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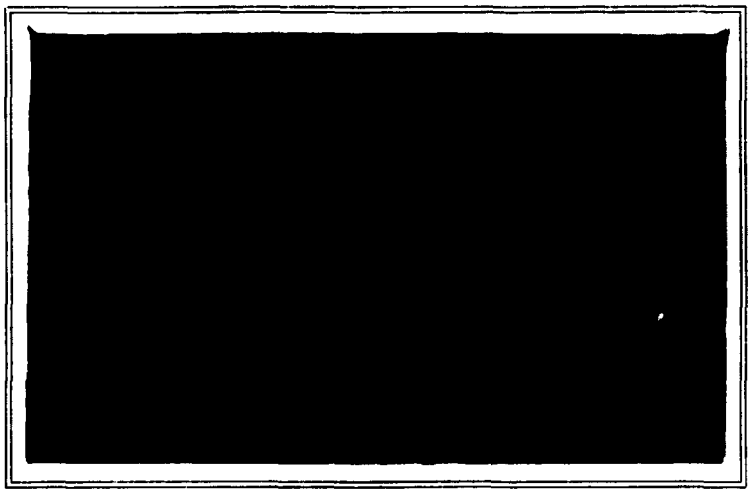

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EFFECTS OF GAMMA RADIATION ON FREEZE-DRIED WHEAT SEEDS*

by

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Abstract

The effect of radiation on freeze-dried wheat seeds are reported. The response of the various parts of the seedling to radiation was found to differ from one another. There was no significant modification of the effect of radiation on the shoot and root growth, while the growth of the coleoptile was slightly reduced in the freeze-dried seeds.

The change in the shoot growth-absorbed dose relationship reported by others to occur at high doses for oven-dried as compared to air-dried barley seeds was not seen for the control and freeze-dried wheat seeds. The freeze-dried seeds are believed to show only the effect of radiation without any modification due to drying as such. The dose-effect relationships may be splited into functions characterised by different radiosensitivity. The high sensitivity effect is mainly taking place within the first 40 krad of energy absorption, and the low sensitivity is dominating at higher doses.

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Introduction

The effect of ionizing radiation on seeds brought to different water contents by drying over different desiccating substances or in hot air has been reported by many authors. Ehrenberg (1955, 1955) and Caldecott (1954,1955,1958) working on different varieties of barley seeds and at various doses of X-rays, observed that the resistance to radiation decreases as the water content of the barley seed decreases. However, Ehrenberg and Nybom (1954), Caldecott (1954) and Sicard and Schwartz (1959) reported an inverse relation between radiation resistance and the water content below 15 %. Sicard and Schwartz further observed that the leaf growth of the air dried seeds (11% moisture) showed more growth than that of the oven dried seeds (3% moisture) at doses below 100 krad and at above 800 krad but not in between those two doses. Moutschen (1956) reported that the storage of seeds after irradiation caused a reduction of the reversal phenomenon on barley coleoptile, the reversal being completely eliminated after 20 days of storage.

Data on the effects of drying on seeds are scarce in the literature. Klingmüller and Lane (1960) observed that there was a dwarfing effect on the seedling height when Vicia faba seeds had been dried at 20°C by desiccators to a moisture content lower than 12%. Ajayi and Larsson (1975) freeze-dried wheat seeds and found that there was no dwarfing effect on the seedling growth. This indicates that the results obtained by the previous workers may have been heavily influenced by the method of drying. Since freeze-drying has been shown not to have effect on the seedling growth, radiation of freeze-dried seeds would therefore be expected to show the actual effect of radiation on the seedling growth.

The aim of the present experiment is to find the effect of radiation on seeds which are freeze-dried . Various growth parameters of the seedlings have been studied. The absorbed dose for which the root, the shoot or the coleoptile fail to develop will be refered to as the killing dose throughout the paper.

Materials and methods

One lot of the wheat grains, variety Starke II, was frozen to about -18°C for one month and freeze-dried at about -4°C, to water content of 9.3% of dry weight.

A sample of fifty seeds was taken each time from the lot and irradiated with gamma rays from a ^{60}Co source (Kinell and Larsson, 1960) for different lengths of times with a dose rate of 350 rads per min. as determined by Fricke dosimetry (Spinks and Wood, 1964). The seeds were kept in a single array in a glass tube of 0.4 cm internal diameter, which was bent into a semicircular form of mean diameter 15.0 cm and placed with the source at its center. The irradiation experiment was repeated with seeds that were not freeze-dried and were of water content 11.5%. The water content of the seeds was kept constant during irradiation by first closing the ends of the semicircular tube with rubber stopper, and using containers filled with dehydrating agents.

Immediately after the irradiating experiment, each sample was sown in plastic dishes containing moist sand (170 gm water to 1 litre of sand) as used for germination tests, and germinated in a climate chamber which was kept at 20°C, 60% humidity and artificially illuminated at 14 hours per day. The non-irradiated seeds used as control, were sown in the same dish. At first the dishes were covered with transparent glass plates for a period of five days to allow all the seeds to germinate under the same condition, using only the water contained in the sand.

The effect of irradiation was investigated with respect to the mean length of the root, the mean length of the coleoptile and the mean length of the shoot. Each of these parameters was expressed as a percentage of the control.

Results and discussion

Figure 1 (a) shows the effect of irradiation on the length of the coleoptile and on the length of the shoot while Figure 1 (b) shows the effect of irradiation on the length of the root for the freeze-dried seeds and the control seeds. In both cases the ionising radiation causes a reduction in the seedling growth. There is a strong reduction per unit of dose in growth between zero and 40 kilorads, followed by an interval of an almost constant length between 40 and about 300 kilorad

for the shoot and the root. At higher doses a further decrease becomes obvious. Also a strong reduction in growth was observed between zero and 40 krad for the coleoptile. This is followed by a region of slower reduction in growth. As seen in Figure 1, the radiation effects were relatively greater on the shoot and root growth than on the growth of the coleoptile. It was observed that the length of the coleoptile of the seedling from the irradiated and freeze-dried seeds was relatively smaller than that of the irradiated control seeds throughout the dose-range investigated except at very close to zero dose and at the 500 krad dose where the two appear to the same. A reduction in the length was observed between 0 and 100 kilorads for the seedling shoot, and between 0 and 40 kilorads in the case of the root. No appreciable difference was observed between the respective measurements for the control and the freeze-dried seeds above 100 kilorads for the shoot and the root. The killing dose was found to be about 500 kilorads for both the shoot and the root; the killing dose for the coleoptile was higher. The report of Sicard et al (1959) of a reversal in the shoot growth ionisation dose relationship at high doses between oven-dried and air-dried (Himalaya) barley seeds was not observed for wheat seeds used in this experiment.

The freeze-drying modification factor defined as the ratio of the doses to give the same seedling height for both the non-freeze-dried seeds and the freeze-dried seeds, was determined from Figure 2 and displayed in Figure 3 as a function of absorbed dose. The general conclusion of Caldecott (1954,1955,1958) and Ehrenberg (1955,1955) that expects the sensitivity of X-rays to decrease as the water content of the seed decreases is in agreement with the results of this experiment below 100 krad for the shoot and the root when the seeds are planted immediately after irradiation.

Figure 2 (a) shows the effect of irradiation on the length of the shoot and of the coleoptile when the irradiated seeds (the control and freeze-dried) were stored for a period of three weeks before planting, while Figure 2 (b) shows the effect for the root. In all the three cases, the length of the seedling parameters was smaller than that of the irradiated control between 10 krad and 160 krad for the shoot, between 10 krad and 180 krad for the coleoptile, and above 0.4 krad

for the root. Above 160 krad and 180 krad respectively, the root and the coleoptile of the freeze-dried seeds grew better than those of the irradiated control seeds.

The dose-effect relationships may be divided into three functions characterlized by different radiosensitivity. The high sensitivity effect is thought to take place within the first 40 krad of energy absorption. The low sensitivity dominates at higher doses followed by the "killing" sensitivity effect that appears to move down to lower doses as the irradiated seed is stored for longer periods before planting.

In conclusion, these results show that the process of freeze-drying of seeds only slightly interferes with the radiation effects on cellular multiplication in the seedlings tested. The study further put emphasis on the fact that effects of drying procedures employed in radiation studies should be considered as a possible source of difficulty in interpretation of results.

Acknowledgement

We wish to thank Dr. Tage Fritz of the Swedish Seed Testing Institute, Stockholm, for supplying us with the wheat samples used in this experiment. We also thank him , as well as the staff of the Gustaf Werner Institute and of the Institute of Radiobiology, Agricultural College, Ultuna, Uppsala, for their assistance and contributing discussion during the experiment.

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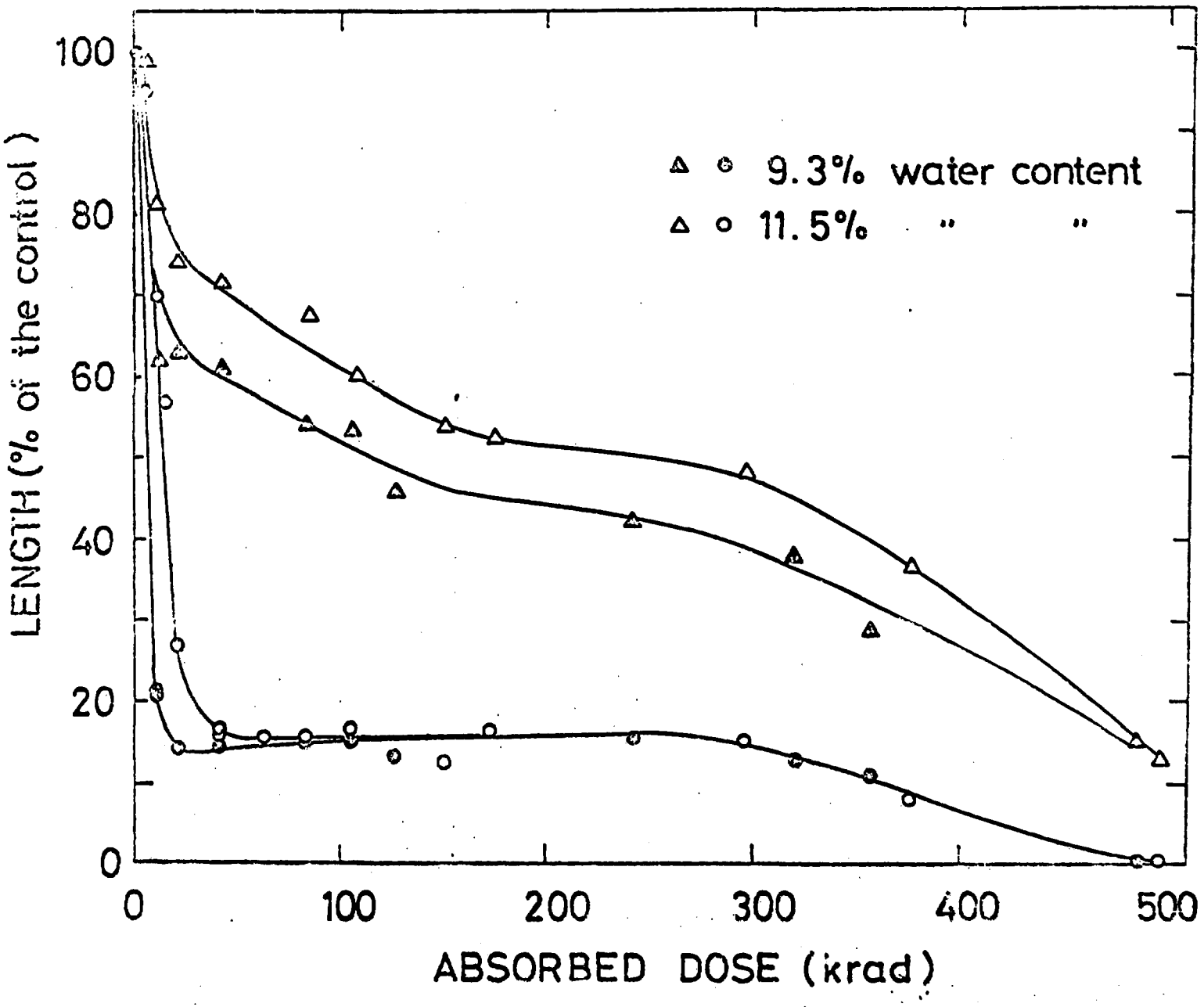
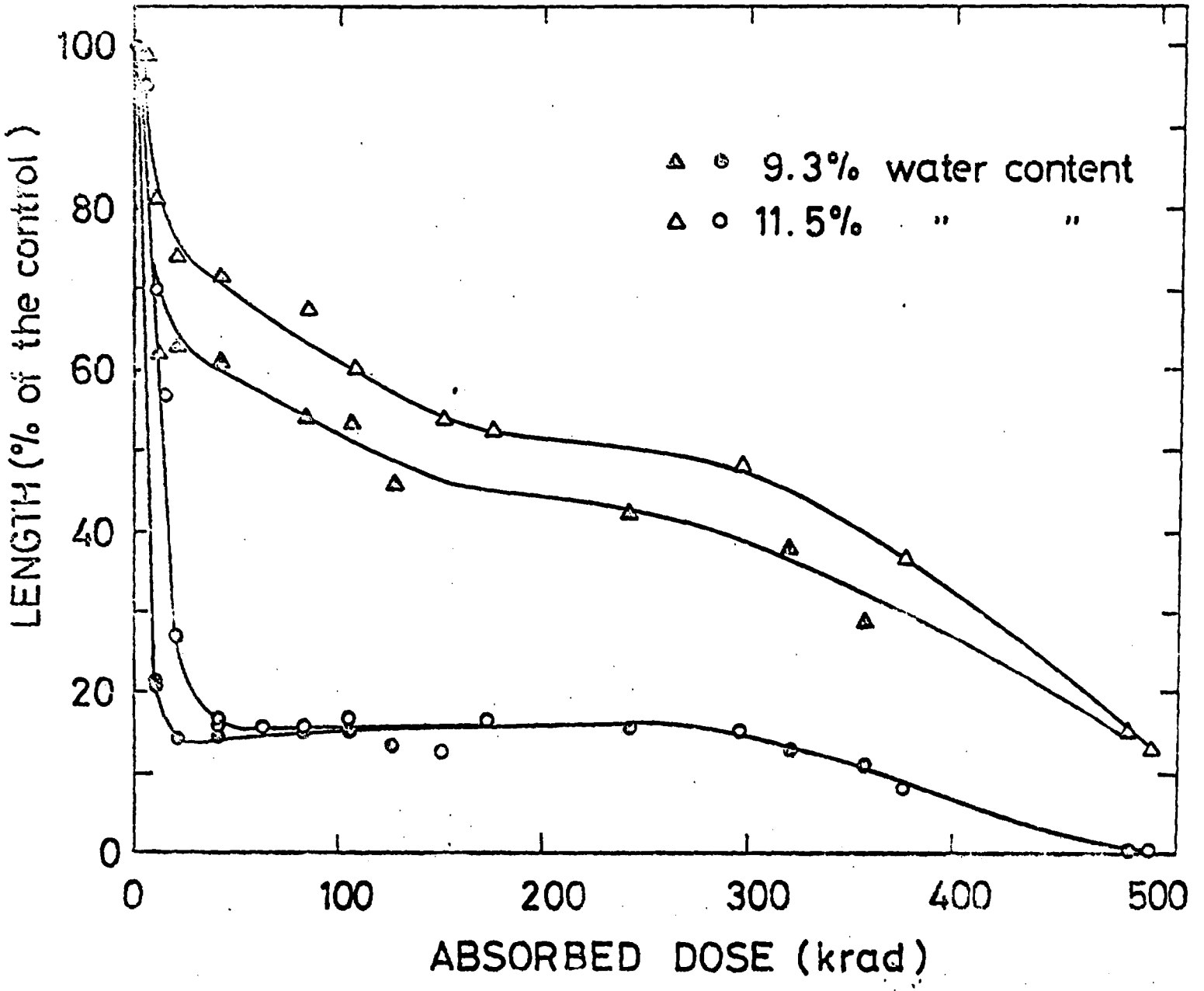


Fig. 1a The effect of irradiation on the length of the coleoptile and shoot of seedlings from wheat seeds planted immediately after irradiation.



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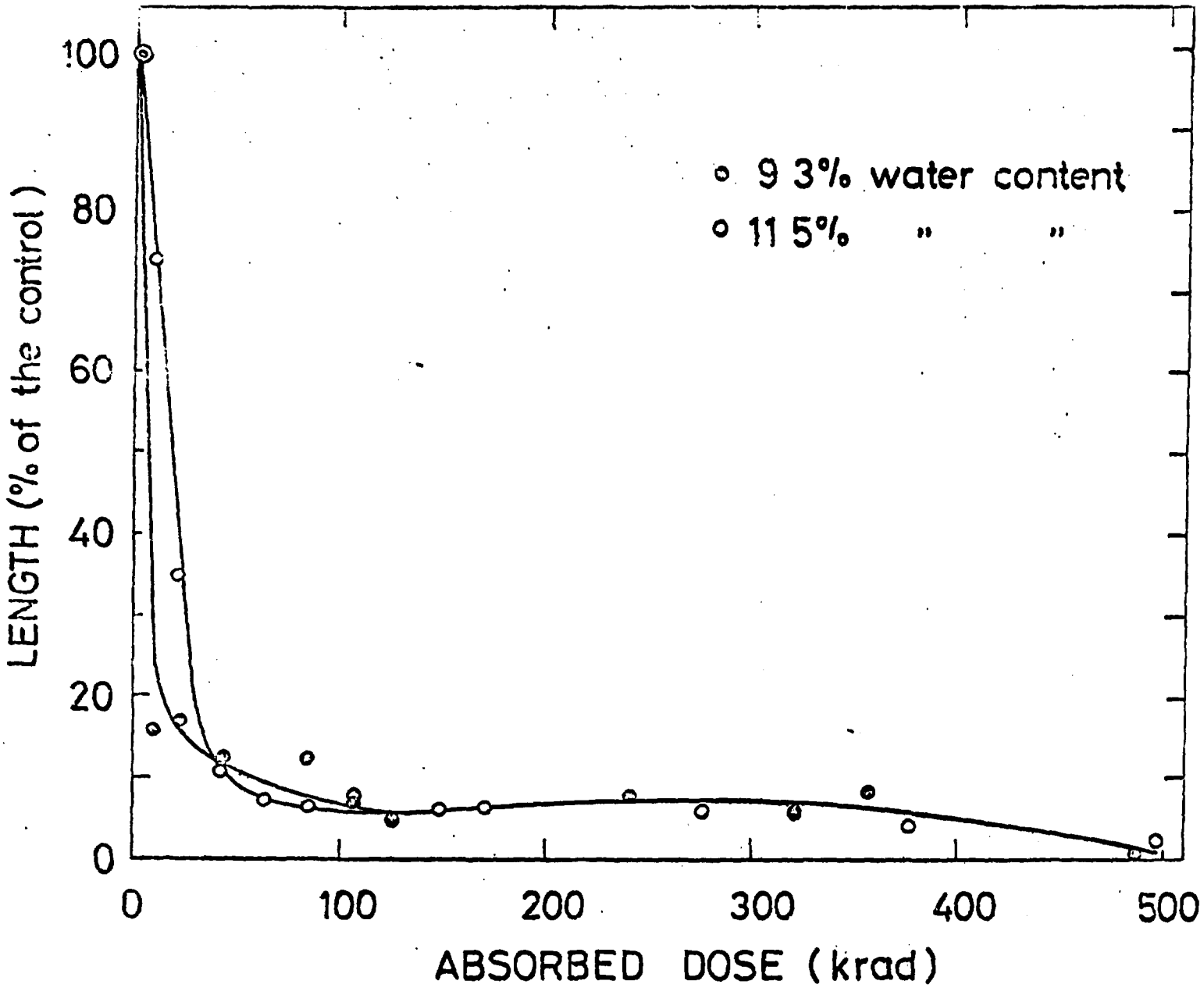

Fig. 1b The effect of irradiation on the length of the root of seedlings from wheat seeds planted immediately after irradiation.

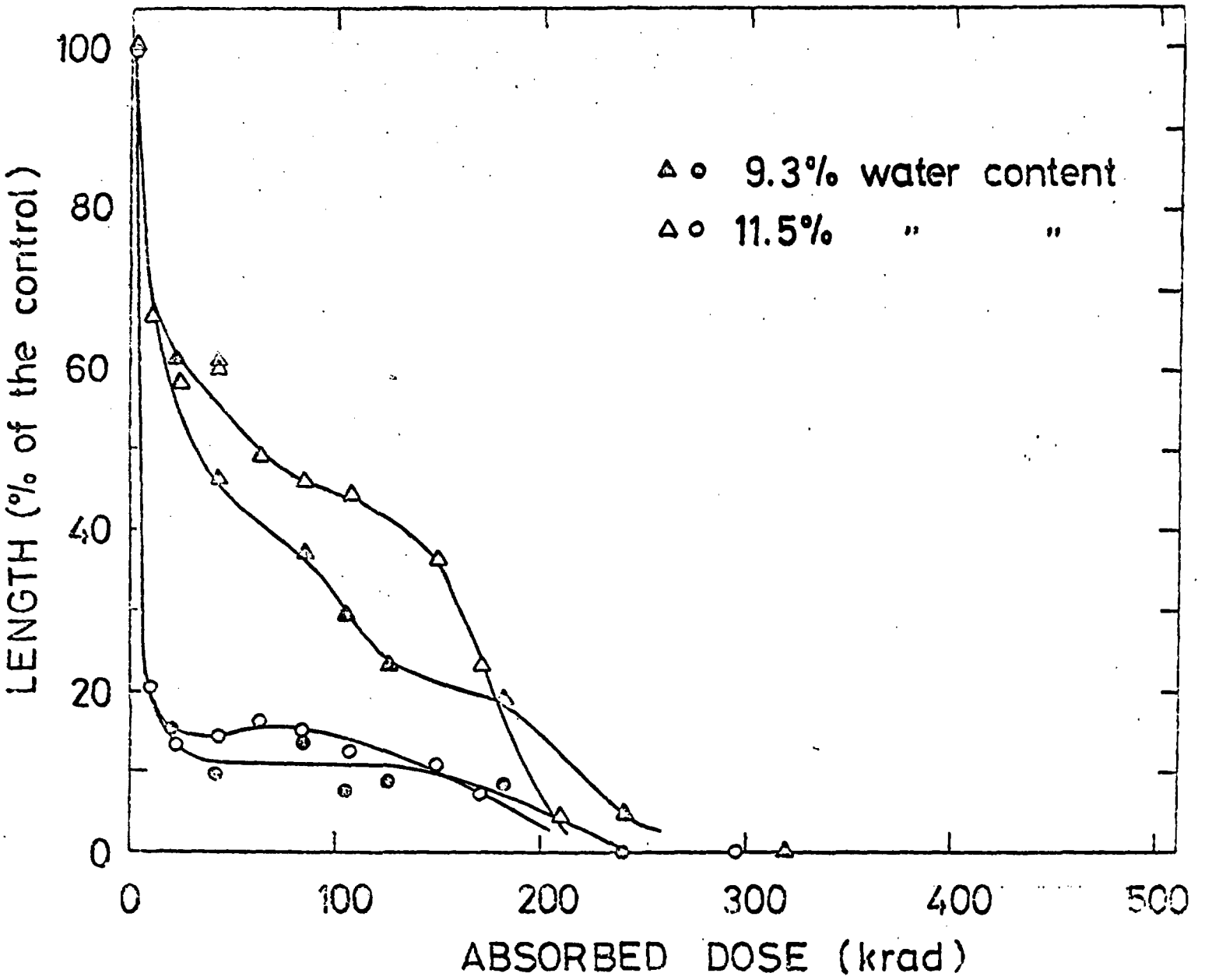

Fig. 2a The effect of irradiation on the length of the shoot and the coleoptile of the seedlings from wheat seeds stored for three weeks.

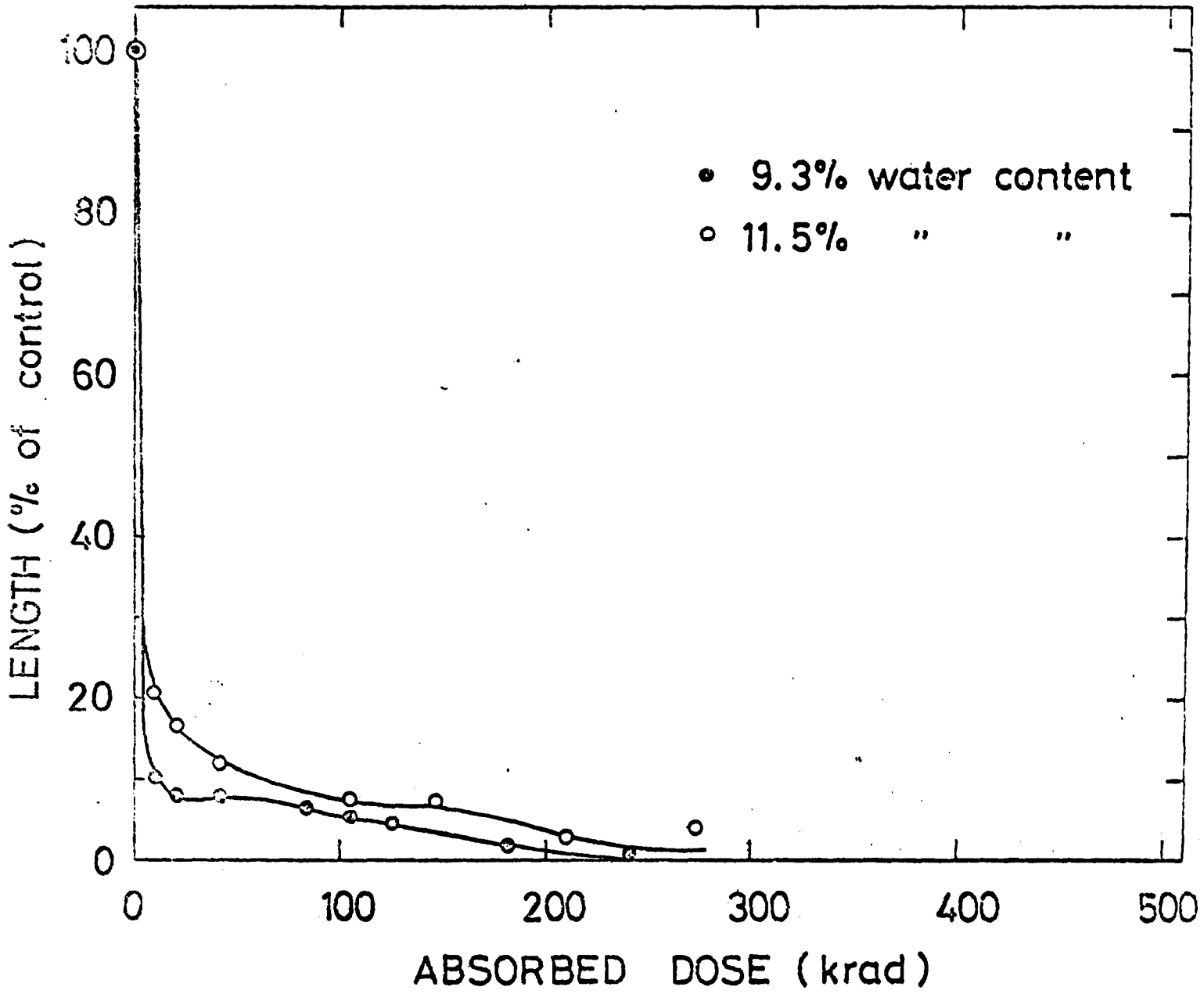

Fig. 2b The effect of irradiation on the length of the root of seedlings from wheat seeds stored for three weeks.

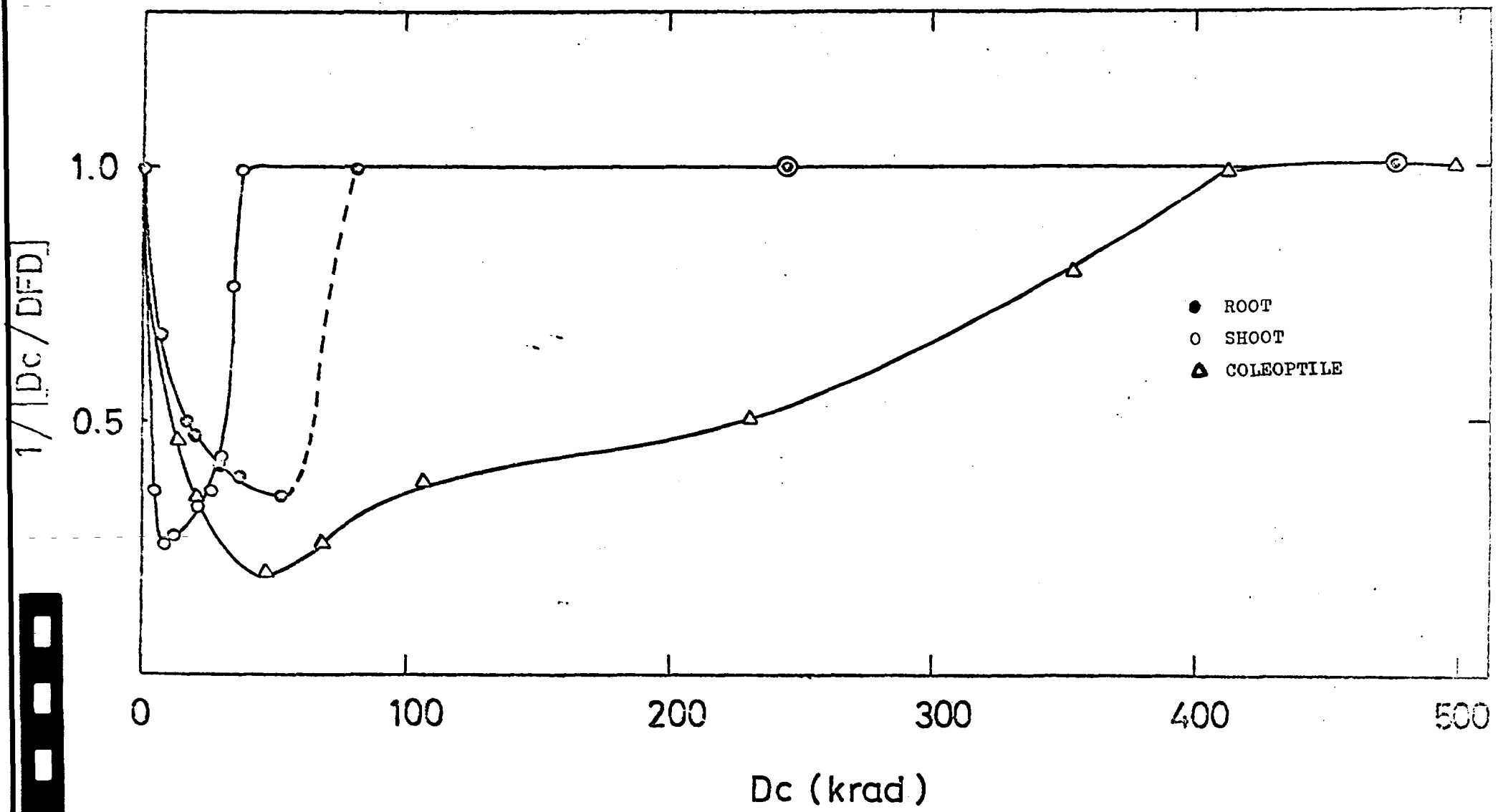

Fig. 3 The inverted freeze-dry modification factor (1/Dc/DFD) as a function of D_c • (D_{FD} = absorbed dose by freeze-dried seeds to give the same seedling height as the control seeds which absorb D_c dose).