouting of 80% of the tubers with at least one sprout longer than 2mm. Tubers were checked at 10 day-intervals for monitoring sprouting initiation and growth, and to accurately recorded the dormancy period. **Number of sprouts per tuber (NSPT)** was counted individually and the average was calculated as the number of sprouts per tuber. **Length of Apical Dominance (cm)** was determined by measuring the length of the longest sprout of the potato seed tubers and the average was considered for statistical analysis. **Length of Branching Sprout (cm)** of each tuber was measured and the average of lateral auxiliary sprout length per tuber was calculated. **Fresh weight of the sprouts (mg)** was measured immediately by using a sensitive balance and the **Dry weight of sprouts (mg)** was estimated after oven dried at 78˚C for 48hr (until constant weight was attained). Finally, the w**eight loss of tubers (%)** was computed by taking the difference between the final and initial weight of tubers when 80% of tubers were sprouted.

2.5 Statistical Analysis

The data were subjected to analysis of variance using Gen Stat, 13th Edition (VSN Ltd, Oxford UK) statistical software package. Least significant difference (LSD) test at 5% probabilities was used to separate means when the analysis of variance indicated the presence of significant differences among treatments.

3. Results and Discussions

3.1 Dormancy Breaking Period and Number of Sprouts per Tuber

Analysis of variance showed that tuber dormancy breaking period was highly significant among plant growth regulators and between varieties (Table 2). The results showed that pre-treatment of GA_3 at different concentrations shortened the dormancy breaking period from the un-treated control. The dormancy period was shortened from 142.7 to 54.7 and 155 to 92.3 days for Jalenie and Belete varieties respectively when GA_3 concentration increased from 0mM to 0.2mM (Figure 1). This means GA_3 concentration of 0.1 and 0.2 mM shortened the dormancy period of tubers by 72.4 and 88 days and 65 and 62.5 days for Jalenie and Belete varieties respectively. The reduction in dormancy period on both varieties due to GA_3 treatment was much higher than the reduction in dormancy period due to BAP and BA (Table 2).

Coleman (1984) reported the importance of early tuber dormancy breaking in seed potato multiplication (two-three production in greenhouse or open field) and rapid post-harvest testing of diseases. According to Vreugdenhil (2007), plant hormones influence the growth and development and can play a crucial role in breaking potato tuber dormancy. Lim et al. (2004) noted that GA_3 treated potato tubers showed fast sprout growth and those tubers treated with higher dose of GA_3 (150 mg/l) sprouted earlier than other. The number of days required to break the dormancy were shortened when the tubers were treated with GA_3, BA or their combination and stored in the DLS. Potato tubers of an Ethiopian variety "Gudanie" treated with an aqueous solution of GA_3 *per se* at concentrations of 0.1, 0.2 and 0.3 mM sprouted 26.67, 33.34 and 30 days earlier than the untreated tubers, respectively, with non-significant difference among the effects of GA_3 concentrations (Kedir, 2016). Salimi et al. (2009) showed that GA broke dormancy of two potato varieties by about 35–72%, while the interaction between GA and thiourea accelerated sprout emergence and decreased dormancy duration (Alexopoulos et al., 2007).

Table 2. Interaction effect of plant growth regulators and potato varieties on Dormancy Breaking period and Number of Sprout per Tuber.

Variety	Dormancy Breaking period(DBP)			Number of Sprout per Tuber(NSPT)		
	Gibberellic acid (GA_3)			Gibberellic acid (GA_3)		
	0.0mM	0.1mM	0.2mM	0.0mM	0.1mM	0.2mM
Jalenie	142.7	70.3	54.7	4.83a	5.36a	5.23a
Belete	155.0	90.0	92.3	1.93c	4.93a	5.36a
	Benzyl amino purine (BAP)			Benzyl amino purine (BAP)		
	0.0mM	0.1mM	0.2mM	0.0mM	0.1mM	0.2mM
Jalenie	142.7	129.3	133.3	4.83a	4.76a	4.23a
Belete	155.0	153.3	155.0	1.93c	2.63c	2.43c
	Benzyl adenine (BA)			Benzyl adenine (BA)		
	0.0mM	0.1mM	0.2mM	0.0mM	0.1mM	0.2mM
Jalenie	142.7	135.7	140.3	4.83a	4.53a	4.10ab
Belete	155.0	145.0	151.7	1.93c	1.86c	2.83bc
LSD (5%)	9.46			1.271		
CV (%)	4.5			19.3		

CV=Coefficient of Variation, LSD=least significant difference, mM = milli mole, cm=centimeter, DBP=Dormancy Breaking Period, NSPT=Number of Sprouts per Tuber, GA_3=Gibberellic acid, BAP=Benzyl amino purine, BA= Benzyl adenine.

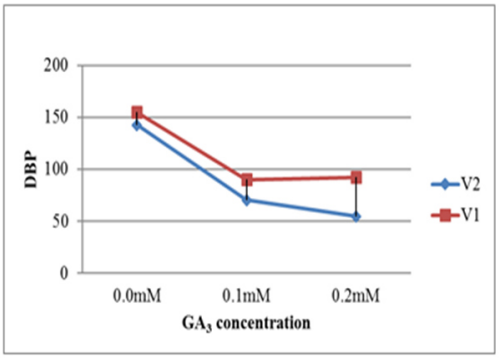

Figure 1: Interaction effect of plant growth regulators and potato varieties on Dormancy Breaking Period (DBP). GA_3=Gibberellic acid, V1= Belete and V2= Jalenie.

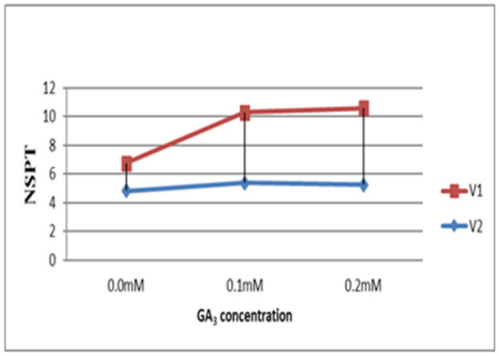

Figure 2. Interaction effect of plant growth regulators and potato varieties on number of sprouts per tuber (NSPT). GA_3=Gibberellic acid, V1=Belete and V2=Jalenie.

Similar to DBP, analysis of variance showed that the number of sprouts per tuber (NSPT) was significantly different among plant growth regulators and between varieties (Table 2). The results showed that pre-treatment of GA_3 significantly increased number of sprouts per tuber as concentration increased from 0 to 0.2mM on both varieties (Figure 2).

However, pre-treatment of BAP and BA showed non-significant differences on NSPT among the different concentrations used and the un-treated control. GA_3 at low concentration (0.1mM) increased the number of sprouts per tuber by 52.48% on Belete and 72.6% on Jalenie over the control (DW) (Table 2).

Alexopoulos et al. (2008) found that irrespective of the concentration, GA_3 treatments (1, 5, 10 and 50 ppm) significantly increased the number of sprouting per tuber than control. Demo (2002) showed that increase in GA_3 concentration led to increase in sprouting percentage, number of sprouts per tuber, sprout length and sprout vigor. Type of PGRs and genotypes (varieties) used also matters on the number of sprouts developed per tuber. The mean number of sprouts increased by 44.69, 46.82 and 65.98% in tubers treated with aqueous solutions of BA concentrations of 0.1, 0.2 and 0.3 mM, respectively; while tubers treated with GA_3 concentrations of 0.1, 0.2 and 0.3 mM resulted in an increase in the mean number of sprouts per tuber by 8.52, 17.04 and 23.43%, respectively for Gudanie variety (Kedir, 2016).

Table 3. Interaction effect of plant growth regulators and potato varieties on length of apical dominance and length of branching sprouts.

Variety	Length of Apical Dominance(cm)			Length of Branching Sprouts(cm)		
	Gibberellic acid			Gibberellic acid		
	0.0mM	0.1mM	0.2mM	0.0mM	0.1mM	0.2mM
Jalenie	1.497^{cdef}	3.993^{a}	3.537^{a}	1.04^{bcd}	3.023^{a}	2.74^{a}
Belete	1.88^{bcde}	2.073^{bcd}	2.463^{b}	0.587^{d}	1.523^{b}	1.44b^{c}
	Benzyl adenine			Benzyl adenine		
	0.0mM	0.1mM	0.2mM	0.0mM	0.1mM	0.2mM
Jalenie	1.497^{cdef}	1.31^{ef}	1.327^{def}	1.04^{bcd}	1.05^{bcd}	1.15^{bcd}
Belete	1.88^{bcde}	1.917^{bcde}	1.84^{bcdef}	0.587^{d}	0.71^{d}	0.803^{d}
	Benzyl amino purine			Benzyl amino purine		
	0.0mM	0.1mM	0.2mM	0.0mM	0.1mM	0.2mM
Jalenie	1.497^{cdef}	1.117^{f}	1.297^{ef}	1.04^{bcd}	0.77^{d}	0.883^{cd}
Belete	1.88^{bcde}	2.123^{bc}	1.46^{cdef}	0.587^{d}	1.057^{bcd}	0.623^{d}
LSD (5%)		0.7526			0.6249	
CV (%)		22.6			30.0	

CV=Coefficient of Variation, LSD=least significant difference, mM=milli mole, cm=centimeter, LAD=Length of Apical Dominance, LBSP=Length of Branching sprouts, GA_3=Gibberellic acid, BAP=Benzyl amino purine, BA= Benzyl adenine.

3.2 Length of Apical Dominance and Length of Branching Sprout

Analysis of variances showed that the length of apical dominance was highly significant among PGRs and varieties (Table 3). Tubers pre-treated with GA_3 significantly increased the length of apical dominance (LAD) of the two varieties more than the control (DW) and increasing trends of LAD was observed with increasing concentration of GA_3 (Figure 3). However, the LAD affected by BAP and BA was not significantly different from the un-treated control in both varieties. The increase in LAD due to GA_3 was more than that of BAP and BA. GA_3 treatment increased the LAD by 73.58% and 52.41% on variety Jalenie and and Belete respectively over the control. Demo (2002) showed that increase in GA_3 concentration led to increase in sprouting percentage, number of sprouts per tuber, sprout length and sprout vigor.

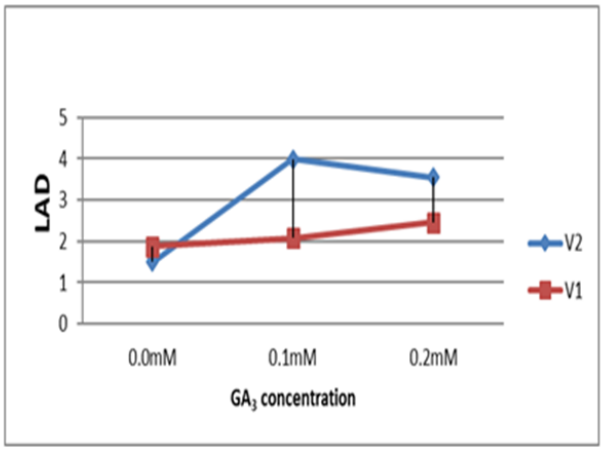

Figure 3: Interaction effect of plant growth regulators and potato varieties on length of apical dominance (LAD). GA_3=Gibberellic acid, V1=Belete and V2=Jalenie.

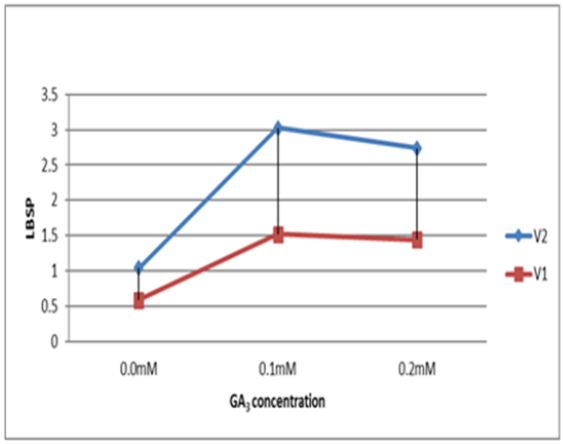

Figure 4: Interaction effect of plant growth regulators and potato varieties on length of branching sprout (LBSP). GA_3=Gibberellic acid, V1=Belete and V2=Jalenie.

Otroshy and Struik (2008) reported that treating mini tubers with gibberellic acid was effective in increasing the length of sprouts. Gibberellins are important in the synthesis of reducing sugars, thus creating an energy source for growing sprouts. GA_3 treatments resulted in high sprout growth rates possibly due to an increase in assimilate flow towards the growing sprouts, which enhance early establishment of crop stand and improved photosynthetic activity. Treatment of tubers with GA_3 and BA as well as GA_3+ BA had significant influence on the length of main and auxiliary sprouts (Kedir, 2016). In addition to LAD, the interaction effect of PGRs and variety was also highly significant on length of branching sprouts (LBSP) compared to the control (Table 3). Analysis of variance showed

that the highest LBSP with application of GA_3 was observed on variety Belete than Jalenie (Figure 4). However, BAP and BA did not significantly affect LBSP at all concentrations compared to the control. The increment in LBSP due to GA_3 treatment was 75% and 74.38% on Belete and Jalenie respectively over the control (DW).

3.3 Fresh and Dry Weight of Sprouts

The analysis of variance revealed that treating tubers with PGRs highly significantly ($p<0.01$) affected fresh weight of sprouts (Table 4). Tubers pre-treated with GA_3 at low concentration (0.1mM) yielded higher fresh weight of sprouts (FWTS) than BAP and BA pre-treated tubers at any concentrations used and the control. Increasing trend of FWTS was observed when GA_3 concentration was increased from 0mM to 0.1mM and then declined when reached at the higher concentration (0.2mM) on both varieties (Figure 5). Tubers pre-treated with GA_3 however produced 70% and 59.98% more FWTS on Belete and Jalenie at 0.1mM over the control respectively. Nevertheless, the FWTS produced due to pre-treatment of BAP and BA was not significantly different from the control (Table 4). According to Alexopoulos et al. (2007), the fresh weight of sprouts per tuber was significantly higher on tubers treated with GA_3 or the combined application of GA_3 and BA than the controls.

Table 4. Interaction effect of plant growth regulators and potato varieties on fresh and dry weight of sprouts

Varieties	**Fresh weight of sprouts(mg)**			**Dry weight of sprouts(mg)**		
	Gibberellic acid			Gibberellic acid		
	0.0mM	0.1mM	0.2mM	0.0mM	0.1mM	0.2mM
Jalenie	3.35^{bcd}	5.02^{ab}	4.797^{abc}	0.453^{e}	1.023^{a}	0.827^{ab}
Belete	2.733^{d}	6.367^{a}	4.977^{ab}	0.437^{e}	0.567^{cde}	0.46^{e}
	Benzyl adenine			Benzyl adenine		
	0.0mM	0.1mM	0.2mM	0.0mM	0.1mM	0.2mM
Jalenie	3.35^{bcd}	3.13^{cd}	3.557^{bcd}	0.453^{e}	0.763^{bc}	0.857^{ab}
Belete	2.733^{d}	3.22^{bcd}	3.26^{bcd}	0.437^{e}	0.56^{cde}	0.573^{cde}
	Benzyl amino purine			Benzyl amino purine		
	0.0mM	0.1mM	0.2mM	0.0mM	0.1mM	0.2mM
Jalenie	3.35^{bcd}	3.083^{cd}	2.977^{cd}	0.453^{e}	0.7^{bcd}	0.717^{bc}
Belete	2.733^{d}	4.04^{bcd}	3.537^{bcd}	0.437^{e}	0.59^{cde}	0.507^{de}
LSD (5%)		1.831			0.2078	
CV (%)		28.3			19.2	

CV=Coefficient of Variation, LSD=least significant difference, mM=milli mole, cm=centimeter, FWTS=Fresh Weight of Sprouts, DWTS=Dry weight of sprouts, GA_3=Gibberellic acid, BAP=Benzyl amino purine, BA= Benzyl adenine.

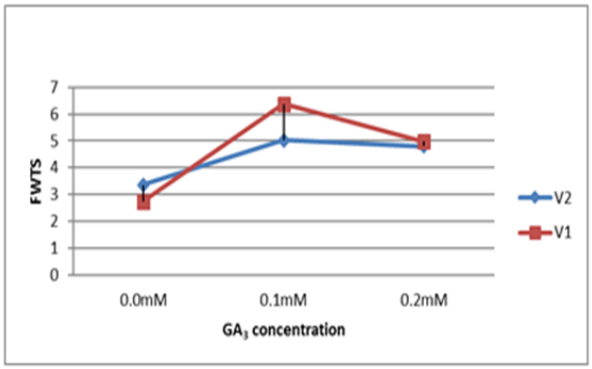

Figure 5: Interaction effect of plant growth regulators and potato varieties on fresh weight of sprout (FWTS). GA_3=Gibberellic acid, V1=Belete and V2=Jalenie.

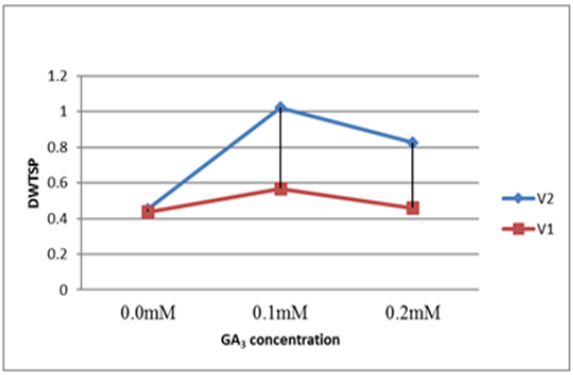

Figure 6: Interaction effect of plant growth regulators and potato varieties on dry weight of sprout (DWTSP). GA_3=Gibberellic acid, V1=Belete and V2=Jalenie.

Furthermore, the authors reported that the sprout growth (length, fresh and dry weight) was higher in tubers treated with GA_3 alone or the combined application of GA_3 with BA than the controls (un-treated).

The increment of FWTS due to GA_3 treatment could be due to the pronounced effect of gibberellic acid on elongation of sprouts and the number of sprouts developed per tuber compared to that of BAP, BA and the control. Gibberellin (GA) promotes stem elongation and growth (Sun, 2010) which invariably increases the fresh weight

of tuber sprouts. Otroshy and Struik (2008) also indicated that growth regulators affected significantly the weight of sprouts. In their investigation the higher doses of gibberellic acid increased the weight of sprouts compared to the control and the weight of the sprouts depends upon the number of sprouts, the length of the sprouts, and the thickness of the sprouts.

Kedir (2016) reported that tubers treated with an aqueous solution of 0.2mM GA_3, 0.3 mM BA or 0.1 mM GA_3+0.3 mM BA produced sprouts that had the highest fresh weight in Gudanie variety. Besides, sole treatment of tubers with GA_3 or BA resulted in 110.21 and 109% increment in the sprout fresh weight over the untreated tubers, respectively. Hence, the findings of the present study on the increasing effect of GA_3 treatment on number of sprouts per tuber, length of apical dominance, and length of branching sprouts contributed to the increase in fresh and dry weight of sprouts. In similar fashion, the PGRs used in the present study and the varieties used had significant effect on dry weight of sprouts (DWTSP) (Table 4). The results showed that the tubers treated with GA_3 recorded more DWTSP than BAP, BA and the control. Even the varieties were varying in DWTSP at different concentrations of the PGRs used. Variety Jalenie responded more than Belete in terms of dry weight increment when GA_3 concentration increased from 0 to 0.1mM (Figure 6). GA_3 at low concentration (0.1mM) recorded 69.31% DWTSP on Jalenie variety over the control.

Besides, tubers pre-treated with BAP and BA at low concentration (0.1mM) yielded about 60.87% and 62.81% DWTSP increment on Jalenie over the control respectively. This was due to the number and the thickness of sprouting and the length (elongation) of sprout owing to the PGR treatment. Alexopoulos et al. (2007) and Kedir (2016) found that the dry weight of sprouts per tuber following treatment with GA_3 or GA_3+BA was significantly higher than that of the controls.

3.4 Weight Loss of Tubers (%)

Highly significant difference was found among treatments with regard to weight loss of the tubers (Table 5). GA_3, BAP and BA at low concentration (0.1mM) increased the weight loss of tubers more than the control. The tubers pre-treated with GA_3 at 0.1mM caused the highest weight loss of 59.3 % on variety Jalenie followed by Belete (42.5%) over the control (26.6%). This clearly depicts that there was an increase in weight loss of tubers when the concentration of GA_3 was increased from 0 to 0.1mM in both varieties used then declined after wards (Figure 7).

In the present study, weight loss of tubers could be obviously due to water loss, utilization of reserve carbohydrates by newly emerging sprouts and respiration of mother tubers. The higher weight loss in GA_3 treated tubers may be due to the higher rate of metabolism which is related with sprout initiation and growth (Reust, 1986). Accordingly, Burton (1989) and Alexopoulos et al. (2008) showed that sprouting is accompanied by many physiological changes including increases in reducing sugar content, respiration, water loss, and glycol alkaloid content and also mentioned that GA_3 increased the rate of weight loss of the tuber than the control. Similarly, Kedir (2016) found that treating the potato tubers with GA_3 as well as GA_3+ BA had a significant effect on weight loss of sprouted or non-sprouted tubers throughout the storage period. However, BA did not significantly influence the weight loss of tubers.

4. Conclusion

The present study found that tubers' dormancy can be shortened by the use of plant growth regulators (PGRs). The results showed the effect of three PGRs on potato seed tubers' dormancy and sprouting at different concentrations. GA_3 at low concentration (0.1mM) significantly reduced the period of tubers' dormancy of both potato varieties in which Jalenie sprouted earlier than Belete. In addition to tuber's dormancy, GA_3 significantly increased the number of sprouts per tuber, length of apical dominance, length of lateral branching of sprout, and fresh and dry weight of tuber sprouts. The highest increment of the aforementioned measurements was recorded at 0.1 mM of GA_3 although differences were observed between the two varieties.

Likewise, weight loss of tubers was significantly affected by the growth regulators at different concentrations, although the highest weight loss was obtained at 0.1mM GA_3 on both varieties. Therefore, based on the results obtained, GA_3 at 0.1mM could be recommended as the best PGR to shorten tubers' dormancy of the two varieties (Belete and Jalenie) after harvest. Using GA_3 treatment as a pre-sprouting hormone could double/ or triple the number of seed tuber production cycle per season using irrigation depending up on the need. However, for concrete conclusion, supplementary study is needed to know the profit margin of using GA_3 at the recommended concentration for large scale seed production. Further study is also required to evaluate the effect of the PGRs on the field performance and tuber yield of the varieties by planting the sprouted tubers from the different concentrations used in the dormancy experiment.

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