STUDIES ON THE PHYSIOLOGY OF DEVELOPMENT IN CROPS.

4. STUDIES ON PHOTOPERIODICAL CONTROL FOR TUBER-FORMATION IN SWEET POTATO

KIM, Yong Choll

(Dept. of Agriculture, College of Agriculture, Chonpuk University.)

金鏞喆 : 作物發育生理의 實驗的硏究

4. 「고구마」 塊根形成에 대한 日長効果에 關한 硏究

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INTRODUCTION

There were many works about the conditions concerning tuber formation of sweet potato for the cultivational purposes to produce its maximum yield, Most of such works have dealt with the external conditions i.e. moisture content and air supplying in the soil, redoxy potential of soil, nitrogen supplying etc. (Sugahara and Noguti 1940. Kamatani 1945.) As far as internal conditions, they dealt with the carbohydrates and nitrogen ratio, or regenerative and lignifing charactor of the tissues of roots which were to induced the tuber formation,

Such conditions studied as above mentioned would not be any determining or regulative conditions but nutritional or influencial conditions for tuber formation. Therefore it has been arisen as a question whether any regulative and determinative factors for the tuber formation are or not as a physiological phenomenon of development. Already, it has been indicated that the tuber formation has a intimate correlation with growing bud rather than leaves which produce carbohydrates, by writer (1953). As to potato, though some workers suggest that the tuber formation is a matter of surplus carbohydrate the others postulated existence of a specific hormone like factor for tuber formation.

Gregory (1953) demonstrated through his experiment that the tuber formation results from a stimulus formed or activated by specific conditions of temperature and photoperiod, and the stimulus appears to be transmitted through a graf union. He induced the tuber formation by short day and low temperature of dark period, i.e. 14°C for 16hour of dark period and 20°C during 8hr of daylight, while no induction took place when the potato plant was kept at 20°C for 8hr daylight followed by 8hr of artificial light (1000 f.c.) at 20°C and 8hr of darkness.

The experiment of this paper intended to know whether sweet potato shows same responce or not for similar photoperiod which Glegory adopted for potato.

Materials and Methods

The variety of sweet potato used for this experiment was Okinawa No. 100. Seedling tubers of medium size were sprouted in wood boxes filled up with sand, under a short day conditin by artificial light, that is, 8hr of 300 wt, electrical light (The light was kept by 1 meter distance from plant) followed by a darkperiod for 16hr, The range of temperature was 26.2°C through lighting period and dark period. After 20 days when the sprouted plant grew about 10 cm length. The three kinds of plant to be transplanted were prepared from the most uniform plants as follows. An apical portion which length was about 6cm, a cutting which possessed a leaf with a axillary bud and a cutting which had a leaf but its axillary bud was excited, were prepared. The three planted together in a bamboo box (diameter was 14cm and the hight 14cm) filled up with sand.

The nutrient solution of Nokuchi and Sugahara for water culture (i, e. NH_4 No_3 43 mg, KH_2PO_4 36 mg, Kcl 44 mg, $MgSO_4$ $7H_2$ 0175 mg, $Ca(No_3)$ 88 mg, $Nncl_2$ $6H_2O$ 0.3~1.0 mg, $Fecl_3$ $6H_2$ Ol. 0 mg, H_3BO_3 0.2~0.4 mg, H_2O1.) was supplied and the moisture content of boxes was kept at 45% of saturated point. The two kinds of photoperiod and temperature were offered. The one was 16hrs of artificial light followed by 8hr. of dark period, at 26±2°C for dark period and lghting period; the other was 8hr. of ar ificial lgiht at 24±2°C by following 16hr; of dark period at 16±2°C.

The artificial light was prepared 300W electrical light at 60 cm distance from plants. The latter conditons of photoperiod and temperature, resulted a complete absence of the tuber formation but the former conditions induced the tuber formation. So that it will be considered the former conditions must be a inductive stative state and the other non-inductive state.

Results and Observation

The growth of plants; —

The growth of plants was very poor unler the artificial light indicating tha

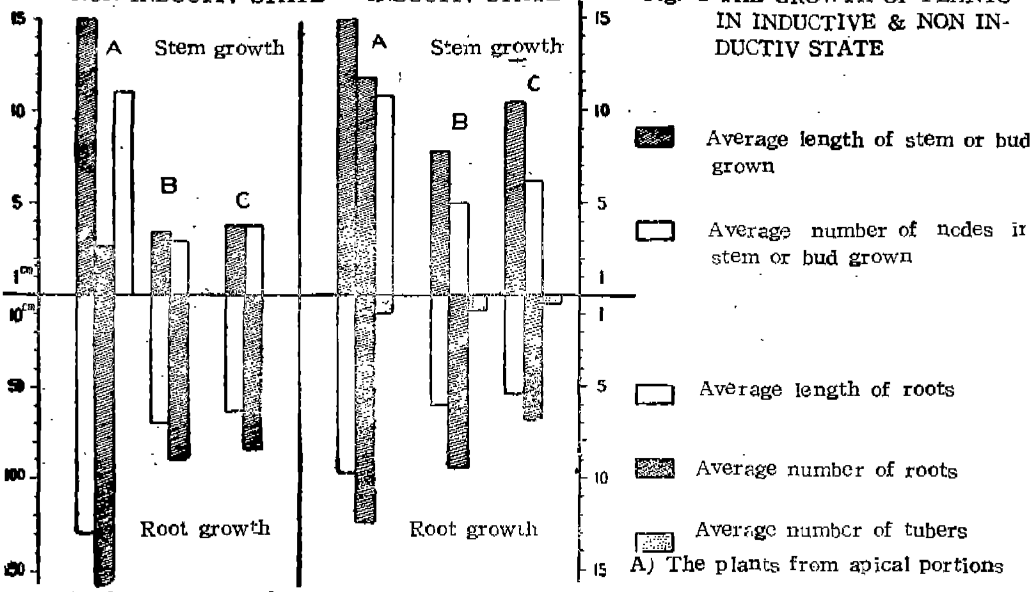


Fig. 1 THE GROWTH OF PLANTS IN INDUCTIVE & NON INDUCTIV STATE

A) The plants from apical portions
B) The cuttings with excied bud in-completely
C) The cuttings with a bud

the intensity of light for growth was very deficient. (Fig. I) The hairy stems and petiols indicated also the deficient light. So the blades of leaves were very small while the petiolls of leave and the internodes of stems were so much elongated that the plants looks very slender (Fig. II, IV). The most of the cuttings which were excised bud reformed new bud at the exiced trace, because of incomplete excisement. Notwithstanding the newly formed buds or formerly existed buds, the growth of buds in comparison with other growths i, e. root growth and the growth of plants from apical portion, was larger distinctly in inductive state than in non-inductive state. As Fig. II shown the relative growth ratio of the buds to the plants which were taken from the apical portion was 34% in inductive state, and 21% in non-inductive state. The growth of excised buds in inductive state was 7.9±1.21 cm

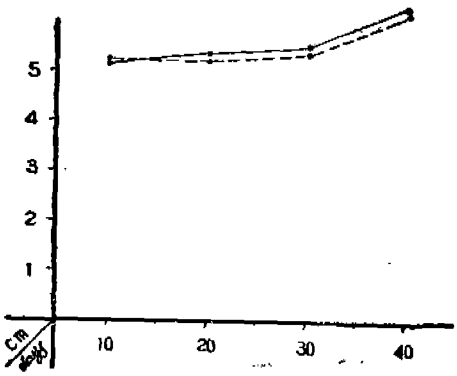


Fig II The growth of leaves in the cuttings
N-The length of blade in Non-inductive state
I-The length of leaves in inductive state

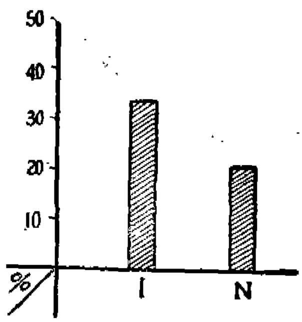


Fig III The relative grotwth ratio cf tuds
I-Inductiv state
N-Non-inductiv state

Table I Tuber formation of sweet potato under artificial light.
(40 days after transplantation)

Conditions	kind of plants	Number of tubers	Number of plants that formed tubers	Number of plants experiment
Inductive state	The plants from apical portions	12	8	12
	The cuttings with a leaf and a bud which excised incompletely	10	7	12
	The cuttings with a leaf and a bud	4	3	12
Non-inductive state	The plants from apical portions	0	0	16
	The cuttings with a leaf and a bud which excised incompletely	0	0	16
	The cuttings with a leaf and a bud	0	0	16

and non excised buds was 10.5±2.22 cm and the growth of buds in non-inductive state was 3.44±0.336 cm (excised), 3.90±0.26 cm (non-excised). The difference of growth of buds between inductive state and non-inductive state showed significant by statistical test. This fact coincided with the fact that the tuber formation had a intimate relationship. i.e. correlation with growing bud as indicated by writer(1953). The growth of roots in inductive state was less than non-inductive state on the contrary with the growth of buds. as Fig. I shown.

The tuber formaton; —

Though the growth of plant was very poor and the photosynthesis in inductive

(NON-INDU TIVE STATE) (INDUCTIVE STATE)

Fig. IV. a: The tuber formation of sweet potato under an artifical light.

Non inductive state · though the root growth was larger, tubers were not formed.

Inductive state···the tubers were formed.

The growth of plants were limited and looks slender. only the inductive state results tubers.

(I) (N)

Fig. IV. b: The tuber formation of the plants prepared from apical portion.

1. (No. 16)·· The plant formed tuber in inductive state.

2. (No. 4)·· The plant in non-inductive state.

(I) (N)

Fig. IV. c: The growth of sweet potato under an artificial light.

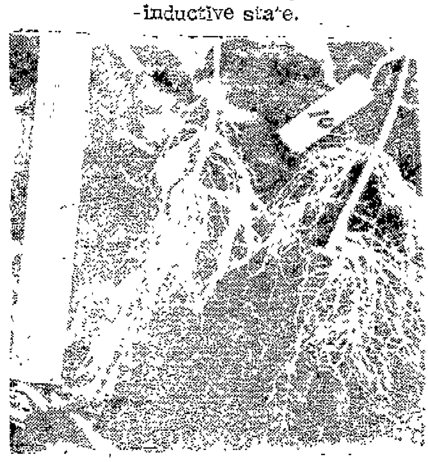
I · inductive state

N · Non-inductive setate

a···the plants from apical portions.

c···the cuttings which had a leaf.

Though the plants hardly showed any remarkable growth the tubers formed in inductive state not formed in non-inductive state



(I) (N)

Fig. V: The growth pattern of roots in sweet potato

I—the thin and delicate pattern in inductive state.

N—the stout and branchy pastern in non-inductive state.

state seemed limited under the artificial light, the tuber formation was very indicative but none of tuber formation was in non-inductive state as table I shown. (Frg. IV)

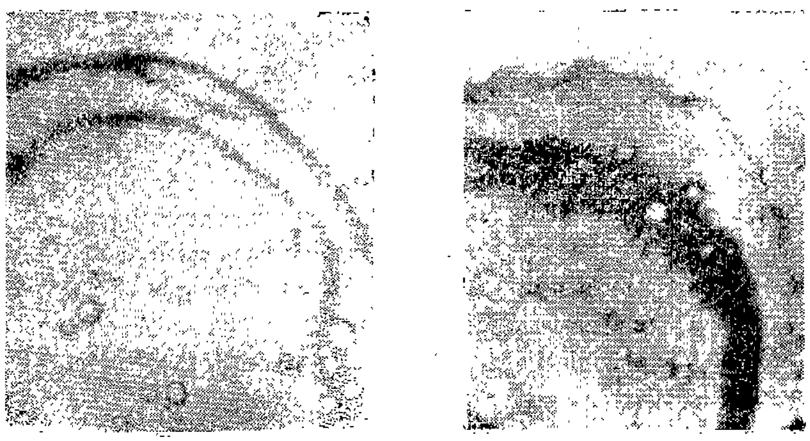
Some plants only having a leaf and a sprouting bud in inductive state formed tubers though they hardly showed any remarkable grow.has Fig IV. shown.

The difference of tuber formation between inductive state and non-inductive state were significant by statistical test. Among three kinds of plant, the plant from apical portion formed more tubers than other, and the cuttings which excised bud incompletely and reformed bud formed more tubers than the cuttings which not excised.

The growth pattern of roots and stems; —

The roots of inductive state were very different when compared with the non-inductive state. The roots of inductive stat look delicate and very thin except tubers, espesially branched roots were very thin. But the roots of non-inductive state look stout and they were more branchy than inductive sctate. (Fig. V)

The distinct different pattern of roots between in inductive and non- inducbtive state had none of exceptions. The stems of inductive state were harder and the xylem more dveloped in comparing with non-inductive state, while the stems of non-inductive state devloped its parenchyma tissue, so its diameter of stems were larger than inductive state (Fig. VI). Generally the leaves of non-induced state were more green then induced state.



(N) (I)

Fig. VI: the cross section of stems. (1956)
N—the stem cf noniodnctive state
I—the stem of inductive state.
C—Cortex. X Xylem. P—Parenchyma. V—Vacuoles

Discussion

In this experiment, the growt of plants and photosynthesis might be surpresed by insuficient, artificial light. But the tubers were formed in inductive state significantly, and none of tubers were formed in non-inductive state. This fact indicate that the tuber formation might have a stimulation which related directly with the conditions of inductive state, that is, continued long day (16L) and high temperature(26°C). It seems also that the physiological cuases or stimulation for tuber formation would be differnt from the physiological phase of growth of plants and of photosynthesis i.e. carbohydreate and light intensity etc. Though it was not certain that whether the result that none of tubers were formed in non-inductive state solely due to the short day condition or low temperature of dark period or to its combination, it was certain that the long day condition in inductive state promoted tuber formation. The results of this experiment with sweet potato were just contrary from the results of Gregory experiment with potato. His experiment indicate that the inductive condion of potato tuber was short day condition and low temperature at dark period and non-inductive condition was long day condition while the inductive condition of sweet potato was long day condition and high temperature and non-inductive was short day condition and low temperature of dark period.

Gregory demonstrated also that the stimulation for inducing tuber of potato were transmisible through the graft union as like the stimulation of floral stage caused by photoperiod. It was interested that the tubers of potatoes and sweet potato were stimulated by advers photoperiod knowing that potato was a long day plant for floral induction while sweet potato was a short day plant. It was also interested that the two kind of developmental phenomena, [i.e. flower and tuber formation were stimulated by adverse photoperiod, both in potato and sweet potato that is, flower of sweet potato was stimulated by short day while tuber formation was stimulated by long day period. This facts may deserve to consider any physiological and ecological significances. There were distinct difference between the root pattern of inductive state and of non-inductive. The roots pattern of inductive state were silky and thin while non-inductive state were branchy and stout. Each state had no exception about this special pattern of roots. The differene of root patterns of each state must have a intimate relation with the photoperiodical and temperature condition. and the difference might have also any relathon with the stimulation for tuber formation, B. E. Pilet and F. W. Went (1950) indicated that the growth of root and stem might have a new correlation with photoperiod and temperature, and that the effect of temperature on root growth is basically an effect on endogenous auxin supply. Pilet (1954) observed that lateral root production is possible only when the auxin concentration in the main root is high. It would be possible to interplete the branchy, stout root pattern of non-inductive state and sillky, thin root pattern of inductive state, and the more bud gr wth and the less root growth of inductive state in comparing with the non-inductive state etc, as a auxin physiology. It was presumed that the branchy pattern and larger root growth of non-inductive state might be resulted by supplying more auxin which was used for root growth. But the fact of larger growth of buds in inductive state made us to presume that the total auxin quantity activated by growing buds in inductive state would be much more than in non-inductive state. But inductive state may produce other stimulating factor for tuber formation rather than auxin and this factor make the supply of auxin concentrated to tuber formation cooperating with auxin. So that the supply of auxin only for root growth limited in inductive state and resulted the fact that the root growth of inductive state was inferier when compared with non-inductive state, and also resulted the silky, thin, pattern of roots. The tendency that root growth parallell with tuber formation in the case of inuctive state Fig. 1) coincided also with above postulation that tuber formation need more auxin from growing bud as well as root growth need auxin. The larger growth of roots and branchy pattern would be resulted from the more auxin supply only for root growth in non-inductive state as postulated above.

Summary

The cuttings and apical portion of stem in sweet potato were growh under artificial light and specific photoperiod and temperature. Though the plant growth was poor under insufficient light intensity of artificial light. the tuber formations were induced at long light period (16L+8D) and not induced at short light period (8L+16D) and low temperature of darkpariod. The determinative factor for tuber formation of sweet potato seems to be a stimulation which has intimate relationship with specific photoperiod and temperature and no direct relation with the growth of plant body and light intensity. The root pattern of inductive state for tubers and non-inductive state were different distinctly, the former were silky and slender, the latter were branchy, and stout appearence. This different root pattern must be due also to the specific photoperiod and temperature and may have any relationship with the stimulation for tuber formation from the point of auxin physiology etc.

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摘　要

1. 發芽時부터의 短日, 暗期低溫 條件下에서는 塊根은 全然 形成되지 않고, 長日條件에서만 塊根이 形成됨. 따라서 長日條件이 고구마塊根 形成에 대한 誘導條件 乃至 促進條件임을 알 수 있다.

2. 本實驗은 始終 弱電光(300W 電球 使用)으로 栽培하였기 때문에 同化作用이나 生長이 極히 微弱한 상태에서도 塊根이 誘導되었다. 따라서 塊根形成에는 同化物質이나 生長보다도 長日條件이 直接的決定要因을 이루는 1種刺戟을 成立하는 것으로 보인다.

3. 長日條件과 短日條件下의 根系가 서로 特異한 狀態를 나타냈고 그것은 短日과 長日條件이 이룬 刺戟과 관계하는 것으로 보인다.

4. 고구마塊根이 長日條件에 誘導되는 事實의 生態學的 意義를 考察함.