Dr. Sidrak :

Prof. Milthorpe, if I have understood you correctly, at a particular stage of growth of the stem and leaves in Irish potato, a slowing down of the growth of the shoot and leaves takes place. Does this cause initiation of tuberisation or increase in the rate of tuberisation of the Irish potato? If so, can this be done on a large scale? Can we decrease or arrest the growth of the shoots in order to increase the tuberisation?

Prof. Milthorpe :

If leaf and stem growth slows down, then tuber initiation and growth usually commences. This can be achieved by applying stem-elongation retardants — substances like CCC and B9. Also, in natural conditions when the tuber starts to grow, then lateral branching and the initiation of leaves from the existing stems also ceases.

I think that in the Irish potato this is pretty much a straight competition effect, involving mobilisation of mineral elements. This appears to be the basis of senescence in this plant. In some other plants there are quite different responses, including very profound metabolic changes, involved in senescence. But I do not think that this is the situation in the Irish potato.

Dr. Sidrak :

Dr. Fujise, you mentioned that the increase in the potassium content of the leaf will cause an increase in the photosynthetic activity of these leaves. Does this continue to be the case, regardless of the age of the leaf?

Dr. Fujise :

The close relation between photosynthesis and potassium concentration is observed among the same aged leaves, but it is not observed among the leaves of different age.

Although potassium concentration in the younger leaves near the top of stem is not high, they have the higher photosynthetic activity.

When nitrogen content in leaves is low, for example, below about 2% in our experiment, photosynthetic activity is lowered, regardless of potassium content.

As Dr. Humphries indicated, we have also considered that photosynthetic activity will be controlled by the rate of movement of photosynthetic product from the leaves (source) to the tuber (sink).

Potassium will cause the acceleration of photosynthetic activity of the leaves, through the increment of tuber growth.

Then, it is more essential that potassium is continuously supplied to the tuber, until a later growth stage.

Mr. Coursey :

I would just like to make a very brief comment on Prof. Milthorpe's paper, to note that the growth patterns of the Dioscorea yams are in general, very similar to that of the Irish potato. I think the lag in tuber development after the leaf growth is rather long. Perhaps, it is somewhat intermediate between Irish potato and sweet potato.

Prof. Milthorpe :

May I ask a question following that? Is it possible to change readily the time of tuberisation relative to leaf growth in Dioscorea?

Mr. Coursey :

There is a great degree of plasticity in time of development of tuber. Even in one species there is adaptation to very wide ranges of climate as far as growth period is concerned. As far as type of tuber is concerned, that is an extremely complex issue.

Mr. Williams :

Can any of the speakers in this session suggest a rapid but reliable index which could assist the plant breeder in selecting out phenotypes which may, with a high degree of reliability, possess physiological characteristics, highly correlated with plant habit and tuber yield?

Prof. Milthorpe :

There is, of course, a working party in this Symposium examining this subject and I am sure that they will provide a much more profound answer than I can at this stage. Generally, I doubt if there is any one simple and reliable index which can be used to assess yield potential, except the yield itself. It is very important to follow the growth of the plant throughout its life in order to understand its behaviour and to assess both its good and poor qualities.

Dr. De Gras :

On the point of the pattern of tuber growth relative to the growth of the leaf stem I have noticed in two varieties of Dioscorea that the growth of the top is ceasing when the tubers begin to grow. This response will not be discussed in my paper, but I have a very precise indication about that.

Prof. Milthorpe :

I do not know whether I can profitably comment on what you have said. It seems to be a very similar situation to that in the Irish potato.

Mr. Gooding :

I observe that under Barbados conditions tuber bulking commenced within 6 weeks after planting and tubers were harvested 16-18 weeks after planting. This was considerably earlier than Walter's data from Trinidad presented as Fig. 1 by Prof. Milthorpe. Prof. Milthorpe, could you suggest some way by which Irish potatoes in the tropics may be manipulated to obtain higher yields? The one thing we cannot alter is uniformly high temperature. But I suspect that with all the physiological knowledge that is available today, there may be several "tricks" that could help us. The second question is to Dr. Fujise. In his table 1 he indicates that applying potassium at 1.5 times the control rate gave an increase in yield of approximately 20% in the tubers. What was the level of fertilisation in this experiment?

Dr. Fujise :

Effect of potassium on the tuber yield is different according to the nitrogen level and potassium level of the soil. Although, it is difficult to apply general cases, it, however, is important to keep the adequate ration of potassium to nitrogen 23:1.

If we manure 2 or 3 times potassium to nitrogen, it would be possible to increase 50% or more of tuber yield, compared with the case in which potassium is not manured, except in the special poor soil or in the nitrogen too rich soil.

Dr. Royes :

You mentioned, on the plasticity that existed in both the time of tuber initiation and the rate of tuber bulking, which varied considerably with various environmental factors. Have you found similar variations between varieties? And the relative extent of each in the environmental plasticity in the variation of the varieties.

Prof. Milthorpe :

Yes, there is quite a large varietal variation, but I think that one can almost achieve as much by agronomic management, of the one variety as one can, by altering genes, involving different varieties. Certainly, the late varieties of Irish potatoes, that is ones that initiate tubers late and give the highest yields, are more responsive to short days and to low temperatures than the early varieties. This means that when they are grown — as they are in Europe — under unfavourable daylengths, we have

a short-day variety which is initiating in the longest days of the year, because they are more responsive means that they delay tuber initiation. I think the key to some of the problems in tropical conditions may well be getting the seed bud tubers in the "correct" stage, at the time of planting. This again, one can do by 'management during storage', but this might be very expensive because it requires strict control of the temperature. Nevertheless, it is likely that the major problem may require very careful manipulation of the seed tubers between the time of planting and the time of production.

Dr. Wilson :

We have been coming around to the idea that the whole process of tuber bulking is the end result of a series of morphogenetic changes. I wonder whether Prof. Milthorpe could comment on this statement in relation to his observations with Irish potatoes?

Prof. Milthorpe :

I do not know whether I can add very much more to what I stated in my paper which I think emphasized this viewpoint.

Dr. Wilson :

I was thinking along the lines that tuber bulking is more dependent on these morphogenetic changes rather than the total amount of photosyntate produced.

Prof. Milthorpe :

I think that this is so. As I was trying to say before, I believe very firmly that the rate of bulking of the plant, and thereby the final yield, is set by about the time of tuber initiation. Thereafter, apart from one effect — the effect of shortage of water — the control is almost entirely by internal factors, the whole bulk of complex factors inside the plant.

Mr. Williams :

Mr. Gooding reported in a seminar recently presented at this university that tuberisation in the alata yams after establishment seemed to be delayed for a period of about 3-4 months after which tuber bulking and the elaboration of leaf area was very rapid. He apparently correlated this with the time taken for the morphogenetic differentiation of what apparently was a tuber primordium. We have made some similar observations in yams held in storage. Can you tell me if the pattern of development as suggested by this data diverges to any great degree from other root crops known to you?

Prof. Milthorpe :

No, not really. I think that, in a sense, the Irish potato will always respond in this way, but not to such a marked degree as you pointed out. I do not know if you established for this plant the case of tuber development. But certainly, it is true that in the Irish potato, if tubers are initiated at very early stages they do not grow rapidly at first; they grow at very slow rates for as long as 3-4 weeks before the rapid phase of growth commences. It might very well be so with the species of yams that you mentioned. But in the sugar-beet this would not be true no matter how the plant is manipulated. This plant is under what we may call "genetic control" as distinct from "environmental control".

Dr. Radley :

I should like to ask Prof. Milthorpe whether he had made any control environment experiments to establish his statement that events at or the time of tuber initiation control the subsequent bulking? This is a very important point, which I think may be readily explored by growing potatoes under different conditions and then switching plants from one environment to another and determining whether or not rate of bulking does significantly change.

Prof. Milthorpe :

No. I agree that this is a most important experiment to do and it is one which we have not done. The evidence on which I based this statement is perhaps tenuous, being solely the constancy of the rate of bulking with time in a varying environment.

Dr. Royes :

Referring again to Mr. Gooding's data of the early start of tuberisation and the fact that you mentioned that plants do not 'play the game' if you made them start tuberisation early, they tend to end up with a lower quota of tubers — in fact we want to change it very gradually to a much later date of tuberisation and therefore get a larger bulk of tubers at the end.

Prof. Milthorpe :

This is quite possible again. But I think that I cannot comment in detail here, because I do not know much about the plant. But I think that this is quite a possibility. The only way, of course, is to follow growth of the plant throughout its cycle, and see what is happening and attempt to change the response.

The type of response will change quite a bit with the species and this is why I tried to emphasise the differences between Irish potatoes and sugar-beet because they provide two extremes of plasticity.

Dr. Wilson :

I would like to make a comment on Dr. Radley's question, because it is the thesis on which some of my ideas on the importance of morphogenetic changes in tuber bulking are based. Now, some experiments, similar to those which you described, have been done by Evans' group at Cambridge and they found that when plants are changed from one set of conditions to another, e.g. from low temperature to high temperature, there were considerable alterations in morphogenesis of the plant. Such plants took some time to establish themselves in the new environment but the morphogenetic changes involved seemed to control photosyntate production and utilization rather than vice versa.

Prof. Milthorpe :

This is a comment on your comment. I believe that one needs to be cautious in arguing from the purely vegetative plant to the root crop. Also I think that the responses which you mentioned are those which are found in the very early stages of growth. The more the plant advances through its growth cycle, the less it responds to any changes in environmental factors.

Dr. Wilson :

I thought that it was rather interesting that in experiments carried out by Whitehead and Meyerscough, along similar lines, fruit yield was found to be related to what was described as 'a photosynthetic entity' which was itself an expression of morphogenetic changes that occurred throughout ontogeny.