EFFECT OF CUTTING AND GIBBERELLIN TREATMENT ON AUTUMN-GROWN SEED POTATOES FOR SPRING PLANTING[1]

ISRAEL SLOMNICKI and IRENE RYLSKI

National and University Institute of Agriculture, Rehovot, Israel

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1. INTRODUCTION

Previous work (SLOMNICKI, 1961a) indicated that length of dormancy was the main factor limiting the use of autumn-grown seed of most varieties for the spring season. As considerable promise was shown by known varieties with short dormancy and a short to medium growing period, a programme of breeding for these characters was commenced (SLOMNICKI, 1961b). Simultaneously, experiments on the breaking of dormancy were started to find out if seed of old established varieties, such as *Up-to-Date*, from locally produced autumn crops could be used.

Reports on the ability of gibberellin to break dormancy were encouraging (DOORENBOS, 1958; TSUKAMOTO, 1958; TSUKAMOTO, ASAHIRA and NAMIKI, 1961; TSUKAMOTO, KAKO and NAMIKI, 1960; LIPPERT, RAPPAPORT and TIMM, 1958a; MATKUR, 1961). In 1958, when the present work was begun, very high concentrations of gibberellic acid (GA) were being used and tubers soaked in the solutions for hours or even days (LIPPERT, RAPPAPORT and TIMM, 1958b; RAPPAPORT, 1956). Such concentrations, even if effective, were very expensive and could not have been used in practice. Other effects of high concentrations were abnormalities in growth and development of both plant and tubers. GA had been tried mainly for breaking the dormancy of spring-grown seed required for autumn planting. The object of the present investigation was the breaking of dormancy of autumn-grown seed for spring planting. The main difference between these two requirements is one of storage temperature. Whereas the spring crop, harvested in June, is stored at dangerously high temperatures (LITTAUER, 1944). the autumn crop, harvested in December, is stored at cool temperatures during the Israel winter. As high temperatures hasten sprouting, breaking the dormancy of spring-grown seed for autumn planting presents no problem in Israel.

Another important difference is the soil temperature at the two planting seasons. The autumn crop is planted in mid-August, when soil temperatures at planting depth reach 31,8 °C, whereas the spring crop is planted in mid-February, in wet cool soil with a temperature of 11–12 °C (ASHBEL, 1950). Soil temperature has a major influence on the rate of emergence, which is why this character was chosen instead of the spruiting of tubers for assessing treatments. Experiments were carried out during four successive

[1] Publication of the National and University Institute of Agriculture, Rehovot, Israel. 1963 series. No. 571-E.

Received for publication 20th May, 1964.

seasons, using the variety *Up-to-Date*. GA solutions were prepared from a commercial product (supplied by Kyowa Fermentation Industry Ltd., Tokyo, Japan) and tubers were dipped for about one minute, unless stated otherwise.

2. TREATMENTS AND RESULTS

2.1. First season (1958)

One hundred tubers of 150 g weight were cut in half along the long axis; 100 pieces were dipped for one minute in 50 ppm GA solution and the remainder used as a control; both were stored for a fortnight before planting. On the day of planting, a second batch of 100 tubers from the same source and of the same weight were cut and treated in the same way. In addition, 200 whole tubers of 75 g weight were divided into two equal groups, one of which was dipped in GA solution and the other kept as control. Altogether, 600 units were planted on 1 March. The rate of emergence was recorded twice weekly.

Cutting of the tubers, without further treatment, greatly influenced the breaking of dormancy (FIG. 1). Tubers cut a fortnight before planting emerged more quickly and more uniformly than tubers cut on the day of planting. Their emergence was as quick and uniform as that of whole tubers dipped in GA. The effect of GA treatment was most evident in tubers cut a fortnight before planting. After emergence, the plants had a yellow to light green colour, the stems were elongated, thin and weak, the stolons were elongated and appeared on the surface a short time after emergence. Tubers were abnormally elongated.

It was concluded that:

a. In order to obtain a quick and uniform emergence, potato tubers should be cut at least a fortnight before planting.
b. Dipping in GA solution was very effective but much lower concentrations should be tried in order to minimize growth abnormalities.
c. The synergistic action of cutting and dipping in GA solution seems to be a promising method of breaking the dormancy of autumn-grown seed required for spring planting.

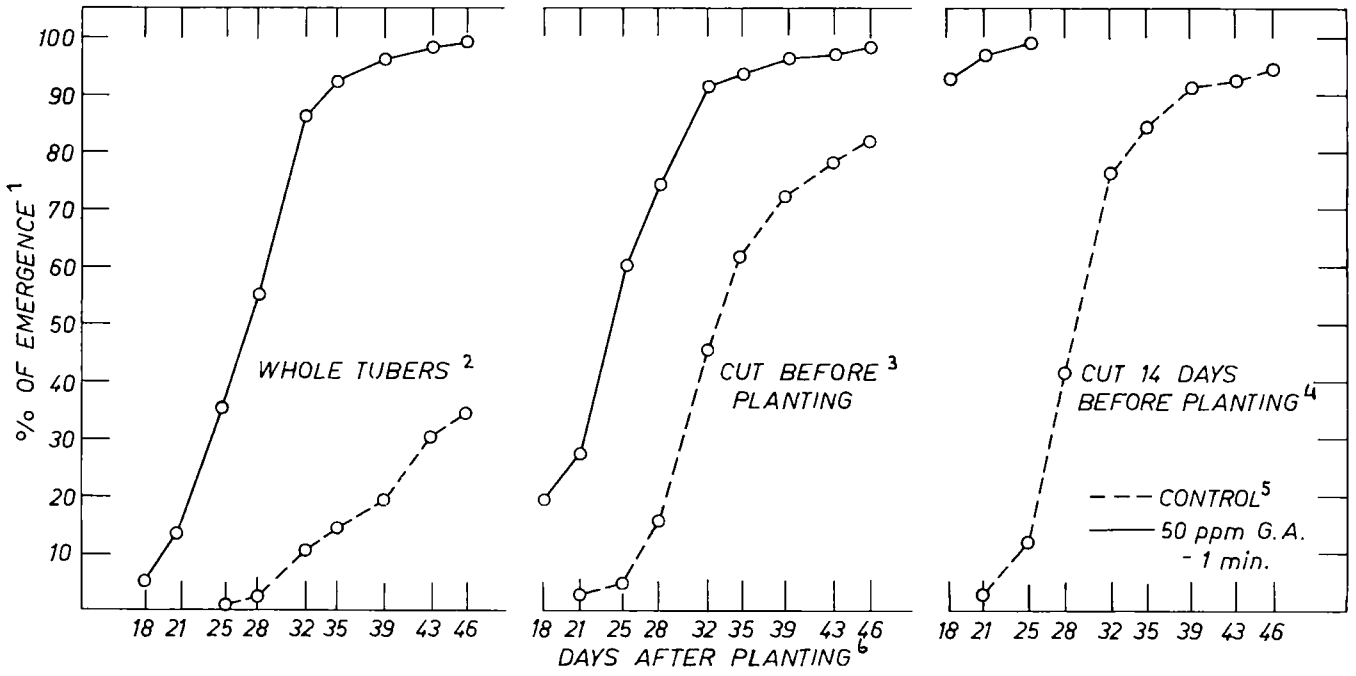
2.2. Second season (1959)

During this season the influence of GA concentration was studied. Two hundred and fifty 150 g tubers were cut in half and divided into 5 groups of 100 seed pieces. The treatments consisted of dipping for 1 minute in 0, 5, 10, 20 and 40 ppm GA solutions. The tubers were cut and dipped on 10 February and planted on 24 February in randomized blocks with 4 replications, each plot containing 25 plants.

In addition to the major experiment, two minor experiments were carried out:

a. An additional 100 seed pieces were soaked for 15 minutes in 5 ppm GA in order to see whether longer contact with the solution might be more effective than the 1 minute dip used in the major experiment.

FIG. 1. Effect on rate of emergence of cutting and gibberellic-acid (GA) treatment of seed from the autumn crop 0 and 14 days prior to spring planting (1958)



[1] *"/o aufgelaufene Knollen – "/o de levée.*
[2] *Ganze Knollen – tubercules entiers.*
[3] *Geschnitten vor dem Auspflanzen – coupés avant la plantation.*
[4] *Geschnitten 14 Tage vor dem Auspflanzen – coupés 14 jours avant la plantation.*
[5] *Kontrolle – témoin.*
[6] *Tage nach dem Auspflanzen – jours après la plantation.*

ABB. 1. *Wirkung des Schneidens und der Gibberellinsäurebehandlung (GA) des Pflanzgutes auf die Auflaufgeschwindigkeit; Behandlung der im Herbst geernteten Saatknollen unmittelbar und 14 Tage vor der Frühjahrspflanzung (1958)*

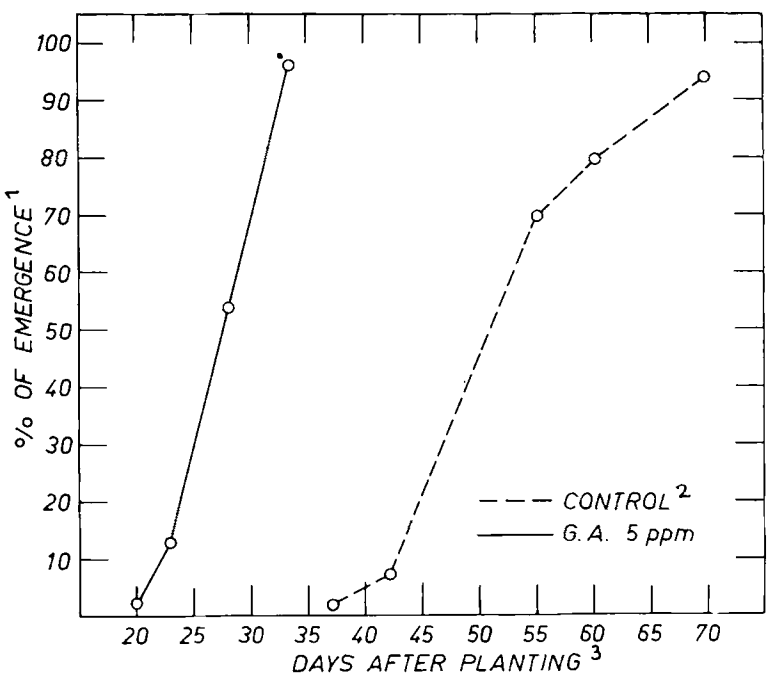
FIG. 1. *Effet sur la rapidité de la levée du sectionnement et du traitement à l'acide giberellique (GA) de plants récoltés en automne, 0 et 14 jours avant la plantation au printemps (1958)*

b. To study further the effect of time of treatment, additional tubers were cut in half and dipped 3 and 4 weeks before planting.

Soaking of seed pieces for 15 minutes in 5 ppm GA had no additional effect in hastening emergence, number of stems, yield or size of tubers in comparison with the 1 minute dip in the same solution. Cutting and dipping seed pieces 3 and 4 weeks before planting also had no additional effect compared with cutting and dipping 2 weeks before planting. There were no significanc differences between the different concentrations in their effect on the rate of emergence, but there was a marked difference between the GA treatment and control (FIG. 2).

The appearance of the plants after emergence resembled that seen in the previous years experiments only where the tubers were treated at the higher concentrations. The appearance of the plants treated with 5 ppm GA solution was closest to the normal. The control plants emerged over a long period of time, and there were large differen-

FIG. 2. Effect on rate of emergence of treating cut seed from the autumn crop with gibberellic acid (GA) 14 days prior to spring planting (1959)



1, 2, 3 *Siehe* ABB. 1 – *voir* FIG. 1.

ABB. 2. *Wirkung der Behandlung von geschnittenem Pflanzgut aus Herbsternte mit Gibberellinsäure (GA) auf die Auflaufgeschwindigkeit; Behandlung 14 Tage vor der Frühjahrspflanzung (1959)*

FIG. 2. *Effet sur la rapidité de la levée de plants coupés récoltés en automne du traitement à l'acide giberellique (GA), 14 jours avant la plantation au printemps (1959)*

ces between the first which emerged 40 days after planting and the latest which emerged 70 days after planting.

When harvested on 18 June, the number of stems (TABLE 1), was lowest in the control plants and was strongly influenced by the concentration of GA. The highest yield was obtained with the lowest concentration and high concentrations resulted in decreased yield.

Size of tubers was strongly influenced by the number of stems. The control and 40 ppm GA gave the same total yield, but the distribution of large, medium and small tubers in the total yield was entirely different.

Treatment with GA was essential for quick and uniform emergence. High concentrations had a negative influence on quantity as well as on grading of the yield. The lowest concentration of 5 ppm GA seems to be the upper limit.

TABLE 1. Yield and number of stems per plant after treatment of cut tubers with gibberellic acid (GA) at various concentrations 2 weeks prior to planting (1959)

Treatment *Behandlung Traitement*	Size of tubers – *Knollengrösse – calibre des tubercules* (%)			Yield – *Ertrag récolte* (kg/are[1])	No. of stems p. plant *Triebe pro Pflanze Tiges par plante*
	small *klein petit*	medium *mittel moyen*	large *gross grand*		
1. Control[2]	6,8	23,4	69,8	236	2,1
2. GA 5 ppm	18,6	44,6	36,8	344	3,2
3. GA 10 „	20,1	47,1	32,8	309	3,5
4. GA 20 „	29,4	46,1	24,5	270	3,6
5. GA 40 „	30,7	47,9	21,4	233	4,3
L.S.D. (at the 5 % level)[3]				76,1	

[1] 1 are = 1 100 ha = 100 m².
[2] *Kontrolle – témoin.*
[3] *G. D. (kleinste gesicherte Differenz) P = 0,05 = D.S. (entre rendements moyens) au seuil de probabilité P = 0,05.*

TABELLE 1. *Ertrag und Anzahl Triebe pro Pflanze nach Behandlung von geschnittenen Knollen mit Gibberellinsäure (GA) bei verschiedenen Konzentrationen zwei Wochen vor der Pflanzung (1959)*

TABLEAU 1. *Production et nombre de tiges par plante après traitement de tubercules coupés à l'acide giberellique (GA) à différentes concentrations, deux semaines avant la plantation (1959)*

2.3. Third season (1960)

Concentrations of 1; 2,5 and 5 ppm GA were tested. All the 150 g tubers were cut and dipped for one minute 2 weeks before planting. At the same time, whole 75 g tubers were pierced with an awl instead of cutting and divided into two groups, one being dipped in 5 ppm GA and the other kept as a control.

At planting time (16 February), untreated 75 g tubers from the same source and imported whole tubers of the same size and variety were also included. The experiment was laid out in randomized blocks with 7 replications, each plot containing 50 plants. The crop was harvested on 21 June.

Whole untreated tubers gave the lowest, and imported whole untreated tubers the highest yield (TABLE 2). Uncut, pierced tubers, dipped in 5 ppm GA gave a total yield not significantly different from that of imported seed, the only difference between these two being in the size grading. Pierced untreated tubers gave a significantly higher yield than whole ones but lower than cut tubers. There was no difference in total yield from untreated cut tubers and those treated at all concentrations of GA used or between these and whole pierced tubers treated with 5 ppm GA. Differences could be detected in the size grading only. Cut tubers treated with 1 ppm GA produced plants of normal appearance.

The results show that the entire yield harvested from autumn-grown potatoes can be used for seed purposes. The large tubers can be cut and the smaller ones can be pierced, being subsequently treated with 1 or 5 ppm GA solution respectively.

TABLE 2. Yield and number of stems after treatment with gibberellic acid (GA) at various concentrations of whole, cut, and pierced tubers 2 weeks before planting as compared with imported whole tubers (1960)

Treatment *Behandlung Traitement*	Size of tubers – *Knollengrösse – calibre des tubercules* (%)			Yield – *Ertrag récolte* (kg are[1])	No. of stems/plant *Triebe pro Pflanze Tiges par plante*
	small *klein petit*	medium *mittel moyen*	large *gross grand*		
1. Imported whole tubers[2]	2,2	9,1	88,7	451	3,2
2. Whole tubers[3]	6,7	12,4	80,9	194	1,0
3. Cut tubers[4]	1,5	8,4	90,1	395	1,5
4. Cut tubers[4] + 1 ppm GA	3,3	16,3	80,4	398	2,6
5. „ „ + 2,5 „ „	5,9	23,3	70,8	391	2,8
6. „ „ + 5 „ „	8,5	18,4	73,1	386	3,6
7. Pierced tubers[5]	4,9	9,9	85,2	265	1,0
8. „ „ + 5 ppm GA	4,5	15,8	79,7	420	2,7
L.S.D. (at the 5 % level)[6]				41,0	

[1] 1 are = 1 100 ha = 100 m².
[2] *Importierte ganze Knollen – tubercules entiers importés.*
[3] *Ganze Knollen – tubercules entiers.*
[4] *Geschnittene Knollen – tubercules coupés.*
[5] *Durchstochene Knollen – tubercules perforés.*
[6] *G.D. (kleinste gesicherte Differenz) P = 0,05 – D.S. (entre rendements moyens) au seuil de probabilité P = 0,05.*

TABELLE 2. *Ertrag und Anzahl Triebe nach Behandlung von ganzen, geschnittenen und durchstochenen Knollen mit Gibberellinsäure (GA) bei verschiedenen Konzentrationen zwei Wochen vor der Pflanzung, verglichen mit importierten ganzen Knollen (1960)*

TABLEAU 2. *Production et nombre de tiges après traitement à l'acide giberellique (GA) à différentes concentrations de tubercules entiers, coupés et perforés, deux semaines avant la plantation, en comparaison avec des tubercules entiers importés (1960)*

2.4. Fourth season (1961)

Since spring-grown, cold-stored seed is an alternative to imported seed, the three possible sources of seed for the spring season were compared.

Autumn-harvested tubers were cut in half and dipped in 1 ppm GA solution two weeks before planting. At the same time, tubers from the previous spring crop, kept in cold storage at 3°C from July, were removed from the cold storage and allowed to sprout under the conditions normally used for imported seed. The imported and the spring-grown local seed both consisted of whole tubers of the same weight as the seed pieces of the autumn-harvested, cut and GA treated tubers.

The experiment was carried out in randomized blocks with 8 replications, each plot containing 140 plants. The planting date was 8 March, the harvest date 10 July.

The highest yield, quantitatively and qualitatively, was obtained from imported seed (TABLE 3). Spring-harvested, cold-stored seed gave the same total yield as imported seed but the percentage of small tubers in the yield was higher, a phenomenon already known to local growers. Autumn-harvested cut seed treated with 1 ppm GA solution produced a yield 20% lower than imported seed. The high percentage of small tubers in the yield of spring-harvested seed was caused by the larger number of stems per plant, which are symptomatic of physiologically older seed potatoes. The small number of stems in autumn-harvested seed produced a high percentage of large tubers. In fact, there was no significant difference between the yield of marketable tubers from the autumn and the spring crops.

TABLE 3. Yield and number of stems per plant using seed from different sources (1961)

Source of seed *Herkunft des Saatgutes Provenance des plants*	Size of tubers – *Knollengrösse – calibre des tubercules* (%)			Yield – *Ertrag récolte* (kg/are[1])	No. of stems / plant *Triebe pro Pflanze Tiges par plante*
	small *klein petit*	medium *mittel moyen*	large *gross grand*		
Imported[2]	3,3	7,3	89,4	367	3,4
Spring harvested, cold stored[3]	8,4	14,1	77,5	368	3,8
Autumn harvested, treated with 1 ppm GA for 1 minute[4]	3,7	8,1	88,2	298	1,8
L.S.D. (at the 5% level)[5]				43,5	

[1] 1 are = 1/100 ha = 100 m².
[2] *Importiert – importés.*
[3] *Frühjahrsernte, kühl gelagert – récoltés au printemps, conservés à basse température.*
[4] *Herbsternte, behandelt mit 1 ppm GA während 1 Minute – récoltés en automne, traités avec 1 ppm de GA pendant 1 minute.*
[5] *G.D. (kleinste gesicherte Differenz) P = 0,05 – D.S. (entre rendements moyens) au seuil de probabilité P 0,05.*

TABELLE 3. *Ertrag und Anzahl Triebe pro Pflanze bei Gebrauch von Saatgut verschiedener Herkunft (1961)*

TABLEAU 3. *Production et nombre de tiges par plante à partir de plants de différentes origines (1961)*

3. DISCUSSION AND CONCLUSIONS

Autumn-harvested seed cut and dipped in a 1 ppm solution of GA provides good quality planting material for the spring season. Quick and uniform emergence and normal growth and development of plants and tubers can be ensured by using a low concen-

tration of GA, which makes the treatment inexpensive. Nevertheless it must be admitted that imported seed is superior and produces yields better both in quantity and size grading. The differences of 10–20% are of such an order that there is little doubt which seed will be preferred by growers.

It is a difficult task to compete with high-quality imported seed. Locally produced seed is either too young, as in the case of the autumn-harvested, or too old, as in the case of spring-harvested crop, whereas the imported seed is in the optimal physiological state for Israeli conditions. In fact it would seem possible that the imported seed, which is the same as that used in Europe for spring planting, is physiologically too old when planted in April, or even in May in the northern parts of Europe. Israeli autumn-grown potatoes, which are too young physiologically for February planting, may be just at the optimal physiological age for April and May planting in European countries. In preliminary experiments carried out in Sweden (SLOMNICKI and LINNELL, 1958), encouraging effects were obtained with Israeli autumn-grown seed potatoes.

SUMMARY

Length of dormancy limits the use of autumn-grown seed potatoes for planting the spring crop. Trials of different treatments for breaking dormancy were carried out for four successive seasons (1958–1961).

Cutting the seed and dipping in gibberellic acid (GA) was effective in breaking dormancy. Cutting two weeks before planting and dipping the seed pieces in a 1 ppm GA solution gave the best results. Instead of cutting, smaller sized seed can be pierced, thus enabling the entire yield of tubers to be used for seed.

Higher concentrations of GA induced growth abnormalities in both plants and tubers without producing any improvement in the breaking of dormancy over the lowest concentration used (1 ppm). Physiological aspects of seed potatoes are discussed.

ZUSAMMENFASSUNG

EINFLUSS DES SCHNEIDENS UND DER GIBBERELLIN-BEHANDLUNG AUF SAATKARTOFFELN (HERBSTERNTE) FÜR DIE FRÜHJAHRSPFLANZUNG

In Israel wird der Gebrauch von Saatkartoffeln aus Herbsternte für die Frühjahrspflanzung durch die Länge der Keimruhe beschränkt. Während vier aufeinanderfolgenden Anbauperioden (1959–1961) wurden Versuche mit verschiedenen Behandlungen zur Brechung der Keimruhe durchgeführt.

Durch Schneiden und Eintauchen der Saatknollen in Gibberellinsäure (GA) wurde die Keimruhe wirksam gebrochen. Die besten Ergebnisse wurden erzielt, wenn das Saatgut zwei Wochen vor der Pflanzung geschnitten und die Knollenstücke in eine GA-Lösung von 1 ppm eingetaucht wurden (TABELLEN 1 und 2). Kleinere Saatknollen können statt geschnitten nur durchstochen werden, so dass der ganze Knollenertrag für Saatzwecke gebraucht werden kann (TABELLE 2). Höhere GA-Konzentrationen führten zu Missbildungen sowohl der Pflanzen wie der Knollen, ohne eine Verbesserung im Brechen der Keimruhe gegenüber der niedrigsten angewendeten Konzentration (1 ppm) zu bewirken. Physiologische Aspekte der Pflanzkartoffeln werden besprochen.

RÉSUMÉ

EFFET DU SECTIONNEMENT ET DU TRAITEMENT A LA GIBERELLINE DE PLANTS DE POMME DE TERRE POUSSÉS EN AUTOMNE EN VUE DE LA PLANTATION AU PRINTEMPS

En Israël, la longueur de la dormance limite l'utilisation de plants de pomme de terre poussés en automne pour la plantation de printemps. Différents traitements pour rompre la dormance ont été effectués pendant quatre saisons successives (1959–1961).

Le sectionnement des plants et le trempage dans l'acide giberellique (GA) sont efficaces pour rompre la dormance. Le sectionnement deux semaines avant la plantation et le trempage des fragments dans une solution à 1 ppm[1] de GA donnent les meilleurs résultats (TABLEAUX 1 et 2).

Les petits plants peuvent être perforés plutôt que sectionnés, ce qui permet alors d'utiliser la récolte entière de tubercules comme plants (TABLEAU 2).

Une plus haute concentration de GA provoquait le développement d'anomalies à la fois dans les plantes et les tubercules sans apporter d'avantage dans la rupture de la dormance, par rapport à la plus basse concentration utilisée (1 ppm[1]). Le point de vue physiologique est discuté.

[1] ppm = partie par million.

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