AGRICULTURE AND ENVIRONMENTAL PROBLEMS IN THE MEDITERRANEAN AREA (with particular reference to Italy)

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Abstract

After a brief analysis of the main characteristics of Mediterranean agricultural areas, with explicit reference to climate, soil conditions and changes caused by human activity, the most important environmental problems related to agricultural management are examined.
The first problem concerns soil conservation. Owing to climatic conditions (rainfall is often heavy and concentrated in short periods), soil clayey nature and large extents of hilly and mountainous areas, water erosion is frequent.
Irrigation is another important problem. It is necessary to grow high-income horticultural, fruit and industrial crops in hot and dry summer Mediterranean areas. Unfortunately, in these zones water is usually highly saline, causing problems both in terms of crop yield response and soil degradation, and is also affected by problems arising from toxic and polluting substances common to other regions.
The third aspect is represented by risks linked to incorrect fertilization management and pesticide treatments.
As far as supplies of organic matter are concerned, effects on soil and its conservation are always positive, particularly in difficult environments such as the Mediterranean. Therefore, it is recommended to supply the soil with the limited amount of organic matter available, to use green manure and properly nitrogen enriched crop residues burial.
As regards herbicides, pesticides and hormones and their current irrational use, it is to be hoped that less toxic products will be used in moderation during certain biological phases.
Finally, we give an optimistic indication based both on possibilities offered by the C.A.P. with regard to reafforestation and other soil conservation practises and mainly on the adoption of agricultural technologies able to reduce both environmental impact and energy consumption and able to provide ever-improving quality products.

Résumé

Après une brève analyse concernant les principales caractéristiques des aires agricoles méditerranéennes, notamment le climat, le sol et les changements dûs à l'activité humaine, on a examiné des principaux problèmes liés à l'agriculture.
Le premier problème concerne la sauvegarde du sol. L'érosion est fréquente pour des raisons climatiques (les pluies sont souvent lourdes et concentrées dans des brèves périodes) et pour la nature argileuse, vallonnée et montagneuse des sols.
L'irrigation pose un autre problème, car elle est indispensable pour cultiver les fruits et les légumes et les cultures industrielles à haut rendement, dans les aires méditerranéennes, où l'été est aride. Malheureusement, dans ces régions l'eau est souvent très saline, ce qui cause des problèmes en termes de rendement des cultures et de dégradation du sol et elle est affectée par des substances toxiques et polluantes, communes à d'autres régions.
Le troisième aspect est représenté par les risques liés à la mauvaise gestion de la fertilisation et des pesticides. En ce qui concerne l'application des substances organiques, les effets sur le sol et sur sa conservation sont toujours positives, notamment dans des milieux difficiles, tels que les milieux méditerranéens. Voilà que des quantités limitées de substance organique doivent être appliquées au sol, avec du verdage et de l'azote enrichi avec des résidus des cultures.
Pour ce qui est des herbicides, des pesticides et des hormones et de leur utilisation irrationnelle, des produits moins toxiques devraient être utilisés pendant certaines phases biologiques.
Enfin, une indication optimiste s'impose à propos des possibilités offertes par la PAC concernant l'afforestation et la sauvegarde du sol et des technologies agricoles en mesure de réduire l'impact environnemental et la consommation d'énergie et de fournir des produits de meilleure qualité.

Agriculture in Mediterranean countries dates back to the beginnings of agriculture itself in the Neolithic. In the *palafitte* dwellings of the Po Valley, seeds and detritus from the main cereal crops, vine and some fruit-trees have been found. Neolithic scythes have been unearthed in Egypt, Syria and Spain. In ancient Egypt, agriculture permeated not only economic and practical matters, but also art and literature.
This situation has first of all led to the build-up of extensive experience over the centuries, corroborated in the last few decades by the achievements of scientific progress in rapid evolution. At the same time, millennia of agricultural activities have progressively impoverished soils with the effect, in some cases, of desertification.
Moreover, the Mediterranean was for many centuries the crossroads and meeting-point for different populations, and above all the centre of civilized and cultural life. The countries facing the sea were at times conquered by populations from other regions, their inhabitants being subdued or, as often happened, culturally assimilating the invaders. The sea itself was for centuries the theatre of religious wars, of racial and commercial conflict.
The consequent demographic pressure and various acts of warfare led to an irrational use of the soil and to its degradation. The former led to agricultural activities being developed often in unsuitable areas and to the detriment of the natural vegetation in order to satisfy the growing demand for food. Warfare entailed the destruction, both for strategic reasons and just for the sake of laying waste, of large expanses of words and sometimes also of Mediterranean **maquis**.

Basic characteristics of Mediterranean agricultural environments

In the Mediterranean area, areas often with very different environmental characteristics are devoted to agriculture; hence it is more precise to talk of various micro-environments.
1. As for climate, it is well known that by Mediterranean climate we mean a climate characterized by mild-wet winters and hot basically dry summers.
However, within the ambit of this definition, on examination of temperature and rainfall data, it becomes apparent that such data vary remarkably from area to area.
Nevertheless, when we speak of Mediterranean agriculture we usually refer to difficult environments, above all as regards the uneven distribution of rainfall during the year. Rainfall, subject to variations in the total amount from year to year, is concentrated in the autumn-winter period and is often of short duration but of considerable intensity. Italian records alone show that in Salerno on 26/10/1954 500.4 mm of rain fell in 15 hours, at Muro Lucano (Province of Potenza) 317 mm fell on 22/11/1954, 315 mm at Pisticci (Province of Matera) on 24/11/1959, 257 mm at Sabetta in the Cilento on 14/11/1982; and this is just to quote a few examples (Postiglione and Marzi, 1983). These downpours, falling on the rugged soil of hills and mountains, bring about serious forms of erosion with considerable loss of soil and agricultural fertility, not to mention floods, landslides and more serious types of damage.
In Summer, on the other hand, in addition to frequent occurrences of a total lack of rainfall, very high temperatures are sometimes recorded. This situation results in considerable evapo-transpiration (ET), which in some cases, in S- and SE-facing areas, make it impossible for forest plants and even the Mediterranean maquis to grow. In the plains, during research carried out by our Department, mean 10-day values in July

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amounted to more than 8 mm of ET per day (Postiglione et al., 1988).
For the above reasons, E. De Cillis (1939) classified the southern Italian climate as subarid and gave the following definition: «that climate which does not permit the fruitful cultivation of spring-summer cycle hoed crops, such as maize, without the aid of irrigation».

2. Also from the pedological point of view, the situation varies considerably from area to area, both due to the nature of the soils and their topography.

In Italy, in typically Mediterranean areas, fine texture soils are prevalent, with a high lime and clay content and a difficult relation with surface water. Alluvial soils are found chiefly in the plains, within the domain of the «fluventes»; «vertic clayey soils» in the plains and hills, with the prevalence of «vertic ustorthens» types in the latter; all expand if wet, form large evident cracks if dry, with tough clods and a coarse structure after tillage; they vary in depth and profile according to the area.

At the opposite extreme, especially along the littoral, there are broad strips of sandy soil which constitute the other considerable problem, that of coastal dunes.

Naturally, besides these soils which entail problems of conservation and utilization in addition to restricting crop choice and work and irrigation systems, there is a whole series of soils, albeit limited, with more favourable characteristics for agricultural activities. In particular, some are enhanced by the contribution of pyroclastic material from active volcanoes in various eras.

Another unfavourable feature of Mediterranean soils is the extremely limited presence of organic matter. This is the consequence of two concomitant factors: on the one hand, low biomass production due to unfavourable climatic conditions, hence the poor annual return to the soil in the form of crop residues or manure (in the few cases of livestock farms); on the other hand the little organic matter in, or added to, the soils, as a result of the high summer temperature, is subject to a phenomenon of slow combustion known as «eremacausis».

Indeed, organic matter performs, as is well known, fundamental functions in agricultural land, some of which assume great importance in difficult Mediterranean soils. For example, the amending function or the formation of a favourable structure, is fundamental in very clayey soils insofar as it improves aeration and drainage; at the same time, it increases water capacity which is of considerable advantage chiefly in sandy soils. Organic matter also adds nutritive elements, avoids sudden pH variations, and forms compounds with several mineral elements (eg. phosphorus), allowing plants to assimilate them. Moreover, it limits the damage caused by the excessive presence of salts, stimulates the formation of root hairs and favours cellular permeability, thereby influencing the absorption of nutritive elements; it provides energy for the soil biomass, thus stimulating its valuable activity. All the above properties are important for southern Italian soils.

As for soil topography, it should be pointed out that above all in the case of the northern shores of the Mediterranean, flat surfaces constitute a small percentage and sloping mountain or hill terrain predominates. Thus in Italy only 23% of the surface is situated in the plains, while hills (42%) and mountains (35%) account for the remainder.

This situation, together with the nature of soils and the frequent rainstorms, plays no small part in the erosion referred to above. In fact, in the last century in Italy, the classical «soil layout» was carried out, which has now become outdated due to the requirements of the mechanization of crop practices.

3. Lastly, human intervention has had considerable bearing upon the characteristics of the individual environments. This could not be otherwise, dealing as we are with areas inhabited since time immemorial and with high population densities.

Indeed, agriculture has always been intensive in every era so as to maximize productivity. However, together with the prevalently sensible use of the soil and rational crop management, there have at times been cases of real agricultural plunder. Regrettably, in recent years there has been an ever-increasing use of monocultures, working the soil to extremes and using strong mineral fertilizers. Many ditches, rows of trees and hedges around the fields, which once made the countryside quite distinctive, have now disappeared in order for the fields to conform to the requirements of mechanization. All these operations have favoured pollution, erosion, frequent wind damage, an increase in ET, and a break in the equilibrium of the CO_2 cycle in the atmosphere. Furthermore, the repeatedly deep working of the soil has contributed to a reduction in organic matter and to a modification of the microflora in the soil, thereby accentuating its continuous degradation. The widespread use of greenhouses and various plastic coverings, besides changing the appearance of the countryside, have contributed to increasing chemical pollution and to a deterioration of the already delicate soil-water relationship.

Urbanization and industrialization, carried out without proper planning and more often than not in the most fertile agricultural areas, have led to the impermeabilization of vast surface areas where rainwater can no longer infiltrate the soil, but collects in large masses on the surface where free flow is impeded by viaducts, railway embankments and surrounding walls such that even light rains may cause frequent flooding, erosion, landslides, bursting drains and channels.

Industrialization, with its undeniable advantages of providing employment and making goods readily available which have undoubtedly improved the standard of living, has however considerably contributed to pollution of the atmosphere, water and soil. Suffice it to think of the quantities of CO_2, CH_4, NO_x, $ClFC$, SO_2, H_2S, CO and aromatic hydrocarbons and of the unburnt carbon particles emitted by a large number of factories concentrated, what is more, right on the coastal strip; then there are the rains or fog which bring some of these compounds in solution or suspension, and the gases emitted in the atmosphere by car engines; let us also consider the harmful materials, from non-biodegradable phosphate-rich detergents to heavy metals, which flow into water courses every day (Postiglione, 1988); take for example, as we are only a few kilometres away, the present condition of the River Sarno, in whose clear waters I swam as a boy, which has today become the most polluted river in Italy. If one just reflects upon this, one appreciates the environmental damage which irrational industrial development has caused in one of the most beautiful areas of the Mediterranean. This situation affects agriculture too, with a reduction in yield, a deterioration in product quality, and, in extreme cases, inability to cultivate.

Parallel to industrialisation, urbanisation has developed which in turn contributes to environmental impact with the problem of detergents for water and that of refuse. The latter, once sought after by vegetable growers in areas near towns as valuable organic matter for farming land, is now a source of worry in terms of disposal.

At this point, it should be underlined that apart from the few livestock breeders left on farms, from whom manure may be obtained to replenish soils with organic matter, the rise of modern intensive livestock breeding has created the disturbing problem of the disposal of livestock slurry, because it is rich in phosphates and other compounds with high environmental impact. Another problem on such farms is constituted by the diffusion in the surrounding atmosphere of microbes and antibiotics.

Human activities have often been directed at the vegetation. It is worth mentioning the senseless deforestation, which began in the Middle Ages for reasons of strife and wanton destruction and was accentuated in the first half of this century to increase the surface areas earmarked for crops; the speed of deforestation has accelerated up to now with the occurrence of chiefly intentional fires. With the destruction of forests, besides exacerbating soil erosion, one of the great sources of CO_2 absorption from the atmosphere, due to photosynthetic assimilation, is eliminated and hence it contributes indirectly to the feared greenhouse effect. The same unfavourable result is obtained with the reduction of cultivated surface areas (120,000 ha in Campania alone in twenty years), as well as the disappearance of parks and tree-lined avenues in cities, consequences of senseless urbanisation and industrialisation which are, as was stated before, the direct cause of the CO_2 increase in the atmosphere.

Main environmental problems connected with agriculture

In the Mediterranean regions, the risks of environmental impact which agricultural activities undergo as a result of other human activities or, in turn, cause in the environment (atmosphere, water, soil), besides being similar to those of other areas, are evidently exacerbated by the particular climatic and pedological conditions and by man's activities, as briefly described above. Simple ploughing of the land with its effect on erosion, on the airing of the lower surface strata and on the consequently slow combustion of organic matter, on upsetting the equilibrium in the soil ecosystem (air, water, microorganisms, root systems of natural vegetation, salt dynamics etc.), constitutes the first step towards environmental disturbance.
There are some activities which cause problems of a considerable order of magnitude, which need to be solved immediately if we want conserve the «soil» resource and seriously safeguard the environment. In this paper, given the time at my disposal, I will confine myself to dealing with only three aspects, which seem to be fundamental in the Mediterranean environment.
1. The first macroscopic problem is that of soil protection and conservation.
It has been restated several times that climatic conditions, the nature and topography of soils, and widespread deforestation encourage erosion and at times the collapsing of whole hillside slopes.
Erosion, which may be caused by the wind or rain according to the environment, is typically caused by water in the Mediterranean area. In particular it affects sloping soils and is due to rainwater which, with its beating action, causes the detachment and dispersal of earth particles; subsequently, flowing on the surface it transports and further removes the particles. The intensity of the phenomenon depends on a set of factors, mainly on those which affect the kinetic energy of water, therefore on the intensity of the rain, often considerable in Mediterranean areas, as has already been recorded. Erosion is favoured by the absence or reduction of vegetation cover, a frequent occurrence in our hills due to the abovementioned irrational deforestation, the poor management of pasture land and the neglect of hill areas as a result of thrural exodus in the last few years. The latter has entailed both a lack of pasture management and the abandonment of well-known farm irrigation systems which supplied land on high ground at some considerable expense so as to support rational crop-growing. There are serious consequences which consist in the loss of earth particles, in the run-off of swollen waters causing damage to the plains below, and in the formation of gullies and a series of falls of clay land.
Erosion also affects the plains, where it occurs with a somewhat different mechanism.

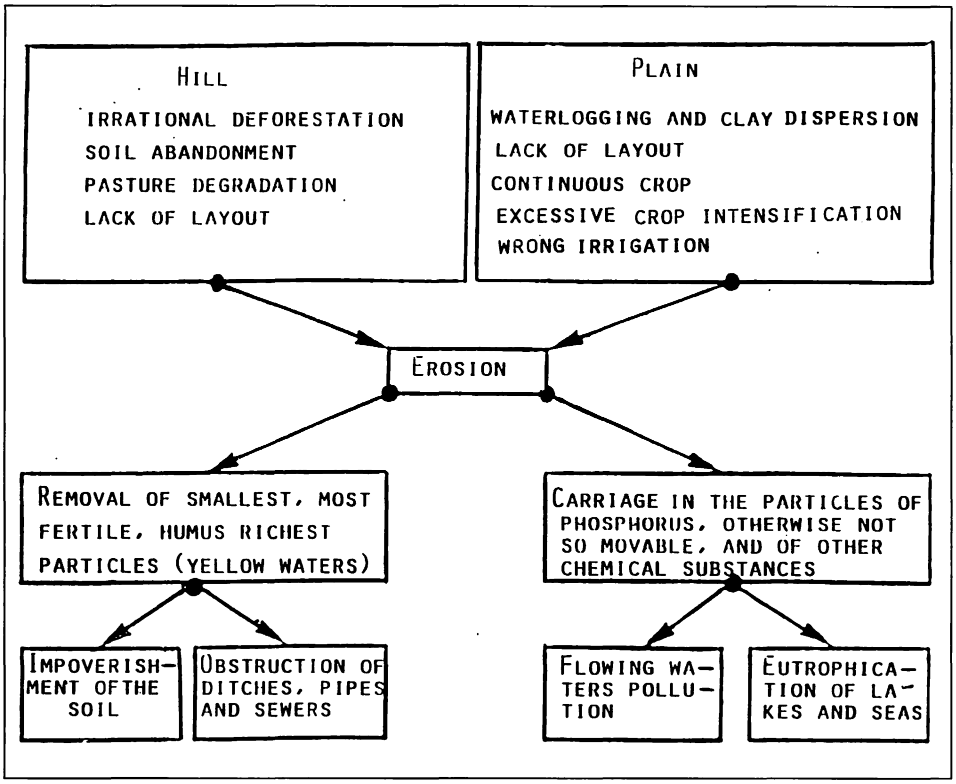

Figure 1 - Scheme of erosion: causes and effects.

Here, particularly on more compact ground, rainwater especially after heavy rainfall cannot infiltrate entirely and thus stays on the surface, thereby causing clay dispersion and the subsequent run-off of deflocculated material in suspension. This phenomenon is often aggravated in our areas by irrational crop techniques, such as monoculture in some situations, excessive intensive farming in others, or the misguided use of irrigation.
In any case, both in hills and plains, erosion causes damage of a two-fold nature (**figure 1**): on the one hand the removal of the smaller particles of earth, which are usually the most fertile and humus-rich, where a definitive, progressive impoverishment of the soil occurs; at the same time, the eroded particles usually transport phosphorus inside them, which is otherwise hardly mobile, and other chemical substances, causing water pollution. In particular, in some circumstances the phosphorus, on reaching lake waters or the sea, may contribute to the phenomenon of eutrophication.
To study erosion, our Department has since 1970 carried out experimental trials in an appropriately equipped field in the hills of Basilicata (Guardia Perticara), in a typically Mediterranean area. Now we are preparing an in-depth study of some particular aspects in the framework of project «Medalus II» financed by the EEC, in collaboration with the Agronomy Department of the University of Potenza and with the Agricultural Hydraulics Institute of our own University. The trials are being held at an average height of 650 m asl, on a hillside in Basilicata with a slope of 18%, consisting of clayey lime soil on a geological formation of polychrome clayey schists, often subject on the surface to landslides. Results from the first 18 years show that soil removal varied between 0.06 and 6.20 t ha^{-1}, ascertained respectively as follows: the minimum in the plots left for natural pasturage in the 1976/77 cropping season when only 246 mm of rain fell in the September-March period, the maximum in plots devoted to grain horsebean cultivation with sowing on unploughed ground in the 1984/5 cropping season when, over the same period, rainfall amounted to 713 mm (Barbieri R. and Bas-

Table 1 ***Year erosion in Guardia Perticara field (mean values of the different treatments).***

Year	Rainfall in MM Autumn-Winter	Soil losses T HA^{-1}
1971/72	413	0,52
1972/73	474	0,17
1973/74	401	0,13
1974/75	427	1,22
1975/76	469	1,38
1976/77	264	0,26
1977/78	409	0,31
1978/79	390	0,17
1979/80	362	2,00
1981/82	368	1,09
1982/83	244	1,14
1984/85	713	5,38
1985/86	396	1,85
1986/87	317	2,11
1987/88	407	1,42

so, 1973; Basso et al., 1986; Postiglione et al., 1990).
In the mean values of the various treatments, erosion (**table 1**) was highest in 1984/1985 with 5.38 t ha^{-1} and lowest in 1973/74 with 0.13 t ha^{-1}. It was markedly conditioned by the number and intensity of rainfall events, besides the total rainfall amount. It was also tied to crops, in the sense that it was greater with grain horsebean, moderate with wheat, low with forage crops; however, erosion was minimal in unworked land left for natural pasturage. As for the system of working the land, erosion assumed greater proportions in plots undergoing minimum tillage, while it was lower for ploughed land. In the former plots, the turbidity of the surface run-off waters was very low, although the quantity of water was high; conversely, in the ploughed plots, even if turbidity was high, the quantity of the run-off was very low, and thus less soil was removed (**figure 2**).
2. Another important aspect of agriculture in a typically Mediterranean environment is that of irrigation and all its connected problems.
In such areas, with a climate characterised by hot dry summers, farming is carried out in two different regimes: a dry regime in areas where there is no water for irrigation, or at any rate irrigation is not possible, with arboreal crops (chiefly vine and olive), with permanent meadows and pastures which interrupt the vegetation in the summer period, and with autumn-spring cycle crops (from wheat to herbage crops), both in the hills and the plains.
In areas where irrigation is feasible, intensive agriculture occurs, on a continuous cycle, with high value industrial, fruit or vegetable crops. Irrigation water, together with the favourable characteristics of the climate, allows a quantum leap in yield insofar as it permits high value produce both in terms of quantity and quality.
The practice of irrigation, however, is not void of dangers.
The possibility of causing soil erosion with too high volumes has already been mentioned. Sprinkling poses the same risk, when operating in clay-rich land with high-pressure equipment and high-intensity rain. Thus, irrigation by sprinkling, even if conducted rationally with regard to the land, entails an increase in relative air humidity, thereby creating favourable conditions for the growth of cryptogams. To limit this drawback, irrigation must be performed from dawn to the hottest hours of the day so as to reduce the need for frequent fungicide treatments.
The most serious drawbacks may arise from the quality of water used. Given the scarcity of water available for irrigation, use is often made of water which has unsuitable characteristics in terms of salt content, quality of dissolved salts, hardness, presence of matter in suspension, polluting substances and, at times, micro-organisms.
It may have more or less serious adverse effects depending on the characteristics of the water, the nature of the land, and crop sensitivity. The effects may appear immediately or in the medium and long term.

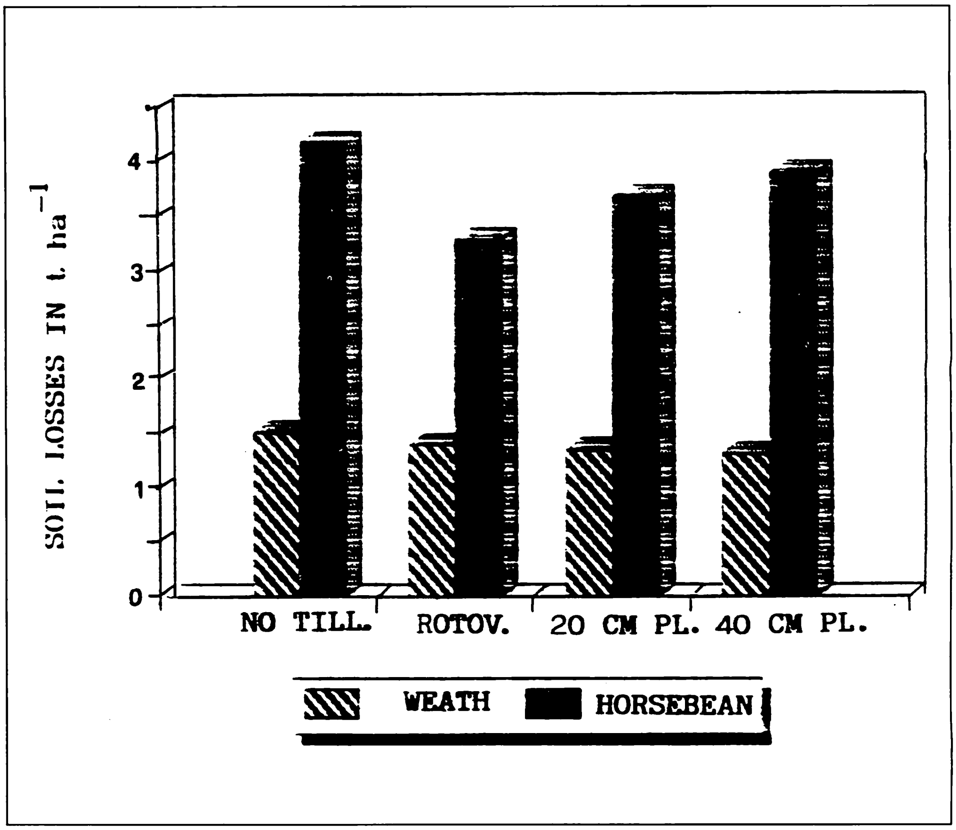

Figure 2 - Soil losses in relation to tillage and crop: average values of a seven-years period (1981-1988).

Apart from the obvious consequences due to the presence of harmful or polluting substances in limited doses, the main problem in sub-arid environments, and thus in Mediterranean coastal areas, is the salinity of irrigation water, which in those very areas is higher. The salts added to the surface layers of the soil by means of irrigation often join those salts from the circulating solution which are continually drawn from the underlying layers by high evapotranspiration. In the case of «fresh» water irrigation, containing 0.5‰. salts, considering that for a normal crop 4000-5000 m^3 ha^{-1} of water is applied annually, 2-2.5 t ha^{-1} of salts is added every year, which if not washed away with rain in the autumn-winter period, may lead to dangerous accumulations.
When saline water is used, adverse effects may well result both in terms of crop yield and soil degradation.
For crops, above all the more sensitive ones, the high saline concentration causes a variation in osmotic pressure with effects upon the total water potential in the layers occupied by the roots, which influences water absorption negatively. The damage increases when there are substantial quantities of some ions which become toxic over a certain threshold (sodium and chlorine more frequently).
For the soil, the deterioration of agronomic characteristics is essentially caused by the presence of sodium ions which lead to the deflocculation of clayey colloids and thus to the loss of the structure, with a reduction in permeability and, in some cases, with the formation of a surface crust. As a consequence, besides the salt concentration, the nature of the ions present must also be considered. Indeed, while sodium disperses clays, the bivalent ions, calcium and masgnesium, perform an aggregating action. Hence, in order to assess the suitability of water for irrigation, above all in very clayey soils, several indices have been proposed. The most commonly used is SAR (Sodium Absorption Ratio) which considers the ratio between sodium content and calcium and magnesium content. In relation to the salt concentration, measured more appropriately as electric conductivity (ECw), this index supplies useful indications as to the possibility of water use in various types of soils.
Thus, on the basis of experimental results from research carried out in the coastal areas of southern Italy, it was observed (Pantanelli, 1941) that in Apulia for the irrigation of several vegetable crops (tomato, egg-plant, pepper, cabbage, fennel, asparagus and artichoke) by adopting certain precautions water may be used which contains up to 3.3‰ salts (equivalent to approximately 5.5 mmho cm^{-1}, as *ECw*) and that in some cases, where irrigated vegetable crops are followed by more resistant dry forage crops for two or three years, water use with 7-8‰ salts may be reached (10.9-12.5 mmho

cm^{-1}). From more recent research conducted in Sicily it emerged that using water with *ECw* from 1.8 to 3 mmho cm^{-1} (1.3-2.1‰) a salinising effect occurs (Fierotti and coll., 1984) which is not corrected by leaching winter rains, and that the vegetable crops tested yield less in terms of quantity and quality, despite showing a different degree of tolerance. In other trials (Lo Cascio and coll., 1982) it was observed that the salification process is barely modifiable with winter rains. Hence the ESP (exchangeable sodium percentage) increases after only two years of irrigation, indicating the involution of the soil towards halomorphy. As regards the crop, it was also observed that soya production was linearly dependent on the electric conductivity of the soil solution. In Campania, in trials carried out by our Department with natural water (*ECw*=0.54 mmho cm^{-1}) and saline water (*ECw*=3.77) on their own or variously mixed, a reduction was noted in bean production (Barbieri and Duranti, 1986; Duranti and Barbieri, 1987) with the rise in salt content, although it was lower than that found by other authors in other countries, and in melon production to a less serious extent, given the relative adaptation of this species to salinity (**figure 3**). In the two years of the trial, no substantial modifications emerged in soil chemical properties, probably due to the leaching action of the autumn-spring rains which are heavier in Campania. Indeed, in subsequent trials (Barbieri et al., 1990) it was noted that in the course of two years the electric conductivity of the solution circulating in the soil increases in plots irrigated with saline water in the irrigating season, although it returns to normal values in the subsequent winter (**table 2**). It also emerged that the yield of two tomato cultivars, partially tolerant to salinity, decreases with the increase in salinity (**figure 3**); such a decrease is correlated to physiological, morphological and chemical modifications in the plant and in the fruit, induced by salinity.

From this set of data, it is evident that the action of saline water is linked to the nature of the soil, the distribution along the profile, the thickness of the soil and its drainage capacity (it has been proposed to increase the irrigation volume to satisfy the calculated leaching requirement expressed as *LR*); it also emerges that such an action is still linked to the amount of rainfall, summer temperatures, the irrigation system as well as the return periods and volumes adopted, to the presence of calcium, the possibility of alternating saline waterings with fresh waterings, or alternating irrigation for one year with one or two dry years, and, naturally, to specific crop requirements (**figure 4**).

It seems however evident that saline water irrigation causes an immediate reduction in yield and often deterioration in product quality. In the medium to long term, in areas where autumn-spring rainfall is unable to wash away the salts, it starts the slow process of salinisation and hardening of soils

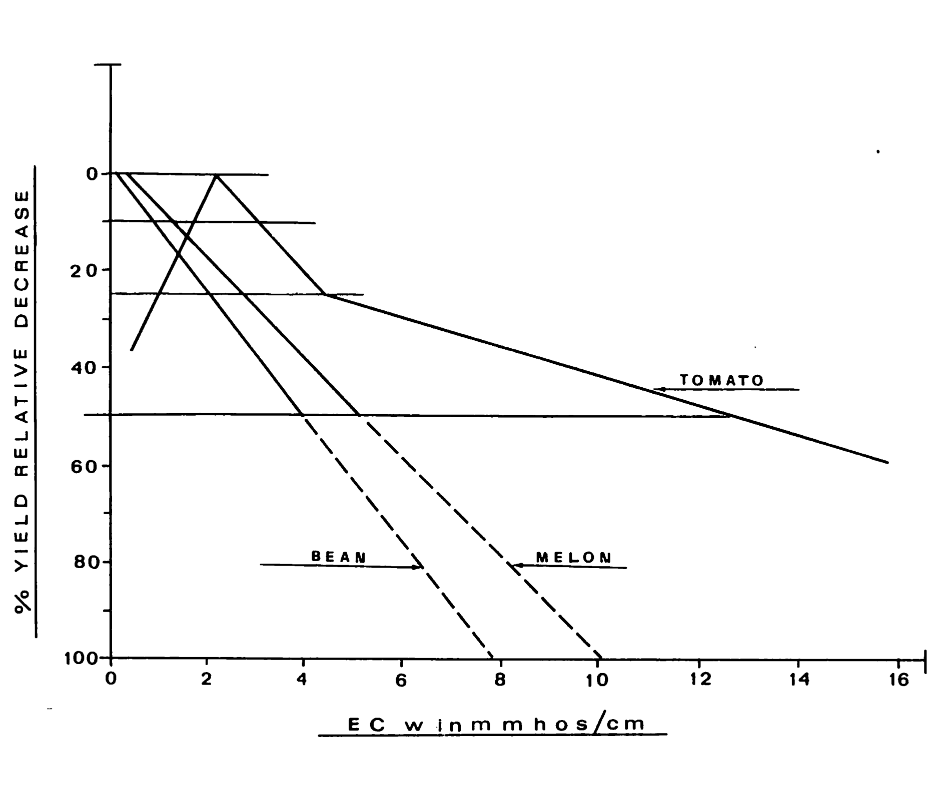

Figure 3 - Trend of vegetable yield in relation to ECw.

which is the first step towards desertification.

On the subject of desertification, even if the term referring only to the land is inappropriate as it also entails climatic implications, it is worth underlining that salinisation is one of the causes, albeit not the only one, even if the others are regrettably present in Mediterranean coastal areas. I refer in particular to erosion, to deforestation through general woodcutting and, nowadays, forest fires, to periods of vegetational absence due to drought, the reduction in organic matter with the consequent reduction in biological activity in the soil, the accumulation of toxic substances (herbicides, *Pb*, *Cu*, *Mo*, etc.) and to misguided farming techniques (**figure 5**).

3. Lastly, there are a large number of problems connected with the use of mineral fertilizers and plant protection products. Agriculture has made considerable progress in recent years thanks to the development and adoption of new technologies in plant cultivation. In particular, the use of products supplied by the chemical industry, such as fertilizers, weedkillers, parasiticides, phytoregulators, together with the improvement of all the other techniques, has led to an increase in production which was unimaginable a few decades ago.

At the same time, the use of such products, above all their irrational use, has contributed a great deal, and still does so, to pollution of the environment in which we live. In the case of industrially prepared fertiliz-

Table 2 ***Trend of soil salinity at 0-20 cm of depth in mS cm^{-1}.***

NaCl / Date	1/6/88	26/)/88	11/10/88	24/2/89	19/6/89	3/10/89	15/1/90
				Return periodo of irrigation 2 days			
0%	0.12	0.43	0.21	0.25	0.69	0.36	0.09
1%	0.12	2.64	0.61	0.34	0.54	1.44	0.99
				Return period of irrigation 10 days			
0%	0.12	0.31	0.23	0.21	0.52	0.25	0.12
1%	0.12	1.81	0.75	0.24	0.70	1.16	0.34

ers, accusations are chiefly levelled at nitrates and phosphates. Nitrogen and phosphorus very often pollute water to such an extent as to make it domestically unusable, and when transported to lakes and the sea, they lead to eutrophication.
With regard to nitrates, it may be noted that, as they are remarkably mobile in the land, their presence in watertables may be caused by excessive fertilization, especially if effected on ground where percolation is easy. As regards phosphates, however, the accusation would appear groundless: phosphorus is retained by the land in various forms, and even when it is contained in particles of earth transported by erosion, only with difficulty is it released by the particles into water.
This is confirmed by recent research carried out in the area of the Lower Volturno River, sampling the drainage waters from the University's experimental farm at Castel Volturno, and the water from the land reclamation Consortium's water station (where waste water converges from the dairy-produce industry, several private houses and livestock-breeding farms). The research showed (Basile et al., 1990) that the amount of phosphorus washed away by leaching is negligible whereas that transported by eroded solid particles and carried in suspension by turbid run-off is much greater. However, in the farm's drainage waters the total phosphorus content was on average 0.28 ppm, which is considerably lower than the limit (10 ppm) believed to cause pollution risks and much lower than that found in the water of the reclamation station with its contribution from the moderately urbanised area (0.53 ppm). These results confirm that phosphorus pollution usually derives from sources external to farming, that is, from urban waste, slurry from intensive livestock activities, and effluent from certain industries.
As regards nitrogen, it is worth adding that in our areas, in the case of vegetable crops and especially those grown in greenhouses, very large quantities of nitrogen fertilizers are administered, often causing justifiable concern regarding groundwater pollution and in some cases pollution of the produce. A previously-conducted survey on fertilization of early potato (Postiglione, 1967) showed that in Agro Nocerino, in loamy sandy soils up to 400 kg ha^{-1} of nitrogen is used just for this crop, which is one of three crops normally grown annually in this area.
Trials in lysimeters under way in our Department, some results of which are referred to in the two posters presented at this conference, have shown that by applying nitrogen fertilizers up to a dose of 400 kg ha^{-1} to two land-types, one clay-silt and one sandy yet well supplied with organic matter, in the percolation waters from both land-types the total nitrogen mineral content, of which 90% was nitrogen in nitric form, reached a maximum of 34-35 ppm, recorded in periods immediately following

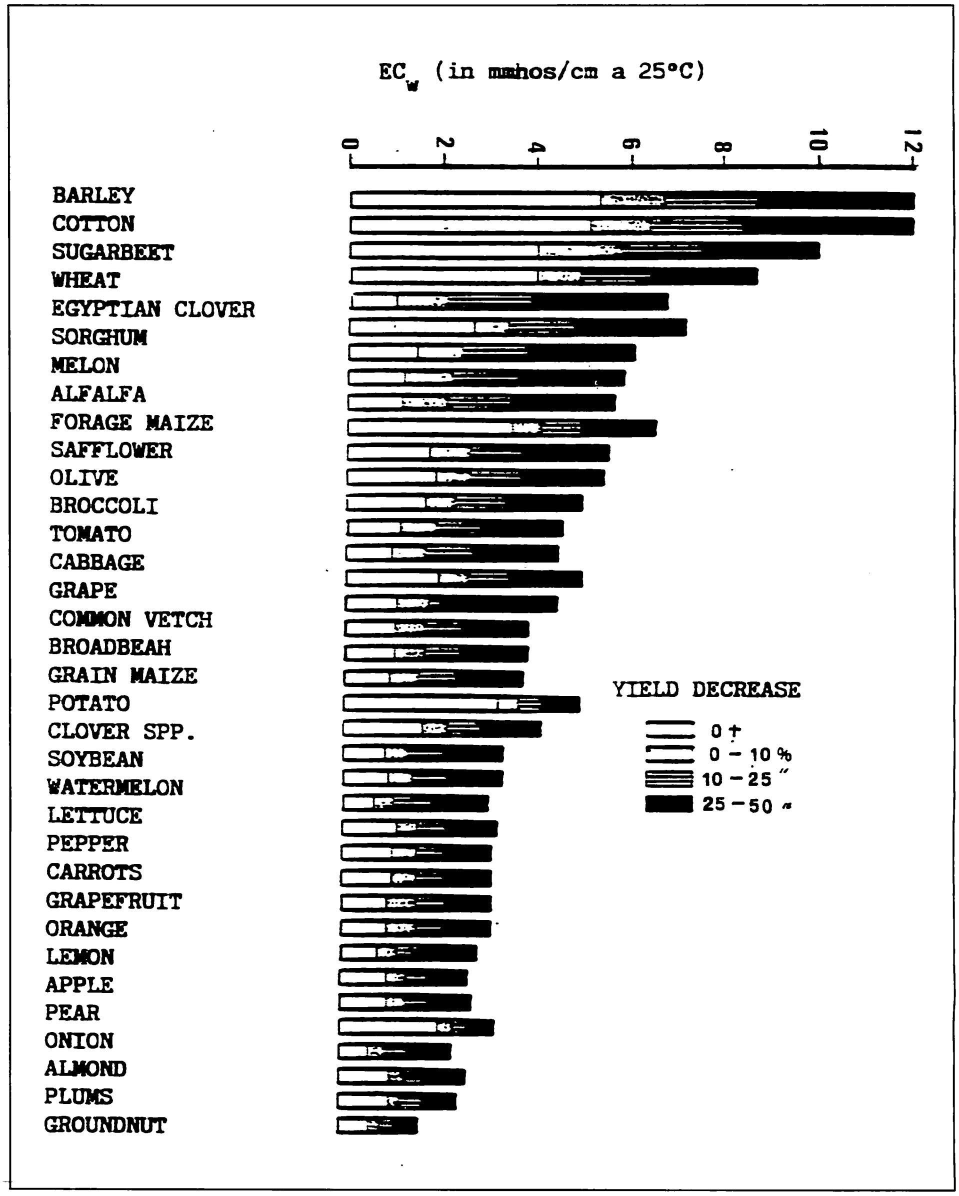

Figure 4 - Relation between electrical conductivity of irrigation water (EC_w) yield decrease (%) in some crops (from Sarno, 1987).

SALINIZATION

SODIFICATION

EROSION

DEFORESTATION → IRRATIONAL CUTS
DEFORESTATION → FIRES

SOIL WITH NO VAGETATION

VEGETATION LACK PERIODS DUE TO DROGHT

ORGANIC MATTER LACK → REDUCTION OF SOIL BIOLOGICAL ACTIVITY

TOXIC SUBSTANCES ACCUMULATION IN THE SOIL (Herbicides, Pb, Cu, Mo,.....)

WRONG CROP MANAGEMENT

(*) SOME ENVIRONMENTAL IMPLICATIONS ARE INCLUDED IN THE WHOLE CONCEPT OF DESERTIFICATION

Figure 5 - Main causes of soil desertification in Mediterranean environment.

planting and dressing fertilizations. However, in the other periods of the vegetative growth cycle, values ranged between 5 and 22 ppm (**figure 6**). We are thus dealing with values which are almost always in excess of the admissable limits for drinking water (11.36 ppm of NO_3^--nitrogen equivalent to 50 ppm of nitrates), albeit recorded directly in percolated water by lysimeters, without possibility of dilution in the groundwater.
Research carried out in France (Remy,1984), in several soils where vegetables were cultivated, showed that the content of NO_3^--nitrogen found in the ground water table varies from 17 to 130 ppm. This is evidently determined by pluviometric patterns, the nature of the land and crop techniques. The presence of nitrates in food products is nevertheless cause for concern, especially in vegetables, and in particular those with leaves. Plants are known to take up nitrogen chiefly in the nitric form: nitric nitrogen is already reduced in the roots and forms aminoacids. Part of the nitrates shifts directly into the leaves and here, still through the action of nitrate-reductase, in the presence of considerable energy quantities derived from the photosynthetic process it undergoes the same reduction process. However, when light conditions are insufficient, some non-reduced nitrate remains, as is found, for example, in vegetables harvested in the early morning (**table 3**), even if the use of fertilizer has not been excessive.
When nitrates in the leaves of vegetables, in foodstuffs in general and above all in water, exceed a certain threshold, they are harmful in that the nitrites derived from them combine with amines to form nitrousamines, cancerogenous substances, in the stomachs of adults and metahemoglobin in breast-fed babies, which may lead to cyanosis.
Therefore, if on the one hand the amount of mineral nitrogen should be reduced to what is strictly indispensable and at the same time be administeredin separate doses according to crop requirements, it must be underlined that in Mediterranean environments characterized by the chronic lack of organic matter, nitrogen fertilization becomes the decisive factor for attaining satisfactory production levels.
Another possible source of serious environmental impact arising from farming activities is the use of herbicides and antiparasitics which is now widespread. These products may cause pollution of foodstuffs, water and the environment. However, in reality, the major culprit is not their use in itself but their irrational use, sometimes arising from ignorance, at other times from a misguided notion of shrewdness on the part of farmers. The chemical products used are often not the least toxic of those available, but the most heavily promoted by chemical manufacturers. Doses are usually increased with the illusion of obtaining better results in less time. The times required for the complete metabolization of the products prior to harvest are frequently reduced. In most cases these are the reasons for such pollution of foodstuffs and water. Nevertheless, in controlling weeds , which are particularly damaging in the Mediterranean environment as they compete with crops for the little water available in the soil, rotation makes a valid contribution, while much is expected of the introduction of

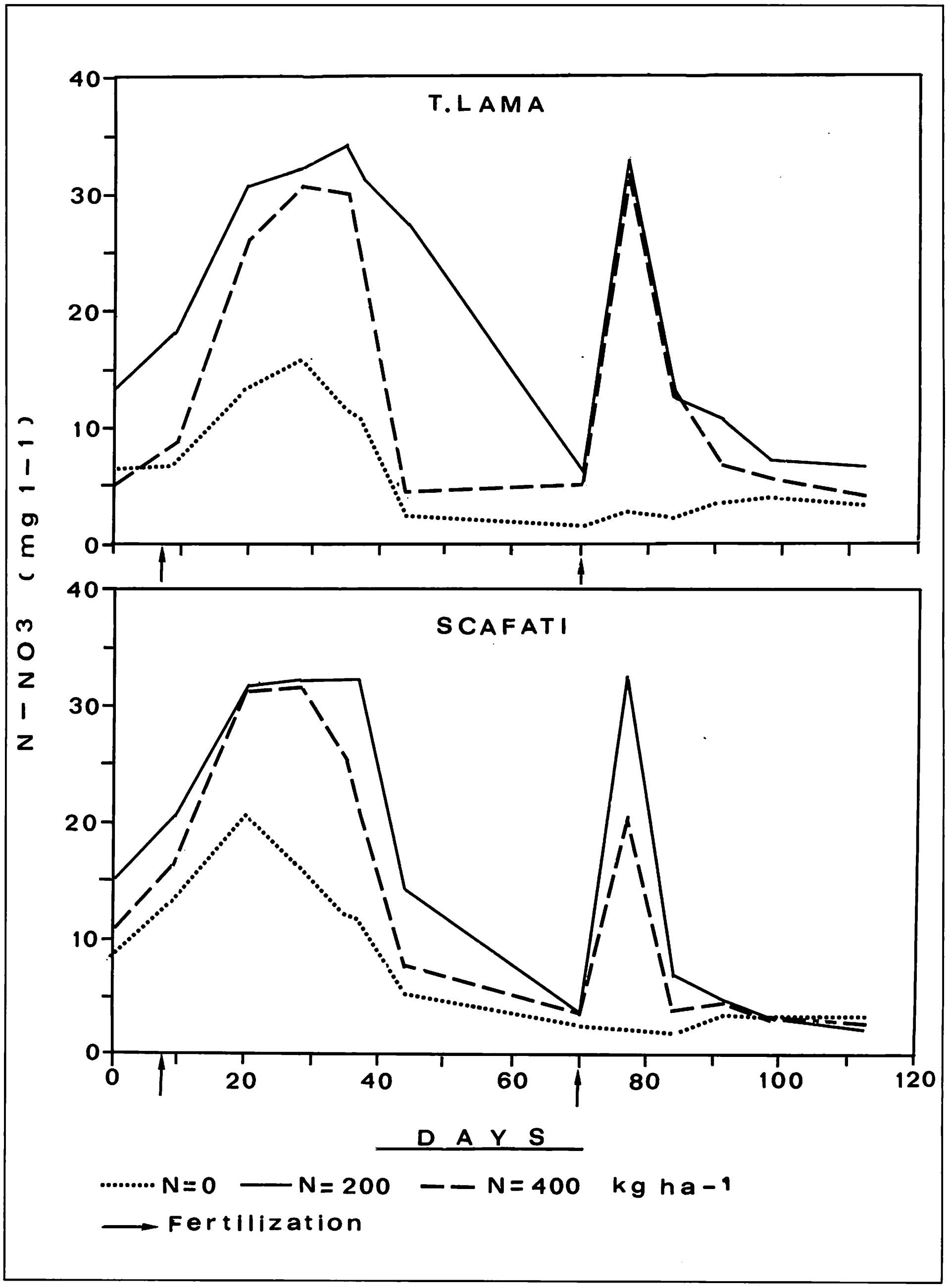

Figure 6 - Trend of $N-NO_3$ concentration.

Table 3 ***Influence of harvest time on nitrogen content in lettuce.***

Time	$N\text{-}NO_3$ (% D.M.)	NO_3 (PPM F.M.)	Tot N (% D.M.)	Cumul. radiation ($W\ M^{-2}$)
7.00 A.M.	2,56 A	647,71 A	2,814 N.S.	175,341
1.00 P.M.	1,70 B	411,28 B	2,877 N.S.	6.484,396
7.00 P.M.	1,12 C	286,60 C	2,901 N.S.	11.506,526

resistance in cultivated plants to several eco-compatible (eg. glyphosate) but non-selective herbicides.
Lastly, to reduce the use of antiparasitics, apart from some agronomic practices such as rotation, use of early varieties and irrigation precautions, guided control, or biological or integrated control may already be carried out, while it is hoped that resistant varieties to animal or plant parasite attacks will be made available.
However, in this case as well it should be added that water pollution often derives from the use of antiparasitics and herbicides on the part of the health authorities in controlling insects, rats etc. and from the cleaning of canals effected by local councils, consortia etc. not with manual and mechanical means, but with massive doses of herbicides.

Conclusions

Agriculture in the Mediterranean environment is often carried out in very difficult conditions. Nevertheless, with some crops and in certain areas it manages to supply high quality products, which, in the general trend towards superproduction, is already a considerable advantage.
However, this fact should not exempt us from taking all the necessary steps to avoid the slow but inexorable degradation of the soil, so as to use in the best possible way this valuable resource and conserve it for future generations.
In order to safeguard and conserve the soil, in the case of hilly and mountainous terrain a vast programme of afforestation and proper pasture management is recommended, which will allow atmospheric CO_2 to be controlled, as well as a modest but secure income. In the case of low hills and plains, soil layout will need particular attention.
As regards ecocompatible farming, much is expected from physiological studies of production, which aim to investigate the growth model of cultivated plants, and knowledge of agrometeorology. When appropriate choices of varieties, environments and cultivation periods are made and variations in climatic conditions are consonant with the physiological requirements of plants in each growth phase, it will be possible to improve production in quantity and quality, to avoid various kinds of plant stress and limit external technical intervention (irrigation, fertilization, various treatments) with a consequent saving in energy and reduction in pollution.
Thus, research projects directed towards utilizing certain crops to produce alcohol and vegetable oils to be used as fuel, so-called bioethanol and biodiesel, and those directed towards producing biogas or other forms of fuel from biomass, crop subproducts, residues and slurry from livestock breeding, may in the not too distant future reduce the use of fossil fuels , thereby emitting into the atmosphere only CO_2 taken from crops and eliminating the emission of other polluting compounds formed in the combustion of petroleum products.
However, environmentally-friendly production is already possible today, with the sensible use of some technologies, without recourse to drastic measures, such as the abolition of fertilizers and plant protection products which would take agricultural production back to the levels of the last century.
In particular, as regards irrigation, it is necessary to take account of the whole dynamics of water in soil-plant relationships, and to rationalize the choice of volumes, of the moment and systems for irrigation; it should be recalled that in a dry-hot environment the water resource is indispensable for production, although it must be used sparingly. In particular, in the areas where saline water is available, irrigation should be carried out with the appropriate precautions, according to the concentration and nature of dissolved salts, the land, the climate, crop sensitivity and growing period.
As for the administering of organic matter, given the many advantages and the abovementioned specific need for organic matter in Mediterranean farming land, it is advisable to use every product available from manure to straw and subproducts of other crops with appropriately added nitrogen, from green manure to compost, and slurry if well-treated.
Industrially-prepared fertilizers, just like herbicides and anti-parasitics, used in appropriate doses, periods and formulation, contribute to improving production without damaging the enenvironment.
The use of these chemical products may be further reduced with the adoption of certain agronomic expedients. Thus, for example, with the use of rotation, together with other advantages, weed growth is reduced and the incidence of animal and plant parasite attacks is controlled; through the introduction of a legume crop, nitrogen fertilization may be eliminated and savings are made on the next crop; by means of appropriate irrigation techniques, relative air humidity is not increased, thereby controlling the development of cryptogams; the cultivation of herbage crops for green manure mobilizes several elements in the various soil layers and reduces the washing away of nitrates; the adoption of new varieties resistant to biotic and abiotic stresses allows savings in irrigation and in combatting plant diseases. Lastly, as regards disinfestation of the soil, we may resort to solarization, and the use of steam at a high temperature for soil substrates.
It may be concluded that agriculture in the broad sense, including forestry management, caused damage to the environment in the past. Nowadays, however, with the acquisition of due respect for nature and resources, agriculture constitutes, thanks to the available technologies, above all in difficult environments, not only a means for utilizing the soil for production purposes, but also an activity aiming chiefly to defend and protect the environment. ●

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