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KAZIMIERZ SŁOWIK

Water relations in soils, salinity, pH etc.

Research Institute of Pomology, Skierniewice, POLAND

In the last years or decades we have observed a smaller and smaller amount of good soil assigned for agricultural use. All over the world we can observe processes of industrialization, urbanization, and preparation of new centers for recreation purposes, quite frequently without paying any attention to the soil as a natural resource which cannot be renovated. This is important in most industralized countries, particularly in Europe where the lack of good soil for use in agriculture or fruit plantings has become notorious.

The governments of some countries, mainly in East-Europe are trying to protect good soils for agricultural use only. For instance in Poland it is prohibited by law of Parliament to use good quality soil for building new industrial centers. Before 1960 we could observe a lot of mistakes in the proper use of good soil for other than agricultural purposes.

In other countries of Eastern and Central Europe, as in Germany and Bulgaria, there are restrictions on the use of good quality soils for orchards. In these countries the first classes of soil are used for agricultural crops only, such as wheat, corn and others. Such an extreme position on the use of land is probably questionable. Should we use soil of good quality for orchard purposes, or not? Is it justified from the economical and social point of view to use first quality soils for one of the most intensive forms of field production of fruit plants?

It is interesting to discuss for a moment why pomologists and orchard owners all over the world are more and more frequently trying to use poor quality land for fruit plants. It seems that the answer to this question is fairly simple. In some countries the reasons

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Currently Visiting Professor in the Postgraduate College, National School of Agriculture, Chapingo, MEXICO.

for this are legal restrictions and in other countries the increasing prices of land. Sometimes it is cheaper to apply a completely new technology for preparing poor land, and later to maintain the modern technology in the orchard, than to buy first class soil. For instance, in California farmers have to pay between 5,000 to 8,000 dollars or more for 1 acre /i.e. 0.4 ha/ for good quality land. This is why currently in California most of the new orchards are planted in hilly and mountain regions and on stony soils. It is cheaper for the growers to buy all the equipment for irrigation /sprinkler or drip irrigation/ and maintain these systems than to buy good but expensive land in flat regions. Scientists and producers have long been looking for a method to adapt poor or inadequate land for orchard purposes. Such methods have been considered as using wet soil for orchards by applying drainage, or preparing raising embankments as was proposed by Zuchkov and done in the vicinity of Leningrad. Others are trying to apply specially deep amelioration ploughing to a very poor sandy soil to prepare better conditions for deep rooting of the fruit plants, as was proposed by Egerszegi in Hungary. This last technique has already been successfully used in Poland for strawberry plants and apple trees /Słowik and Niezborala 1970, Słowik, Ceglowski and Niezborala 1972/. In strawberries there was an increase of 20 % in the yield with deep placement of manure or peat, in comparison to the shallow application of the same amount of organic matter, as was recorded by Slowik and Niezborala /1970/. This technique was also used in Germany on soil of good quality.
For a long time, deep plowing before plantation of the orchards has been, and still is, a commen practice in the Soviet Union. This practice is also used in Bulgaria, Hungary and Rumania. In Poland Soczek et al./1970/ could not find any increase in the yield of apple trees in good pseudopodsolic soil with deep ploughing, in comparison to the common preparation practice. Occasionally, the method of digging deep holes and adding organic matter or bentonite etc. is used before planting fruit trees. Dynamite is principally used when it is necessary to destroy hardpan. In the western European countries and in USA deep plowing is frequently used before planting trees only in the case of the existence of hardpan, but very seldom in a good quality soil.
To summarize some of the aspects of the soils currently used for orchard purposes, we can say that from the technical and research point of view we are now able, in very different environmental conditions, to prepare, almost any kind of poor land and adapt it for

orchard purposes. The most important question arises, however, "What is the price of the preparation and the later maintainence of the system or instalation?"

In the arid and semiarid regions in the world the biggest problem is a shortage of water which now becomes the No.1 problem and this is related to an excess of salts.

Different authors classify the resistance of fruit plants to salt by using different criteria. It is commonly considered that, among economically important fruit plants, strawberries are the most sensitive to high concentration of salt in the soil and/or in the water used for irrigation. Sometimes pecans belong to this group. As very sensitive species are considered: lemons, oranges, peaches, apples and plums.

On the opposite side, very resistant species are: date palms, pistachios and Prunus davidiana.

The above mentioned groups of some fruit plants and their sensitivity to the level of salt in the water are divided very roughly because in some conditions the question of salt concentration, the kind of salt, pH and moisture of the soil during the vegetative period can play a very important role.

In recent years, probably the most work has been done on the salinity problems in the citrus /Bielorai and Levy 1971, Heller, Shalhevet and Goel 1973, Bingham et al 1974, and others/. Although the citrus is considered to be salt sensitive in comparison to deciduous fruit /Bernstein 1965, 1969/, there are no established diagnostic criteria for evaluation of soil salinity levels in terms of lower yield or decline in fruit quality. Usually judgments of salinity hazards are based upon the electrical conductivity of the saturation extract /ECe/ value of soil representative of the root-zone.

In the last years many experimental results have been collected in this respect. Quite recently Bingham et al. /1974/ presented interesting data on fruit production and tree growth characteristics of a Valencia orange orchard, which were related to salt distribution throughout the root profile in response to uniform application of irrigation waters varying in salinity and sodicity hazard during eight years of differential irrigation treatments.

It is interesting to note that the authors found that both the quantity and quality of oranges have declined under irrigation treatments producing an accumulation of soluble salts within the root zone.

On the basis of this experiment the authors proposed diagnostic criteria for interpreting ECe data of the rootzone for Valencia orange trees as follows:

Salinity hazard	ECe /mohm/cm/
None	below 2.0
Slight	2.0-3.0
Definite	above 3.0

The concept of soil water availability to plants was and still is a source of controversy among different schools of thought. One of the strongest and probably most controversial hypotheses was presented by Veihmeyer and Hendrickson /1950, 1953/, and repeated recently by Veihmeyer /1972/. These authors claim that soil water is equally available to the fruit plant from the field capacity to the permanent wilting point. This schematized model has enjoyed widespread acceptance for many years. Other schools, however, produced evidence indicating that a plant may suffer water stress and reduction of growth and yield considerably before the wilting point is reached. Some others were searching for a "critical point" somewhere between field capacity and wilting point, as an additional criterion of soil water availability. These different hypotheses are discussed by Hillel /1972/.

Over the years /Salter and Goode, 1967; Dochev, 1969/ a great mass of empirical data has been collected, quite frequently controversial data, which for a long time no one knew how to explain because of the short term of the experiments and the sometimes ill-defined conditions. This problem is particularly difficult to resolve in the area of perennial fruit plants, in which vegetative growth, flowering and fruiting may be related quite differently to the content or state of soil water.

The concept of Veihmeyer and Hendrickson cannot be accepted and there are numerous experimental data which are contrary to their hypothesis. For instance, the work of Bielorai and Levy /1971/ with the irrigation of grapefruit in Israel showed that there was a decrease in the yield when the moisture content in the soil of the main root zone was maintained at a low level for a certain critical period, even though it did not drop to the wilting point.

One of the methods of applying water, particularly to fruit plants, is the method known as drip irrigation, trickle irrigation or what in Australia is called "daily flow". This method solved the great demand for good water, which is a problem all over the world.

The problems with water are: short supply, poor quality and/or expense. This technique of application of water has been used for years, but the application to modern pomology is new.

For the results of the new technique of irrigation in fruit trees, we have to wait quite a few years. Many questions concerning this technique of application of water to fruit trees are still unanswered.

To obtain an idea of how great the progress, that we can observe in the last year in the application of drip irrigation to fruit plants in the world, we can ilustrate the situation with data presented at the 2nd Drip Irrigation Congress in July 1974 in San Diego California, by Gustafson et al. /1974a/.

WORLDWIDE SURVEY OF DRIP IRRIGATION /INCOMPLETE/
/Gustafson et al. 1974a/

Country	Hectares
USA	28,495
California only	16,000
México	6,400
Israel	6,000
Australia	6,000
South Africa	3,200
Central America	2,400
New Zealand	800

In the United States before 1969 drip irrigation on a comercial scale was almost unknown. According to the incomplete survey made by Gustafson et al. in 1974, it is estimated that now 28,500 hectares are irrigated by this method. The largest area with drip irrigation is in California, with about 16,000 hectares. The second leading country with drip irrigation is Mexico, with 6,400ha. In Mexico in the last years there have been established new plantations of guava and avocado orchards in a mountain region of Calvillo, Aguascalientes, with slopes of sometimes more than 60%. It was not possible to use this waste land for any kind of cultivated plants without solving the irrigation problem. In the last years this problem was solved with the application of modern technology in irrigation i.e. a drip irrigation system.

In the last years, we have more fruit crops irrigated with drip irrigation, for experiments and on a commercial scale. Mostly this technique is used in arid, semi-arid and subtropical regions /Goldberg et al. 1971, Aljibury and Marsh 1974, Gustafson et al. 1974 b, and many others/. Irrigation includes: citrus, coffee, bananas, mangoes, avocados, nut-trees, olives, papaya, guava, strawberry and other berries, grapes, peaches, apple and other

deciduous fruit.
The use of the drip irrigation system is expanding rapidly with a speed not observed with any other new technique of irrigation introduced in the history of irrigation previously. More than 100 papers from all over the world were presented at the Drip Irrigation Congress, in San Diego in July 1974. During this Congress more than 90 companies presented new approaches to drippers, filters and all equipment necessary for this type of irrigation.
Nevertheless, a lot of questions have not yet been answered. From the scientific and practical point of view, probably the most important question is: do we have a chance to have a similar yield from fruit trees irrigated by the drip system with a partly irrigated root system or volume of soil, in comparison to irrigation to the total root?
The answer to this question for very different environmental conditions and for different patterns of root distribution of numerous fruit plant species is still obscure.
We can have some information on the basis the work done by Black /1971/. Black and West /1974/, in Australia. In these experiments Black was trying to find the effect on the water use of young apple trees when varying proportions of the root systems were supplied with an optimum moisture regime.
The high proportion of water loss from the tree with only 25 percent of its root system wet compared to the loss when the entire root system was wet /74%/ suggest, according to Black /1971/ and Black and West /1974/, that wetting substantially less than a total root system daily would produce a good regime for plant water supply. Black and Mitchell /1974/ also presented some data on the root distribution of mature pear trees irrigated with a drip system under field conditions, showing well developed roots in the portion of soil irrigated with drippers. It is interesting to point out that Shmueli et al. /1973/, investigating citrus water requirements in Israel,demonstratedthat sprinkler irrigation of every row, compared with irrigation of every alternate row, showed a very high sprinkling irrigation efficiency of 90% or more in the optimum treatments by partial wetting of the root zone.
This aspect of partial irrigation of the rot system has to be investigated in full detail in the near future, as will its effects on growth and cropping.
We have to keep in mind that among scientists working with drip systems we can find interesting and glorifying opinions on drip systems, in comparison with conventional irrigation methods

/Goldberg and Shmueli 1970/.
It is considered by some authors that moisture content with drip irrigation is more constant and close to field capacity and so the yield has a high value, as opposed to the soil moisture level with conventional methods where yield has a lower value. Probably we still have a too limited amount of experimental data to have such an ideal situation in the fields with a drip system, as some enthusiasts of this system think, but this is an interesting new approach to fruit plant irrigation in the world.
Quite frequently among specialists there are discussions about the question which of the two, the plant or the soil, we should ask: do you need some water? Still in practice all over the world we are addressing the question concerning the need for irrigation mainly to the soil, or to the measurements based on the soil, and within the soil the only practical acceptance had been found by tensiometers and many modifications of these /Slowik 1970, Baranowski 1971 and many others/. and sometimes various modifications of the electrometrical method for determining soil moisture. These methods are fairly accurate but they are inert in time, and tensiometers can only measure a range from 0 to 0.8 atm. soil water potential. More precise information on soil moisture can be obtained by using the neutron method. However the high cost of such equipment limits the possibilities of its practical application.
Among the methods based on physiological criteria, although used for scientific purposes only, a pressure bomb /Boyer 1969, Tyre and Hammel 1972, Acevedo et al. 1973, Goode and Higgs 1973, Hsiao 1973, Gee et al. 1974, and others/ and beta ray gauge/Bielorai 1968, Antoszewski 1973, Slowik, Antoszewski and Kielak 1973, Kielak, Antoszewski and Slowik 1974/ have been frequently used in recent years.

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