Effect of Gibberellic acid and Super Gro foliar Fertilizer on potato tuber sprouting in diffused light, pit and bulk storage conditions

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Abstract

Effects of rest breaking agents such as gibberellic acid (GA3) and Super Gro on dormancy release and sprouting on potato genotypes stored under diffused light, pits and bulk were determined. Ndinamagara, Victoria and Rutambiro respectively short (6 weeks), moderate (8 weeks) and long (12 weeks) dormancy were used. Dormancy period was exponentially reduced to 2, 5 and 6 weeks for all the genotypes treated with GA3. Similarly, treatment with super Gro mostly under pits and bulk also accelerated potato sprouting. It is suggested that treatment with super Gro a low cost inductor should be adopted for promotion of potato tubers.

Introduction

The potato tuber quality for multiplication can be affected by a dormant phase which is a physiological rest that start at the tuberisation and end with sprouting. Dormancy is defined as a temporary suspension of visible growth of any plant structure containing a meristem (Lang *et al*., 1987). This physiological state is primarily induced by a hormone named abscisic acid (ABA) that enters tubers from the vine during the season during tuber growth and is released when its amount in the potato eyes declines through metabolic breakdown to a level that favors the eyes to sprout.

Dormancy is classified in three types: (a) “Endodormancy” which occurs after harvest, due to the internal or physiological status of the tuber (Suttle, 1998). In this state, sprouting will not occur even if tubers are placed in favorable conditions of germination (Lang *et al.,* 1987; Aksenova *et al.,* 2013). The end of endodormancy is marked by the emergence of the apical bud. (b) “Ecodormancy” is when sprouting is prevented or delayed by environmental conditions. This is for instance when tubers are stored at lower temperatures, the dormant period is longer compared to those stored at warmer temperatures. (c) “Paradormancy” is similar to endodormancy, even if the signal for dormancy is originated in a different area than where it occurred. This stat is marked by the apical dominance which is mediated by an auxin (indole acetic acid, IAA) and its suppression is influenced by a decline in IAA level as dormancy depends on ABA concentration (Kumar and Knowles, 1993). These hormones can be counteracted by the increase in cytokinins (CK) and gibberellins (GA) concentrations (Suttle, 2004b). The apical dominance is ended by the appearance of several eyes and multiples sprouting

Dormancy is a complex process that depends on genetic control (variety) and several factors. The environmental factors can affect both pre- and post- harvest period (Suttle, 2004a and 2007; Muthoni *et al*., 2014). For instance during plant growth, warm seasons are often associated with shorter dormancy and cool seasons with longer dormancy while during storage, high storage temperature hastens the physiological ageing processes and could terminate dormancy. Previous studies showed that storage gas phase composition such hypoxic and anoxic conditions or carbon dioxide (CO_2) and oxygen (O_2) concentration can influence tuber sprouting (Muthoni *et al*., 2014). They also reported that the presence or absence of light during post-harvest storage (photoperiod) has little effect on dormancy duration but highly affects the emerging sprouts. Similarly, the physiological tuber ageing process affects le dormant period, immature tubers have longer post-harvest dormancy than tubers harvested at maturity. Benkeblia *et al*. (2008) highlighted that phytohormones such as IAA for sprout growth and that GA and CK regulate the termination of endodormancy and enhance sprouting, whereas both ABA and ethylene are required for dormancy induction but only ABA is needed to maintain bud dormancy.

To break dormancy tubers, several methods are used. Endogenous and applied dormancy-breaking compounds (catalase inhibitor), for instance thiourea GA_3 hormone, breaks dormancy according to Pérez and Lira (2005) and stimulates sprouting of potato (Suttle, 2007). It is known that the tuber skin is a main part for chemical permeation, rest breaking application as liquid solutions accelerates eye growth via sprout emergence (Mani *et al.,* 2014). Most of rest breaking such antioxidant system and phytohormones are involved in breaking potato dormancy, since they affect cellular balance, regulate the expression of genes whose expression products are involved in dormancy and act on the protein metabolism of the tuber. In Burundi, most of potato varieties with high yielding, diseases resistant and test quality have long period of dormancy. For instance Rukuzi, Rutambiro, Uganda 11 and Ruhanyura have three to four months of dormancy. The objective of this study was to determine the effect of GA3 and super Gro foliar fertilizer on the sprouting and number of sprouts at the end of dormancy under diffused light, pit and bulk storage conditions.

Material and methods

The freshly harvested potato tubers of three genotypes namely Ndinamagara, Victoria and Rutambiro respectively short, medium and long period of dormancy were washed under normal water and subjected to treatments through diffused light, pit and bulk storage conditions. Forcing sprouting trials were set at the same time, laid out in Completely Randomized Design (CRD) with three replications. Sprouting was calculated as a percentage of the samples according to Shibairo *et al*. (2006) (0 sprout: 0%, 1 small sprout <1mm: <25%, 2+ small sprouts <1mm: 25-50%, 1 sprout with 1-3mm: 50-75%, 2+ sprouts with > 3mm: 75-100%). The end of dormancy was defined as the period when 80% of the tubers had at least two sprouts of at least 3 mm length. For each replication of 50 tubers, sprouts were counted and the cote recorded the average for more than 25 tubers.

Experiments in diffused light storage conditions.

For each varieties, 150 tubers were soaked into GA3 (0.34637g / L) according to Shibairo *et al*, 2006. The tubers were allowed to dry, splitted into three replications and placed under diffused light store and evaluated until 80% of sprouting and number of sprouts. Other 150 tubers were treated with SUP (25cc/L), allowed to dry, separated into three replications and placed under diffused light store until 80% of sprouting.

Other 150 tubers only washed with water followed the same procedures as the sets treated with inductors before to be placed under diffused light store for evaluation.

Experiments in pit storage conditions.

Forty eight pits of 0.5 m length x 0.5 m width x 0.5 m depth were dug. Layers of grasses were put at the bottom of the pit, tubers were buried and removed from the pits at different days. Similar to diffused light, the three varieties and amount of treatments were used. For each variety, 150 tubers were treated with GA3, allowed to dry, divided into three replications, placed in the pits, covered with layers of grasses and a layer of soil was put on top to cover the pits. These pits were kept covered and were opened at 14 days for sprouting and number of sprouts evaluation. Other 150 tubers were treated with GA3 following the same procedures in triplicates and pits were opened after 21 days, further 150 tubers treated with GA3 in three replications pits were opened at 28 days and last 150 tubers treated with GA3 into three replications pits were opened at 35 days for sprouting and number of sprouts evaluation. In the same processes, a total of 600 tubers were treated with SUP and placed in different pits, first 150 tubers were divided in three replications, placed in pits and some to be opened at 14 days, other 150 tubers in triplicates to be opened at 21 days, further three replications to be opened at 28 days and finally other three replications at 35 days for sprouting and number of sprouts evaluation. With similar methods, 600 control tubers (untreated) of each varieties were prepared, 150 tubers were divided in triplicates and placed in pits to be opened at 14 days, others at 21 days, at 28 days and at 35 days for sprouting and number of sprouts evaluation.

Experiments in bulk storage conditions.

In this adapted method to bulk, tubers were wrapped in jute bags and were removed at different days (14, 21, 28 and 35 days) for determination of sprouted tubers and number of sprouts. For each variety, a total of 600 tubers were treated with GA3 and placed in different jute bugs, first 150 tubers divided in three replications which were removed at 14 days, other 150 tubers separated in three replications to be removed at 21 days, further three replications to be opened at 28 days and finally three other replications to be removed at 35 days for sprouting and number of sprouts evaluation. With a similar method as GA3, a total of 600 tubers were treated with SUP allowed to dry and placed in different jute bags. First 150 tubers were divided in three replications, placed in bags and were opened at 14 days, other 150 tubers separated in triplicates to be opened at 21 days, further three replications to be opened at 28 days and finally other three replications at 35 days for sprouting and number of sprouts evaluation. 600 untreated tubers of each variety were prepared following the same methods as above. Three replications (50 tubers each) placed in bags were removed at 14 days, other triplicates opened at 21 days, others for 28 days and other at 35 days.

Data analysis, the repeated measurements were performed on data using XLSTAT 2019 (version, 2019.4.2). Means differences were separated by Turkey's least significant difference (LSD) was at 5% level of the significant.

Results and discussion

Sprouting %: In general, the below table compare the effect of differents technologies (pit:FS; bulk: VR and diffused light:LD) on the varieties Rutambiro, victoria and Ndinamagara respectively late, moderate and early sprouting at different days of removing tubers from storages conditions (14, 21, 28 and 35 days). The analysis of variance between sprouting rate showed a significant difference between all technologies except for the variety Ndinamagara after 28 days. The variety Ndinamagara treated with GA3 and SUP

allowed 100 % sprouting, then represent an increase of more than 40% of sprouting rate compare to the control (untreated Ndinamagara).

At 14 days, the effect of SUP on Rutambiro variety sprouting rate was high in pit (42.5%) compare to GA3 (25.8%) while the effect of GA3 was high than SUP from 21 up to 35 days on the same variety. The use of SUP on Rutambiro variety allowed to enhance sprouting rate of more than 60% for all sprouting technologies and increase it for more than 30 % and 40% respectively in bulk and in pit. The diffused light with GA3 allowed also to increase in sprouting of Rutambiro and victoria while the sprouting in diffused light with SUP was low for all varieties but higher to the untreated tubers. At 14 day, the sprouting rate of Rutambiro treated by using pit with SUP technology was 74.17% and 100% for Ndinamagara variety. These represent an increae of more 43 % and 37.5% respectvely for Rutambiro and Ndinamagara varieties. The increase is also more than 50% and less than 20% respectvely for Rutambiro and Ndinamagara varieties at 21,28 and 35 days by uing pit with SUP sprouting technology. For the variety victoria, the increase is relativelly low (20 to 36%) except at 35 day where the sprouting rate increase by more than 48%. These results show the pit technology with SUP can enhance the sprouting rate of Rutambiro variety. The genotypes with early sprouting period may be said to have no problem of dormancy (van Ittersum, 1992). The characteristic behaviour of genotypes supports our results of the three gynotypes.

Table 1 : Comparison of different technologies on sprouting rate of Rutambiro, Victoria and Ndinamagara irish potatoes varieties by using Tukey test at 5% threshold

Technologies	**Sprouting of Rutambiro**				**Sprouting of Victoria**				**Sprouting of Ndinamagara**			
	14 Jrs	**21 Jrs**	**28 Jrs**	**35 Jrs**	**14 Jrs**	**21 Jrs**	**28 Jrs**	**35 Jrs**	**14 Jrs**	**21 Jrs**	**28 Jrs**	**35 Jrs**
FS_0	32 d	29 e	36 c	29 f	19 d	58 de	68 f	52 c	63 b	83 ab	100 a	100 a
FS_GA3	59 b	86 ab	92 a	100 a	90 a	96 a	90 a	100 a	100 a	100 a	100 a	100 a
FS_SUP	74 a	80 b	85 a	88 bc	56 bc	79 bc	88 b	100 a	100 a	100 a	100 a	100 a
LD_0	33 d	36 e	41 c	46 e	45 c	53 e	58 g	67 bc	88 a	100 a	Na	Na
LD_GA3	78 a	83 ab	91 a	98 b	68 b	75 bc	85 c	96 a	100 a	100 a	Na	Na
LD_SUP	46 c	51 d	57 b	63 d	30 d	35 f	42 h	48 c	88 a	100 a	Na	Na
VR_0	53bc	31 e	32 c	30 f	58 bc	71bcd	83 d	60 bc	58 b	67 a	100 a	100 a
VR_GA3	78 a	91 a	89 a	96 ab	57 bc	81 b	90 a	100 a	100 a	100 a	100 a	100 a
VR_SUP	60 b	60 c	66 b	80 c	50 c	65 cde	73 e	79 ab	100 a	100 a	100 a	100 a

In this research, tuber sprouting differed significantly ($p<0.05$) among technologies, treatments and forcing period (14, 21, 28 and 35 days) (Figure 1 and 2). Statistically, there was a significant interaction between the technologies and the time of sprouting ($p < 0.0001$) for both medium and long period of dormancy (Figure 1 and 2). In this study, it has been observed that tubers sprouted especially in pits had poor quality due the apical dominance and sprouts etiolation caused by the dark conditions. This poor quality was also reported by Shibairo et al. (2006) on tubers treated with GA3 removed from pits. Therefore, in order to improve the quality of the sprouts, tubers removed from pits and bulk were laid under diffused light to allow sprouts vigor and hardness. As highlighted above, the genotype with short period of dormancy (Ndinamagara) showed rapid sprouting in all technologies, storage conditions, treated or untreated. In one week, sprouts were at the 80%, ready to be planted. For other varieties, the progression of sprouting increased towards 100% with the increase of storage.

The percentage of sprouting in genotype with medium period of dormancy (Victoria) progressively increased. At 14 days of storage (Fig.1A), only tubers treated with GA3 and Super Gro (SUP) placed under pits (FS) and bulk (VR) showed a certain level of sprouting. When tubers are placed under diffused light toward the end of germination, those treated with GA3 and placed under pits storage conditions reached 80% at the following week (21 days). The tubers untreated placed under VR, treated with GA3 placed under diffused light (LD), treated with SUP placed under pits were not statistically different at 35 days and were at the end of sprouting. Other technologies and treatments reached 80% between 35 to 50 days. At 21 days of storage (Fig. 1B), all technologies showed at least 25% of sprouting except untreated tubers form FS and tubers treated with SUP placed under LD. Treated tubers with GA3 removed from FS, sprouting was at 75% and at the following week (35days) it rapidly increased and was at 100%. At this time, sprouting increased in tubers treated with GA3 placed under VR and LD, tubers treated with SUP under FS and untreated placed in VR reached 80%. Other technologies ended sprouting between 42 and 56 days. At 28 days of storage (Fig. 1C), treated and untreated tubers under all technologies showed at least 17% of sprouting. At the following week, there was no significant difference between tubers treated with GA3 and placed under FS, VR and LD, tubers treated with SUP under FS and untreated tubers placed under VR, they were at the end of sprouting. Tubers treated with SUP placed under VR and untreated tubers ended sprouting at 42 days. The remaining technologies (untreated and treated with SUP both under LD) reached 80% of germination at 56 days. At 35 days of storage (Fig.1D), tubers treated with GA3 under FS, LD and VR, and those treated with SUP under VR were statistically at the end of sprouting (100%) when collecting data at the first time. A part tubers treated with SUP and untreated both placed under VR which reached 80% at 42 days, this sprouting level was reached by all other technologies at 56 days. GA3 had a significant influence on the percentages of sprouting, they increase sprouting which support earlier works on potato (Shibairo *et al*., 2006) and on garlic (Rahman *et al*., 2006).

The percentage of sprouting in genotype with long period of dormancy (Rutambiro) progressively increased. At 14 days of storage (Fig. 2A), tubers treated with SUP under VR and FS, treated with GA3 under LD and VR had 25% of sprouting. Only those treated with GA3 under LD and VR reached 80% between 35 to42 days while these treated with SUP under FS and VR reached this % at 42 days. Most of other technologies ended the germination between 56 to 77 days. At 21 days of storage (Fig. 2B), tubers treated with GA3 and placed under pits (FS), diffused light (LD) and bulk (VR), and tubers treated with Super Gro (SUP) placed under pits showed at least 25% of sprouting. They all progressively increased and reached the end of germination between 35 and 42 days under diffused light. Tubers treated with SUP placed under VR and LD also showed a progressive sprouting compare to the remaining technologies. Except untreated tubers placed under LD and FS at 28 days of storage (Fig. 2C), all other technologies had at least 8% of sprouting. Sprouting in tubers treated with GA3 placed under FS, LD and VR, and treated with Super Gro (SUP) placed under pits showed rapidly increased and reached the 80% at 35 days (GA3 under FS and LD) and 42 days (SUP under FS and GA3 under VR). Tubers treated with SUP placed and placed under VR and LD ended sprouting between 56 to 63 days. The untreated tubers either under VR, FS or LD reached 80% at 70 days. At 35 days of storage (Fig. 2D), tubers treated with GA3 and placed under FS, LD and VR showed high sprouting around 80%. Tubers treated with SUP under FS and VR showed 17to 50 % of sprouting at 35 days and reached 80% at 42 days. Untreated tuber placed under FS, LD and VR were not sprouted at 35 days and were the last to reach 80% between 70 and 77 days. The results of the present study indicate that there was different period of dormancy in the three genotypes and GA3 was successful in breaking it and promoting their sprouting as indicated by Shibairo et al. (2006).

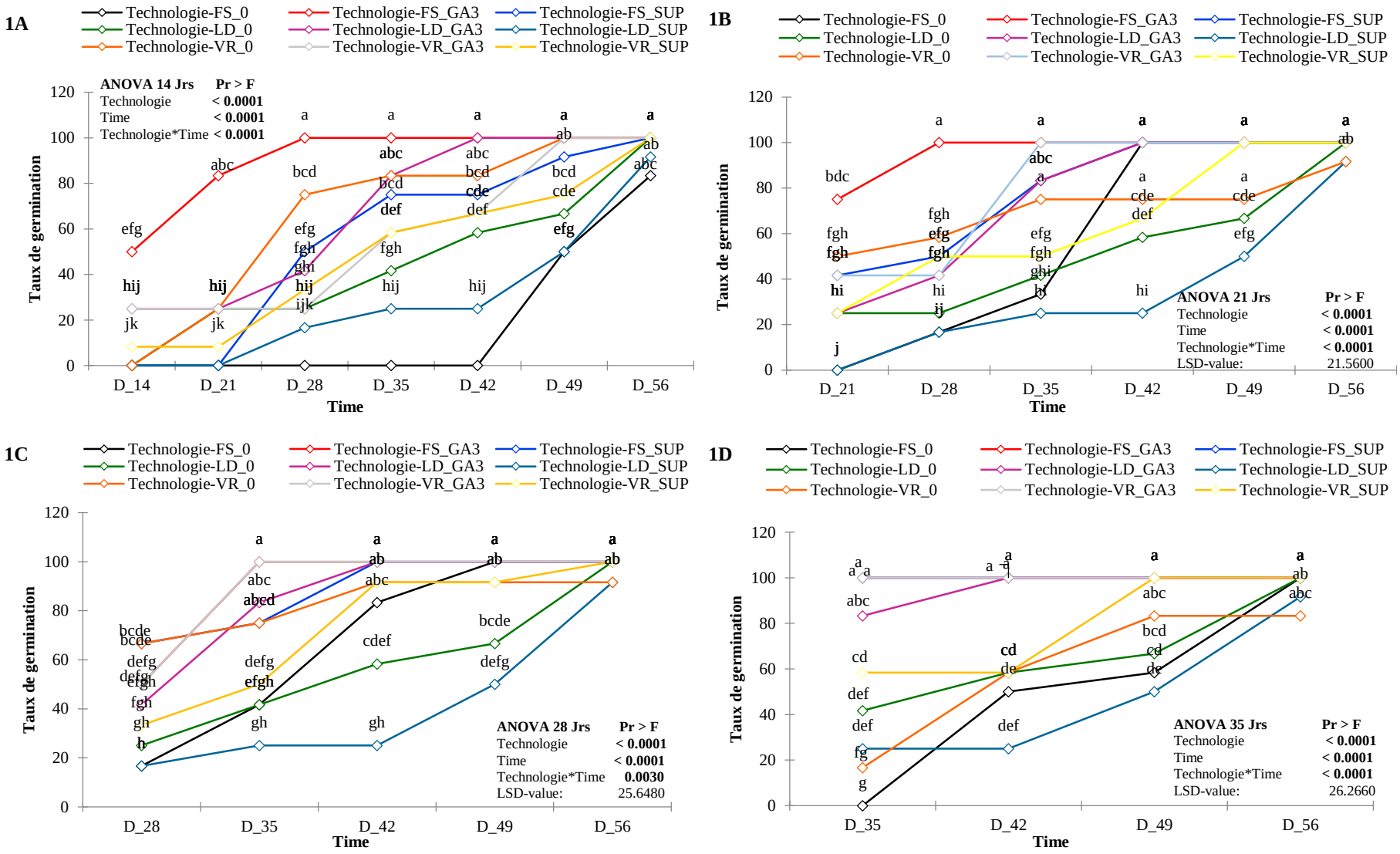

Figure 1: Effect of giberellic acid (GA3) and Super Gro on sprouting (%) of Victoria tubers (potato gynotype with long period of dormancy) under diffused light, pits and bulk storage conditions and monitored from 14 days (1A), 21 days (1B), 28 days (1C) and 35 days (1D).

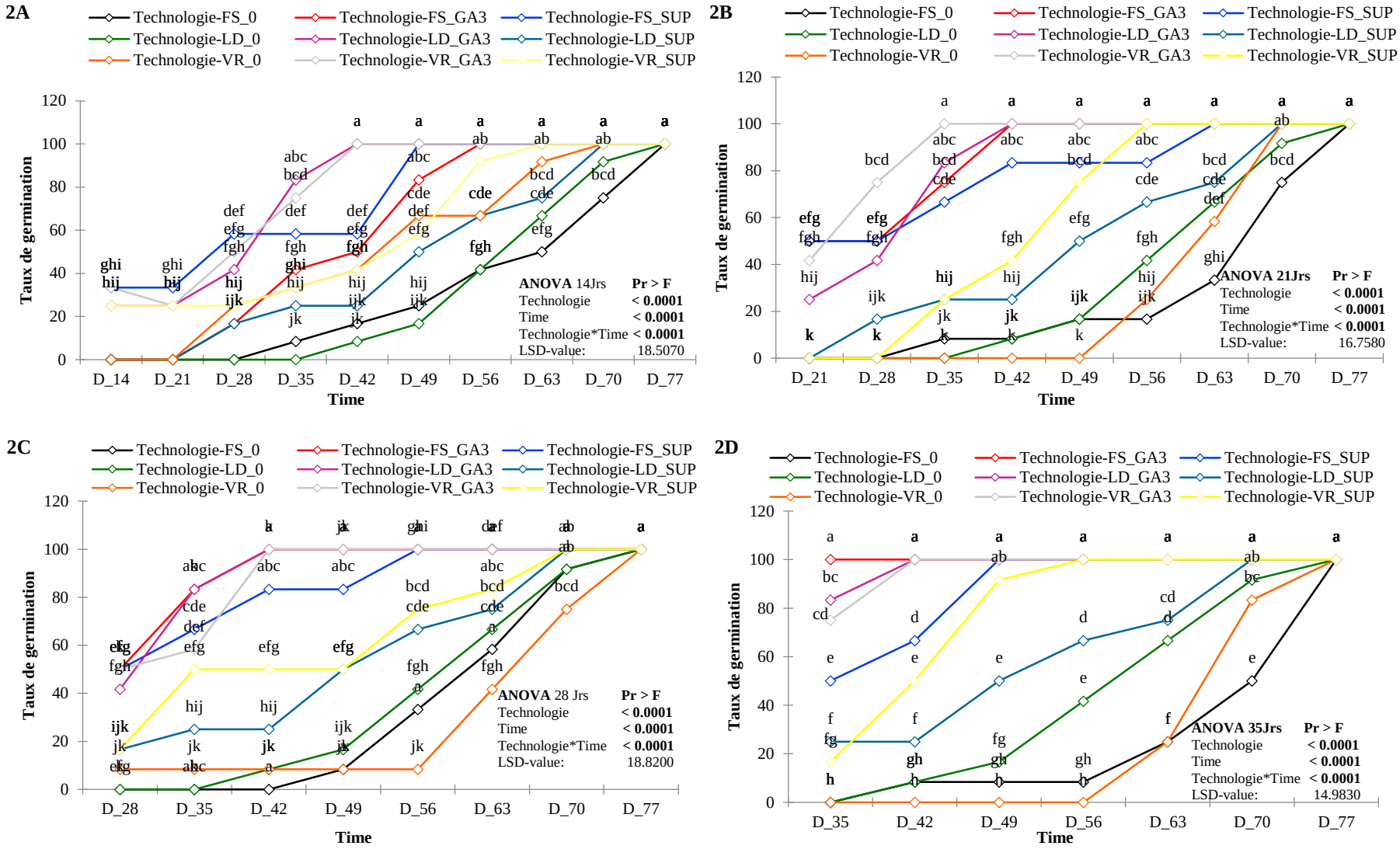

Figure 2: Effect of giberellic acid (GA3) and Super Gro on sprouting (%) of Rutambiro tubers (potato gynotype with long period of dormancy) under diffused light, pits and bulk storage conditions and monitored from 14 days (2A), 21 days (2B), 28 days (2C) and 35 days (2D).

Number of sprouts

The below table shows a significance difference between the tested technologies on number of sprouts of different varieties at different period of time. For all the periods (14,21, 28 ad 35 day), the bulk technology with GA3 allowed high number of sprouts for Rutambiro and Victoria varieties except the variety Rutambiro in pit with SUP and the variety Ndinamagara where the pit technology with GA3 allowed high number of sprouts. The effect of GA3 and SUP increased the number of sprouts (one more sprout) at 14 day and more than 4 times at 21day in bulk and in pit for the variety Rutambiro. For the variety Victoria, the effect of GA3 was more than 2 to 3 times respectively in bulk and in pit at 14 day. For the variety Ndinamagara, GA3 increased the number of sprouts respectively of 1.33 and 2 for the bulk and pit technologies. At 21, 28 and 35 day, the increase of sprouts number is high, respectively for more than 3 and 4 times.

The effect of SUP was effective from 21 day for the variety Rutambiro in bulk as it shows a high effect (more than 1 to 4) in pit. The number of sprouts increase with period of time. At early stage (14 and 21 day), the number of sprouts obtained by using bulk technology was relatively equal for Rutambiro and Ndinamagara varieties and increased rapidly from 28 to 35 day for Ndinamagara. The number of sprouts increased gradually for the variety Rutambiro while it increased rapidly for the variety Ndinamagara by using pit with super agro technology. In general, the pit technology allowed a high increase of sprouts compare to the bulk technology for Rutambiro variety and Ndinamagara while the effect of the two technologies on number of sprouts are quite the same for victoria variety. These results show that the pit technologies with SUP contribute to increase the number of sprouts of the variety Rutambiro (long dormancy) and consequently increase the number of tillers and yield. Generally, the GA3 treated potatoes had higher number of sprouts and slightly differ with SUP.

Table 2 : Comparison of different technologies on sprout number of Rutambiro, Victoria and Ndinamagara potatoes varieties by using Tukey test at 5% threshold

Technologies	Sprouts number of Rutambiro				Sprouts number of Victoria				Sprouts number of Ndinamagara			
	14Jrs	21Jrs	28Jrs	35Jr	14Jrs	21Jrs	28Jr	35Jrs	14Jrs	21Jrs	28Jr	35Jrs
FS_0	3 e	2 d	2 f	3 f	2 e	2 e	3 d	3 e	4 d	2 f	4 c	4 b
FS_GA3	4 bc	6a	6 ab	7 ab	5a	5 b	5 ab	5 c	6 a	6 b	8a	8a
FS_SUP	4 bc	4 c	6 ab	7a	4 bcd	4 cd	5 ab	4 d	5 b	7a	7 b	3 c
LD_0	3 de	3 c	4 de	4 e	4 bcd	5 bcd	5 ab	6 b	5 c	5 c	Na	Na
LD_GA3	5 ab	4 b	5 bc	5 cde	4 abc	5 bc	5 ab	5 c	6 a	6 d	Na	Na
LD_SUP	4 cd	4 c	4 cd	5 de	3 d	4 d	5 bc	5 c	5 b	5 c	Na	Na
VR_0	4 bc	2 d	3 e	2 g	4 cd	4 cd	4 cd	4 d	3 e	3 de	3 d	4 b
VR_GA3	5a	6a	6a	6 bc	5a	6a	6a	7a	4 d	3 e	7 b	8a
VR_SUP	4 bc	4 bc	5 bc	5 cd	4 ab	5 bc	5 ab	5 c	4 d	4 d	8a	3 c

Conclusion

Selection for genotypes with low dormancy will be necessary for successful cultivation in consecutive seasons. Otherwise, rest breaking agents can reduce moderate and long period dormancy of potato varieties. The cultivars with a short dormancy responded more strongly to the assay than cultivars with a long dormancy. Good results were observed when treated with GA3 however, this hormones is very expansible. Super Gro is recommended to be used by potato producers as it is available and at a low cost. This study confirm that the longer the treated or untreated tubers are stored under pit and bulk, the easier it is to break dormancy.

Compte tenu du prix élevé du GA3, Cette étude recommande l'utilisation du Super gro moins cher et accessible sur le marché local pour forcer la dormance

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