Reprinted from the Proceedings of the Fifth Triennial Conference of the European Association for Potato Research, Norwich, September 1972. (Published 1973)

REQUIREMENTS OF THE USER OF SEED POTATOES

Standards of health, grading and physiological age; time and mode of delivery; price.

D. E. VAN DER ZAAG

Research Station for Arable Farming, Wageningen, The Netherlands

The Council of the E.A.P.R. have asked me to discuss the standards of health, grading and physiological age, time and mode of delivery and price of seed potatoes. It is clear that in half an hour it is impossible to go into all these matters in detail, or in relation to specific situations in particular European countries. I hope, however, that I will be able to give sufficient information to stimulate discussion between scientists and potato growers and also between producers and users of seed potatoes.

I am much indebted to the Association Representatives, who have given me information on the situation in their respective countries. This enables me to place my remarks – wherever possible – against a European as distinct from a national background.

Standards of health

One of the main purposes of seed potato production is to control diseases and pests. Initially, most attention was paid to the control of virus diseases. Nowadays, however, the control of fungal and bacterial diseases and nematodes by means of seed production techniques has assumed an equal or even greater importance, as shown, for example, by the clean seed project, developed in Scotland.

Virus diseases

In 1970 Reestman published a great deal of information, both from his own work and from the literature, on the effect of virus diseases on the yield of ware potatoes. This depends ón (1) the crowding coefficient of the crop and (2) the relation between the yield of a crop with 100% healthy plants and a crop with 100% virus diseased plants.

The crowding coefficient is mainly determined by soil fertility (including manuring), weather conditions and variety. Reestman found in his experiments a relative crowding coefficient of about 2.

Under poor growing conditions the coefficient will be 1–1½ and in fields with abundant haulm growth it may be 2½ or more. Yield reduction by virus infection is mainly determined by the type of virus and is chiefly caused by reduction in haulm growth. The more haulm growth is reduced by a virus, the more the yield will be affected. Under western European conditions we can conclude from the literature (summarised by Reestman, 1970) that leaf-roll and severe Y and A virus will often reduce yield by about 50%, while with X, S and mild A virus the reduction will seldom exceed 25%.

In Fig. 1 yield reduction is shown in relation to the percentage of virus infected plants. Both of the factors mentioned have been incorporated in this figure, which was prepared by means of the formula developed by Reestman (1970). From the data in Fig. 1 it can be concluded that:

1. Yield reduction in fields with less than 5% diseased plants is negligible. Even in fields with 10% secondary leaf-roll, yield reduction will rarely exceed 2–3% given good growing conditions. This is in good accord with the 10% of virus diseased plants permitted in certified seed by agreement within the countries of the Common Market and that is advised by the Economic Commission of Europe.

2. The more vigorous the haulm growth of the healthy plants, the less is the effect of virus diseased plants on total yield.
Under poor growing conditions the effect is, therefore, naturally larger than under fertile conditions.

It has been estimated, in collaboration with the Association Representatives that in Europe (excluding the U.S.S.R., D.D.R., the Balkan countries, Italy and Spain) virus infection exceeds 10% in 20–25% of the potato acreage. This shows that there is still room for improvement.

Another aspect of the problem is that of economics. The extra cost of producing seed with a high standard of health must not exceed the profit received by the increase in yield. I believe that many growers in western Europe could use seed of a lower class for their ware crop (*i.e.* a lower standard of health with respect to virus infection) than they do at the moment. This point will be discussed further under the heading "Price".

Fungal diseases

We are interested only in diseases that are transmitted by seed tubers and which can cause considerable losses in ware production. Special attention must be paid to dangerous fungi that can survive in the soil. From among all the fungal diseases that may affect seed potatoes we will discuss only six.

Phytophthora infestans

Many growers try to minimise late blight infection by spraying. It is also very important to avoid primary foci arising from infected seed. Two or three infected tubers per bag of seed mean about 100 such tubers per ha. This is sufficient to produce in a susceptible variety one primary focus per ha. (Hirst 1955; Van der Zaag 1956). In particular, seed that is planted in regions where late blight is common, should be substantially free of tubers infected with this fungus. In some years much of the available seed of susceptible varieties does not, unfortunately, meet this requirement.

Rhizoctonia solani

Rhizoctonia can influence both the emergence of the crop and the shape and appearance (black sclerotia) of the harvested tubers. Though this fungus is a normal soil

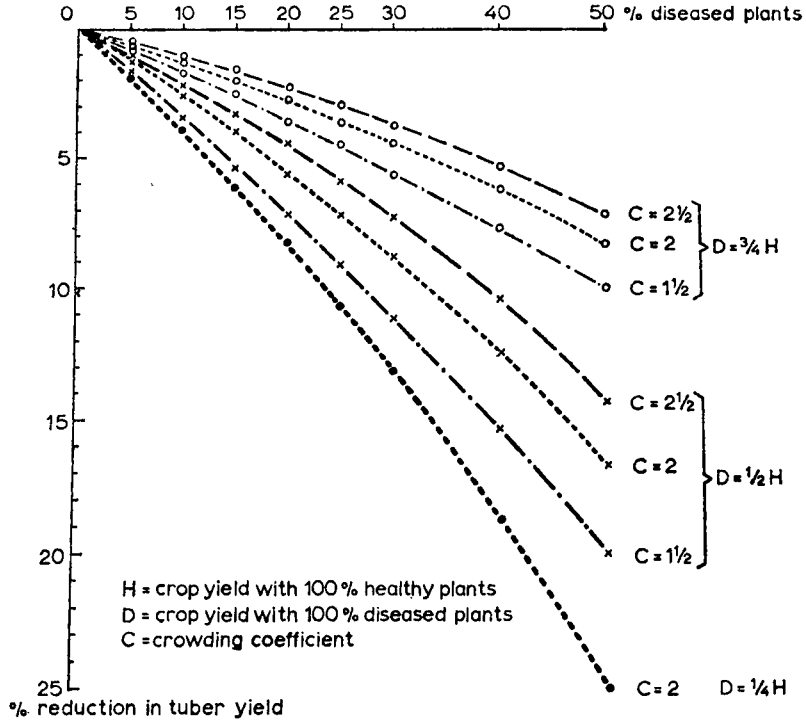

Fig. 1

Yield reduction in relation to percentage of virus diseased plants, type of virus and and crowding coefficient (derived from data of Reestman, 1970).

organism on many soil types, seed infection may play an important role in reducing both yield and quality.

On sandy soils, with a high organic matter content, and on heavy silt soils, however, seed infection has a less marked effect. Seed disinfection is so complicated and full of difficulties that ware growers should be supplied with seed that has been disinfected or that is so clean that disinfection is unnecessary. That means that the large majority of the tubers should be clean and there should not be too many tubers with some small sclerotia. Tubers with thick black sclerotia may not be present in good seed. How clean the seed must be, depends, however, on the soil type on which the ware will be produced and on the purpose for which the crop is to be grown.

Phoma exigua var. foveata

Gangrene is a dangerous tuber disease that is more or less confined to cooler areas of the temperate zones. Mainly from British workers it is known that it can cause extensive losses (Boyd, 1964; Kahn and Logan, 1968; Gray and Paterson, 1971). As the pathogen can survive in the soil and as it has not yet been found in many European countries, growers whose soils are free of it, should never plant infected seed. Even where the fungus is present in the soil, it pays to plant healthy seed. I should like to repeat the words of Dr. Boyd, spoken at the Pisa Conference in 1963: "Gangrene is a disease which merits more attention".

Oospora pustulans

Skin spot also tends to be confined to northern European countries. Seed with severe infection may lead to a diminished and delayed emergence, to a decrease in yield and to a severe infection of the harvested tubers (Boyd and Lennard, 1961; Bjør, 1970). It is assumed that the fungus survives in the soil.

It is clear that ware growers whose fields are still free of this fungus, must, as far as possible, avoid the use of infected seed.

Streptomyces scabies

This pathogen, which causes common scab, is a normal soil organism. In western Europe, on normal arable land, infection of the seed is not likely to influence the incidence of scab on the progeny if a normal crop rotation is followed (Labruyère, pers. communication). Another question is how far seed tubers with scab may reduce ware yield. In a recent publication, Wenzl and Demel (1971) dealt with this question. They found that tuber yield was not reduced if less than 50% of the surface of the seed tuber had been affected with deep common scab. For superficial scab there was not even a reduction in yield if 75% of the surface of the seed tuber had been covered. Therefore, the permissible level of occurrence of common scab in seed potatoes could be raised considerably without any danger for the user of the seed.

Helminthosporium atrovirens

Silver scurf is mainly transmitted by seed. Mooi (1968) found, however, that slightly infected tubers may transmit more inoculum to the progeny than severely infected ones. Zimmerman-Gries and Blodgett (1970) found that in Israel there was no difference in disease incidence between the produce of slightly or severely infected seed. If tubers are so severely infected that they have become severely shrivelled, sprouting and also emergence can, however, be delayed. Such tubers should not occur in seed.

Other fungal diseases transmitted by seed, such as wart disease, dry rot, early blight and verticillium wilt cannot be discussed in the time available to me.

Bacterial diseases

Two dangerous bacterial diseases that do not occur in most European countries are brown rot (*Pseudomonas solanacearum*) and ring rot (*Corynebacterium sepedonicum*). All precautions must be taken to prevent their entry into areas at present free from them.

Another well known bacterial disease is black leg (*Erwinia carotovora* var. *atroseptica*). The pathogen is transmitted by seed and several research workers have assumed that it does not survive in the soil. However, survival in ground keepers cannot be excluded. The danger is that the seed can be infected without showing symptoms (Pérombelon, 1970). Black leg may reduce yield, but more important are the subsequent storage losses which may occur, mainly through secondary infection. For this reason alone the percentage of seed tubers infected with black leg bacteria should be kept extremely low. I believe that much of the certified seed in Europe does not meet this requirement.

Nematodes

The most dangerous nematode is *Heterodora rostochiensis* and careful precautions are taken to limit its spread. The certification requirement that the seed must be free of cysts of this nematode is essential. For that reason alone no reasonable farmer would now permit the planting of uncertified seed from other farms on his land.

Defects

One defect I should like to mention here is greening of the tubers. For seed tubers this has no disadvantages whatsoever, but nevertheless in all regulations regarding seed, greening is regarded as a defect and the percentage of green tubers permitted is restricted. Ware growers could assist seed producers considerably if they would help to have this unnecessary restriction lifted.

Grading

Difference in seed size may result in differences in stem number, in emergence and in haulm growth during the first week thereafter. Yield and tuber size of the harvested tubers are largely determined by the number of main stems per m^2 (Fig. 2). Assuming that seed of 28/35 mm give rise to an average of three main stems, seed of 35/45 mm to

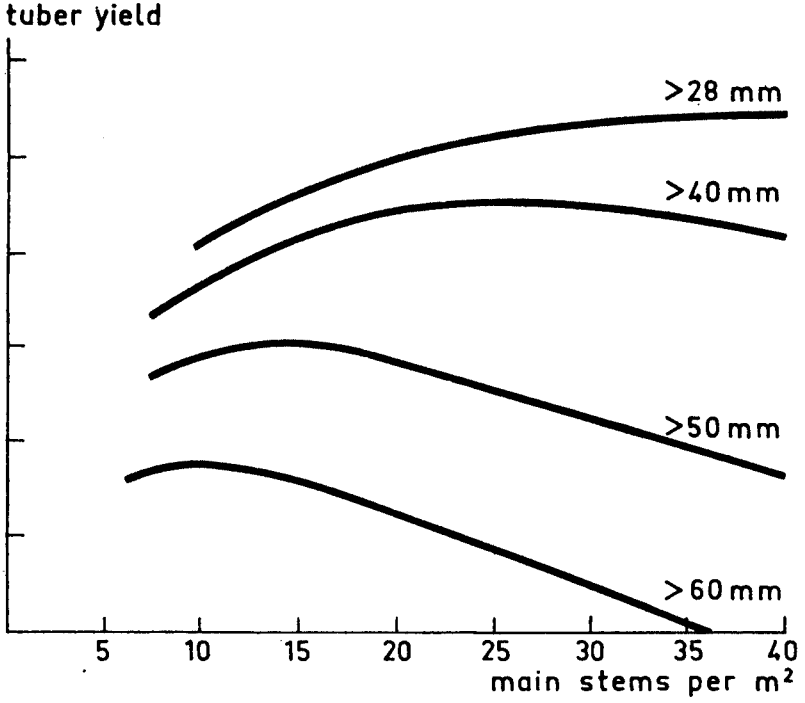

Fig. 2

Relationship between number of main stems, yield and tuber size (derived from data of Reestman and Bodlaender).

an average of 4½ main stems and seed of 45/55 mm to an average of six main stems, then in order to obtain the same number of main stems per m^2, the relative weight of the three size grades required for planting would be as 4:6:9.

For early crops, early emergence and rapid haulm growth is essential and growers should use large seed despite the extra cost of storage and planting. In other cases where earliness is not so important, seed price will come more in the picture, approximately this same ratio of 4:6:9 being applicable to the prices of size grades 45/55, 35/45 and 28/35.

Another question is the influence of variation in seed size on yield and tuber size of the crop produced. There are no indications that a mixture of small and large seed produces a lower yield than when the same seed is planted in separate size grades. No reliable data are available on the effect of variation in seed size on the grading of the crop produced. Such an effect might be of practical importance. It is at this moment more important for growers to know that most modern planters plant much more regularly if the seed used is reasonably uniform in size. For that reason seed size should not vary much more than 10–15 mm. However, in many European countries, the majority of the seed used varies by more than 15 mm (e.g. Poland, Czechoslovakia, Germany, Austria, U.K. and Denmark). Much could be done to improve this situation in Europe.

De Haan (1968) found that tubers of the variety Bintje of the size 35–45 mm varied in weight from 20–140 g and tubers of 45–55 mm from 70–240 g. In view of such wide variations, grading on a weight basis for seed seems worthy of discussion, although if applied to seed alone it is doubtful if the extra cost involved would not exceed the extra profit to be gained.

Physiological age

During the last few decades a number of research workers have proved that the physiological age of the seed tuber has an effect on crop growth (Kawakami, 1952; Pérennec and Madec, 1960; and others). This factor may affect the number of main stems, rate of sprouting and haulm growth, ratio of haulm weight to tuber weight and time of tuber initiation.

The number of main stems per plant increases with the physiological age of the seed tuber. Initially the rate of sprout and haulm growth increases, later on it decreases. The ratio of haulm weight to tuber weight and the number of days between emergence and tuber initiation decrease with the physiological age (always on the basis of the same number of main stems per m^2). The effect of the physiological age of the tuber on sprout growth is shown in Fig 3.

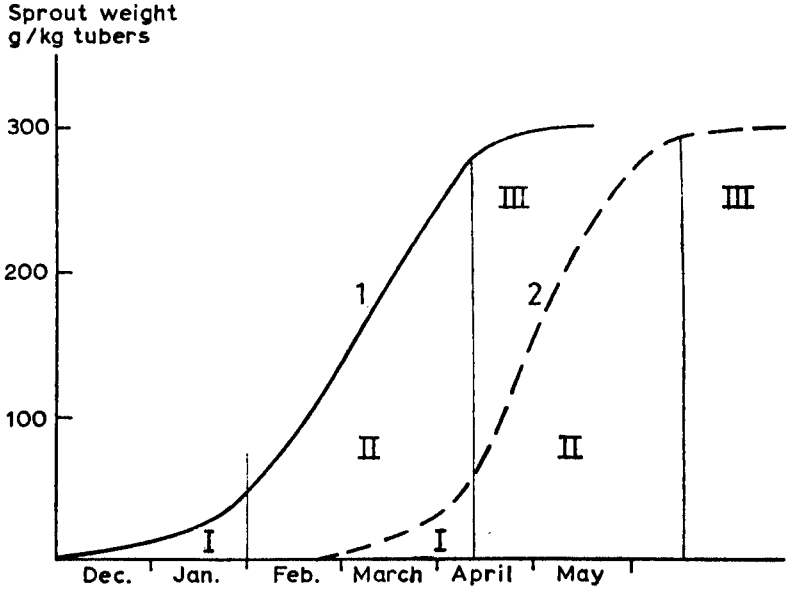

Fig. 3

Sprout growth in relation to physiological age of the tuber (data of Hédou, 1965).

Seed tubers should be in phase II at planting time. For crops that must be harvested early, seed should be used that is at the end of phase II (seed 1) and for crops that must give maximum yield over a long growing season, seed that is at the beginning of phase II (seed 2) is preferable.

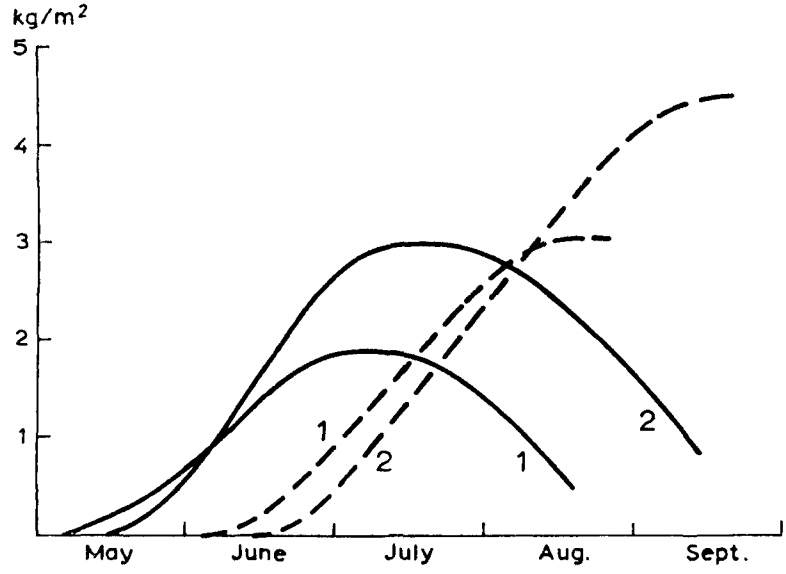

Fig. 4

Growth types:
1 from physiologically old seed.
2 from physiologically young seed.
——— *haulm growth*
— — — — *tuber growth*

The difference in growth of plants from seed that is at the beginning and at the end of phase II is shown in Fig. 4. As the number of main stems is also an important characteristic of a potato crop, growers should take into consideration the relation that exists between physiological age of the seed tuber and the number of stems per plant when planning the pretreatment of the seed.

The physiological age of the seed is determined by the growing conditions of the preceding crop and storage conditions. When the seed is delivered a few weeks before planting the ware grower depends on both the skill and integrity of the seed grower to have an assurance that the seed is at the correct physiological stage. In practice almost no attention is paid to this most important factor. In most years, however, we believe that the majority of the growers in western Europe receive their seed in a near optimal physiological condition. We think, however, that following hot dry summers and warm autumns seed from much of the continent that is to be used for the normal ware crop may well be at the end of phase II (Fig. 3, Seed 1) before planting. On the other hand seed from northern countries like Scotland or Northern Ireland when produced in a cold wet summer may well be difficult to bring to an optimal physiological state for the grower of early potatoes by planting time in March. Furthermore, seed from northern Europe, planted in southern Europe in November and later, will not always be in an optimal physiological condition.

Much attention has been paid to the health standards of seed. Physiological age standards appear to be very important also, but less amenable to application in practice than are health standards. Now would seem to be the time for ware growers to demand seed of a specific physiological age. This requirement is especially important now that more and more seed is being delivered only a few weeks before planting.

Time and mode of delivery

Time of delivery of seed varies from country to country. Switzerland and Czecho-

slovakia are countries where delivery in autumn predominates; while in Poland, DDR, France, Belgium and the Netherlands there is autumn, winter and spring delivery and in West Germany, Austria, U.K., Norway, Denmark and Sweden spring is the main delivery time.

There is an increasing tendency to deliver seed later. If the distance between the area of production and the area of use is not too great, it is much more economical for the seed grower to store the seed during the winter in order to avoid duplication of storage capacity, as is the case if seed is delivered in autumn or winter.

In all European countries seed is delivered in bags, except in the DDR where the main tonnage of seed is delivered in bulk. In Poland bulk delivery is practised on a small scale for lower class seed. In almost all countries trials are being made of boxes of 500 or 1,000 kg capacity for seed potatoes. In Sweden almost 10% of the seed is already either delivered in bulk or in 500 kg boxes. It is evident that within a short time much more seed will be delivered in these ways. Does the future lie in bulk delivery or delivery in boxes of 500 or 1,000 kg? Seed and ware growers should discuss these points between themselves. I assume that the problems and possibilities of boxes will be discussed tomorrow by Mr. Specht. A working group of the Association could, with great benefit, stimulate international co-operation on this topic. Not only technical problems are involved, but also physiological ones such as seed pre-treatment.

Price

I feel that it is not my task to say much about seed prices as this is a matter between the seed and ware growers. I intend, however, to make a few points.

1. We have seen that to obtain the same number of main stems per m^2 with all three size gradings, the weight of seed planted should be of the ratio 4:6:9 for the sizes 28/35, 35/45 and 45/55, assuming that the number of stems per plant is respectively 3, 4½ and 6. If we consider the seed requirements for a given area, small seed is therefore cheaper to transport, to store and to plant than is large seed; on the other hand small seed is slower in emergence and growth. In the Netherlands the price ratio between these gradings (28/35, 35/45 and 45/55) has, over the years, been about 10:7:5. This means that the ware growers in Holland find that the disadvantages of small seed slightly outweigh the advantages.

2. In most European countries the price ratio of certified seed delivered at the farm and ware grown on the farm is between 2:1 and 3:1. This means that a price difference between certified seed and ware of *f* 10–*f* 20 per 100 kg is quite normal.

Fig. 5, derived from Fig. 1, shows the points where the reduction in financial return through virus infection is in balance with the price difference of the seed used and seed

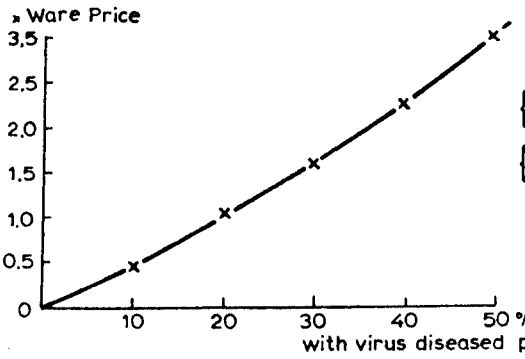

Fig. 5
Difference in seed price (expressed in terms of ware price) between seed with or without virus infection in relation to the reduction in financial return resulting from the use of seed with virus infection (derived from Fig 1).

producing less than 1 % virus diseased plants. This figure shows clearly that, with respect to virus diseases, seed growers must recognise that seed can rapidly become too expensive, especially where ware prices are low.

In a number of countries it is said that the price ratio seed:ware should not exceed 3 if ware growers are not to be discouraged from buying certified seed. In regions where the spread of virus is not rapid and increases in tuber infection by fungi and bacteria are not large, however, it pays even at a ratio of 2 to multiply certified seed once (once grown seed). This holds for many parts of Europe; as an example, in Denmark only 15% of the total potato acreage is planted with certified seed each year, yet less than 0·5% of the fields have more than 10% plants with clear virus symptoms. Not in all countries, however, would such good results be obtained.

Now we come to the main problem. From a technical point of view the use of certified seed is to be recommended. However, the danger is that if such advice were unwisely followed, the price difference between certified seed and ware would become so large that from the point of view of pure economics ware growers would have to multiply their own seed. If this were done on a large scale in Europe and done for a number of years, the health standard of the potato crop in Europe might well deteriorate to a dangerous level. It is, therefore, very important that everything should be done to keep the price difference between seed and ware to a reasonable level. The approach must be through rationalizing seed production and by avoiding exaggerated requirements. It would seem essential for seed and ware growers and scientists together to keep the problem under continuous review on a national and international level.

Summary and Conclusions

It is essential to bear in mind that for each requirement of the seed, the increase in price caused by this requirement must be smaller than the extra return obtained by the user.

1. Virus diseases remain important, but should not be exaggerated. Potato crops with 10% virus diseased plants need not be indicative of poor farming. In some European countries, however, considerable effort is still needed to reduce the number of diseased plants in ware crops.

2. Fungal and bacterial diseases that can be transmitted with the seed tuber need more attention in western Europe. Certification requirements for these diseases must be kept either at the same level or raised according to country and parasite. The requirement for common scab and the defect of tuber greening should be reduced.

3. Physiological age of the seed tuber is an important characteristic. Seed growers and merchants should take care that seed delivered a few weeks before planting is at the right physiological stage for the purpose for which the crop is to be grown.

Ware growers must, in turn, inform the seed grower or his merchant which physiological stage is required.

4. To improve fully automatic planting, seed size should not vary by more than 10 or at the most 15 mm. In several countries certified seed may vary by 20 mm or more.

5. There is a growing tendency to deliver seed a few weeks before planting. Furthermore it is expected that, in future, an increasing amount of seed will be delivered in bulk or in boxes of 500 to 1,000 kg. An international working group could study the various aspects of such developments which might well reduce the price of seed.

6. The extent to which certified seed is used depends on the price ratio between ware and seed. To keep the use of certified seed on a reasonable level this ratio must not become larger, preferably smaller, than it is at the moment.

Acknowledgements
I am grateful to Ir. Th. de Bruin, Ir. J. Hiddema, Ir. R. E. Labruyère and Dr. J. C. Mooi for criticizing the manuscript and to Dr. A. R. Wilson for language editing.

REFERENCES

BJØR, T. (1970): Observations on response to infection of *Oospora pustulans* in the potato varieties King Edward VII and Kerrs Pink, *Proc. 4 Trien. Conf. EAPR*, 191–192, *Brest, 1969.*
BOYD, A. E. W. (1964): Recent developments in mycology and bacteriology. *Proc. 2 Trien. Conf. EAPR*, 60–93, *Pisa, 1963.*
BOYD, A. E. W. and LENNARD, J. H. (1961): Some effects of potato skinspot (*Oospora pustulans*) in Scotland. *Eur. Potato J. 4*, 361–377.
GRAY, E. G. and PATERSON, M. I. (1971): The effect of the temperature of potato tubers in the incidence of mechanical damage during grading and of gangrene (caused by *Phoma exigua*) during storage. *Potato Res. 14*, 251–262.
HAAN, P. H. de (1968): Sorteerkenmerken bij aardappelen. *Jaarboek IBVL, 1967/68, Wageningen*, 22–42.
HÉDOU, J. (1965): Croissance et tuberisation de la pomme de terre. *Brochure d'information 20*, I.T.P. Paris.
HIRST, J. M. (1955): The early history of a potato blight epidemic. *Pl. Path. 4*, 44–50.
KAHN, A. A. and LOGAN, C. (1968): A preliminary study of the sources of potato gangrene infection. *Eur. Potato J. 11*, 77–87.
KAWAKAMI, K. (1952): Physiological aspects of potato seed tubers. *Mem. Hyogo Agric. Coll. 2*, 1–11.
MOOI, J. C. (1968): De aantasting van de aardappel door zilverschurft (*Helminthosporium solani*). *Versl. Landbouwk. Onderz. 716*, 1–62.
PÉRENNEC, P. et MADEC, P. (1960): Influence du tubercule sur la croissance et le développement du germe de pomme de terre. *Ann. Physio. Vég.*, 29–67.
PÉROMBELON, M. (1970): Preliminary implications for potato growing of recent research on bacterial soft rot/blackleg complex of potatoes. *Proc. 4 Trien. Conf. EAPR*, 131, *Brest, 1969.*
REESTMAN, A. J. (1970): Importance of the degree of virus infection for the production of ware potatoes. *Potato Res. 13*, 248–268.
WENZL, H. und DEMEL, J. (1971): Kartoffelschorf und Pflanzgutwert. *Pflanzenschutz Ber. XLII*, 137–154.
ZAAG, D. E. van der (1956): Overwintering en epidemologie van *Phytophthora infestans*, tevens enige nieuwe bestrijdingsmogelijkheden. *Tijdschr. Pl. Ziekt. 62*, 89–156.
ZIMMERMAN-GRIES, S. and BLODGETT, E. C. (1970): The incidence and tuber transmission of silver-scurf on potatoes in Israel. *Proc. 4 Trien. Conf. EAPR* 194–196, *Brest, 1969.*