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Haulm application and dipping treatments of gibberellic acid on tuber dormancy breaking and sprout induction of potato *(Solanum tuberosum* L.) in Central Highlands of Ethiopia

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Potato, an important food and nutrition security can be produced two or more times in a year in Ethiopia. It plays an important role in human diet and a source of income for smallholder farmers. However, its productivity is low owing to limited availability of planting materials and poor tuber sprouting of improved varieties. Lack of quality seed is a major problem affecting expansion of potato production. The objective of the study is to determine effects of different methods and rates of Gibberellic acid (GA_3) application on dormancy of potato variety, Gera cultivar. The experiment was conducted at Holetta Agricultural Research Center during 2008 to 2009. It consisted of five levels of GA_3 as haulm application, a week prior to destruction and five levels of GA_3 as a dipping treatment immediately after harvest for 24 h. Randomized Complete Block Design with three replications was used. Result revealed GA_3 application affects dormancy and sprouting. Haulm application of GA_3 at 750 and 1000 ppm reduced dormancy period by 24 to 27 days, respectively. Dipping treatments of 40 and 50 ppm reduced dormancy period by 18 to 20 days, respectively. The study indicated that haulm application of GA_3 at 750 or 1000 ppm and dipping treatments of 40 or 50 ppm resulted in early dormancy termination, shoot emergence and increased sprout.

Key words: Gibberellic acid, dormancy breaking, haulm application, dipping, sprout induction.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the third most important food crop in the world after wheat and rice, with an annual global production exceeding 374 million tons (CIP, 2016). It is perceived only as a source of carbohydrates, but is also an excellent source of essential amino acids (King and Slavin, 2013). Since

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2007, more potatoes are produced in developing than in industrialized countries (FAO, 2008). More than a billion people consume potato on a regular basis, and it is a vital source of income for millions of farmers (Devaux et al., 2014). In many African and low-income countries, such as Ethiopia, potato has emerged as an important crop, especially in the high and mid-altitude areas (Haverkort et al., 2012). Ethiopia has favorable climatic and edaphic conditions that favor the production of ware potato and high quality and virus-free seed potato that can be grown on 70% of the arable land in the country (Solomon, 1985; FAO, 2008). Despite the prevailing suitable conditions, potato productivity has remained low with the productivity of 13.9 t ha^{-1} (CSA, 2017/18) which is still below world average of 19 t ha^{-1} (FAOSTAT, 2018). Estimated potato cultivated land was 160,000 ha in 2001 (CSA, 2001) while it reached 0.3 million hectare in 2015 with production volume of 572,000 to 3.66 million tons, respectively (CSA, 2015/16).

Farmers produce between 19 and 38 t ha^{-1} using improved seed and crop management practices (Gebremedhin et al., 2008). Paul et al. (2012) also stated that potato yields vary considerably across the world, with the lowest being in Sub-Saharan Africa which is less than 75% of the global average and less than 30% of the top producing regions. Many factors contribute to the low yield of potato such as narrow genetic basis of the varieties, lack of appropriate agronomic practices, use of poor quality planting material (seed tuber), low soil fertility, poor storage management for ware and seed potato, besides pest and diseases resistant high yield varieties which are stable (Haverkort et al., 2012; Gebru et al., 2017). In areas with a tradition of more than one production cycle per year and a bimodal rainfall pattern, there is little time between growing seasons to permit adequate tuber sprouting of improved potato varieties released in Ethiopia. In general, there is a limited supply of high quality seed tubers and it is one of the major constraints to potato production in many developing countries including Ethiopia (Gildemacher et al., 2009).

In central highlands of Ethiopia in particular and in the country in general, potato area coverage and production cycle is increasing owing to increased use of irrigation facilities and economic importance of the crop. However the Ethiopian, potato breeding program has so far failed to develop varieties with a shortest dormancy periods, which can fit the production cycle of most farmers. Most potato varieties released by research institutions in Ethiopia have suffered low rates of adoption by farmers, especially for irrigated agriculture and low moisture stress areas, due to long dormancy periods and other tuber quality attributes. Medium to long dormancy genotypes are thus not easy to incorporate into the predominant cropping system in which farmers retain seed from the previous harvest for replanting the next season (Abebe, 2010).

Productivity of good seed tubers in potatoes relies on factors like; day length, temperature, physiological age of seed tubers, plant density, nitrogen, water supplying, and finally growth regulating materials or plant growth regulators (PGR) (Gregory, 1965). Plant growth regulators have considerable effects on tuber fertility and it is highly related to hormonal balance (Stuart and Cathey, 1961; Vreugdenhil and Struik, 2006). By treating the tubers using gibberellic acid, the tubers can sprout faster (Burton, 1989). Gibberellins are able to break dormancy of potato tubers by dipping (pre-soaking) the seed tubers or spraying the potato plants (Lorreta et al., 1995; Rappaport et al., 1957; Vreugdenhil and Sergeeva, 1999). More buds can be generated per unit area by using gibberellic acid (GA_3) in potatoes. It has been observed that sprouting management strategies are especially needed in production conditions where storage lasts several months and the growing season is short. This is especially the case of seed and ware potato production areas. Furthermore, farmers generally use poor tuber sprouting techniques, which also contribute to poor supply of quality seed for year-round potato production (Nigussie, 2011). The improvements of crop productivity in modern agricultural systems are increasingly dependent on manipulation of the physiological activities of the crop by chemical means (Subhadrabandhu et al., 1999). The management of potato tuber dormancy is of great importance for the ware, packing and processing markets and also for the seed industry. After harvesting, potato tuber is naturally dormant for 1 to 15 weeks depending on the cultivar and storage conditions (Wiltshire and Cobb, 1996).

Depending on the intended purpose, accelerated (that is, seed tubers) or delayed (that is ware potato, industrial processing) sprouting of the harvested tubers is favorable. As with many aspects of plant development, plant hormones have been playing a primary role in the regulation of potato tuber endo-dormancy (Rappaport and Wolf, 1969; Hemberg, 1985). Four of the five principal classes of plant hormones abscisic acid, cytokinins, gibberellic acid, and ethylene have been implicated in dormancy regulation (Hemberg, 1985; Suttle, 1996, 2004). It has been hypothesized that dormancy is regulated by the relative concentrations of growth promoters and inhibitors. Gibberellins and cytokines are generally considered to be growth promoters, whereas abscisic acid and ethylene are believed to inhibit sprout growth (Sonnewald, 2001). Endogenous hormones have been proposed to play a significant role in tuber dormancy regulation (Bruinsma et al., 1967). The level of endogenous GAs remains low during the middle period of storage (deep dormancy) and increase near the onset of dormancy (Rappaport et al., 1958). Thus, exogenous application of GA_3 is used to break potato tuber dormancy (Hemberg, 1985) and it is commercially used to break dormancy of potato tuber. Dipping or soaking of tuber in to GA_3 solution on wounded tuber break the dormancy of tuber (Lippert et al., 1958). According to Van Ittersum et al. (1993) and Alexopoulos et al. (2008), GA_3 is also applied on haulm to shorten the dormancy of

potato and stimulate sprout initiation in a short period of time. Moreover, haulm application of GA_3 two weeks prior to vine killing and dipping the tubers in GA_3 solution shorten the dormancy period (Lippert et al., 1958). The use of chemicals to regulate dormancy is a common practice in many countries. Being environmentally friendly and less toxic, GA_3 treatment is widely used in many countries for breaking tuber dormancy (Alexopoulos et al., 2008). Lack of good quality seed among growers is the major problem adversely affecting the expansion of potato production in many developing countries (Shibairo et al., 2006). One major problem facing production of quality potato seed is poor sprouting, due to dormancy, which leads to delayed planting and poor crop emergence and vigor (Wiersema, 1985).

Timely availability of well-sprouted seed tubers at the on-set of rain as well as for irrigated potato production is a prerequisite for attaining proper planting materials which leads to high yields. Due to unavailability of sprouted tubers for planting at desired time, small-scale farmers often promote potato sprouting by placing them in pits, sacks, teff straw and trenches and use genotypes with short dormancy. However, the availability of potato genotypes with short dormancy period is scarce while medium to long dormancy genotypes are thus not easy to incorporate in the predominant cropping system in which farmers retain seed from the previous harvest for replanting the next season. Farmers mostly prefer various traditional storage methods to enhance sprouting. Potato seeds sprouted in traditional ways are, however, of poor quality due to apical dominance, rotting and sprout etiolation caused by the dark conditions. Under Ethiopian condition, the utilization of chemicals to regulate potato dormancy is not common. This attributed to the lack of information regarding suitable chemicals, and their methods, rates, and time of application for efficient use. Hence, introduction of chemical that induced dormancy breaking is vital to have early seed planting materials. Therefore, this research aimed to determine the optimum method and rate of GA_3 application to shorten potato tuber dormancy using improved potato variety having long dormancy periods, under diffused light storage (DLS).

MATERIALS AND METHODS

Description of the study sites

The tuber dormancy breaking experiment was conducted during 2008 to 2009 cropping seasons at Holetta Agricultural Research Centre, which is located in the Oromia National Regional State and about 29 km far from Addis Ababa in west direction. The site lies at 9° 00' N latitude, 38° 30' E longitude and with an elevation of 2400 m in central Ethiopia. The daily average minimum and maximum temperatures of the area during the growing seasons (2005-2015) were 6.42 and 27.2°C, respectively, and the mean annual rainfall was 918.31 mm. The soil of the experimental site is Nitisols, which is characteristically reddish to brown in color. It has soil pH of 6.67 and clay in texture with contents of 62.5% clay, 30.0% silt and 7.5% sand. The soil has organic matter content of 2.18%, and total nitrogen, available phosphorus and exchangeable potassium contents of 0.18%, 30.58 ppm and 0.14 meq 100 g^{-1} soils, respectively (Kidest et al., 2019).

Description of experimental materials and design

Potato cultivar, Gera which was nationally released in 2003 with a yielding potential of 25 tons/ha and having extended dormancy period of more than three months and having large, round and white tubers with deep eyes was used for the experiment. The experimental plots size of 3 m × 3 m was arranged in a Randomized Complete Block Design (RCBD) with three replications. Forty medium sized (35-45 mm) and well sprouted tubers were planted at a spacing of 75 cm and 30 cm between rows and between plants, respectively, in four rows having ten plants each. Phosphorus (P) was applied at the rate of 92 kg ha^{-1} in the form of P_2O_5 and Nitrogen (N) at the rate of 110 kg ha^{-1} as urea. The entire rate of P and the half rate of the N fertilizers were applied at the time of planting. The remaining half of the N was side dressed 45 days after planting. As a crop protection measure Ridomil® MZ 68% WP was sprayed twice at a rate of 2 kg ha^{-1} before the occurrence of late blight to control the disease. Other cultural practices such as cultivation, weeding and earthing up were carried out according to the research recommendation (Lemaga et al., 1994).

Treatments

In this experiment, a week before harvesting (98 days after planting), from each plot, ten plants from the central rows were tagged and treated with the different rates (0, 250, 500, 750 and 1000 ppm) of GA_3 as a foliar application. The stock solution of GA_3 was prepared by dissolving a total of 3 g GA_3 (90% gibberellins A_3 Biochemical, BDH Limited Poole England) in 10 ml of ethanol (96%) and the final volume was made up to 1000 mL with double distilled water (DDW). The solution was applied as a fine spray by using a manual sprayer early in the morning to avoid rapid drying of the spray solution, due to transpiration until the solutions run off all plants.

Similarly, at harvest freshly harvested forty medium sized (35-45 mm) and healthy tubers were selected and dipped into the different concentrations (0, 10, 20, 30, 40 and 50 ppm) of GA_3 solution for 24 h. The stock solution of GA3 was prepared by dissolving 3 g GA_3 (90% gibberellins A_3 Biochemical, BDH Limited Poole England) in 10 mL of ethanol (96%) and the final volume was made up to 2000 ml with double distilled water (DDW). The control tubers were treated with ethanol and double distilled water (DDW) only for the same duration (AL-Qesi, 1996).

Storage trial

To determine the effect of GA_3 on dormancy and sprout growth, ten uniform medium sized (35-45 mm) tubers for each treatment (foliar sprayed and dipped) were selected, labeled and stored in a naturally ventilated diffused light store being arranged in a randomized complete block design with three replications. Tubers were monitored every other day and continued until 95% of the tubers get sprouted. During the storage period, the internal temperature and relative humidity of the storage room was recorded every day using thermo hygrometer. The mean minimum and maximum temperatures in the store were 3.2 and 21.3°C, respectively and the average relative humidity was 62.4%.

Characteristics studied

Storage trial

Dormancy period: Dormancy period was counted as the number of days from dehaulming (haulm cutting) to sprouting of 80% of the tubers with at least one sprouts longer than 2mm.

Average number of sprouts per tuber: Average number of sprout per individual tubers was recorded when 95% the tubers sprouted (110 days after harvesting).

Average sprout length (mm): The mean length of each sprouted tuber that emerged from individual tubers was measured when 95% of the tubers sprouted (110 days after harvesting).

Fresh mass of sprout (mg): When 95% of the tubers sprouted (110 days after harvest) tubers were de-sprouted and fresh weight of sprouts were recorded using sensitive balance.

Dry mass of sprout (mg): After measuring the fresh weight, the sprouts were dried at 70°C to constant mass in an oven and dry mass of sprout was recorded.

Weight loss of the tubers (%): Calculated from the difference in final weight of tubers selected, labeled and stored when 95% the tubers sprouted (110 days after harvesting) to initial weight.

Statistical analysis

The data was analyzed using analysis of variance (ANOVA) and treatment means were separated by Least Significant Differences (LSD) at 5% probability level by using SAS statistical software packages version 9.00 (SAS, 2010).

RESULT AND DISCUSSION

Dormancy break experiment

Dormancy period

Highly significant differences ($P<0.01$) was found among the treatments with regard to tuber dormancy period (Table 1). The data showed that all haulm applications and dipping of GA_3 significantly reduced tuber dormancy period below the control with more reduction when the concentration of GA_3 increased. Haulm application of 750 and 1000 ppm GA_3 reduced the duration of tuber dormancy by about 24 and 27 days, respectively after harvesting as compared to control and other treatments. Similarly, tubers treated with 40 and 50 ppm GA_3 solutions reduced the duration of tuber dormancy by about 18 and 20 days, respectively. Moreover, low GA_3 concentration (10 ppm) used as dipping resulted in 8 days of reduction as compared to untreated tubers. In accordance with the current results (Dogonadze et al., 2002) reported that GA_3 treatment immediately after harvesting reduced the duration of tuber dormancy by 38 to 42 days. These authors indicated that GA_3 is involved in breakage of dormancy and growth stimulation. Alexopoulos et al. (2008) showed that a haulm application of GA_3 just before haulm destruction, shortened the dormancy period of the harvested seed tubers up to three months. In line with this study, a foliar spray of gibberellic acid, 3 to 6 days before haulm killing shorten potato tuber dormancy period and induced sprouting (Van Ittersum et al., 1993). In addition, Shibairo et al. (2006) reported that postharvest application of gibberellins to tubers grown from seed potatoes promotes the breakage of dormancy. Coleman (1987) also reported that exogenous gibberellins (GA) generally terminate dormancy in potatoes and may play important roles as endogenous regulators of bud dormancy and development. This is also in agreement with several other reports (Kim et al., 1996; Claassens and Vreugdenhil, 2000).

Average number of sprout per tuber

Highly significant differences ($P<0.01$) was found among treatments with regard to the number of sprout per tuber as presented in Table 1. Regardless of the concentration, all haulm application treatments and dipping of tubers in 40 and 50 ppm GA_3 gave significantly higher sprout number compared to the control. In line with the current investigation, Alexopoulos et al. (2008) reported that, sprout number of tubers from plants sprayed with high GA_3 concentration was significantly higher than that of tubers from control plants. Similarly, Shibairo et al. (2006) found that irrespective of the concentration, GA_3 treatments (1, 5, 10 and 50 mg/L) significantly increased the number of sprouting buds per tuber compared to the control. GA_3 treatments increase the number of sprouts (Van Hiele, 1961; Ezekiel and Singh, 2005; Alexopoulos et al., 2007a; Otroshy and Struik, 2008) the length of the sprouts (Bruinsma and Swart, 1970) and proportion of sprouts by about 10% (Holmes et al., 1970). Similarly, 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. Results of the current experiment indicated that both haulm application and dipping treatments of GA_3 increased number of sprouts and sprouting capacity and a good alternative to improve potato seed quality to be utilized as for next planting.

Average sprout length per tuber

Average sprout length was significantly ($P<0.01$) influenced by GA_3 treatments (Table 1). Applications of GA_3 at a rate of 500, 750 or 1000 ppm increased sprout length by about 91% as compared to the control. Similarly, in reference to the control (48 mm long) about 83% sprout length increment was obtained in response to dipping of the tubers in 40 or 50 ppm GA_3 solution. The data revealed that both haulm application and dipping treatment with GA_3 showed increasing trend of sprout length with increasing the rate of GA_3. In agreement with

Table 1. Effects of treating seed tubers with gibberellic acid on length of dormancy period, average sprout number and length of potato tuber.

Treatment	Dormancy period (days)	Average sprout number per tuber	Average sprout length (mm)
Control (Ethanol and DDW)	106.00^{a}	2.00^{d}	48^{d}
Haulm application of 250 ppm GA_3	94.67^{b}	4.00^{abc}	80^{b}
Haulm application of 500 ppm GA_3	85.33^{cd}	4.00^{abc}	90^{a}
Haulm application of 750 ppm GA_3	82.33^{de}	4.33^{ab}	92^{a}
Haulm application of 1000 ppm GA_3	79.00^{e}	5.33^{a}	93^{a}
Dipping tubers in 10 ppm of GA_3	98.33^{b}	2.67^{cd}	55^{d}
Dipping tubers in 20 ppm of GA_3	97.67^{b}	3.00^{bcd}	70^{c}
Dipping tubers in 30 ppm of GA_3	95.67^{b}	3.33^{bcd}	80^{b}
Dipping tubers in 40 ppm of GA_3	87.67^{c}	3.67^{bc}	86^{ab}
Dipping tubers in 50 ppm of GA_3	86.00^{cd}	4.00^{abc}	88^{a}
Mean	91.27	3.63	78
CV (%)	2.34	20.58	5.31
Level of significance at p ≤ 0.05	0.0001	0.0001	0.0001

Means within a column followed by the same letters are not significantly different at the prescribed level of significance. ** = significant at 1% probability level, LSD (0.05)-Least significant difference at 0.05 probability level, CV (%)-Coefficient of variation in percent.

current results, Alexopoulos et al. (2007b) observed that the mean sprout length per tuber following treatment with GA_3 or GA_3 + BA was significantly higher than that of the controls. Similarly, Bruinsma et al. (1967), Alexopoulos et al. (2007b) showed that sprout length on seed tubers increases by exogenously application of GA_3. In addition, Bruinsma and Swart (1970) reported that mini-tubers treated with gibberellic acid were effective in increasing the length of sprouts. Lim et al. (2004) also noted that tubers of GA_3 treated showed fast sprout growth and potato tubers treated with higher dose of GA_3 (150 mg/L) sprouted earlier than other treatments. Thus, GA_3 treatments resulted in high sprout growth rates possibly due to an increase in assimilate flow towards the growing sprouts.

Fresh and dry mass of sprouts

Highly significant difference (P<0.01) was found among treatments with regard to fresh and dry mass of sprout per tuber (Table 2). Haulm application of GA_3 at 1000 ppm resulted in the highest fresh mass (1040 mg) of sprout which was 103% more as compared to the control. In the same way, foliar spray of GA_3 at a rates of 500, 750 or 1000 ppm and dipping in 50 ppm of GA_3 brought about 78 and 52% dry sprout mass increment compared to the control (112 mg). In agreement to this study, Lim et al. (2004) found that the fresh weight of sprouts per tuber following treatment with GA_3 or GA_3+BA was significantly higher than that of the controls. Therefore, increased concentration of GA_3 treatment increased growth of sprouts per tuber and also the rate of transfer of dry matter from tuber to sprout and final improved sprout dry matter. In the current study, fresh and dry mass of sprouts were positively correlated with average sprout number (r = 0.97**; r = 0.81** at (P<0.01) and sprout length (r = 0.98**; r = 0.86** at (P<0.01) indicating that GA_3 treatment increased sprout mass by increasing both sprout number and length.

Percentage weight loss of tubers

Highly significant differences (P<0.01) was found among treatments with regard to percentage weight loss of the tubers (Table 2). The percent weight loss of tubers were significantly higher in the tubers treated with 1000 ppm (92.8%) followed by 750 ppm (78.7%) of GA_3 as compared to the control (58.2%). In the present study, tubers weight loss may be due to water loss, utilization of reserve carbohydrates by newly emerging sprouts and respiration of mother tubers. In agreement with this study, Alexopoulos et al. (2007a) reported that GA_3 treated tubers showed significantly higher weight loss as compared to untreated tubers. The authors described that, the higher weight loss in GA_3 treated tubers in the first 7 days after treatment could be attributed to the incisions made to facilitate the entry of GA_3. Similarly, Burton (1989) and Shibairo et al. (2006) indicated that sprouting is accompanied by many physiological changes including increases in reducing sugar content, respiration, water loss, and glycoalkaloid content and also mentioned that GA_3 increased the rate of weight loss as compared to untreated tubers. The higher weight loss in GA_3 treated

Table 2. Effects of seed tubers treatment with gibberellic acid on sprout fresh and dry mass, and weight loss percentage of tubers.

Treatment	Fresh mass of sprout per tuber (mg)	Dry mass of sprout per tuber (mg)	Percentage weight loss per tuber (%)
Control (Ethanol and DDW)	510^{e}	112^{c}	58.2^{f}
Haulm application of 250 ppm GA_3	750^{bcd}	174^{b}	71.5^{cd}
Haulm application of 500 ppm GA_3	780^{bc}	182^{ab}	75.2^{bc}
Haulm application of 750 ppm GA_3	820^{b}	191^{ab}	78.7^{b}
Haulm application of 1000 ppm GA_3	1040^{a}	224^{a}	92.8^{a}
Dipping tubers in 10 ppm of GA_3	600de	145^{bc}	62.5^{ef}
Dipping tubers in 20 ppm of GA_3	630^{cde}	149^{bc}	66.5^{de}
Dipping tubers in 30 ppm of GA_3	640^{cde}	150^{bc}	70.0^{cd}
Dipping tubers in 40 ppm of GA_3	730^{bcd}	170^{b}	70.5^{cd}
Dipping tubers in 50 ppm of GA_3	730^{bcd}	171^{b}	71.3^{cd}
Mean	720	170	71.7
CV (%)	12.09	14.77	4.81
Level of significance at ($p \leq 0.05$)	0. 001	0.001	0.001

Means within a column followed by the same letters are not significantly different at the prescribed level of significance. ** = significant at 1% probability level, LSD (0.05)-Least significant difference at 0.05 probability level, CV (%)-Coefficient of variation in percent

tubers may be due to the higher rate of metabolism which is associated with sprout initiation and growth (Reust, 1986). Burton (1989) stated that treating potato tubers with GA_3 or GA_3 + BA caused an increase in weight loss and respiratory activity. The author further indicated that, the higher rates of weight loss and respiration in tubers from GA_3 treated plants probably resulted from the presence of sprouts on these tubers.

Conclusion and Recommendation

In Ethiopia, potato is the fastest growing major crop in the developing world with important economic impact on many resource-poor farming families. However, in Ethiopia, the yield per unit area of potato is very low compared to those of other countries. It is one of the most widely used root and tuber crop in human diet. It is also an important cash crop for farmers in the mid and highlands of the country, where it is grown abundantly. However, lack of quality planting materials among growers is a limiting factor adversely affecting production and productivity in these areas. Most potato producer farmers generally use poor tuber sprouting techniques, which also contribute to poor supply of quality seed for year-round potato production. Thus, bringing potatoes to a warm place was used by more than 20% of the farmers in Ethiopia, while also putting the seed potatoes in bags was frequently mentioned. Conversely, identifying appropriate management practices to improve the quality of planting materials is a priority to introduce plant growth regulator for potato producers. Thus, both haulm application and dipping methods of treatments have effect on breaking dormancy, early emergence of shoots. Haulm applications of GA_3 at 750 and 1000 ppm reduced dormancy period by 24 and 27 days, respectively. It also hastened early physiological maturity, increased average sprout number and sprout length of tubers, respectively. Similarly, dipping treatment of 40 and 50 ppm reduced dormancy period by 18 days and 20 days, respectively, and had more effect over the control than lower concentrations. Haulm application of 750 or 1000 ppm reduced days to emergence by 11 days while dipping of seed tubers in 40 and 50 ppm reduced days to emergence by 6 and 8 days, respectively. Therefore, GA_3 affected the physiological age of the tubers by inducing the breakage of bud dormancy at all stages of tuber growth. Although the experiment was conducted in one location and season using a single cultivar it is reasonable to point out that foliar application of gibberellic acid one week before harvest and dipping tubers resulted in shortened dormancy period, increased sprout mass and improved both yield and quality of the subsequent potato generation.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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