Selection of avocado rootstocks, tolerant to saline irrigation water, and their vegetative propagation

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The aim of this work was to select types of avocado more resistant to a high salt concentration in the irrigation water than those used at present, and to propagate them as clonal rootstocks in order to ensure this characteristic.

The work is divided into two parts: the first part deals with the selection of avocado rootstocks tolerant to high saline irrigation water, and various aspects of ion absorption and their influence on plants. The second part deals with the vegetative propagation of avocado rootstocks, particularly the factors influencing rooting of avocado cuttings.

In 1957 a preliminary experiment was carried out, under glasshouse conditions with Mexican and West Indian avocado seedlings, using 3 types of soils and 3 constant salt concentrations within the soil. With the high salt concentration, (0.25%) all plants died within a short period; with the medium concentration, (0.15%) most Mexican and part of the West Indian seedlings died. In the controls all plants developed nicely. No significant differences due to soil types were found.

During the years 1958/60, a large scale experiment was carried out to select avocado seedlings tolerant to saline irrigation water, using 576 seedlings from 8 varieties 3 representing the Mexican and Guatemalan races, a hybrid between these two and a hybrid between the Guatemalan and West Indian races. The experiment was carried out under natural climatic conditions, in deep, large containers, buried in the soil. The plants were irrigated with water, containing 830 ppm sodium chloride except for the winter seasons, when plants received rain water only.

Periodical measurements on growth additions as well as grading of plants according to damage, were carried out. Leaf samples were taken every 2 months to study the chemical composition variations. Soil samples were analyzed to determine the changes within the soil during the experiment.

All plants showed various degrees of leaf scorch two months after the beginning of the experiment. Simultaneously a great increase in chloride concentration was found in the leaves. The percentage of sodium within the leaves was low and in most cases did not increase during the experimental period. Only in seedlings of the Mexican variety ‘Nortrop’ was a high increase of sodium in the leaves found after one year. This increase became more pronounced towards the termination of the experiment. Parallel to the high sodium concentration, damage symptoms appeared on the leaves, due to sodium excess. In the roots of all plants a high level of sodium was found, with a ratio of 1:10 up to 1:20 to that in the leaves. In the ‘Nortrop’ seedlings the ratio was very narrow and reached only 1:1.

An examination was carried out to check the reliability of the criteria for growth addition as a measurement of plant resistance to saline conditions. It was found that these figures are reliable.

A simple way was found to compare the immunity between different seedling populations and seedlings within each population, according to growth additions and the stage of damage, by a method of ranking.

Before the termination of the experiment, 9 plants were marked as outstanding in their resistance to saline water: 5 Guatemalans, 2 from a cross of a West Indian type and 2 from a Mexican seedling.

Apparently avocado seedlings have two types of resistance against high chlorine concentrations in irrigation water. One works through prevention of uptake and accumulation of chlorine, probably the common type in the West Indian and Guatemalan seedlings which are genetically more immune, and the second, through a specific tolerance against high concentrations in the plant, despite high uptake and chlorine accumulation in the leaves. This is probably the type of resistance characteristic of offspring's of the Mexican seedlings 'Glikson 7'. Although these seedlings had highest chlorine content, their degree of leaf scorch was among the lowest. It is possible that certain types may show high resistance as seedlings but may not make good rootstocks because of the possible movement of chlorine to the scion.

Almost all 'Nortrop' seedlings, and many of the 'Mexicola' seedlings declined during the experimental period. It was found that sodium content in 'Nortrop' leaves reached up to 1%; in 'Mexicola' leaves the content was much lower, but still higher than in all other varieties. All plants were left for further observations after the termination of the experiment. In the spring of 1961, after the winter rains, they were irrigated with tap water. All plants recovered completely during the summer of 1961.

Analyses of soil samples showed wide variations in chlorine distribution, during the experiment and after its termination. Irrigation with good quality water easily leached chlorine from the upper layers. This makes possible the recovery of avocado orchards seriously damaged by saline water.

During the years 1959-60 an experiment was carried out with West Indian rootstocks and their hybrids, using high saline water for irrigation. The plants, fifty seedlings representing 4 West Indian x Guatemalan hybrids, and one pure West Indian type, were grown in a lath-house, in relatively small containers, one plant in each container. Half of the seedlings from each variety, received irrigation water containing 1330 ppm of sodium chloride, the second received water with 830 ppm.

The pure West Indian seedlings showed by far the greatest resistance; 3 out of 5 plants in the high salt concentration remained in good condition and recovered completely when good quality water was applied after termination of the experiment, whereas only 2 plants among all of the hybrids showed similar resistance. In this experiment, salt concentrations in the soil gradually reached almost twice the maximum concentration used in the preliminary experiment. This shows that it is possible for avocado plants to adjust to high saline conditions, by a gradual increase of the concentration, whereas a sudden transfer of plants to such conditions causes their death.

During 1959-60, avocado seedlings were grown in nutrient solutions. The experiments included seedlings of the Mexican, Guatemalan and West Indian races. To some of the solutions only chlorine was added to others only sodium. This was done in order to recognize and describe the exact symptoms produced by each of these ions separately. Symptoms caused by chlorine excess appeared early, after a few days of treatment. They were recognized at the beginning as leaf tip and margin scorch; later the scorches spread to a larger part of the leaf area and the affected leaves dropped. In such cases, generally, new growth developed from buds along the stem. Although roots showed a certain degree of deterioration, new root growth was still maintained.

Sodium excess symptoms appeared in the leaves much later, but caused more damage than chlorine. In the first stage the symptoms in the leaves, after about 2 months of treatment, as roundish, concentric necrotic spots. These scorches later covered most the area, and then the affected leaves dropped. In contrast to chlorine, almost no new growth developed. In most cases the buds deteriorated before they started to grow. The roots of the plants in the sodium solutions showed a high degree of deterioration, and no new growth was observed. Within 3-4 months most plants receiving sodium treatments died. West Indian and Guatemalan seedlings showed much higher resistance than Mexican seedlings.

During 1961, several experiments with radioactive isotopes were carried out. Mexican seedlings were grown in nutrient solutions containing 1000 ppm chloride; in some of the solutions the chlorine was marked as Cl^{36}, in others the sodium was marked as Na^{22}. The connection between the rate of transpiration and the uptake and accumulation of Cl^{36} and Na^{22} within the leaves was examined by means of a Geiger counter. Results showed that under conditions of high transpiration uptake and movement of chlorine to the leaves was very rapid, while the sodium moved slower. In both cases movement under high transpiration was much more rapid than under conditions of low transpiration. Autoradiographs showed that under normal conditions, the chlorine accumulates in the tip and margin of the leaf, and the sodium within the main veins.

In another experiment, the influence of a root respiration inhibitor, (KCN), on the uptake and accumulation of chlorine and sodium in avocado seedlings was tested. This treatment caused some inhibition in the uptake and passage of the ions to the leaves. Four days after treatment, autoradiographs of leaves showed concentrations of Na^{22} in the veins; they also appeared as spots in the leaf mesophyll between the veins. These spots appeared similar to necrotic spots of 'Nortrop' seedling leaves in the main rootstocks selection experiment seen after 1.5 years of irrigation with saline water, or after 2 months in the nutrient solution experiments. In the radioactive treatment leaves looked completely green and normal with no necrotic spots. In the autoradiographs of the control treatments sodium was found to be concentrated only in the veins. This deterioration of the root system may allow Na passage from roots to leaves and from main leaf veins to the leaf mesophyll tissue long before these phenomena can be recognized as characteristic leaf scorches.

During 1957 a preliminary experiment was carried out for the rooting of avocado cuttings taken from adult grafted trees. Two rooting media were tested, vermiculite, and very coarse sand. The cuttings were under constant mist spray during daytime. Different plant hormones were used.

Cuttings were taken four times during the season. None of the hundreds of cuttings used in this experiment produced roots, although most of them produced callus.

During the years 1958-61, many experiments were carried out for the rooting of avocado cuttings, all of them under intermittent mist spray of 4-8 seconds/minute, during daytime only. The influence of various factors on the rooting of avocado cuttings was tested: source of cuttings, age of parent plant, age of branch from which cuttings were taken, type of cuttings, season, treatments with plant hormones, rooting media, length of spray and light intensity.

Results showed that the decisive factor for rooting is an inherent characteristic of the parent plant. There were types, e.g. seedling rootstock 'Benik 31/6', which always gave a high percentage cuttings, while cuttings from some other rootstocks, under the same conditions, did not root at all. Mexican types appeared to root better than Guatemalan or West Indian types. In almost all cases percentage of rooting declined with age of the parent plant. As for the age and type of the cutting itself, no clear results were obtained. In some cases a higher percentage and faster rooting were obtained from soft top cuttings than from semi-hardwood cuttings, whereas in other cases semi-hardwood cuttings gave better results. In a few cases sub-terminal and basal cuttings showed a high percentage rooting. Suckers and water shoots always gave a high percentage of rooted cuttings. No clear differences were found between cuttings taken during the spring or during the summer. But since it sometimes takes up to 5 or 6 months for roots to form, it seems more advisable to take cuttings early in the season.

Treatments with plant hormones did not always increase the rooting percentage, but in most cases the root system of the treated cuttings was more developed. Among the rooting media tested, coarse-grained vermiculite was found to be the best. Silica sand medium also gave some rooting but tended to form a hard crust under mist spray, resulting in excess of water and lack of aeration.

Satisfactory results from the mist spray were obtained with 4-6 seconds on, within a minute, even during the hottest hours and season. It may be advisable to reduce the on time to 2 seconds in a minute during the cooler seasons. Reducing the light intensity to 50% gave better results in the rooting of avocado cuttings than full sunlight.

In some of the later experiments, cuttings from types found to be highly resistant to saline conditions were used. Success was obtained with 2 such types, thus forming the starting point of new clones. Many of the rooted cuttings were planted in a special plot in order to use them in the future for further experiments.