EFFECT OF GIBBERELLIC ACID ON SPROUTING, GROWTH OF INTERNODES, TUBER SHAPE AND YIELD IN DIFFERENT VARIETIES OF POTATOES

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1. INTRODUCTION

In West Bengal seed potatoes are produced in the hills during the summer at an altitude of 7–8.000 ft and are harvested from August to September. This seed is used for planting the winter crop in the plains in October, which necessitates the use of the tubers before their rest period is over. Thiourea has often been employed to break the dormancy and to ensure uniform sprouting. RAMANUJAM, SINGH and SWAMINATHAN (1957) showed that treatment with thiourea was effective when cut seed pieces were soaked in a 1% solution, but the use of cut seed pieces is hazardous because of uncertain weather conditions during planting season in the plains of West Bengal.

RAPPAPORT, LIPPERT and TIMM (1957) studied the effect of gibberellic acid (GA) on the sprouting behaviour of *White Rose* and *Russet Burbank* potatoes, but information on the effect of GA on the growth, development and yield of potato plants is meagre. The present study is concerned not only with the effect of GA on breaking dormancy of tubers but also its effect on the growth of internodes, leaf index, yield and shape of tubers in different varieties.

2. MATERIALS AND METHODS

Samples of potatoes from the Darjeeling hills of West Bengal were harvested on 5th August 1958, when the crop was nearly mature. On the same day, whole tubers of *Royal Kidney*, *Up-to-Date* and *Voran* were sorted, washed and dipped for periods of 5 or 90 minutes in water or in solutions of GA at concentrations of 25, 50 and 100 p.p.m. After treatment, the tubers were stored in open trays at a room temperature of 61°–74°F for four hours, before planting in 16 in. pots. There were 20 seed tubers in each treatment and the experiment was continued for 120 days after treatment.

3. RESULTS

The results shown in FIG. 1 (a, b, c) indicate that tubers sprouted completely in 21–35 days after treatment with GA. Sprouts developed within 7 days in treated tubers, whereas, in untreated tubers, no sprout was produced before 14 days. The experiment also showed that GA at a concentration of 100 p.p.m. had a more pronounced effect

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FIG. 1. Percentage of sprouted tubers in different varieties following treatment with Gibberellic acid

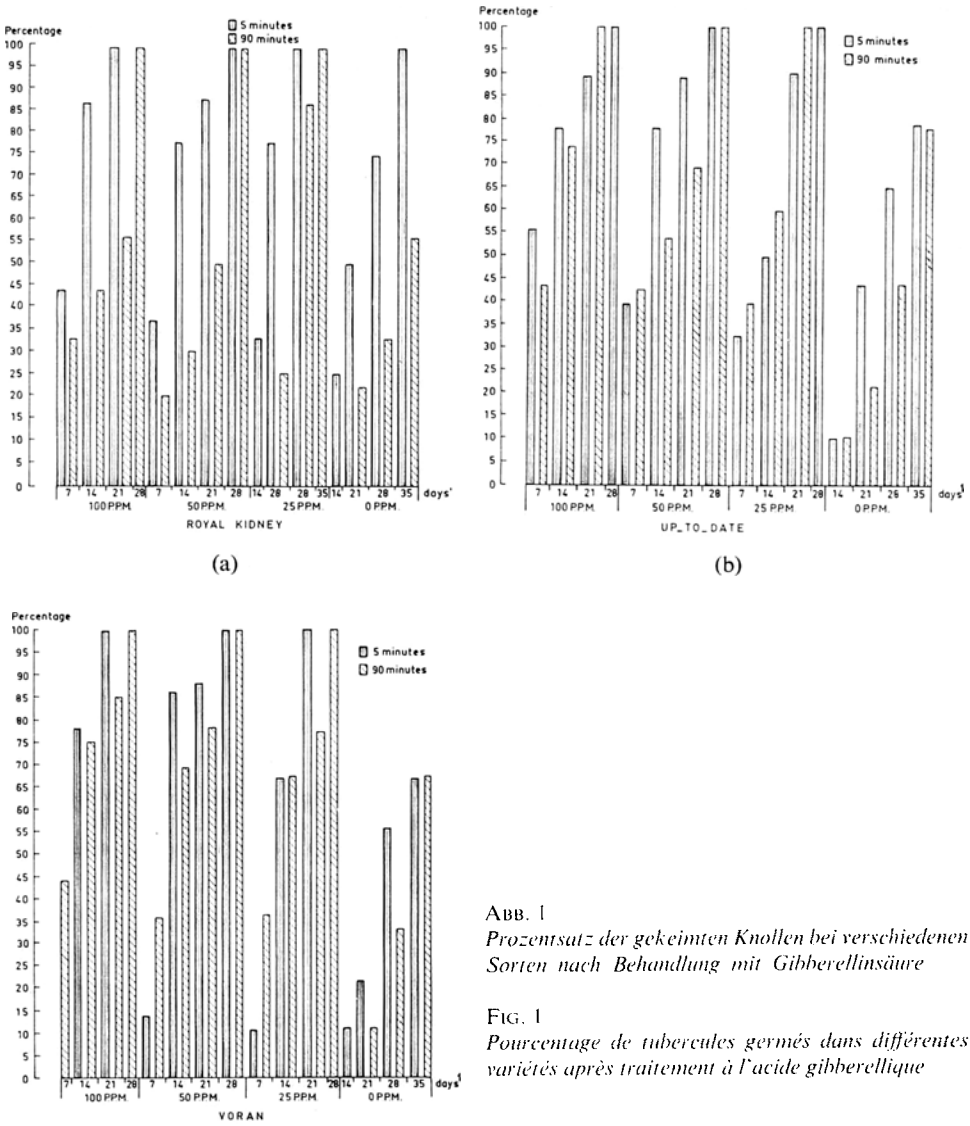


ABB. 1
Prozentsatz der gekeimten Knollen bei verschiedenen Sorten nach Behandlung mit Gibberellinsäure

FIG. 1
Pourcentage de tubercules germés dans différentes variétés après traitement à l'acide gibberellique

[1] *Tage – jours.*

than 25 or 50 p.p.m. in breaking dormancy in some varieties. Dipping for 5 min. in GA solution at a concentration of 25 p.p.m. induced sprouting in *Up-to-Date* and *Voran*, whereas 50 p.p.m. was required to produce similar results in *Royal Kidney*.

3.1. Growth of internodes

All internodes above the first leaf were measured at 48 hr intervals. In all the varieties studied extention of internodes increased with increasing strength of GA. The rate of elongation of internodes declined during the later stages of growth. The TABLE shows the results obtained with *Royal Kidney*, *Up-to-Date* and *Voran*.

TABLE. Average length of internodes in mm, 120 days after treatment with three concentrations of gibberellic acid (G.A.)

Variety *Sorte Variété*	GA (p.p.m.)	Dipping time – *Eintauchzeit – temps d'immersion*																			
		5 minutes										90 minutes									
		Internode No. – *Internodium Nr – No. de l'entre-noeud*										Internode No. – *Internodium Nr – No. de l'entre-noeud*									
		3	4	5	6	7	8	9	10	11	Total	3	4	5	6	7	8	9	10	11	Total
Royal Kidney	25	10	16	16	13	10	11	10	10	8	104	18	17	20	15	14	13	10	8	8	123
	50	22	19	29	32	24	19	21	17	12	195	24	26	38	23	23	20	16	16	11	197
	100	11	22	43	53	30	20	17	17	12	225	16	32	34	37	26	38	28	26	16	253
	Control	10	15	15	15	13	10	10	7	7	102										
Up-to-Date	25	20	26	30	29	18	16	11	10	8	168	25	10	26	42	45	21	18	15	8	210
	50	24	27	44	45	26	24	15	12	9	226	30	38	52	42	44	36	29	16	13	300
	100	60	38	106	33	48	39	38	32	16	410	28	57	64	56	77	50	31	26	26	415
	Control	20	25	19	19	17	16	11	10	5	142										
Voran	25	21	27	26	37	16	18	20	17	13	195	21	37	22	16	15	16	16	17	12	172
	50	17	22	58	55	20	21	11	8	8	220	19	35	40	20	18	17	17	15	10	191
	100	30	41	44	51	37	29	17	15	13	277	13	40	42	38	26	36	17	9	9	230
	Control	14	14	14	11	10	9	8	6	6	92										

TABELLE. *Durchschnittliche Länge der Internodien in mm, 120 Tage nach Behandlung mit Gibberellinsäure (GA) in drei verschiedenen Konzentrationen*

TABLEAU. *Longueur moyenne des entre-noeuds en mm, 120 jours après traitement à trois concentrations d'acide gibberellique (GA)*

It is apparent from this TABLE that, following treatment with the higher concentrations of GA, maximum growth occurred between the internodes 4–6 in *Royal Kidney* and *Voran*, whereas in *Up-to-Date* it occurred between internodes 4–7 with prolonged dipping of 90 min. and in internode 5 only with a shorter period of treatment for 5 min. The maximum extention of internodes in the untreated tubers varied from internodes 4–7, 3–4 and 3–5 in *Royal Kidney*, *Up-to-Date* and *Voran* respectively.

3.2. Leaf index

The leaf indices tended to be reduced by treatment in *Royal Kidney* and *Up-to-Date*, whereas, *Voran* at all concentrations showed a higher leaf index than the control. FIG. 2 shows the average leaf indices of three varieties following various treatments.

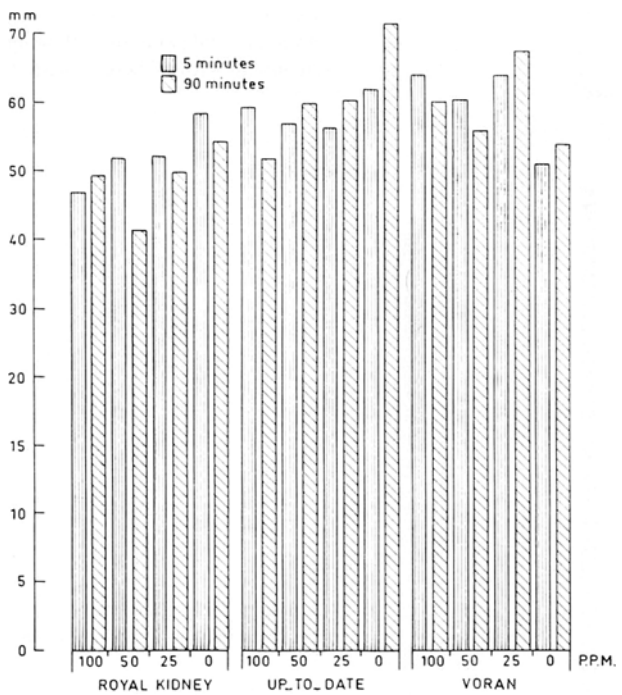


FIG. 2
Leaf index of different varieties following treatment with gibberellic acid

ABB. 2
Blattindex bei verschiedenen Sorten nach Behandlung mit Gibberellinsäure
FIG. 2
Index foliaire chez différentes variétés après traitement à l'acide gibberellique

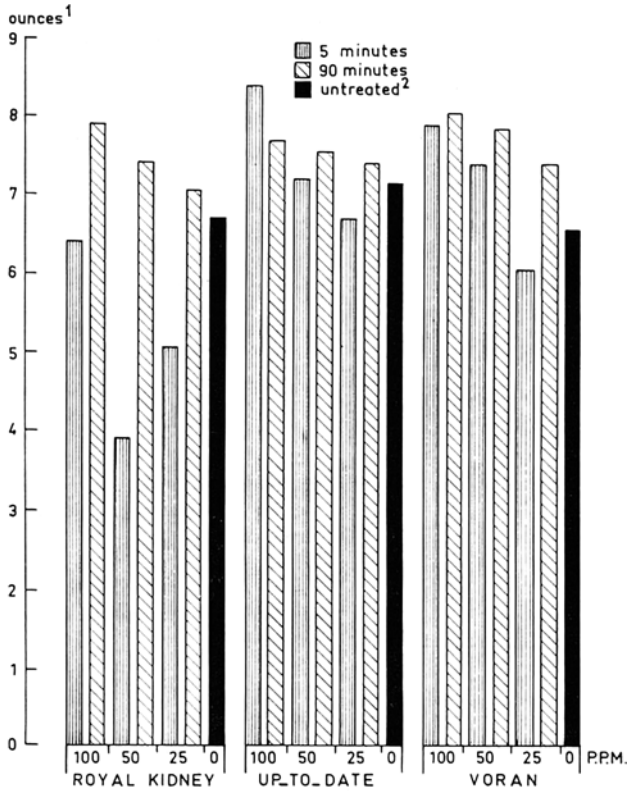
3.3. Tuber shape and yield

The effect of treatment with GA on yield varied according to the variety (FIG. 3). It is apparent that in all varieties it was increased by treatment at 100 p.p.m. for 90 min.

Seed tubers treated with GA produced a high percentage of deformed tubers in all the three varieties studied (FIG. 4). It can be seen that treatment with two higher concentrations for the longer period had the most marked effect in this direction. Treated seed produced, on average, a larger number of tubers per plant than did the control and, where the number of tubers was very large, they were invariably smaller in size.

4. DISCUSSION

Gibberellic acid induces more rapid germination in certain true seed. For example, lettuce seed, which needs red light to stimulate germination, may show a similar response to treatment with GA (HOPKINS, 1958). Sprouting was hastened by one to two weeks when newly dug potatoes of *Royal Kidney*, *Up-to-Date* and *Voran* were dipped in solutions of GA at concentrations of 25–100 p.p.m. although there were distinct varietal differences in the rate of sprouting and sprout elongation resulting from treatment. It is clear that a suitable concentration of GA is required to produce an optimum effect on a particular variety.



[1] = 28,35 g [2] *unbehandelt – non traité.*

FIG. 3
Average yield per plant following treatment with gibberellic acid

ABB. 3
Mittlerer Ertrag je Pflanze nach Behandlung mit Gibberellinsäure
FIG. 3
Production moyenne par plante après traitement à l'acide gibberellique

RAPPAPORT, LIPPERT and TIMM (1957) reported a similar effect when newly dug *White Rose* potatoes were dipped in solutions of GA at concentrations of 25 to 2000 μg/ml. They also demonstrated differences in varietal response to treatment.

The difference in extension of internodes in treated potatoes may be due either to absorption of different levels of gibberellic acid or to the accumulation of different levels of GA-like substances in the epidermal cells or the cumulative effect of both.

Treatment with GA had a depressing effect on the leaf index in most varieties except *Voran*, in which all the treatments produced a higher leaf index than the control. HUMPHRIES (1958) reported that spraying of GA and kinetin had the effect of increasing leaf area and dry matter in *Majestic*. In our experiments the depressing effect of gibberellic acid on leaf index in *Royal Kidney* and *Up-to-Date* was not followed by decrease in yield except in the former variety when dipped for 5 minutes. *Voran* invariably showed higher yield due to all treatments with GA except at a concentration of 25 p.p.m. for the 5 min. dip. It was noted that all the potatoes produced from seed treated with GA showed a high percentage of deformed tubers. Deformity increased considerably as the concentration of GA increased. MORGAN and MEES

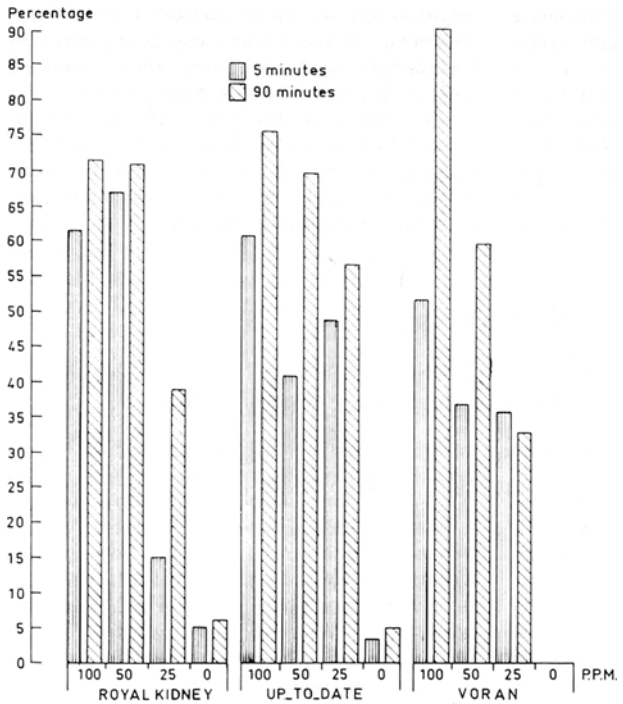


FIG. 4
Percentage of deformed tubers produced following treatment with gibberellic acid

ABB. 4
Prozentsatz der deformierten Knollen nach Behandlung mit Gibberellinsäure
FIG. 4
Pourcentage de tubercules déformés après traitement à l'acide gibberellique

(1958) reported that spraying of GA at 2 and 4 oz.* per acre** on potatoes, three weeks before flowering, increased both the growth of the haulm and the number of tubers but caused reduction in total yield. Malformation of tubers were also noted by these workers. It has been shown by MACLEOD and HOWATT (1958) that the treatment of stolon tips of *Green Mountain* with GA, at a concentration of 20 p.p.m., produced deformed tubers but had no adverse effect on yield.

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SUMMARY

Sprouting was hastened by one week by treatment for 5 min. with gibberellic acid (GA) at a concentration of 25 p.p.m. in newly dug potatoes of *Up-to-Date* and *Voran*. A similar effect was noted in *Royal Kidney* treated at a concentration of 50 p.p.m. Although some sprouting occurred

*1 ounce = 28,35 g. **1 acre = 0,4047 ha.

within 7 days in treated tubers, 100% sprouting had not occurred until 21–36 days after treatment.

There was increased extention of internodes following treatment with GA at concentrations of 25, 50 and 100 p.p.m. Treatment at 100 p.p.m. resulted in the greatest extention of internodes. At the higher concentrations the maximum extension occurred between internodes 4–6 in *Royal Kidney* and *Voran*, and 4–7 in *Up-to-Date*. Treatment with GA had a depressing effect on leaf indices in *Royal Kidney* and *Up-to-Date* whereas in *Voran* it had the reverse effect.

In all varieties, yield in pot experiments was increased by treatment with GA at 100 p.p.m. for 90 min. All treated seed invariably produced deformed tubers the numbers of which increased with the concentration of GA.

ZUSAMMENFASSUNG

WIRKUNG VON GIBBERELLINSÄURE AUF KEIMUNG, WACHSTUM DER INTERNODIEN, KNOLLENFORM UND ERTRAG VERSCHIEDENER KARTOFFELSORTEN

Das Auskeimen von frisch geernteten Kartoffeln der Sorten *Up-to-Date* und *Voran* (Abb. 1 b und c) wurde durch Behandlung mit Gibberellinsäure (GA) (Eintauchzeit 5 Minuten, Konzentration 25 ppm) um eine Woche beschleunigt. Eine ähnliche Wirkung konnte bei der Sorte *Royal Kidney* festgestellt werden, die mit GA in einer Konzentration von 50 ppm (Abb. 1a) behandelt wurde. Obwohl einige der behandelten Knollen nach 7 Tagen austrieben, wurde 100%ige Keimung erst 21–36 Tage nach der Behandlung erreicht.

Die Behandlung mit GA in Konzentrationen von 25, 50 und 100 ppm bewirkte eine Verlängerung der Internodien. Die Konzentration von 100 ppm verursachte die grösste Ausdehnung der Internodien. Bei der höchsten Konzentration lag die grösste Verlängerung zwischen den Internodien Nr. 4–6 bei *Royal Kidney* und *Voran*, zwischen 4–7 bei der Sorte *Up-to-Date* (Tabelle).

Behandlung mit GA hatte bei den Sorten *Royal Kidney* und *Up-to-Date* eine Verkleinerung des Blattindexes zur Folge, während bei *Voran* eine umgekehrte Wirkung hervorgerufen wurde (Abb. 2).

Topfversuche ergaben nach Behandlung mit GA in einer Konzentration von 100 ppm und einer Eintauchzeit von 90 Minuten bei allen Sorten höhere Erträge (Abb. 3). Alle Behandlungen führten zu Knollendeformationen, deren Anzahl sich mit der stärker werdenden Konzentration von GA erhöhte (Abb. 4).

RÉSUMÉ

L'EFFET DE L'ACIDE GIBBERELLIQUE SUR LA GERMINATION, SUR LA CROISSANCE DES ENTRENOEUDS, LA FORME DES TUBERCULES ET LE RENDEMENT DANS DIFFÉRENTES VARIÉTÉS DE POMME DE TERRE

Un traitement pendant 5 minutes à l'acide gibberellique (G.A.) à une concentration de 25 p.p.m. a avancé d'une semaine la germination de tubercules nouvellement récoltés des variétés *Up-to-Date* et *Voran* (fig. 1, b et c). On a obtenu un semblable effet avec *Royal Kidney* traitée à une concentration de 50 p.p.m. (fig. 1 a). Quoique quelque germination apparaissait endéans 7 jours chez les tubercules traités, la germination à 100% ne se manifestait que 21 à 36 jours après le traitement.

Un allongement des entre-noeuds suivait le traitement avec G.A. aux concentrations de 25, 50 et 100 p.p.m. Le traitement à 100 p.p.m. causait le plus grand allongement des entre-noeuds. Aux concentrations les plus élevées, l'accroissement maximum se manifestait entre les entre-noeuds 4 et 6 chez *Royal Kidney* et *Voran*, et 4 et 7 chez *Up-to-Date* (Tableau).

Le traitement au G.A. a un effet dépressif sur les indices foliaires chez *Royal Kidney* et *Up-to-Date*, tandis que chez *Voran* l'effet est inverse (fig. 2).

Chez toutes les variétés, la production dans les expériences en pots est accrue par le traitement avec G.A. à 100 p.p.m. pendant 90 minutes (FIG. 3). Tous les plants traités produisent invariablement des tubercules déformés dont le nombre augmentait avec les concentrations de GA (FIG. 4).

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