American Journal of Agriculture and Forestry
2015; 3(5): 192-201
Published online September17, 2015 (http://www.sciencepublishinggroup.com/j/ajaf)
doi:10.11648/j.ajaf.20150305.14
ISSN: 2330-8583 (Print); ISSN: 2330-8591 (Online)

Comparative Effects of Foliar Application of Gibberellic Acid and Benzylaminopurine on Seed Potato Tuber Sprouting and Yield of Resultant Plants

Martin Kagiki Njogu[1], Geofrey Kingori Gathungu[1, *], Peter Muchiri Daniel[2, 3]

[1]Department of Plant Science, Chuka University, Chuka, Kenya
[2]Department of Plant Science and Crop Protection, University of Nairobi, Kangemi, Kenya
[3]MoA, Wambugu Agriculture Training Centre, Nyeri, Kenya

Email address:
gkgathungu@yahoo.com (G. K. Gathungu)

To cite this article:
Martin Kagiki Njogu, Geofrey Kingori Gathungu, Peter Muchiri Daniel. Comparative Effects of Foliar Application of Gibberellic Acid and Benzylaminopurine on Seed Potato Tuber Sprouting and Yield of Resultant Plants. *American Journal of Agriculture and Forestry*. Vol. 3, No. 5, 2015, pp. 192-201.doi: 10.11648/j.ajaf.20150305.14

Abstract: Seed potato tubers planted immediately after harvest is characterized by delayed plant emergence, poor establishment and low yields. Gibberellic acid (GA) and Benzylaminopurine (BA) or their combinations cause dormancy breakage though little information is available on their combined application to dormancy termination. The effects of foliar application of GA and BA on potato tuber sprouting and subsequent yield were studied. Three potato varieties with different tuber dormancy period; 'Asante' (short dormancy), Dutch Robyjn (medium dormancy) and 'Kenya Sifa' (long dormancy) were planted at National Potato Research Centre, Tigoni and sprayed with a factorial combinations of 0, 50, 100, 300 ppm GA and 0, 50, 75, 100 ppm BA separately and combined at the rate of 1000 lts/ha spray volume towards the end of maturation. The resulting tubers were put in diffuse light storage (DLS) and data on number, length and vigour of sprouts recorded. Sprouted seed tubers were subsequently planted and evaluated for both growth characteristics and yields. The data collected was subjected to analysis of variance and significantly different means were separated using Fisher's protected least significant difference at $p \leq 0.05$. Higher rates of foliar application of GA+BA (300 ppm + 100 ppm) compared with the control (0 + 0) resulted in significant increase insprout length (cm), number of sprout/tuber, sprout vigour (score), and % sprouting from 3.24 to 7.02 and 3.84 to 9.03, 2.04 to 4.45 and 2.07 to 4.8, 1.7 to 3.06 and 1.63 to 3.23, 61.21to 86.67and 63.3 to 83.7 in Asante, 2.94 to 8.03 and 2.8 to 7.99, 1.84 to 5.24 and 1.87 to 4.76, 1.3 to 3.0 and 1.27 to 2.63, 50.61 to 92.7 and 52.7 to 85.7in Dutch Robyjn and 0.79 to 6.43 and 1.32 to 6.99, 0.61 to 3.49 and 0.79 to 3.33, 0.61 to 3.03 and 0.73 to 2.83, 22.12 to 85.76 and 28.3 to83.7 in Kenya Sifa after storage in 2008 and 2009 respectively. A combination of BA and GA resulted in significantly more growth than using only GA or BA alone at the same level. Similarly the subsequent tuber numbers per plant and yield (tons/ha) in resultant plants increased from 7.13 to 12.53 and 24.66 to 32.27, 6.93 to 10.47 and 16.73 to 23.37, and 5.63 to 9.6 and 17.53 to 30.13 in Asante, Dutch Robyjnand Kenya Sifa respectively. Combined application of GA + BA at varied rates can be used to improve sprouting characteristics of seed potato and yield of resultant plants.

Keywords: Potato, Giberrelic Acid, Benzylaminopurine, Seed Sprouting, Resultant Plants, Yield

1. Introduction

Potato tuber buds normally remain dormant throughout the growing season until several weeks after harvest [1] and the conditions that influence tuber formation and growth in potatoes may influence the duration of dormancy [2].Plant internal factors including plant hormones such as gibberellic acid, auxins, ethylene, cytokinins and abscissic acid have been known to affect potato sprouting [3]. There have been a number of studies of the effects of exogenous plant growth regulators (PGRs) on dormancy in potato where they have been applied to leaves shortly before harvest [4] or to whole tubers at harvest or during storage [5, 6, 7].The most consistent effects have been observed with gibberellins [8, 9].

A foliar spray of gibberellic acid, 3–6 days before haulm killing shorten potato tuber dormancy period and induced sprouting [10, 11]. When GA_3 was applied to the foliage of potato plants grown from true seeds towards the end of the

vegetative cycle (60 days after transplantation), it induced rapid breakage of tuber dormancy, a reduction in specific weight, a higher rate of respiration and increased weight loss during storage [4]. The magnitude of the GA effect depends on the cultivar and storage temperature regime [11]. Most studies of foliar application of cytokinins have been based on potato yields [12, 13]. Foliar applications of 50 mg/L benzylaminopurine (BAP) and 50 mg/L gibberellic acid (GA) at early tuberization phase increased both tuber number and yields [12]. Dwelle[13] found that foliar application of a commercial sea weed extract "Cytex" containing cytokinins equivalent to 100ppm resulted to substantial increase in potato yields.

However, reports show that tuberization and sprouting of tubers are associated with high level of cytokinins[14]. Supplying cytokinins to tubers with innately dormant buds induce sprouting growth.It was found that cytokinins is the primary factor in the switch from innate dormancy to non-dormant state in the potato tuber buds but probably do not control the subsequent sprout growth [15].Early bioassay data suggested that increases in endogenous cytokinins accompanied dormancy break [3, 16]. It is proposed that cytokinins may be responsible for dormancy breakdown [15] while the gibberellins promote the subsequent sprout growth [14, 17]. Since potato tuber dormancy is thought to occur on or about the time of tuber initiation, it may be possible that application of gibberellic[4] acid and cytokinins[12] at late vegetative (tuber bulking) phase may shorten the dormancy period. However, there are no reports of the effect of combined use of GA and cytokinins on potato seed sprouting.

However, in Kenya there exists less information on the effects of exogenous application of gibberellic acid and benzylaminopurine on tuber sprouting characteristics and subsequent effect on yield of generated plants. This study was aimed at investigating the effects of foliar application of a factorial combination of Gibberellic acid and Benzylaminopurine in breaking dormancy and subsequent sprouting in three cultivars of different dormancy period.

2. Materials and Methods

2.1. Establishment of the Experiment

The experiment was conducted at Kenya Agricultural & Livestock Research Organisation (KALRO) formally Kenya Agricultural Research Institute (KARI), National Potato Centre, Tigoni from September 2008 to October 2009. Three potato varieties with different tuber dormancy period [18]; 'Asante' (short dormancy), Dutch Robyjn (medium dormancy) and 'Kenya Sifa' (long dormancy) were planted in staggered manner so that all varieties flowered at the same time. The experiment was laid out as a randomized complete block design (RCBD) with a split plot layout where the main blocks were the different rates of combinations of GA and cytokinins and the sub plots were the different genotypes. Each experimental plot was 4.5 m by 0.9 m. Plots and blocks were separated by 1 m and 1.5 m respectively. Di-ammonium phosphate (DAP) fertilizer was applied during planting at the rate of 500 kg/ha. The potatoes were sprayed with a factorial combinations of concentrations of 0, 50, 100, 300 ppm Gibberellic acid (GA) and 0, 50, 75, 100 ppm Benzylaminopurine (BA) at the rate of 1000 litres/ha spray volume towards the end of tuberization phase (75 days after emergence). Dehaulming was done 6 days after treatment application [11] and harvesting was done 14 days thereafter. Untreated varieties were used as control.

2.2. Data Collection

2.2.1. Tuber Dormancy and Sprouting Characteristics

At harvest, twenty uniform potato tubers from each treatment were randomly selected and put in paper trays, labeled and put in diffuse light store (DLS). Data on dormancy period, number, length and vigour of sprouts and subsequent yields were collected, recorded and analyzed. Tuber sprouting was defined as when a tuber had at least one visible sprout of at least 2mm long [3].For dormancy period, the buds of all seed tubers from each treatment were observed after every week. The number of sprouted tubers was counted and recorded. Sprouting was got as a percentage of the number of sprouted tubers in a sample. A sample was considered to have broken dormancy when its sprouting was 80% and dormancy period was given by the duration from when the sample was treated to time when sample tuber dormancy was broken [6]. For the number and length of sprouts, five tubers from each treatment were picked at random after every week and the number of sprouts per tuber and the length of the longest sprout per tuber were noted.

Sprout vigour was determined as a 5 point rating score based on sprout base thickness and sprout length where;1= Very low vigour (where half or more of the tubers in a treatment sample had produced sprouts of at least 1mm base diameter and 2mm long), 2=low vigour (where half or more of the tubers in a treatment sample had produced sprouts of at least 2mm base diameter and 3mm long), 3= medium vigour (where half or more of the tubers in a treatment sample had produced sprouts of at least 3mm base diameter and 4mm long), 4=high vigour (where half or more of the tubers in a treatment sample had produced sprouts of at least 4mm base diameter and 4mm long) and 5=very high vigour (as described in score 4 but had green colouration, firm and had no defects).

2.2.2. Field Evaluation of Sprouted Tubers

After data collection, the sprouted tubers were conventionally planted at the same station for field yield evaluation. Pest and disease management was done using karate® and ridomil®. Supplementary irrigation was also done. The experiment was laid in a complete randomized block design with three replications. In the field, data on %germination (score), number of stems per plant and number of leaflets per plant were taken after every two weeks and recorded.

Germination score was determined as a 4 points rating whereby; 1 means $\leq$ 25% germination, 2 means > 25% $\leq$ 50% germination, 3 means > 50% $\leq$ 75% germination and 4 means >

75% germination. After germination, 5 plants per treatment per genotype were selected at random, labeled and the number of stems per plant and leaflets per plant were counted and recorded. At harvest, the tuber were graded into three grades (Chatts, Seed, and Ware) based tuber size where; Chatts = tubers < 25mm diameter, Seed = tubers ≥ 25 mm ≤ 55 mm and Ware = tuber > 55mm.

2.3. Data Analysis

The data collected was subjected to Analysis of variance (ANOVA) using the PROC ANOVA procedure of Genstat (Lawes Agricultural Trust Rothamsted Experimental station 2006, Version 9). Where the treatment was significant, difference among the treatment means were compared using the Fisher's protected LSD test at p≤0.05 probability level.

3. Results

3.1. Sprouting

Potato tuber sprouting exhibited significant differences among treatments and genotypes in both seasons compared with the control (Tables 1 and 2). Duration to commencement of sprouting of tubers from plants treated with GA alone or its combination with BA decreased with increased rate of GA concentration in all genotypes in both seasons except for 50ppm GA which was not significantly different with the control.GA at 50ppm level had no significant difference in all genotypes in both seasons compared with the control. However, at 100ppm level duration to sprouting was reduced by 1 week in Asante, 3 weeks in Dutch Robyjn and Kenya Sifa with respect to control. Visible sprouts were observed during the first week after harvest in Dutch Robyjn and Kenya Sifa at 300ppm GA while all the three genotypes sprouted in the second week at the same rate in the second season. When GA and BA were sprayed in combination, duration to sprouting was the same as that of GA alone at the same rate of concentration in all genotypes in both seasons. Benzylaminopurinealone exhibited no significant difference in sprouting at all rates in all genotypes in both seasons compared with the control. Kenya Sifa took the longest time (7weeks) to sprout at low rates of GA (0-50ppm) while Asante sprouted during the 4th week at the same rate. At higher rates (300ppm) all varieties took the same time (2 weeks) except in 1st season where visible sprouts were observed during the 1st week in Kenya Sifa.

Table 1: *Effects of foliar application of rates of combination of gibberellic acid and benzylaminopurine on sprouts length, number of sprouts per tuber, sprouts vigour and % sprouting of potato genotypes Asante, Dutch Robyjn and Kenya Sifa (Year 2008).*

Treatments	Genotypes											
	Asante				Dutch Robyjn				Kenya Sifa			
	Sprout length (mm)	Sprouts/ tuber	Sprouts vigour	%Sprouting	Sprout length (mm)	Sprouts/ tuber	Sprouts vigour	%Sprouting	Sprout length (mm)	Sprouts/ tuber	Sprouts vigour	%Sprouting
Control	3.24a*	2.04a	1.70a	61.21a	2.94a	1.84a	1.30a	50.61a	0.79a	0.61a	0.61a	22.12a
0G.50C	3.53b	2.11a	1.73a	64.24b	3.09ab	2.03b	1.36a	51.21a	0.86a	0.67a	0.67ab	24.85b
0G.75C	3.67bc	2.30b	1.73a	65.76bc	3.21bc	2.17bc	1.36a	53.33b	0.98ab	0.70ab	0.76b	32.76c
0G.100C	3.84c	3.38b	1.91b	67.27c	3.30bc	2.32c	1.33a	54.24bc	1.13bc	0.74abc	0.82c	31.82c
50G.0C	3.84c	2.38b	1.91b	66.33cd	3.31bc	2.18c	1.39a	53.03b	1.24cd	0.79bc	0.88cd	33.33cd
50G.50C	3.81c	2.44b	1.94bc	66.33cd	3.40cd	2.34d	1.67b	55.15c	1.27cd	0.88cd	0.88cd	32.13c
50G.75C	4.11d	2.56cd	2.03c	67.76d	3.57d	2.42de	1.61b	56.36d	1.30cd	0.98d	0.97d	43.24d
50G.100C	4.16d	2.68d	2.15d	73.94e	3.90e	2.55ef	1.67b	60.00e	1.47d	1.34e	1.00e	36.36e
100G.0C	4.61e	2.99e	2.27e		5.41f	3.63fg	2.39c	77.58f	3.26e	1.65f	1.55f	49.70f
100G.50C	4.84ef	3.10f	2.46f	74.85e	5.53f	3.77gh	2.39c	76.06f	3.35e	1.92g	1.52f	53.33g
100G.75C	4.99f	3.19f	2.58g	75.15e	5.84g	3.91hi	2.30c	81.52g	3.81f	2.16h	1.76g	57.88h
100G.100C	5.24g	3.89g	2.58g	73.95e	6.02g	4.02i	2.29c	80.91g	4.08g	2.29h	2.03h	59.09h
300G.0C	6.15h	4.14g	2.94h	80.00f	6.82h	4.71j	2.51d	89.70h	5.26h	2.90i	2.58i	72.73i
300G.50C	6.30h	4.04g	2.91i	84.85g	7.12i	4.97k	2.67e	89.70h	5.67i	3.15j	2.76j	79.39i
300G.75C	6.62i	4.05g	3.03j	85.76h	7.67j	5.01k	2.79f	92.12i	6.06j	3.35k	2.76j	84.55j
300G.100C	7.02j	4.45h	3.06j	86.67i	8.03k	5.24L	3.00g	92.73i	6.43k	3.49k	3.03k	85.76j
$LSD_{0.05}$ Treatment	0.12	0.05	0.04	0.90	0.12	0.05	0.04	0.90	0.12	0.05	0.04	0.90
$LSD_{0.05}$ Genotype	0.45	0.21	0.18	3.36	0.45	0.21	0.18	3.36	0.45	0.21	0.18	3.36
CV%	6.8	4.2	5.5	2.8	6.8	4.2	5.5	2.8	6.8	4.2	5.5	2.8

*Means followed by the same letters along the column are not significantly different (p≤0.05).$LSD_{0.05}$ =least significant difference at 5% probability level; CV% =percent coefficient of variation and xG.yC means combination of x parts per million (ppm) gibberellic acid and y ppm Cytokinins (benzylaminopurine).

3.2. Sprout Length

Sprout length showed significant difference following treatment with different rates of GA, BA or their combinations and genotypes in both seasons compared with the control. When GA was applied alone, it exhibited significant ascending difference of sprouts length with increasing doses of GA in all varieties. However, when BA was applied alone, variation amongst different rate was

genotype dependent with significance observation from 50 ppm for Asante, 75ppm for Dutch Robyjn and 100ppm for Kenya Sifa with respect to control(Tables 1 and 2).At lower doses of GA (0-50ppm), Asante genotype produced longer sprouts than Dutch Robyjn but at higher doses (100-300ppm) GA, it was the vice versa. Kenya Sifa recorded the shortest sprout in all treatments. There were higher sprouts length observed when a combination of GA and BA was employed than when each hormone was applied alone at the same rates. It was noted that BA exhibited significant difference after each increase rate at highest rate of GA (300ppm) unlike at lower rates of GA. There was a linear increase of sprout length with duration of storage.

3.3. Sprouts per Tuber

The number of sprouts per tuber was significantly different amongst treatments and genotypes in both seasons (Tables 1 and 2). The number of sprouts per tuber was significantly higher with increased rate of GA in all genotypes while the same occurred in BA treated tubers except in Kenya Sifa where increasing the rate of BA caused no significant difference when applied alone. However, the number of sprouts per tuber increasingly and significantly varied with increase in rate of combination of GA and BA in all genotypes. At lower doses of GA (0-50ppm), Asante recorded higher number of sprouts per tuber than Dutch Robyjn but this was the vice versa at higher doses of GA (100-300ppm) (Tables 1 and 2).

Table 2: *Effects of foliar application of rates of combination of gibberellic acid and benzylaminopurine on sprouts length, number of sprouts per tuber, sprouts vigour and % sprouting of potato genotypes Asante, Dutch Robyjn and Kenya Sifa (Year 2009).*

Treatments	Genotypes											
	Asante				Dutch Robyjn				Kenya Sifa			
	Sprout length (mm)	Sprouts/ tuber	Sprouts vigour	%Sprouting	Sprout length (mm)	Sprouts/ tuber	Sprouts vigour	%Sprouting	Sprout length (mm)	Sprouts/ tuber	Sprouts vigour	%Sprouting
Control	3.84a	2.07a	1.63a	63.3a	2.80a	1.87a	1.27a	52.7a	1.32a	0.79a	0.73a	28.3a
0G.50C	3.99ab	2.15a	1.77a	64.3a	2.91ab	1.99b	1.27a	52.0a	1.36a	0.87ab	0.77a	30.3a
0G.75C	4.07b	2.34b	1.73a	64.3a	2.99b	2.03b	1.33a	52.3a	1.41a	0.94b	0.83a	35.0b
0G.100C	4.15bc	2.41b	1.93a	63.3a	3.13b	2.16c	1.30a	54.7a	1.46ab	0.99bc	0.90b	35.7b
50G.0C	4.28cd	2.41bc	1.97a	63.3a	3.51c	2.39d	1.43b	61.7b	1.47ab	1.02c	0.90b	36.3b
50G.50C	4.36d	2.47cd	2.00ab	64.3ab	3.60c	2.46de	1.73c	64.0bc	1.58bc	1.10c	0.90b	36.3b
50G.75C	4.52e	2.58de	2.10bc	65.3ab	3.86d	2.51e	1.70c	65.3c	1.61c	1.15cd	1.07c	38.7b
50G.100C	4.70f	2.67e	2.17bcd	66.3b	3.97d	2.64f	1.77c	69.3d	1.68c	1.22d	1.07c	37.7b
100G.0C	5.67g	3.32f	2.43cde	75.7c	5.32e	3.76g	2.40d	80.7e	3.38d	1.91e	1.60d	54.7c
100G.50C	5.88h	3.39f	2.53de	75.7c	5.51f	3.85g	2.40d	80.0e	3.53d	2.04ef	1.60d	58.3d
100G.75C	6.17i	3.55g	2.60de	76.1c	5.70g	4.04h	2.37d	82.0e	3.76e	2.13f	1.76e	61.7e
100G.100C	6.38j	3.75h	2.70ef	75.7c	5.92h	4.16i	2.43d	81.0e	3.98f	2.28g	2.17f	65.0f
300G.0C	8.31k	4.42i	3.03fg	82.0d	7.19i	4.39j	2.50de	84.3f	6.11f	3.11h	2.53g	75.0g
300G.50C	8.60l	4.55j	3.17g	84.0d	7.48j	4.55k	2.60e	83.3ef	6.38g	3.22h	2.70h	79.3h
300G.75C	8.92m	4.65j	3.20g	83.0d	7.72k	4.60k	2.73e	85.0f	6.71h	3.33i	2.53g	83.0i
300G.100C	9.03m	4.80k	3.23g	83.7d	7.99l	4.76l	2.63e	85.7f	6.99i	3.33i	2.83h	83.7i
$LSD_{0.05}$ Treat.(T)	0.166	0.105	0.138	3.05	0.166	0.105	0.138	3.05	0.166	0.105	0.138	3.05
$LSD_{0.05}$ Genotype	0.078	0.065	0.055	1.22	0.078	0.065	0.055	1.22	0.078	0.065	0.055	1.22
CV%	4.1	5.8	6.8	2.8	4.1	5.8	6.8	2.8	4.1	5.8	6.8	2.8

*Means followed by the same letters along the column are not significantly different ($p \leq 0.05$).$LSD_{0.05}$ =least significant difference at 5% probability level; CV% =percent coefficient of variation and xG.yC means combination of x parts per million (ppm) gibberellic acid and y ppm Cytokinins (benzylaminopurine).

Kenya Sifa had the least number of sprouts per tuber in all treatments in both seasons.

3.4. Sprout Vigour

Sprouts vigour score varied significantly among treatments and genotypes in both seasons (Tables 3 and 4). Vigour score increased with duration of storage and with rates of application of GA, BA or their combination. Asante genotype had the highest vigour score in all treatments while Dutch Robyjn recorded higher vigour score than Kenya Sifa at lower dose of GA (0-100ppm) alone or in combination with BA but at 300ppm GA, the Kenya Sifa scored higher than Dutch Robyjn. At higher doses of GA (300ppm), Dutch Robyjn produced longer but slender sprouts.

3.5. Germination Score

Onset of germination was evident in all treatments in all genotypes by the second week after planting. However, there was significant difference in % germination score among treatments and genotypes (Table 5). At lower rates of GA applications, there was no significant difference in % germination score for Asante (0-50ppm) and Dutch Robyjn (0ppm) even with increased rates of concentration of BA. Kenya Sifa exhibited significant variation in the same rate bracket of GA with increase of BA concentration. Tubers treated with 300ppm GA recorded the highest % germination score in all genotypes while at the same rate no significant difference was observed with increase in BA concentration

rates in all genotypes. Asante had the highest %germination score in all treatments. Dutch Robyjn recorded higher germination than Kenya Sifa at lower rates of GA (0-50ppm) while the opposite occurred at higher rates (100-300ppm) of GA applications.

3.6. Stems per Plant

Variation in the number of stems per plant differed significantly between treatments and genotypes (Table 5). Gibberellic acid treated tubers produced significantly more stems per plant with increase in the rate of application in all genotypes. Plants treated with BA alone showed no significant variation with increased rates of BA for Asante and Dutch Robyjn genotypes. However, increase in BA concentration exhibited significant difference in stems per plant when applied in combination with GA. A combination of BA and GA gave significantly more stems than when each hormone was applied alone. Asante genotype had the highest number of stems per tuber in all treatments while Kenya Sifa had the lowest.

3.7. Leaflets per Plant

The number of leaflets per plant differed significantly among treatments and genotypes.Increase in concentration of GA or BA when applied alone or in combination resulted in significant increase in the number of leaflets per plant. However, results for the combination were significantly higher than when each hormone was applied alone at the same rate. The number of leaflets per plant increased with time in each treatment in Asante and Dutch Robyjnupto the 8th week after which no increase was observed (Table 5).

However, Kenya Sifa exhibited linear increase in the number of leaflets per plant throughout the 12 weeks. The plants in the control had the lowest leaflets while those treated with a combination of 300ppm GA and 100ppm BA gave the highest in all genotypes. Asante gave the most number of leaflets per plant while Kenya Sifa produced the lowest in all treatments (Table 5).

3.8. Tubers per Plant

Number of tubers per plant varied significantly between treatments and genotypes (Table 5). When GA was applied alone, increase in concentration caused significant upward variation in all the genotypes compared with the control and previous rate except Kenya Sifa where concentration of 50ppm caused no significant difference with respect to control. Increase in the rate of concentration of BA resulted in significant increase in number of tuber per plant in all genotypes except in Kenya Sifa. When GA and BA were used in combination, variation of BA concentration rate had no significant difference at high level of concentration of GA (100-300ppm) in all genotypes. At low concentration rare of GA (0-50ppm), the number of tuber per plant in Asante and Dutch Robyjn were not significantly different except at when BA was 100ppm at 50ppm GA. When GA concentration was 100ppm and 300ppm, Asante genotype significantly outweighed Dutch Robyjn in the number of tubers per plant. Kenya Sifa had the lowest number of tubers in all treatments.

Table 3: *Effects of sequence of application of gibberellic acid and benzylaminopurine on sprouts vigour of potato tubers stored under diffuse light conditions (2008).*

Treatment	Genotypes								
	Asante			Dutch Robyjn			Kenya Sifa		
	Sprouts vigour score			Sprouts vigour score			Sprouts vigour score		
	2Wks	6 Wks	10 Wks	2 Wks	6 Wks	10 Wks	2 Wks	6 Wks	10 Wks
Control	0a*	2a	3a	0a	1a	3a	0a	0a	2a
0G.50C	0a	2a	3.33b	0a	1a	3a	0a	0a	2.33b
0G.75C	0a	2a	3.33b	0a	1.33a	3a	0a	0a	2.33b
0G.100C	0a	2a	4c	0a	1a	3a	0a	0a	2.67c
50G.0C	0a	2a	4c	0a	1.33a	3a	0a	0a	2.33b
50G.50C	0a	1.67a	4c	0a	2b	3a	0a	0a	2.33b
50G.75C	0a	2ab	4c	0a	1.33a	3.33b	0a	0a	3d
50G.100C	0a	2.33b	4c	0a	1.33a	3.67c	0a	0a	3d
100G.0C	0a	2.33bc	4c	1b	2b	4d	0a	1b	3d
100G.50C	0a	2.67cd	4.33d	1b	2.33bc	4d	0a	1.67c	3d
100G.75C	0.33b	3de	4c	1b	2.33bc	4d	0a	2cd	3d
100G.100C	0a	3de	4.33d	1b	2b	4d	0a	2.33d	3.33e
300G.0C	1c	3de	5e	1b	2.67cd	3.67c	1b	3e	3.33e
300G.50C	1c	3de	5e	1.33c	3d	4d	1b	3e	3.67f
300G.75C	1c	3de	5e	2d	2.67cd	4d	1b	2.67de	3.67f
300G.100C	1c	3.33e	5e	2d	3d	4d	1b	3e	3.67f
$LSD_{0.05}$ Treat.(T)	0.12	0.37	0.28	0.12	0.37	0.28	0.12	0.37	0.28
$LSD_{0.05}$ Genotype (G)	0.05	0.13	0.13	0.05	0.13	0.13	0.05	0.13	0.13
CV%	17.8	12.1	4.7	17.8	12.1	4.7	17.8	12.1	4.7

*Means followed by the same letters along the column are not significantly different ($p \leq 0.05$). $LSD_{0.05}$ =least significant difference at 5% probability level; CV% =percent coefficient of variation and xG.yC means combination of x parts per million (ppm) gibberellic acid and y ppm Cytokinins (benzylaminopurine).

Table 4: *Effects of sequence of application of gibberellic acid and benzylaminopurine on sprouts vigour of potato tubers stored under diffuse light conditions (2009).*

Treatment	Genotypes								
	Asante			Dutch Robyjn			Kenya Sifa		
	Sprouts vigour scores after n weeks			Sprouts vigour scores after n weeks			Sprouts vigour scores after n weeks		
	n=2	n=6	n=10	N=2	n=6	n=10	n=2	N=6	N=10
Control	0a	3.47a	3.73a	0a	3a	3.33a	0a	2a	2.33a
0G.50C	0a	3.33a	3.73a	0a	3a	3.47a	0a	2.33b	2.33a
0G.75C	0a	3.33a	3.67a	0a	3a	3.33a	0a	2.33b	2.47ab
0G.100C	0a	3.47a	4b	0a	3.33b	3.27a	0a	2.67cd	2.67bc
50G.0C	0a	4b	4.13b	0a	3a	3.33a	0a	2.33b	2.47ab
50G.50C	0a	3.93b	4b	0a	3.33bc	3.53ab	0a	2.47bc	2.47ab
50G.75C	0a	4b	4b	0a	3.47cd	3.47ab	0a	2.93d	2.73cd
50G.100C	0a	4b	4b	0a	3.67d	3.67b	0a	3d	2.933d
100G.0C	0.67c	4b	4.14bc	1.33c	4e	4c	0a	3d	3d
100G.50C	0.67c	4b	4.33c	1b	4e	4c	0a	3d	3d
100G.75C	0.69c	4.33c	4.27bc	1b	4e	4c	0a	3.33e	3.33e
100G.100C	0.67c	4.33c	4.33c	1b	4e	4c	0a	4f	4f
300G.0C	1.63c	4.67d	4.73d	1b	4e	4c	1b	4f	4f
300G.50C	1.33b	4.67d	5d	1b	4.13e	4.13cd	1b	4f	4f
300G.75C	1.33b	4.73d	5d	1b	4e	4.33d	1b	4f	4f
300G.100C	1.63c	4.57cd	5d	1b	4.33	4.33d	1b	4.33	4.13f
$LSD_{0.05}$ Treat.(T)	0.210	0.298	0.282	0.210	0.298	0.282	0.210	0.298	0.282
$LSD_{0.05}$ Genotype (G)	0.99	0.136	0.138	0.99	0.136	0.138	0.99	0.136	0.138
CV%	28.0	5.0	4.7	28.0	5.0	4.7	28.0	5.0	4.7

*Means followed by the same letters along the column are not significantly different ($p \leq 0.05$).$LSD_{0.05}$ =least significant difference at 5% probability level; CV% =percent coefficient of variation and xG.yC means combination of x parts per million (ppm) gibberellic acid and y ppm Cytokinins (benzylaminopurine).

Table 5: *Effects of foliar application of rates of combination of gibberellic acid and benzylaminopurine on subsequent germination, number of stems per plant and number of leaflets per plant of potato genotypes Asante, Dutch Robyjn and Kenya Sifa (2009).*

Treatments	Genotypes											
	Asante				Dutch Robyjn				Kenya Sifa			
	%Germ. Score	Stems/ plant	Leaflets /plant	Tubers/ plant	%Germ score	Stems/ plant	Leaflets /plant	Tubers/ plant	%Germ score	Stems/ plant	Leaflets /plant	Tubers/ plant
Control	3.50a	1.90a	204.0a	7.13a	2.94a	1.82a	159.1a	6.93a	3.00a	1.74a	131.6a	5.63a
0GA.50BA	3.50a	1.98a	208.2b	7.37ab	2.94a	1.81a	165.1b	7.13a	3.11b	1.81ab	137.2b	5.70a
0GA.75BA	3.50a	2.20b	213.0b	8.60bc	3.00a	1.81a	171.1c	7.67ab	3.11b	1.90bc	142.4c	6.00ab
0GA100BA	3.50a	2.34c	218.4c	8.01bc	3.07bc	1.89a	178.7d	8.43b	3.13b	2.00cd	147.2d	6.17ab
50GA.0BA	3.50a	2.41c	220.4c	9.00c	3.02b	1.90a	181.1d	8.63b	3.22c	2.01cd	153.7e	6.13ab
50GA.50BA	3.50a	2.59d	226.4d	9.00c	3.11c	2.16b	189.3e	8.47b	3.22c	2.08de	160.2f	6.67abd
50GA.75BA	3.50a	2.73e	229.0d	10.95d	3.28d	2.20b	195.6f	8.47b	3.22c	2.11def	165.8g	6.87abd
50GA.100BA	3.56a	2.82e	235.6e	10.83d	3.28d	2.40c	200.5g	8.33b	3.28d	2.18efg	171.4h	6.80abd
100GA.0BA	3.61b	3.11f	245.6f	11.10d	3.31d	2.46c	205.2h	9.33c	3.39e	2.23fgh	185.2i	7.10bd
100GA.50BA	3.67b	3.14f	251.7g	11.73de	3.39e	2.69d	219.4i	8.60b	3.50f	2.28ghi	192.9j	7.93de
100GA.75BA	3.78c	3.30g	257.4h	11.27de	3.39e	2.60d	224.6j	10.20cd	3.56g	2.33hi	197.7k	7.60bde
100GA.100BA	3.78c	3.32g	262.4i	12.20de	3.56f	2.69d	231.2k	10.07cd	3.61g	2.39ij	204.9l	8.73e
300GA.0BA	3.83c	3.52h	272.4j	11.73de	3.56f	2.93e	239.6l	10.43d	3.67h	2.49jk	218.6m	8.80e
300GA.50BA	3.83c	3.63h	275.2j	11.70de	3.56f	2.97e	246.6m	10.93d	3.67h	2.62kl	229.6n	8.93e
300GA.75BA	3.83c	3.90i	282.6k	12.37e	3.56f	3.19f	246.8m	10.33d	3.67h	2.60kl	236.7o	8.67e
300GA.100BA	3.85c	3.96i	287.1k	12.53e	3.56f	2.98e	258.2n	10.47d	3.67h	2.72l	245.3p	9.60e
$LSD_{0.05}$Genotype	0.06	0.08	4.69	0.44	0.06	0.08	4.69	0.44	0.06	0.08	4.69	0.44
CV%.	1.00	3.4	6.7	12.1	1.00	3.40	6.7	12.1	1.00	3.40	6.7	12.1

*Means followed by the same letters along the column are not significantly different ($p \leq 0.05$).$LSD_{0.05}$ =least significant difference at 5% probability level; CV% =percent coefficient of variation and xG.yC means combination of x parts per million (ppm) gibberellic acid and y ppm Cytokinins (benzylaminopurine).

Table 6: *Effects of foliar application of rates of combination of gibberellic acid and benzylaminopurine on subsequent yields of potato genotypes Asante, Dutch Robyjn and Kenya Sifa (Year 2009).*

Treatments	Yields in tons per hectare											
	Asante				Dutch Robyjn				Kenya Sifa			
	Chatts	Seed	Ware	Total	Chatts	Seed	Ware	Total	Chatts	Seed	Ware	Total
Control	0.93a	10.83a	12.90f	24.66a	1.60a	9.63a	5.50i	16.73a	0.73a	5.33a	11.27ef	17.53a
0GA.50BA	1.06a	11.73ab	12.37ef	25.26ab	1.70a	10.27ab	5.17i	17.13a	0.92ab	6.07ab	10.80cdf	17.80ab
0GA.75BA	1.07a	12.63bc	12.37ef	26.07b	1.53a	10.37ab	4.97gi	16.87a	0.73a	6.40b	10.67cde	17.80ab
0GA100BA	1.33b	13.23cd	12.20e	26.26b	2.03b	10.63bc	4.47fg	17.13a	1.03bc	6.90b	10.40abcd	18.33abc
50GA.0BA	1.47bc	14.13d	11.73de	27.33cd	2.00b	11.30cd	4.13ef	17.43a	1.00bc	7.97c	10.40abcd	19.07bc
50GA.50BA	1.40bc	15.80e	11.27cd	28.47de	2.10c	11.07c	4.43fg	17.60a	1.13cd	7.93c	9.93ab	18.99bc
50GA.75BA	1.53c	16.07ef	10.87dc	28.47de	1.90b	12.10d	3.87e	17.87a	0.93bc	8.47c	10.20abc	19.60cd
50GA.100BA	1.57cd	16.90f	10.70dc	29.17ef	2.33d	13.40e	3.70e	19.43b	1.33def	8.97e	9.83a	20.43d
100GA.0BA	1.67cde	17.93g	10.37d	29.97fg	2.47de	15.60f	2.90d	20.97c	1.20d	13.63f	10.57bcd	25.40ef
100GA.50BA	1.73cde	19.30h	9.30c	30.33fg	2.43de	15.67f	2.70cd	20.80c	1.27de	14.17f	10.97df	26.41fg
100GA.75BA	1.77def	19.63hi	9.60c	31.00gh	2.30d	16.30f	2.60bcd	21.20cd	1.40e	14.40f	10.93df	26.73g
100GA.100BA	1.83ef	20.30i	9.20bc	31,33hi	2.47de	17.37g	2.50bcd	22.34d	1.33def	15.47g	11.13ef	27.63g
300GA.0BA	1.73cde	21.33j	8.80ab	31.86i	2.40de	18.57hi	2.10abc	23.32e	1.50fg	16.50h	11.37f	29.37h
300GA.50BA	1.93f	21.67j	8.47a	32.03i	2.57e	18.90i	2.20abc	23.29e	1.60fh	16.67h	11.07ef	29.34h
300GA.75BA	1.88f	21.40j	8.60ab	31.88i	2.60e	18.80i	1.97ab	23.37e	1.73h	16.87h	11.13ef	29.73h
300GA.100BA	2.10g	21.97j	8.20a	32.27i	2.57e	19.20i	1.90a	23.37e	1.93i	17.20h	11.00def	30.13h
$LSD_{0.05}$ Genotype	0.13	0.46	0.30	0.60	0.13	0.46	0.30	0.60	1.13	0.46	0.30	0.60
CV%	19.1	7.9	2.7	6.1	19.1	7.9	2.7	6.1	19.1	7.9	2.7	6.1

*Means followed by the same letters along the column are not significantly different ($p \leq 0.05$).$LSD_{0.05}$ =least significant difference at 5% probability level; CV% =percent coefficient of variation andxG.yC means combination of x parts per million (ppm) gibberellic acid and y ppm Cytokinins (benzylaminopurine). Chatts= tubers< 25mm diameter, Seed= tubers ≥25mm≤ 55mm and Ware=tuber >55mm

3.9. Yields of Generated Plants

Both treatments and genotypes showed significant variation in total yields compared with the control (Table 6). When GA singly applied, there was a significantly difference in total yields in all genotypes with increased hormone application rates. However for BA treated plants, effects were only significant at higher application rates (75-100ppm) for Asante but total yields showed no significant difference in Dutch Robyjn and Kenya Sifa.

When a combination of GA and BA was employed, significant total yields was only observed at higher dose (100ppm) of BA at each rate of GA except at 300ppm where no significant difference was observed compared to that of GA treated plant at that rate in all genotypes. Asante gave the highest total yields while Dutch Robyjn gave the lowest in all treatments.

Tuber grades (tuber sizes) differed significantly between treatments and genotypes compared with the control (Table 6). The potato seed and the quantity of chatts increased with increase in rates of rate of concentration of GA in all genotypes. A decrease in yields of ware was registered with increased concentration of GA when applied alone or in combination with BA. However, application of BA alone only reflected significant difference at 100ppm in Asante and Dutch Robyjn while variation of ware yield in Kenya Sifa was not sequential and did not vary greatly with concentration of both GA and BA. Yields of chatts were highest in Dutch Robyjn while Kenya Sifa had the lowest grades of both chats and seed in all treatments. Asante yielded most seed grade in all treatments. Dutch Robyjn gave the lowest ware yields while at lower levels of GA concentration (0-50ppm), Asante outweighed Kenya Sifa. However, at higher GA concentration (100-300ppm), Asante recorded lower ware yields (less than 10tons/ha) while Kenya Sifa steadily maintained yields above 10 tons/ha (Table 6).

4. Discussions

4.1. Effects of Foliar Application of Gibberellic Acid and Cytokinins on Subsequent Potato Tuber Sprouting

In this study, foliar application of GA alone or GA+BA resulted in significant decrease in duration of subsequent tuber dormancy period and sprouting and this varied among the genotypes. However, BA alone had no effect on duration of tuber dormancy and sprouting. These results are in agreement with [11] findings that a foliar spray of 300ppm- 375ppm gibberellic acid, 3–6 days before haulm killing shorten potato tuber dormancy period and induced sprouting. The results were also in agreement with [4] findings that when GA was applied to the foliage of potato plants grown from true seeds towards the end of the vegetative cycle, it induced rapid breakage of tuber dormancy. Alexopoulos [5] also observed that exogenous application of GA on potato plant foliage drastically increased the concentration of endogenous gibberellins and simple reducing sugars of the resulting tubers leading to visible sprouting. These results also agreed with[3] findings that application of low doses of cytokinins had no effect on potato dormancy.

This study revealed that foliar spray of GA, BA or GA + BA increased tuber sprout length, number of sprouts per tuber and sprout vigour in a dose dependent manner and also varied with genotype. The number of sprouts per tuber, sprout length and vigour were significantly higher with increased rate of GA in all genotypes. However, when BA was applied alone, variation of tuber sprout length and number for different rate was genotype dependent with significant observation from

50ppm for Asante, 75ppm for Dutch Robyjn and 100ppm for Kenya Sifa with respect to control. Results from various researchers while working on effects of foliar spray of individual hormones on different variable found similar findings. The growth length and vigour of potato tubers sprouts was greatly advanced by a foliar spray with gibberellic acid [10], the magnitude of the GA effects depended on the cultivar [11] and increased level of GA was found to exhibit premature sprouting [14]. The number and length of sprouts of tubers treated with a combination of GA and BA were higher than those of tubers treated with each hormone at the same rate and varied with increase in rate of combination of GA and BA in all genotypes. At each rate of BA, both sprouts length and number of sprouts per tuber increased with increased rate of GA concentration. However, it was noted that BA exhibited significant difference after each increase rate at highest rate of GA (300 ppm) unlike at lower rates of GA. Vigour score increased with duration of storage and with rates of application of GA, BA or their combination. Asante tubers produced the strongest sprouts while Kenya Sifa gave the weakest. However, at higher doses of GA (300ppm), Dutch Robyjn produced longer but slender sprouts.

Despite the involvement of BA in cell division, the number of cell may not necessarily results to visible growth [19, 20]. The results from this study indicate that GA alone effected duration of dormancy termination and sprouts growth. This may indicate that GA is involved in both cell division and elongation. The above results may also be physiologically explained by several research findings that GA is involved in synthesis of α-amylase enzyme [19, 21] involved in breakdown of starch to glucose and fructose and facilitation of the movement of cytokinins to the buds enhancing cell division [22].

4.2. Effect of Foliar Application of Gibberellic Acid and Cytokinins on Subsequent Potato tuber Yields

Foliar application of GA alone caused significant increase in subsequent germination, stems per plant, leaflets per plant and number of tubers per plant and yields at harvest with increased rate of application in all genotypes. Asante had the highest germination score in all treatments. Dutch Robyjn recorded higher germination than Kenya Sifa at lower rates of GA (0-50ppm) while the opposite occurred at higher rates (100-300ppm) of GA applications. At low concentration rate of GA (0-50ppm), the number of tuber per plant in Asante and Dutch Robyjn were not significantly different. These results are in agreement with Abd[23] findings who observed thatfoliar application of GA enhances vegetative growth, length of plant, average number of shoots, leaves number, fresh and dry weight of shoots and gives more yields. They also agree with Alexopoulos[22] findings that foliar application of GA in plants derived from TPS caused an increase in the number of tubers per plant and increased the yields.

Spraying of BA alone caused significant increase in germination in Dutch Robyjn and Kenya Sifa genotypes but not in Asante, whereas application of 100ppm BA resulted in increased stems/tuber, leaflets/plant and tubers/plant except in Kenya Sifa for tubers/plant. This was in tandem with Dwelle[24] and Blunden [25] who while working separately found thatfoliar application of 'Cytex' product, a commercial aqueous seaweed extract equivalent to 100ppm cytokinins activity and synthetic cytokinin 'kinetin' produced a significant increase in the yield of potatoes. However, at lower rates of GA applications, there was no significant difference in germination score for Asante (0-50ppm) and Dutch Robyjn even with increased rates of concentration of BA.

Plants treated with a combination of BA and GA gave significantly more stems per plant, leaflets per plant than when each hormone was applied alone. Asante genotype gave the highest stems per plant and leaflets per plant and total yields while Kenya Sifa gave the lowest except the total yield which was given by Dutch Robyjn. These findings were in agreement with Caldiz[12] findings who also observed that foliar applications of a combination of benzylaminopurine and gibberellic acid under both field and glasshouse conditions increased both tuber number and tuber yields. However,yields of ware decreased with increased concentration of GA when applied alone or in combination with BA but in BA treated plants, yields of ware tuber differed only at 100ppm in Asante and Dutch Robyjn. Production of ware yield did not vary with concentration of GA, BA or their combination in Kenya Sifa. Both the number and weight of seed and chatts tubers increased with increase in rates of concentration of GA alone or its combination with BA in all genotypes.These observations agree with Stuik[26] results who similarly observed that increase of GA application on potato plant increased the number of tubers and total yields but production shifted the tuber size distribution towards the smaller grades. It was observed that not all sprouts gave rise to stems. Increase in the numbers of sprouts per tuber may have resulted in increased stems per plant, leaflets per plant and faster rate of canopy cover. This may have resulted to higher amount of intercepted radiation increasing number of tubers per plant and total yields [27].

5. Conclusions and Recommendations

This study revealed that foliar application of GA alone or a combination of GA and BA late in the growth cycle results in significant decrease in duration of subsequent tuber dormancy period and sprouting and this vary among the genotypes. Foliar spray of GA, BA or GA + BA increase tuber sprout length, number of sprouts per tuber and sprouts vigour in a dose dependent manner but varies with genotype. A combination of BA and GA results in significantly more growth than using only GA or BA alone at the same level.It seems that BA and GA has dose dependent synergistic effect on potato tuber sprouting and sprouts growth.

Foliar application of GA alone or GA+BA causes significant increase in subsequent germination, stems per plant, leaflets per plant and number of tubers per plant at harvest with increased rate of application in all genotypes. GA enhances vegetative growth; average number of stems, leaflets number and more yields. More sprouts per tuber may result in more stems per plant. Consequently, more stems per plant

results more leaves, and the ground cover taking place at a faster rate of ground cover, higher amount of intercepted radiation and assimilation and hence higher total yields. Foliar application of gibberellic acid or a combination of GA and BA late in the growth cycle may be of practical value in cases where tubers are required for planting soon after harvest. However, higher doses of hormones are recommended for foliar application than when the hormones were directly sprayed on tubers

Acknowledgements

The authors appreciate assistance by International Potato Centre (CIP), Nairobi in importation of True Potato Seed (TPS) from Lima, Peru; Centre Director, KALRO, National Potato Research Centre, Tigoni and Principal, Njabini Agricultural Training Centre, Nyandarua, for providing land resource and other facilities essential for the field work.

References

[1] Demo P., Akoroda M.O., El-Bedewy R. and Asiedu R. (2004). Monitoring storage loses of seed potato (*Solanumtuberosum* L.) tubers of different sizes under diffuse light conditions. Proceedings of 6th triennial congress of the African Potato Association (APA). 5-10 April, 2004. Agadir, Moroco. Pg. 363-370.

[2] Burton W.G., Van E. A. and Hartmans K.J. (1992). The physics and physiology of storage. In: Harris P. M., ed. The potato crop. London: Chapman and Hall; 608–727.

[3] Suttle J.C. (2004). Involvement of endogenous gibberellins in potato tuber dormancy and early sprout growth: a critical evaluation. Journal of Plant Physiology 161:157-164.

[4] Alexopoulos A. A., Akoumianakis A., Olympio C. M. And Passam H. C. (2007). The effect of time and mode of application of gibberellic acid and inhibitor of gibberellic acid biosynthesis on the dormancy of potato tubers grown from true potato seed. Journal of the science and agriculture 87(10): 1973-1979.

[5] Alexopoulos A. A., Akoumianakis A. K., Vemmos S. M and Passum H. C. (2006).The effect of postharvest application of gibberellic acid and benzyl adenine on duration of dormancy of potato produced by plant grown from true potato seeds. Post harvest biology and technology 46(1): 54-62.

[6] Shibairo S. I., Demo P., Kabira J.N., Gildemacher P., Gachago E., Menza M., Nyankanga R.O., Cheminingwa G.N. and Narla R.D. (2006). Effects of Gibberellic Acid (GA3) on Sprouting and Quality of Potato Seed Tubers in Diffuse Light and Pit Storage Conditions. Journal of Biological Sciences 6 (4): 723-733.

[7] Suttle J.C. (1996).Dormancy in tuberous organs: problems and perspectives. In: Lang GA, ed. Plant dormancy: physiology, biochemistry and molecular biology, Wallingford, UK: CAB International, 133–146.

[8] Craufurd P.Q., Summerfield R. J., Asiedu R. and Vara P.V. (2001).Dormancy in yams (*Dioscorea spp*.). Experimental Agriculture 37: 147–181.

[9] Ile E. I. (2004). Control of tuber dormancy and flowering in yam (*Dioscorearotundata*Poir.) tuber. PhD. Thesis, The University of Reading, Reading, United Kingdom.

[10] Ittersum M. K.(1992). Dormancy and growth vigour of seed potato. Wageningen Agricultural University dissertation No. 1556 Wageningen University.

[11] Ittersum M. K.and ScholteK. (1993). Shortening dormancy of seed potatoes by a haulm application of gibberellic acid and storage temperature regimes. American Journal of Potato Research 70(1): 7-19

[12] Caldiz D. O., (1996). Seed potato (Solanumtuberosum L.) yield and tuber number increase after foliar applications of cytokinins and gibberellic acid under field and glasshouse conditions. Plant Growth Regulation20 (3): 185-188

[13] Dwelle, R.B. (1985). Photosynthesis and Photoassimilate Partitioning. Potato Physiology. Academic Press, Inc. Orlando, Florida: 35-38

[14] Suttle J.C. and Banowetz, J. (2000). Comparing potato tuberization and sprouting opposite phenomena. Cited on American journals of Potato Research, July/Aug. 2004.

[15] Turbull C. G and Hanke D. E. (1985). The control of bud dormancy in potato tubers. Springer Link journals 165(3): 359-365.

[16] Banas A., M. Bielinska-Czarnecka, and J. Klocek.(1984). Activity of endogenous cytokinins in potato tubers during dormancy and sprouting 23:213-218.

[17] Mikitzel. L.J. and Fuller N. (1995). Dry Gibberellic Acid Combined With Talc or Fir Bark Enhances Early Stem and Tuber Growth of Shepody Potato. American Potato Journal. 72: 545-550.

[18] National Potato Council of Kenya (NPC). (2015). Potato variety catalogue. 2015. Eagle Creations, Nairobi, Kenya. 50p. http://www.npck.org/images/potato%20variety%20catalogue%202015.pdf

[19] Arteca R.N. (1996). Plant growth substance. Principles and application: 148-156. Chapman and Hall, New York.

[20] Vreugdenill D. (2004). Comparing potato tuberization and sprouting: Opposite phenomena? American Potato Research 81: 275-280.

[21] Vivanco J.M. and Flores H.F. (2000). Control of root formation by plant growth regulators. In: Basra A.S. (ed). Plant growth regulators in agriculture and horticulture. Their role and commercial use: 1-16.

[22] Alexopoulos A. A., Akoumianakis A. K. and Passum H. C. (2006). The effects of time and mode of application of gibberellic acid of the growth and the yields potato plant derived from true potato seeds. Journal of science of food and agriculture Vol. 86:2189-2195.

[23] Abd El-Aal F.S., Shaheen A.M. and Fatma A.R. (2008). The effect of foliar application of gibberellic acid and soil dressing of NPK at different levels on the plant productivity of potatoes *(Solanumtuberosum L*). Research Journal of Agriculture and Biological Sciences, 4(5): 384-391.

[24] Dwelle R. B. and Hurley P. J.(1984). The effects of foliar application of cytokinins on potato yields in southeastern Idaho American journal of Potato Research 61 (5): 293-299.

[25] Blunden G and Wildgoose P.B. (2006). The effects of aqueous seaweed extract and kinetin on potato yields. Journal of the science of food and agriculture 28 (2): 121-125.

[26] Stuik P.C., Kramer G. and Smit N.P. (1989). Effects of soil application of gibberellic acid on yields and quality of tuber of Solanumtuberosum L. cv.Bintje. Journal of potato research 32(2): 203-209.

[27] Wiersema S.G. (1989). Comparative performance of three small seed tuber size and standard size seed tubers planted at similar densities. Potato Res. 32:81-89.