EFFECT OF POTASSIUM ON THE DRY MATTER PRODUCTION OF SWEET POTATO

— by —

.K Fujise and Y. Tsuno

The yield of crop is obtained through the process of dry matter production. Therefore, we have carried out the studies on the dry matter production of sweet potato in the last few years, to draw out knowledge which may be utilized for improving cultivation methods. It is considered that dry matter production is composed of three factors. The first factor is photosynthesis, the second factor is respiration and the third factor is distribution of dry matter produced. A series of experiments with sweet potato was undertaken to make clear the influence of the various environmental and internal conditions on these three factors.

However, in relation to actual cultivation technique, it is recognized that potassium is the most effective nutrient for increasing sweet potato yield. Therefore, it is very important to elucidate the relationship between potassium and dry matter production. We intend to report, here, with special reference to potassium of the studies on the dry matter production of sweet potato. Table 1 shows the effect of potassium on the dry matter production of sweet potato. Numerals in the table show the potassium plot as a percentage of the control plot. Potassium used in the high potassium plot is 1.5 times the control plot.

Table I. Effects of potassium on dry matter production (1962, Sept. 17)

Variety	Norin No. 1	Okinawa No. 100	Kanto No. 48
Total dry weight	109	109	112
Tuber dry weight	119	120	125
Top dry weight	100	96	96
Leaf area index	96	100	91
Net assimilation rate	126	128	123

Note:

1) Numerals show the percentage of high potassium plot for the control plot.
2) Potassium amount fertilized in the high Potassium plot is 1.5 times the control plot.
3) Net assimilation rate was calculated from two determinations, Aug. 27 and Sept. 17.

Tuber dry weight on the high potassium plot was about 20% higher than that of the control plot in the all three varieties, while the top dry weight, that is the aerial parts of the plant showed no difference between both plots. It seems that heavy application of potassium promoted especially the growth of tubers.

The increment of dry weight per unit field area is expressed with the product of "Leaf Area Index" and "Net Assimilation Rate". In this experiment, the "Leaf Area Index" was somewhat low in the high potassium plot as compared with the control plot, but the "Net Assimilation Rate" in the high potassium plot was about 20 to 30% higher than that of the control plot. This may suggest that potassium contribute to the higher photosynthetic activity of the leaves. We have confirmed in many experiments that potassium has really high positive correlation to the photosynthetic rate.

For instance, as shown in the sample correlation of Table II, photosynthetic activity showed a very high correlation with potassium content and a high correlation with nitrogen content, but did not show clear interaction with phosphorus

Table II. Correlation of the three major nutrient elements and starch content in leaves to photosynthetic activity (1963)

	Simple correlation coefficient	Partial correlation coefficient
Potassium	0.824 ***	0.095
Nitrogen	0.698 ***	0.119
Phosphorus	0.539 **	−0.082
Starch	−0.924 ***	−0.648 **

** Significant at 1% level.

*** Significant at 0.1% level.

content. Carbohydrate content in leaves had a high negative correlation with photosynthesis.

As intimate correlation, positive or negative, were found among factors concerning photosynthetic activity, such as potassium percent, nitrogen percent, carbohydrate content, it was not clear which one of these factors showed a true correlation with photosynthetic activity. Then, partial correlation coefficients were calculated between the factors and photosynthetic activity. In the partial correlation coefficient, a high negative correlation was found only between starch content and photosynthetic rate. All the other correlations were insignificant.

We have also observed the photosynthetic depression of the starched leaves in many other experiments. But, it is unknown which exert direct inhibitory influence upon the photosynthetic rate, either accumulation itself of starch in leaves, or translocation velocity of photosynthates from leaves.

Therefore, the diurnal changes of both photosynthetic and carbohydrate rate content in the leaf were determined, in order to evaluate the influence of carbohydrate accumulation in the leaf on the photosynthetic rate. Those are shown in Figure 1. Po, that is the photosynthetic rate showed no marked diurnal fluctuation through morning to afternoon, while the carbohydrate content as shown in the figure on the right side showed higher values in the afternoon than in the morning. It is considered from this figure that the carbohydrate accumulation does not exert, at least, direct inhibitory influence upon the photosynthetic rate. (see Table III).

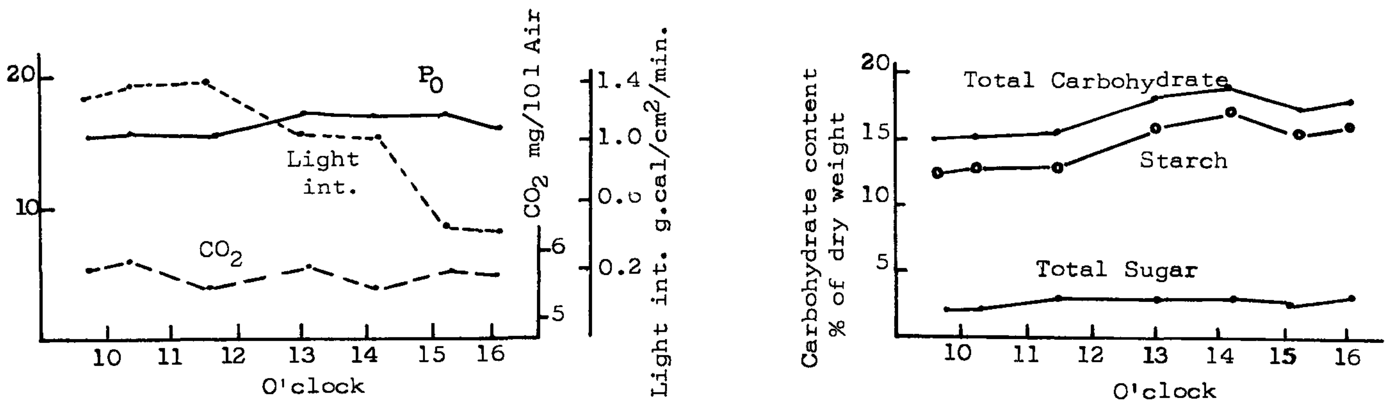
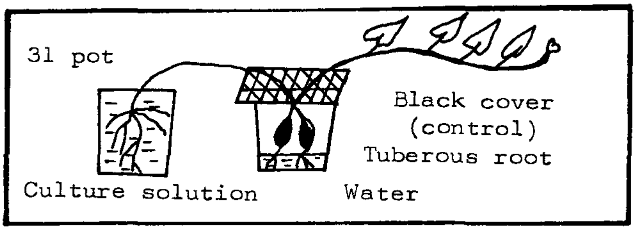


Fig. 1. Diurnal changes of Photosynthetic rate and Carbohydrate content in leaf blade (1963. Sep. 4)

Table III. The influence of exposing tuber to sunlight on photosynthetic activity and its concerning factors.

(Water culture as shown in diagram under the table, 1963)

	%, dry-weight of leaves			Tuber weight	Total weight
	K_2O	Starch	Pow	g/Plant	g/Plant
Control	2.50 (100)	16.88 (100)	27.1 (100)	35.70 (100)	96.20 (100)
Exposing	1.88 (75)	20.38 (121)	11.0 (41)	7.10 (20)	80.43 (84)



P_0W : Photosynthetic activity per unit leaf dry weight

mg CO_2/g/hr.

The growth of tubers, which are the largest acceptor (sink) of photosynthates, was inhibited by exposing tubers to sun light. The treated plant was increased in starch content of leaves and was depressed in its photosynthetic activity. In the table it was shown as PoW that is the photosynthetic activity per unit leaf dry weight. This is presumably due to the restricted translocation of photosynthatcs from the leaves. These results suggest that the rate of movement of photosynthates from the leaf (source) to the acceptory tissues (sink) is essential in controlling photosynthetic activity.

As shown in the figure under Table III, the absorbing roots and the bulking roots were cultivated separately in the individual pot.

The culture solution was filled in the left pot in which absorbing roots grew. The right pot filled pearlite and watered occasionally. To expose the plot to the sunlight, pearlite was removed at the beginning of tuber bulking. In the control, the surface of the pot was covered by black vinyl film to intercept the sunlight, after pearlite was removed.

In figure 2 which was obtained from the results of the gravel culture experiments, sweet potato was grown under identical nutritional conditions for 53 days prior to the treatments, then they were transferred to the different nutritional conditions. That is, C indicates Control, +K indicates high potassium, –N indicates Nitrogen deficiency, +NK indicates high nitrogen and Potassium, +N indicates High Nitrogen, –K indicates Potassium deficiency. Abscissa shows K_2O/N ratio, that is, the ratio of potassium to nitrogen in tuber. Ordinate shows the amount of increased dry weight of tuber during the experimental period.

Increase of the tuber dry weight runs parallel with the K_2O/N ratio in the tuber. The inferior tuber growth in both +N and –K plot was caused by the decreased K_2O/N ratio in the tuber . Therefore, it is very important to maintain high K_2O/N ratio in the tubers.

Figure 3 shows the relation between K_2O/N ratio of tuber and whole plant. As shown in the figure, the K_2O/N ratio of tuber was reflected by that of the whole plant. Therefore, it is necessary to rise the K_2O/N ratio in the fertilizer used, in order to keep a high K_2O/N ratio in the tuber.

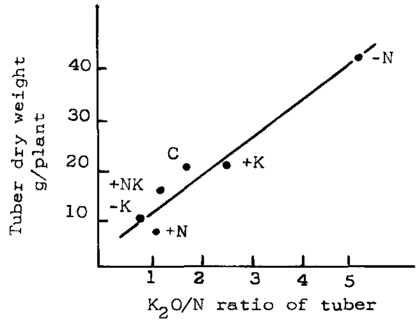


Fig. 2. Relation between K_2O/N ratio of tuber and tuber dry weight (1963)

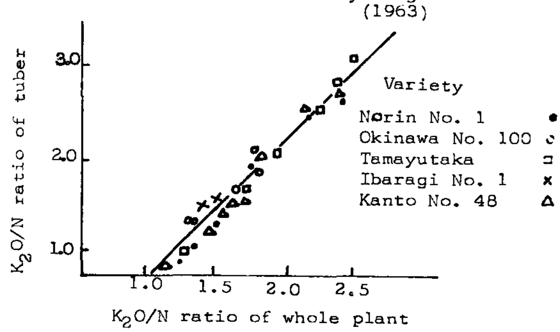


Fig. 3. K_2O/N ratio of tuber compared with K_2O/N ratio of whole plant (1963)

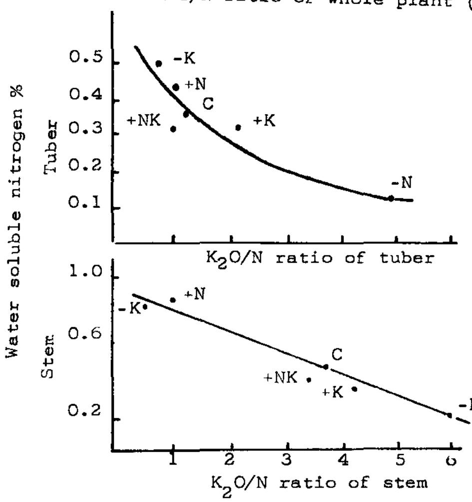


Fig. 4. Relation between K_2O/N ratio and water soluble nitrogen of tuber and stem

Then how does potassium participate in the growth of tuber ? Figure 4 shows the relations between K_2O/N ratio and water soluble nitrogen of tubers and stems. Water soluble nitrogen in the +N and –K plot considerably increased in both tubers and stems. This might be suggesting that protein matabolism was disturbed in the plant of these plots.

Figure 5 shows K_2O/N ratio and water content of tubers grown under the different potassium conditions. The white column shows the control plot, the half-shaded column the higher potassium plot and the shaded column shows the highest potassium plot. A, B, C and D are the varieties. Through all the varieties, the higher the K_2O/N ratio of tubers the more the water content of the tubers. An increase of the K_2O/N ratio in tubers seems to be beneficial for the hydration of tuber tissue.

In Figure 6 the relation between the respiratory rate of tuber and water content of tuber is shown. The water content of tuber was positively correlated with their respiratory rate. Through the increasing of the water content in tuber, potassium acts progressively for the respiratory activity.

In Figure 7, the relation between respiration of tuber and relative growth rate of tuber dry weight is shown. There is a close relationship between growth rate and respiratory rate of the tuber. Tubers showing a higher respiratory rate have also a higher growth rate.

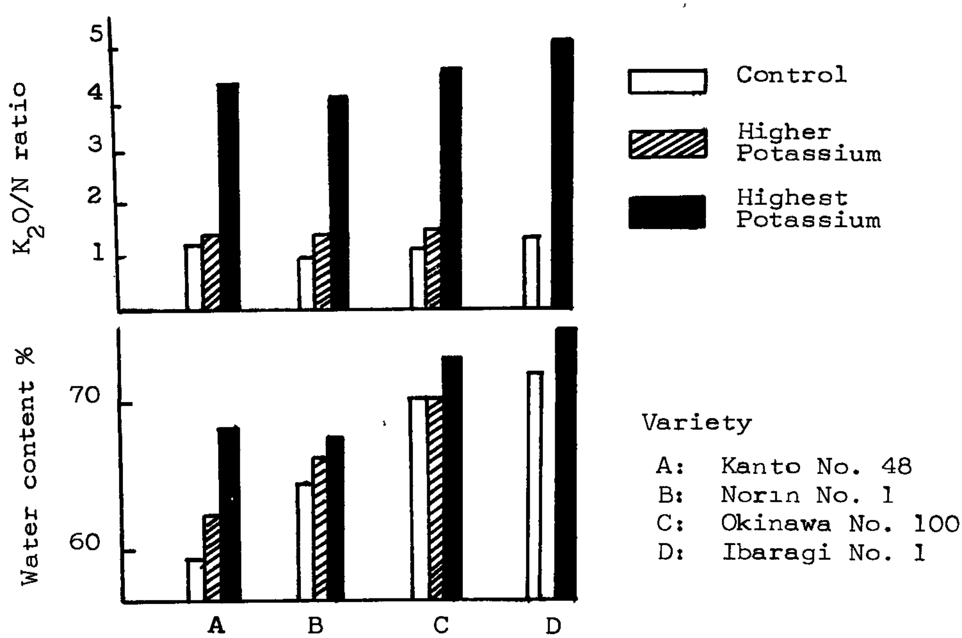


Fig. 5. K_2O/N ratio and water content of tuber grown under the different potassium conditions

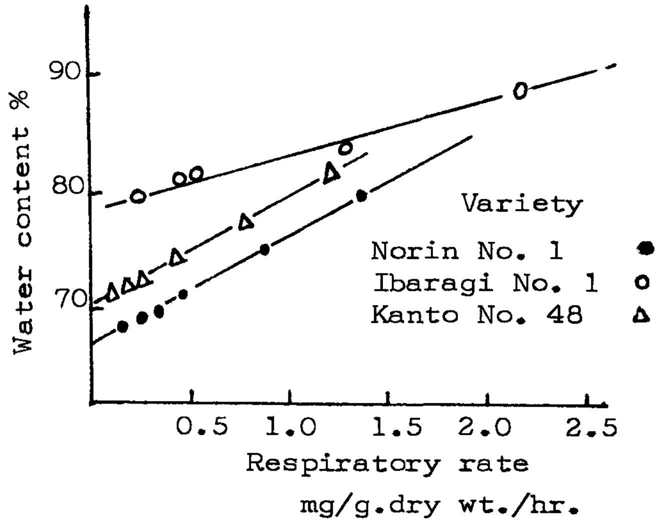


Fig. 6. Relation between the respiratory rate of tuber and water content of tuber (1962)

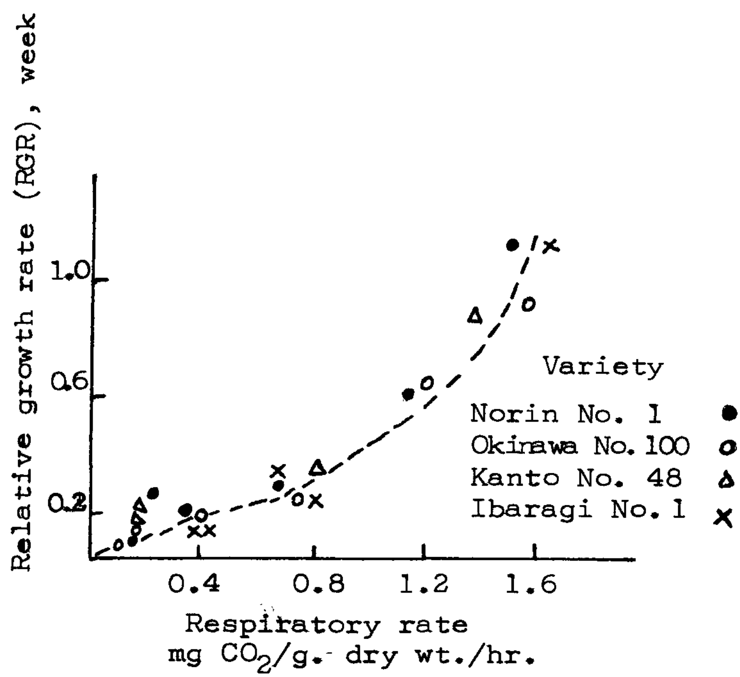


Fig. 7. Relation between respiration of tuber and relative growth rate of tuber dry weight (1962)

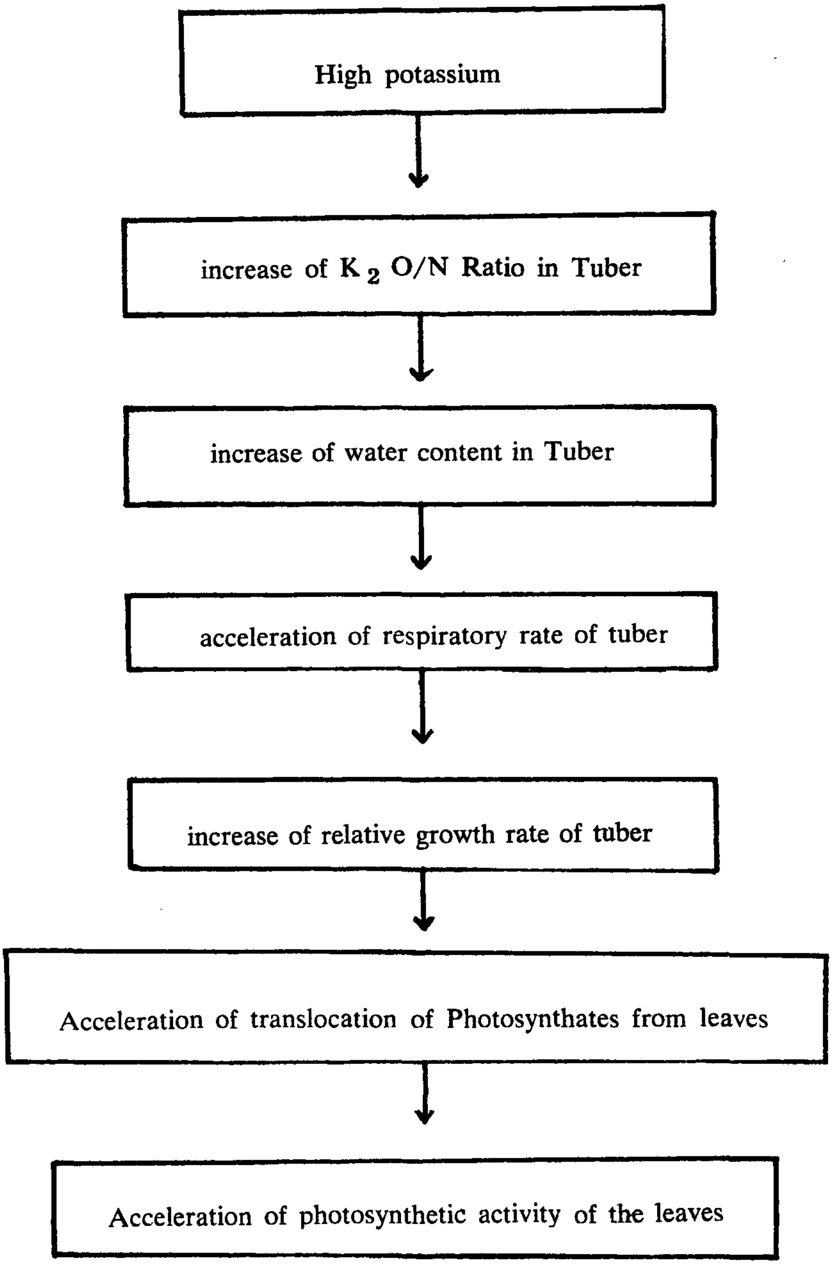


Fig. 8 Effects of high potassium on the acceleration of photosynthetic activity of leaves.

It was the final aim of our studies to increase the tuber yield in the actual cultivation by applying the knowledge obtained from the studies on the dry matter production of sweet potato.

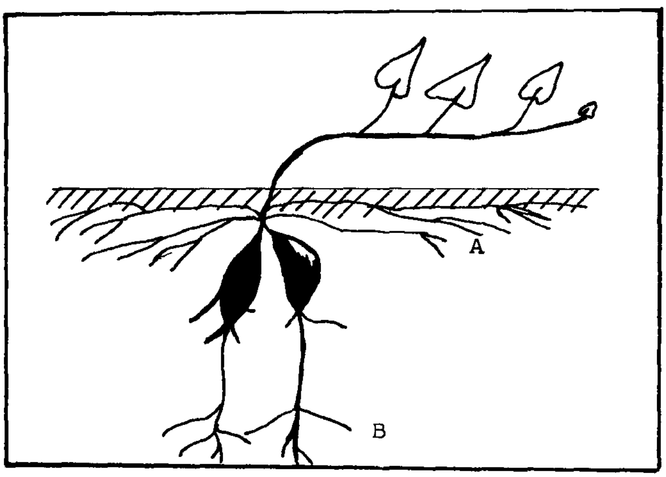
It is desirable to supply continuously a great deal of potassium in order to maintain vigorously the tuber growth until a late growth stage.

Now, as shown in fig. 9, the distribution of sweet potato roots was classified into the two kinds of type, that is, the first, shown as A in the figure was the roots near the soil surface, which were derived from the stem, the second, shown as B was the roots located in the deep layer of the soil, which were derived from the tuber.

The absorption of water and nutrient elements in the roots near the soil surface seemed to decline due to withering of the roots on a late growth stage, although the roots grown deeply in the soil seemed to be healthy until a late growth stage. On the other hand, we observed the facts that potassium existed in the deep layer of the soil on the farmer's field having a splendid harvest.

Therefore, we considered that it would be effective to apply the mineral manure especially potassium deeply in the soil for supplying the mineral nutrients to tuber until a late growth stage.

Table IV shows an effect of the deep application of the mineral fertilizer manure. Part 1 of the table shows the result of the fertile soil. The tuber yield of the plots 4 and 5 manured three major nutrient elements or potassium deeply in the soil were about 35 percent higher than that of the control plot in ordinary plough that is plot 6. The field of this experiment was fertile and the effect of deep plough was also observed.



A: Roots derived from the stem

B: Roots derived from the tuber

Fig. 9. Distribution of two kinds of the root

Table IV. Effects of deep application of mineral manure on the yield of sweet potato.

1) Fertile Soil (1966)

Plot	Top wt. kg/10a	Tuber weight kg/10a	Index		Dry Matter %	Amount of mineral manure elements kg/10a Surface N	P	K	Deep Place N	P	K	
I	3323	2696	100	121	32.4	3	10	10	—	—	—	Deep Plow
II	3960	2706	100	122	30.6	6	20	20	—	—	—	(27 cm)
III	3062	2850	106	128	33.2	3	10	30	—	—	—	
IV	3535	3029	112	136	32.2	3	10	10	2	8	8	
V	3233	2972	110	134	33.2	3	10	10	—	—	20	
VI	—	2223	—	100	—	3	10	10	—	—	—	Normal Plow

Variety Tamayutaka, Planting : May 25th, Digging : Oct. 24th

2) Poor Soil (1965)

Plot	Top wt. kg/10a	Tuber weight kg/10a	Index	Dry Matter %	Amount of mineral manure elements kg/10a Surface N	P	K	Deep Place N	P	K	
I	—	1890	100	33.3	4	5	20	—	—	—	Normal Plow
II	2930	2450	130	32.9	4	5	20	—	—	—	
III	3140	2360	125	33.8	4	25	20	—	25	—	Deep Plow
IV	3290	2450	130	33.0	4	5	10	—	—	10	
V	3160	2640	140	33.3	4	25	10	—	25	10	(40 cm)
VI	3140	2840	150	32.0	2	25	10	2	25	10	

Variety : Tamayutaka, Planting : May 25th, Digging : Oct. 20th

In the poor soil, as shown in Part 2 of the table, the effect of deep application of potassium only, that is, (Plot 4) was not more than that of the deep plough, that is (Plot 2). In this case, the deep application of three major nutrient elements, that is, (Plot 6), was only effective.

In the other experiment, it was observed that the deep application of potassium only in the poor soil withered the roots, whereas, the deep application of the nutrient elements kept the roots holding healthy.

It would be important that the balanced absorption of three major nutrient elements is kept on until a late growth stage for increasing the tuber yield. Thereby, the deep application of mineral manure would be an effective method.