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REVUE DE LA RECHERCHE AGRONOMIQUE MAROCAINE

Institut National de la Recherche Agronomique
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SOMMAIRE

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Soil fertility assessment at agricultural experimental stations in Chaouia, Abda, and Doukkala[1]

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ABSTRACT

Levels of soil fertility — whether deficient or in excess — are important characteristics in field experimentation. As nutrient levels tend to increase in soils at experiment stations due to continuous fertilizer use, periodic assessment is necessary in order to validly extrapolate research findings to farmers. This study surveyed the status of organic matter, major nutrients (NO_3, P, K), micronutrients (Fe, Zn, Mn, Cu) and in some cases, salinity, at five experiment stations in the semi-arid rainfed area of Morocco : Aïn N'Zagh, Sidi El Aydi, Jemaa Shaim, Khemis Zemamra and Monnin Lucien. While data varied within and between stations, the main features were high NO_3 Levels at Sidi El Aydi and high P levels at all stations. This was mainly due to fertilization. Soil K levels were naturally high. At some stations Fe and Zn levels were marginal. The survey has implications for administrators as well as scientists involved in experiment station use.

INTRODUCTION

Experimentation is the primary catalyst for innovation and development in agriculture. During the past few centuries to modern times, the establishment of research farms or stations

1. Soil Fertility Specialist, Visiting Professor, and Soil Scientist, respectively.

have been significant milestones in the history of agriculture. The early researchers or thinkers were able, through such farms set aside for experimentation, to clarify and refine their ideas about fundamental aspects of agriculture, as well as identify more suitable farming practices. Field experimentation in agriculture gained momentum in response to the compelling need to improve the lot of the farmer. Agricultural research advanced with developments in the sciences that supported it.

Experimentation emerged as an established discipline in France in the eighteenth century through the efforts of Boussignault. Through such experimentation, Liebig, in Germany, established his now well recognized theories of plant nutrition. Similarly, the monumental work of Gilbert and Lawes at the renowned Rothamsted station in England Ushered in the era of modern chemical fertilizers. Similarly, progress in U.S. agriculture has been — and still is — closely linked with a well-developed system of experiment stations. Given decreased support in recent years, the emphasis on improving their efficiency is more crucial than ever (Feltner, 1988). Such stations may be associated with research and/or teaching institutions or commercial interests; they range in size and complexity, and may specialize in one commodity or embrace a range of concerns. It is a system that is constantly evolving in response to societal change. Irrespective of their stage of development, most countries have a system of agricultural research involving field stations. Such systems usually reflect the extent of economic and social development of the host countries. While agricultural research is relatively new in lesser developed countries, the need is even more crucial, given the urgency to provide adequate food for their usually rapidly growing populations.

Agricultural research in Morocco is primarily the responsibility of the Institut National de la Recherche Agronomique (INRA). Its origins and functions can be traced back to colonial times in 1919. To support its research endeavors, INRA has an extensive network of experiment stations and research-demonstraction farms throughout Morocco. These may be commodity — or discipline — oriented, depending on location. A major research thrust of INRA, along with the Mid-America International Agricultural Consortium (MIAC) and with support from the United States Agency for International Development (USAID), has been the Dryland Agriculture Project in Settat, which focuses on crop production in the semi-arid 200-450 mm rainfall zone. Through primary emphasis of this multi-disciplinary effort has been on cereal, legume, and forage crops, the entire farming system is considered. The success of the project, in terms of research and technology transfert, is dependent to a large extent on effective utilization of the experiment stations in this zone.

A number of considerations are involved in the siting of an agricultural experiment station. A major requirement is that a station be located in an area which represents the climate of a broader climatic zone. Ideally, it should be located on major soil types of that region. As such, technologies developed at the station can be transferred to farmers in that region. While other considerations are involved in site selection for a station, land from Government and State agencies; i.e., nearness to roads and railways, physical facilities such as buildings, farm roads, irrigation structures, and both costs and availability of suitable land tracts, the issue of representiveness in terms of soil and climate is paramount.

However, once selected and used for the normal range of experiments, the soil undergoes slow but inexorable change. Continuous cultivation has been shown to reduce levels of soil organic matter, while use of irrigation frequently leads to a build-up of soluble salts, the extent of which depends on the irrigation water quality. Few characteristics of soil change as much as its fertility; indeed, such changes have been monitored for over a century in Rothamsted in England. However, it was not until recently - with the advent of the age of intensive chemical fertilization — that such changes had a significant impact on farming practices. Previously, it was thought that fertilizer elements such as nitrogen, phosphorus and potassium did not accumulate to any significant extent as a result of continued application.

Nitrogen, the major fertilizer input, normally does not significantly build-up in soil; any excess N left over after a cropping season, i.e., residual N, can be taken up by the following crop, while it may also be subject to losses from leaching or loss as a gas through volatilization and denitrification. In dryland agriculture, such N losses are considered to be minimal. Thus, significant carry-over can occur. Indeed, Abdel Monem et al. (1988 a) showed that carry-over of N from a previous legume was adequate for the succeeding grain crop.

Potassium is known to build up in the soil in exchangeable or plant available forn with continued utilization, though some soils have the capacity to hold or «fix» K in unavailable form. Phosphorus, on the other hand, exhibits more complex behavior in soil. As a result of «fixation» reactions of fertilizer P with soils, only a small fraction, i.e., 5-20 % of applied P., is taken up by the currently fertilized crop. While most of the P remaining in the soil is unavailable to plants, some of this adsorbed P can be potentially available to plants (Ryan et al., 1985). In the past decade or so, several studies have focused on residual P in soils and its implications for crops (Alessi and Power, 1980; Halvorson and Black, 1985). With continued yearly use of P fertilizers, crop response decreases to the point that fertilizer P can be omitted or applied in small maintenance amounts.

The phenomenon of residual P build-up has been observed in the semi-arid areas of the Middle East-North Africa. For instance, Gharbi et al. (1988); observed little response to P in field studies in Tunisia; they attributed this to continued yearly use of P fertilizer by farmers. In assessing the impact of P fertilizer use in Syria, Jones and Matar (1988) arrived at a similar conclusion. In Lebanon, Ryan et al. (1980) documented the impact of continued use of P in soils of an intensively used experimental station under a diversity of rainfed and irrigated crops. Similarly, Orphanos and Metochis (1988) pointed to a build-up of available P at experimental stations in Cyprus. Indeed, recent data from a 3-year residual study in Morocco at Sidi El Aydi demonstrated how quickly available P can build up in the soil; these workers found no response to P in any of the three years. Indeed, in the initial year of the study, no response was found even for applied N (Soltanpour and El Gharous, 1986; Abdel Monem et al. 1988c). These researchers attributed this to a build-up of N from legumes in the previous fallow.

It is thus apparent that levels of N in the soil in any cropping season are related to the previous management; where land has been fallowed, N may increase from mineralization and legume fixation, and, where cropped and heavily fertilized, residual N may be carried over from one year to the next. What are the implication of such yearly increases in soil fertility? Based an experimental data from Morocco (Soltanpour et al., 1987; Abdel Monem et al., 1988 a), it is clear that no fertilizer response is likely where available soil

P levels are above 5 - 7 ppm; criteria for N are less definite, but critical values are generally considered to be in the order to 7 to 10 ppm as NO_3. Similarly, a response to K is not likely where NH_4OaC-K is greater than 150 ppm (Halvorson et al. 1987).

Fertility build-up at stations has implications for researchers as well as administrators. Where soil levels of any nutrient exceed the critical level, experiments which seek a fertilizer response for any crop should be avoided. Similarly, studies involving methods of application are pointless; recently, Abdel Monem et al. (1988b) showed that where critical levels of soil P exceed 7 ppm, no difference can be expected between banding and broadcasting fertilizer P. However, where such considerations are not the objective, researchers frequently tend to add «insurance» levels of the major nutrients, despite adequate levels indicated by the soil test. This not only leads to further build-up in the soil, but also is an additional and unnecessary expense.

Though fertility build-up is already apparent to many researchers who have moved their fertilizer-related trails to farmers fields, which are usually of lower fertility and more responsive, this has not been, documented for the stations in the semi-arid zone. In addition to assessing the levels of N, P and K. a systematic survey should reveal levels of other nutrients or soil characheristics which influence crop growth; criteria for micronutrient availability have been developed (Lindsay and Norvell, 1978). These considerations are all the more crucial in view of the current awareness of soil characterization for agrotechnology transfer (Silva, 1985). Therefore, the objective of this study was to survey the fertility status of several major agricultural stations in the semi-arid ad predominantly wheat-growing area of Morocco.

STATION DESCRIPTION

The stations chosen for the study are located in the Aridoculture Project area as shown in fig. 1. These were Aïn N'Zagh — the Aridoculture Center headquarters, Sidi El Aydi in the Settat area in the province of Chaouia, and Jemaa Shaim and Khemis Zemamra in the Province of Abda to the south; and the newly-aquired SOGETA farm east of Sidi El Aydi, Monnin Lucien.

Some general details of these stations are presented in Table 1. These involve the year of establishment, area and altitude, rainfall, land use patterns, and the principal cultivated crops. The stations range in size from 17 hectares at Aïn N'Zagh to 320 hectares at Khemis Zemamra. All stations are relatively new; the longest in operation are Jemaa Shaim and Khemis Zemamra (1972); while the most recent of the currently operating stations is Aïn N'Zagh. The station at Monnin Lucien is scheduled for research operations in 1989/90. The stations in the Settat area- Aïn N'Zagh, Sidi El Aydi and Monin Lucien — have a mean annual rainfall of about 380 mm, while as one goes south, this decreases to 308 for Khemis Zemamra and to 275 for Jemaa Shaim. However, these figures are subject to considerable yearly variation (Watts and El Mourid, 1988). Indeed, in the current low rainfall year (1988/89), the pattern was reversed, with southern areas receiving somewhat higher rainfall. Temperature in the dryland rainfed cereal-growing area range from about 1°C in December to a maximum of 47°C in July.

The proportion of land devoted to any crop and the cropping systems vary from year to year depending on researcher needs and other considerations. All are rainfed with the exception of a section of about 50 hectares available for irrigation at Khemis Zemamra, while supplementary irrigation is available in Sidi El Aydi and used when drought threatens crops. The Aïn N'Zagh Station, which houses the Aridoculture Center and its facilities, is currently mainly devoted to research in forage utilization. The Sidi El Aydi station is intensively used for cereals, involving research in the areas of breeding, agronomy, soil management, mechanization and soil fertility; a relatively smaller section is devoted to chickpeas, lentils and medics. Cereals dominate the Jemaa Shaim and Khemis Zemamra Stations; much of their land is used for seed multiplication. As both are relatively dry, a considerable portion of the land is in fallow each year. The irrigation at Khemis Zemamra allows for other crops to be grown, i.e. sugarbeets, corn, beans, etc... The newly-acquired Monnin Lucien land is - and has been for several years - under continuous and heavily fertilized wheat.

SOILS AND PLOT LAYOUT

The stations vary in their level of development and organization, i.e., from the relatively new Aïn N'Zagh facility, where field plots are not delineated in the three disparate parcels of land, to the well established Sidi El Aydi Station with permanent plots and connecting roads. Soil — the major consideration in any station — ranges from being fairly homogeneous in some stations to being highly heterogeneous in others. Thus, some details are pertinent here for each.

Aïn N'Zagh

By virtue of topography, the soil at this station is highly variable in terms of depth and slope; other characteristics also vary as a consequence of these. Such variability renders normal research difficult. Initial soil surveys of the site pointed to the difficulty of distinguishing treatment effects from soil differences. Even over distances of a few meters, marked changes in soil depth occur; the major impact is on water-holding capacity of the soil, and therefore on crop growth.

The distribution of soil depth and slope is depicted in fig.2. The soil is predominantly of the sub-order Rendoll or Calixeroll, i.e., shallow with dark surface horizons containing considerable amounts of organic matter. While degrees of shallowness are recognized, little of the area is greater than 50 cm in depth. Similarly, about 25 % of the land is steeply sloping, i.e., above 8 % slope, while the remainder is of medium to moderately slope; virtually no area is level.

Sidi El Aydi

Contrary to Aïn N'Zagh, the experimental station at Sidi El Aydi is ideally adapted to experimentation as its topography is level and the soil deep and, for the most part, uniform (Bouksirate, 1972). Three depth categories are depicted in fig. 3. While the soil reaches a depth of one meter or more, the composition on dense layers below 60 to 75 m limits normal root growth. In general, the soil at Sidi El Aydi can be identified as a Calcic Argixeroll tending towards being Vertic; deep cracks characteristic of Vertisols are evident during the dry period. It is a black heavy clay soil with $CaCO_3$ accumulations at varying depths. Bulk density varies from 1.2 g/cc at the surface to 1.8 g/cc at depths of a meter or so. The layout of plots at the station, as well as the adjacent rented land, is depiceted in fig. 4.

Jemaa Shaim

The most important station after Sidi El Aydi is Jemaa Shaim, 150 km to the south. Of the stations considered in this report, this station is also described by a soil survey (Bouksirate, 1982). While several phases were identified in that survey, the dominant soil type is a Vertisol, i.e., well developed deep clay soil, generally dark color with varying amounts of $CaCO_3$. Despite detailed physical descriptions of the seven profiles exposed, no information was obtained with respect to fertility level. Thus, it was relatively similar to Sidi El Aydi, in terms of soil type and slope, differing only in that Jemaa Shaim is normally drier; however, the soil is deeper than at Sidi El Aydi, reaching to 2 m in places.

The 203 ha at the station, including buildings etc., are divided into two sections, i.e., 121 ha consisting of eight 15-ha blocks at the main station with a further 76 ha about 1 km away. The Latter part is used for seed multiplication, while the main section is primarily for annual cereals alternating with fallow. A sketch of this station indicating plot divisions and soil types as indicated by bouksirate's survey (1982) is show in fig. 5. These different types of soil are described in Table 2.

Khemis Zemamra

The station at Khemis Zemamra is similar to that at Jemaa Shaim in terms of soil type and climate. Indeed, they are only 40 km apart. Khemis Zemamra is mainly used for seed multiplication, but also differs form Jemaa Shaim in having some irrigation from an adjacent canal. While only limited irrigation is practiced at the main station, part of the station about 1 km or so away is set aside as irrigated land. The locations of the 29 samples in the main section and the five in the irrigated area, along with plot numbers where appropriate, are shown in fig. 6.

Monnin Lucien

The soil at this location differs from the others. While not as deep as the Vertisols at Sidi El Aydi, Jemaa Shaim and Khemis Zemamra, it is deeper than at Aïn N'Zagh. It is a red clay to a depth of 50-60 cm indurated $CaCO_3$. Based on observations of pits, the soils is relatively uniform throughout the whole 200 ha site. It is classified as an Isohumique, Chatain, Modaux as indicated in the survey by Stitou (1984). A sketch of the station along with sample sites in the surveyed area is presented in fig. 7.

SAMPLING PROCEDURE

Soil sampling was done so as to reliably reflect the fertility status of the soils at each station. This was facilitated where the station was laid out in regular plots, e.g. Sidi El Aydi, Jemaa Shaim, and Khemis Zemamra. In this case, plot plans were obtained, and a composite sample of 10 sub-samples chosen from the surface 0-20 cm in a zig-zag pattern on each plot. Where differences in soil type were observed on any plots, separate samples were taken from these areas. In addition, and for purposes of comparison, some adjacent non-station or non-plot samples within stations were taken.

Where the stations were not laid out in regular plots, a different strategy was adopted; at Aïn N'Zagh, several composite samples were obtained from each of the three sections of land with separate ones for each piece of land with similar soil type and slope. Whether the land area of a station was in plots or not, the location of the composite samples was indicated.

In Order to assess the distribution of nutrient elements with depth, representative cores were taken to various depths as appropriate. A Giddings probe was used for depthwise sampling at Jemaa Shaim and Sid El Aydi, while exposed pits were used to take sub-surface samples at Monnin Lucien. With the exception of one sub-sample, depth samples were not taken at Aïn N'Zagh since the soil was so shallow there, while at Khemis Zemamra, no probe was available at time of sampling, However, this station's soils are similar to those at Jemaa Shaim, i.e., Vertisols. In this case, comparisons were made between soil from the plots with samples from adjacent non-fertilized borders.

After sampling, the soil was taken in the laboratory and air-dried for subsequent analysis: pH (1:2.5, soil: solution) on an electronic meter; electrical conductivity (EC) of a saturated paste using a conductivity bridge, organic matter with standard Walkley-Black procedure; $CaCO_3$ by calcimetry; NO_3 by colorimetry using chromotrophic acid, P extracted by 0.5 M $NaHCO_3$ (Olsen method) and determined colormetrically with molybdenum blue; K extracted by 1 M NH_4OaC and determined by atomic absorption; and the microunutrient elements extrated by DTPA solution and determined by atomic absorption. The latter procedure was according to Lindsay and Norvell (1978), while the others are standard procedures in Black et al. (1965).

RESULTS

The soil analyses are reported for each individual station for the major nutrients — N, P, and K and organic matter (O.M.), and separately for the micronutrients — Fe, Mn, Zn and Cu. For each element, critical values are presented, i.e., below which a deficiency is likely. Additional information, where relevant, is given in the test. For interpretation, the sample numbers in each table correspond to similar numbers depicted on figures for each station. Where depthwise samples were obtained, the analyses were indicated in accompanying figures.

Aïn N'Zagh

Reflecting the inherent variability in the soil at this station, values for organic matter and major nutrients varied widely (Table 3). Organic matter was, on average, relatively high for such a semi-arid environment and varied from 2.3 to 5.6 %. With a few exceptions, most NO_3—N levels were low and below the critical value of 7 ppm. While P values varied widely from 8.4 to 38.4 ppm, all were excess of the critical values of 5 ppm. This variability was probably related to fertilizer addition. While K values were also higher than the critical value, they were fairly uniform — probably reflective of the mineralogy of the native soil. The sub-sample at 50 cm showed no decrease from the surface.

As micronutrients are not normally added as fertilizers, the values for these were fairly consistent (Table 4). Iron values for these were all marginal with respect to the critical values of 5 ppm. However, the other three were consistently above their respective critical values of 0.8, 0.2 and 0.1. ppm for Zn, Cu, and Mn. An examination of the analyses at each sampling location suggested that there was no obvious relationship between soil depth and nutrients or soil O.M. distribution.

Sidi El Aydi

Some measurements taken at this station were consistent across all plots, while others were highly variable. The most consistent property was organic matter; that was little deviation from the mean value of 2.5 % (Table 5). However, the levels, of NO_3 varied widely (CV 56.1), ranging from a low of 7 ppm in Plots 9, 11, and 19, to a high of 49.5 ppm in Plot 31. This variation was related to previous cropping anf fertilization history as evidenced by the fact that there was as much variation with the present fallow area, i.e., 7 to 32 ppm on the fallowed plots at the southern section of the rented land. Even in the irrigated area, which is represented by Samples 30 and 31 and which had been fertilized that year, NO_3-N ranged from 14 to 49.5 ppm. Despite such variation, it was evident that most plots had levels of NO_3, which were adequate for most crops; this would thus render a response to fertilizer N unlikely.

While P is relatively stable in soils, and less subject to yearly or seasonal variation as NO_3, the distribution of available P values varied widely also, i.e., 11.4 ppm in Sample 7 and 35.4 ppm in Sample 22. Both sites had been fertilized the previous year. However, it is likely that Sample 44 from the corn plot adjacent to the main buildings had a history of more intensive P use than the wheat plot which was farther away in the rented land area. The main feature of the P data was that all were above the critical value of 5ppm.

Similarly, values for exchangeable K were uniformly high and well above the critical value of 125 ppm for that element.

As the soil at the station is fairly uniform, and since micronutrient elements are not normally added as fertilizers, one would expect uniformity in levels of Fe, Mn, Zn, anf Cu. Indeed, this was the case with mean values of 3.7, 2.3, 0.6 and 0.7 ppm for these elements, respectively (table 6). However, with the exception of the Mn and Cu, mean values for other micronutrients, i.e., Fe and Zn, were below the critical levels for these elements. This would suggest a possibility of these being deficient for some sensitive crops. It was of interest to note that in one subsequent depthwise sampling, Cu and Zn were uniform with depth to 60 cm, while Mn and Fe tended to decrease with depth.

Jemaa Shaim

As the soil is similar to that at Sidi El Aydi (Table 5), data in many ways were similar. Organic matter levels were uniform with a mean value of 1.5 %. Though there was no apparent relationship with cropping pattern, values on the F and G fields tended to be somewhat higher.

While NO3 levels varied widely as at Jemaa Shaim (cv, 65.3) there was no relationship between organic matter and NO3, but there appeared to be some relationship with cropping systems. For example, the lower half of the A, B, C and D fields — all in fallow — had higher levels of NO3 than the corresponding upper half which had been in cereals. This is consistent with the observation that little N is normally left over after a cereal crop, while an increase in soil N usually occurs in fallow as a result of mineralization. Other areas with somewhat elevated levels of NO3 were the G plot adjacent to the main buildings and on the area of whitish soil in the adjoining H field.

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The distribution of the NaHCO3 - P was less erratic than that of NO3 (cv, 23.9) with a mean value of 15.8 ppm. There was no apparent relationship between individual plots or fields on any section of the station. All plots had higher than the critical level for P. The highest P value was at the anomalous site in F field. This was in contrast to the lowest value of 9.4 which was obtained at an adjacent road cutting. That all values in the station were higher than the value for the same unfertilized soil supports the view that the increases were due to previous fertilization. That there were little differences in P levels between fields suggests a history of uniform P application.

As with Sidi El Aydi, K values were consistently uniform, with two notable exceptions, and well above the critical level. As K fertilizers are not currently applied at the station, these levels are the result of native soil mineralogy. The two exceptions were both anomalous areas of which soil in the F and H fields. As previously noted, such areas were also higher in organic matter and both NO3 and P.

The analyses of micronutrients revealed some interesting information (table 8). The Fe values varied widely from 2.3 to 16.7 ppm, with a mean value of 7.9; however, most in the 7 to 9 ppm range. Only two samples were less than the critical level of 5 ppm; these came from the anomalous white soile patches in the F and G fields. Therefore, with these minor exceptions, one could conclude that Fe deficiency is unlikely there. In contrast, values for available Zn were generally less than the critical level of 0.8 ppm. Possible observations of Zn deficiency at this station may have given rise to studies on Zn (Azzaoui et al., 1987). The mean value of 0.8

reflected two unusually high values, i.e., 3.9 ppm at the site of the Zn-P study of Azzaoui et al., 1988) and at the anomalous site in H field. Though the latter study did not detect any response to Zn, this may be due to the fact that the test crop was wheat, which is one of the least responsive crops to Zn. Recent observations by the authors indicated symptoms of Zn deficiency in corn in April 1989, at this station. Levels of Cu were uniform and well above the critical level. The one high value of 2.5 ppm came from the experimental plots of Azzaoui et al. (1987) who used Cu as a variable. While Mn values were more variable, they were all less than 10 ppm, but were well above the critical level of 1 ppm for that element.

Distribution of nutrient elements with depth reflect not only the nature of the parent material from which the soil developed and the pedogenic processes involved but also the extent to which fertilizer has been added. Therefore, in order to describe the soil profiles in terms of soil fertility, depthwise samples were taken at three sites in the main section and at the H field and one at the land about 1 km from the station. As all profiles exhibited the same trend, all values were averaged and means of each element were presented. Not surprisingly, the highest values of N, P and K were in the upper 20 cm layer (Fig 8). On would expect NO3, being mobile, to accumulate through evaporation in this layer. The accumulation of P and K was due to either soil development processes or fertilization. It was, however, interesting to note that the lower layers were deficient in P but still well supplied with K.

Micronutrient distribution with depht varied with the element (Fig. 9). Iron was slightly higher in the surface 0-20 cm, but was fairly uniform with depth thereafter, similarly with Cu and Mn. Zinc, on the other hand, appeared to be uniformly distributed with depth. With the exception of some Fe samples, none of the lower samples of the other elements were deficient.

Khemis Zemamara

Analyses of the sample taken from the main station and its adjacent irrigated section are show in Tables 9 and 10. The location of the samples are indicated on the accompanying map (Fig. 6). This station exhibited a number of similarities with both Sidi El Aydi and Jemaa Shaim since all three are located on similar soil type, i.e., deep clay Vertisol. However, the analyses detected differences due to fertilization and due to irrigation; most samples were about 0.5 mmhos/cm or less.

Organic matter levels were relatively uniform; however, values from the irrigated section were all less than the average of 1.8 % for the station as a whole. Indeed, levels of all three major elements were less than for the rainfed main station; mean values of N, P and K were 56,80, and 40 % of the respective means for the overall station. The relatively low values for K probably reflected a textural change in the soil surface, i.e., increasing silt due to irrigation water laden with sediments.

Despite the uniform soil at the main station, difference in fertility were also detected. Organic matter values tended to be higher in road samplings by comparison with cultivated fields, as well as in fields adjacent to the main buildings and on the patch of whitish soil (Sample 26 on Plot 12). These results may be explained by the fact that continuous cultivation reduces soil O.M., and those areas adjacent to main buildings usually receive more O.M. from animal manure and household refuse. As with the other stations, there was the apparent relationship between organic matter and NO3. However, high values of NO3 were also found at the anomalous site, where P values were also high. It is apparent that this was a building site or dumping site in the past — values of P are reliable in detecting such past human activities (Miller and Ryan, 1987).

Little N was evidently left in the soil at the end of cropping, since no differences were apparent between the plots and adjacent roadsides. When such a comparison was made for P, the situation was different from either O.M. or NO3. Here the cultivated fields

Little N was evidently left in the soil at the end of cropping, since no differences were apparent between the plots and adjacent roadsides. When such a comparison was made for P, the situation was different from either O.M. or NO3. Here the cultivated fields had higher levels of P — reflecting the added fertilizer P which had accumulated over the years. None of the samples were lesse than the critical value for NaHCO3—P. Though K values varied little over moste of the rainfed part of the station, values tended to be higher in Samples 25 to 29 which were adjacent to the house. This was further evidence of the effects of manure and animal tethering.

The distribution of micronutrients indicated some differences associated irrigation and previous human activity (Table 10). Data for Fe were highly erratic; while the irrigated area had two values less than the critical level, it also had two high ones. In the rainfed section, there was no obvious effect of cropping; the abnormally high value 63.6 ppm (Sample 26) was found at the anomalous site in Field 13. Values for Zn were remarkably uniform, whether irrigated or not. However, Cu and Mn values tended to be higher at the irrigated location. In terms of plant availability, all fields were adequate for Mn and Cu, moste were adequate for Fe, while all were marginal for Zn. Thus, should any micronutrient deficiency occur, it would most probably be Zn, especially with irrigation and sensitive crops such as corn and lentils.

Monnin Lucien

The area of this farm sampled was about 80 ha as one field east of the farmhouse. The locations of the composite samples are shown in Fig. 7. The analyses (Table 11) revealed similarities found in the other stations – and some startling differences. While O.M. was similar to that of Sidi El Aydi, Jemaa Shaim and Khemis Zemamara, the distribution varied somewhat; higher levels occurred near the private road at the lower side of the field and adjacent to the house. Nitrate levels, though generally low, tended to follow this pattern. As with the other stations, P levels were well above the critical level, with moste being between 20 to 30 ppm; an exceptionally high value of 88 ppm occurred near the house with the first sample. The distribution of K was fairly uniform, with a mean of 160 ppm which, though lower than other stations, was nevertheless above the critical range.

The analyses for DTPA – extractable micronutrient (Table 12) indicated possible deficiency of Zn and unusually high levels of Mn. Virtually all samples were less than the critical level for Zn, i.e., 0.8 ppm; the mean value was 0.6 ppm. Though Fe was variable, all except one sample were above the critical 5 ppm level. However, levels of Mn were the highest shown at any station, with an average of 78.4 ppm. Indeed, samples taken from adjacent non-station but similar soil revealed considerably lower levels of Mn which were in accord with most other soil types in the region.

Depthwise date were obtained from sampling at three exposed pits; these were in increments of 20 cm to a depth of 40 or 60 cm depending on soil depth. Average values in Fig. 9 show accumulation of NO3-N and P towards the surface, while K was relatively constant with depth. This would suggest that K was a reflection of inherent soil mineralogy, while N and P were increased due to fertilization.

STATION COMPARISON

Despite being in a similar semi-arid zone and with fairly similar soil types, there was a wide range in soil properties and fertility between stations as depicted in Figs. 10 and 11, notwithstanding the wide differences at any one station. The percentage of samples at each station falling below the critical level is shown in table 13. In fact, the mean profile for each parameter varied widely.

With respect to organic matter, the most notable difference was the high levels of Aïn N'Zagh Station. These were about twice those for Jemaa Shaim, Khemis Zemamra, and Monnin Lucien, and about 25 % higher than at Sidi El Aydi. While a trend for decreasing organic matter with decreasing rainfall was evident, given a similar soil type at Sidi El Aydi and Jemaa Shaim and Khemis Zemamra, differences between soil types were evident by the disparity between Aïn N'Zagh, Sidi El Aydi and Monnin-Lucien — all in the Settat area with similar rainfall.

Mean NO3 levels showed a similar disparity between stations. Ironically, the lowest level was at Aïn N'Zagh which had the highest organic matter level. However, such relationships are tenuous at best. The most notable feature was the high level of NO3 at Sidi El Aydi, while other stations were marginal with respect to critical NO3 levels, this station was on average well above the critical level. While the percentage of individual plots falling below this level ranged from 48 to 64 for the other stations (table 13), none at Sidi El Aydi were less than the critical level.

By contrast with NO3, the profile for available or NaHCO3-P was well above the critical value of 5 ppm for Jemaa Shaim to over 30 ppm for the new station at Monnin Lucien. In fact, no sample at any station was less than the critical level. These elevated P levels were mainly due to P fertilization. For example, the high P values from the intensively fertilized Monnin Lucien Station contrasted sharply with low values for 2 to 5 ppm in an adjacent unfertilized field on the same soil.

The profile for K was similar to that of P in some respects; all were above the critical level, with mean values at Khemis Zemamra and Monnin Lucien being marginally so. However, the order differed from that of P; in this case, the highest values were with Sidi El Aydi and Jemaa Shaim. Only Khemis Zemamra had some plots with lower than critical levels of available K. As samples frome non-plot areas at the stations were not markedly different from station plots, différences in K values were probably due to inherent soil differences rather than to fertilization.

Micronutrient distribution (Fig. 11) was as variable as macronutrients were between stations. However, there were no similarities in the patterns between the two groups of nutrients. The mean values for Fe were highest at Jemaa Shaim and Khemis Zemamra and well above the critical value of 5 ppm, although a few samples at each station were below the value. Monnin Lucien had no sample below the critical level. However, there was indication of Fe deficiency at Sidi El Aydi where the mean value (3.7 ppm) and 79 % of all samples were below this critical level. Zinc exhibited an even greater extent of deficiency; only one station, i.e., Aïn N'Zagh, had a mean value above the critical level of 0.8 ppm, and also had no deficient sample. The other four stations had a higher percentage of their samples deficient, ranging from 68 % for Jemaa Shaim to 91 % for Monnin Lucien (Table 13).

The distribution of Cu and Mn was, however, quite different from that of Fe and Zn. For Cu, most samples were above the critical level of 0.2 ppm, with the exception of 10 % of the Khemis Zemamra samples. Highest mean Cu values were at Monnin Lucien and Sidi El Aydi, intermediate at Jemaa Shaim, and lowest at Aïn N'Zagh and Khemis Zemamra. While only four samples, i.e., at Sidi El Aydi, were less than the critical value of 1 ppm, the analyses were unusual in that they identified abnormally high levels of this element at Monnin Lucien. The probable causes of thise anomaly and the implications for crop growth are currently being investigated by the authors.

DATA SUMMARY

The principal findings this fertility survey may be summarized as follows:

1. There was considerable variability in soil properties and fertility between the five stations sampled.

2. Similarly, most stations were characterized by a wide variation in fertility between plots.

3. Marked differences in soil types at some stations were unrelated to rainfall.

4. Organic matter was considerably higher at Aïn N'Zagh and Sidi El Aydi Than the other stations.

5. With the exception of Sidi El Aydi, levels of NO3 were marginal to deficient.

6. All stations had avaibable P levels well above the critical value.

7. All stations had extractable K levels well above the critical value.

8. Most stations were adequate in available Fe, except Sidi El Aydi.

9. With the possible exception of Sidi El Aydi, levels of DTPA-extractable Zn were below the critical value.

10. Virtually all samples were adequate in plant available or DPTA-Cu.

11. While virtually all samples were adequate in DTPA-extractable or «plant extractable» Mn, samples from Monnin Lucien were about ten times as high as the other stations.

12. Where irrigation was practiced, i.e., at Khemis Zemamra, there was no evidence of any harmful build-up of soluble salts.

13. The survey pinpointed two anomalous patches of soil at Jemaa Shaim and one at Khemis Zemamra; the high levels of P at these sites indicate the location of a previous dwelling or other man-made artifact.

CONCLUSIONS

Some of the principal conclusions which can be made from the study's findings are:

1. The variation between plots or samples for individual stations can be attributed to man or nature depending on the element.

2. The highest levels of NO3 at Sidi El Aydi is probably due to continuous use of N fertilizers leading to N accumulation. However, with cropping and reduced fertilization, this «surplus» soil N could be depleted in a few seasons.

3. The high levels of P at all stations was probably due to fertilization. Unlike NO3, this level could not be reduced within a few seasons' cropping.

4. The variation in K is probably related to differences in mineralogy of the individual soils.

5. Potassium deficiency is unlikely to occur for dryland wheat in the limited rainfall area.

6. If any micronutrient deficiency would occur, it would probably be that of Fe or Zn. Of the crops grown in the semi-arid rainfll area, wheat and barley are least likely to have problems with either element.

7. The high levels of Mn at the Monnin Lucien station were apparently related to intensive P fertilization.

8. The variation in micronutrients is probably due to natural soil variation, since these elements are not normally added as fertilizers.

IMPLICATIONS

The study has several implications for both researchers and administrators.

Researchers

1. The most obvious consequence of N and P accumulating — through routine yearly application — to levels well above the critical values is that little or no response can be demonstrated to N or P fertilizer application. This may lead to erroneous conclusions regarding crop responsiveness to fertilizers; these «high fertility» conditions do not normally occur on farmers fields. Similarly, excessive levels of N or P tend to invalidate conclusions about methods and times of application or any experiment where N and P are variables. Where trials involving fertilizers have, of necessity, to be done on-station, the study has identified individual plots where such trials can be conducted because of their lower N or P values. This is particularly important where long-terme trials are involvec.

2. In identifying the micronutrient states of station plots, the study should facilitate researchers in their choice of plots if the proposed crops are sensitive to micronutrient deficiency such as Fe or Zn. It should be borne in mind that not only are there specific differences with respect to susceptibility, but also withing varieties or lines. The critical values for micronutrients presneted here were developed for corn and sorghum (Lindsay and Norvell, 1978). However, recent studies (Halvorson et al., 1987) suggest that values for wheat are lower; critical levels of Fe and Zn for wheat are 2 and 0.3 ppm, respectively.

3. While the levels of high soil fertility primarily concern agronomists, they also concern breeders since performance of varieties or lines under conditions of high fertility on-station may not be similar in farmers fields where fertility is normally lower.

Administrators

4. Knowledge of the fertility statuts of the stations, along with its resultant limitations for some types of field research, should enable administrators to more effectively allocate and utilize the stations limited land res ources. Only the moste appropriate studies should be located there. Fertilizer response studies under the present conditions are more appropriate to on-farme conditions. In fact, this study justifies the current trend among researchers to do such trials off-station.

5. It is apparent that in some areas fertilizer, particularly in the case of P, is applied when it is not needed. Eliminating such unnecessary use would result in considerable cost savings for the stations. There is little justification for indiscriminate use of fertilizer when suitable locally vertified soil tests are available upon which to base such decisions.

6. The authors conclude that some parts of the stations could be cropped intensively to reduce fertility levels, thereby providing researchers with land area where fertilizer responses can be obtained.

PERSPECTIVE

This study was designed to provide baseline information on the principal research station in the semi-arid rainfed area of Morocco with the view to improving their use efficiency. The results not only serve as a basis for better research management, but also provide an explanation for the frequently observed lack of fertiliszer response at stations over the past years. This has logically been attributed to nutrient build-up from continuous fertilizer use. Not surprisingly, this phenomenon has been shown for research stations in the Middle East-North Africa region and elsewhere; indeed, reduced response to P fertilizer on farmers fields due to its continuous use now a commonplace occurrence. As nutrients built up in soil with continued use, so also may they decrease with time depending on cropping and the extent of further fertilizer inputs.

The study established an awareness of the possible significance of micronutrients such as Fe and Zn in dryland farming. Though micronutrients, and the soil conditions which affect them, remain constant with time, the status of N, P and K needs to be monitored every few years.

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Table 1. Details of experimental stations in Chaouia, Abda and Doukkala

Station	Year	Area	Altitude	Rainfall	Land Use	Principal Crops
		ha	m	mm/yr	%	
Ain N'Zagh	1982	17.0	450	380	Research Ley Farming	Cereals Forag, medics Legumes
Sidi El Aydi	1975	39.75	366	380	Research-50 Fallow-44 Production-6	Cereals: Wheat, barley Forages: medics, grasses Legumes: chickpea, beans, lentils Oil crops: sunflower
Jemaa Shaim	1972	203	170	275	Research-25 Production-25 Fallow-50	Same crops as Sidi El Aydi
Khemis Zemamra	1972	320	168	308	Research-15 Seed increase-50 Fallow-35	Same crops as Sidi El Aydi
Monnin Lucien	1989	100	375	380	Production-100%	Wheat

Table 2. Soil types with French and soil taxonomy systems as identified in map of Jemaa Shaim

Classes et Sous-Classes (Orders and Suborders)	Groupes et Sous-Groupes (Great Groups and Sub-Groups)	Familles (Families)	Séries	Unités
Vertisol à Drainage Externe Réduit (Vertisol-Xerert)	Sol à structure arrondie, vertique (Palexerollic Chromoxerert)	Limon rouge, (Clayey, fine, non-acid, thermic)	Très profond (>80 cm) argileux, charge très faible, pente nulle, non-calcaire	1
			Profond (60 à;80 cm), argileux, charge très faible, pente nulle, calcaire	2
	Sol à structure anguleuse modal (Palexerollic Chromoxerert)	Limon rouge, (Clayey, fine, non-acid, thermic) calcaire	Très profond (>80 cm), argileux, charge très faible, pente nulle	3
Calcimagnesique Saturé (Mollisol-Rendoll)	Brun calcique épais (Rendollic)	Limon rouge, (Clayey, fine, non-acid	Profond (60 à 80 cm), argileux, pente nulle, calcaire	4
Calcimagnesique Carbonate (Mollisol-Xeroll)	Brun calcaire à encroûtement calcaire	Limon rouge, (Clayey, fine, non-acid, thermic)	Profond (60 à 80 cm), argileux, pente nulle, calcaire	5
	Brun calcaire sur croûte (Petrocalcic-Palexerollic)		Moyennement profond argileux, charge faible, pente nulle	6
	Brun calcaire vertique (Vertic Calcixerollic)	Limon rouge, (Clayey, fine, non-acid, thermic	Très profond (> 80 cm) argileux, charge faible, pente nulle	7

After Bouksirate (1982)

Table 3. Distribution of organic matter and major nutrients at Aïn N'Zagh Station

Sample n°	Organic Matter %	NO_3-N	P ppm	K
1	3.7	3.0	13.4	160
2	2.3	6.4	13.0	165
3	3.1	7.8	17.0	175
4	5.6	15.0	26.0	240
5	4.8	8.8	25.0	220
6	2.5	3.0	8.4	160
7	4.3	4.4	35.4	220
8	4.3	12.0	32.0	285
9	4.8	5.6	19.0	220
10	5.1	11.2	25.4	285
11	4.8	5.4	17.4	190
Sub Sample				
12				
Mean	5.0	7.3	22.5	21.4
C.V.	26.4	51.3	41.8	21.1
Critical Level		7.0	5.0	150

Table 4. Distribution of micronutrients at Aïn N'Zagh Station

Sample n°	Fe	Zn	Cu	Mn
	ppm			
1	5.5	0.92	0.20	6.5
2	5.4	0.86	0.42	9.6
3	6.1	0.96	0.46	11.2
4	5.1	1.08	0.28	9.4
5	5.2	1.12	0.32	10.2
6	4.9	0.96	0.22	4.2
7	3.9	0.82	0.26	5.5
8	4.1	1.34	0.24	5.9
9	4.2	1.18	1.26	4.5
10	5.3	0.98	0.32	9.6
11	5.5	1.08	0.34	12.3
Sub Sample				
12	6.0	1.24	0.26	9.2
Mean	5.1	1.05	0.3	8.18
C.V.	13.9	15.0	76.0	33.0
Critical Level	5.0	0.8	0.2	1.0

Table 5: Distribution of Organic matter and major nutrients at Sidi El Aydi Station

Sample n°	Organic Matter %	NO_3-N	P	K
		ppm		
1	3.2	16.2	13.4	275
2	2.9	26.0	17.4	345
3	3.4	22.9	15.4	345
4	2.6	32.0	22.0	345
5	2.2	28.0	14.0	355
6	2.5	22.8	17.4	260
7	2.6	26.0	11.4	290
8	2.9	29.0	14.0	280
9	2.3	7.0	15.4	225
10	2.6	15.0	15.0	330
11	2.5	7.0	13.4	295
12	2.5	12.0	19.0	250
13	2.5	22.0	16.0	285
14	2.5	2.0	11.4	260
15	2.5	39.0	25.4	280
16	2.5	24.0	19.0	370
17	2.5	8.0	18.0	250
18	2.6	12.0	17.0	285
19	2.6	7.0	16.0	275
20	2.2	11.0	17.0	290
21	2.6	12.0	23.4	375
22	2.6	38.0	35.4	440
23	2.5	11.0	22.0	330
24	2.3	17.0	26.4	280
25	2.2	10.0	22.4	325
26	2.3	9.5	22.0	295
27	2.5	13.0	29.0	335
28	2.3	33.5	23.4	280
29	2.9	25.5	25.4	330
30	1.9	14.0	29.0	295
31	3.3	49.5	29.0	295
32	3.3	11.0	16.0	295
33	2.6	13.5	20.0	335
34	2.3	11.0	20.0	360
35	2.5	23.0	22.0	375
36	2.9	28.0	18.0	350
37	2.6	18.0	25.0	405
38	2.9	16.3	21.0	290
39	2.4	8.5	19.4	295
40	2.5	13.5	17.0	345
41	1.9	14.0	17.4	310
42	2.8	15.5	23.4	390
43	2.8	26.4	33.4	495
44	3.1	9.6	27.4	390
Mean	2.5	18.4	20.3	324
C.V.	12.5	56.1	27.2	163
Critical Level		7.0	5.0	125

Table 6. Distribution of micronutrients at Sidi El Aydi Station.

Sample n°	Fe	Zn	Cu	Mn
	ppm			
1	4.1	2.0	0.6	2.1
2	3.2	0.6	0.6	1.8
3	4.6	0.6	0.6	1.2
4	5.9	1.1	0.8	1.2
5	5.7	0.7	0.7	1.0
6	3.3	1.3	0.6	1.4
7	3.0	0.9	0.6	1.3
8	2.6	0.2	0.6	1.1
9	3.0	0.6	0.6	1.0
10	4.7	0.3	0.7	1.4
11	4.3	0.5	0.7	2.1
12	3.0	0.1	0.6	0.8
13	3.1	0.3	0.7	1.0
14	3.5	0.6	0.6	1.4
15	3.2	0.6	0.6	3.4
16	5.7	0.5	0.8	4.6
17	3.2	0.2	0.7	1.5
18	3.3	0.3	0.7	1.6
19	3.3	0.5	0.6	1.5
20	5.1	0.8	0.8	1.7
21	8.4	1.2	0.9	2.1
22	7.1	1.2	0.9	3.1
23	3.9	0.4	0.7	2.0
24	3.9	0.3	0.6	2.6
25	5.4	0.3	0.7	4.5
26	3.4	0.3	0.7	3.0
27	3.4	0.8	0.8	4.4
28	3.5	0.3	0.7	4.1
29	2.3	0.3	0.7	2.9
30	2.5	0.3	0.7	2.2
31	3.0	0.7	0.7	4.8
32	3.1	0.3	0.5	2.3
33	2.5	0.5	0.5	2.6
34	2.9	0.5	0.6	3.8
35	2.0	0.7	0.6	3.4
36	1.8	0.4	0.7	1.7
37	2.3	0.5	0.8	2.4
38	1.9	0.3	0.5	1.6
39	1.0	0.4	0.5	0.9
40	3.4	0.5	0.9	5.4
41	3.4	0.7	0.9	5.4
42	2.8	0.6	1.4	4.2
43	2.6	0.3	1.6	7.9
44	5.2	0.6	1.2	4.4
Mean	3.7	0.6	0.7	2.3
C.V.	39.9	65.2	15.1	51.2
Critical Level	5.0	0.8	0.2	1.0

Table 7. Distribution of organic matter and major nutrients at Jemaa Shaim Station.

Sample n°	Organic Matter	NO_3-N	P	K
		ppm		
1	1.4	13.8	12.4	300
2	1.2	8.0	15.0	250
3	1.4	3.8	13.0	285
4	1.5	21.8	15.4	320
5	1.4	20.4	17.4	330
6	1.4	8.9	21.0	330
7	1.4	3.4	15.0	270
8	1.4	12.2	13.4	275
9	1.2	6.8	17.0	300
10	1.4	5.2	18.0	315
11	2.1	9.2	18.4	320
12	2.8	17.8	17.4	(1250)[1]
13	1.2	4.0	22.4	210
14	1.2	7.2	20.0	300
15	1.9	13.8	18.0	255
16	2.5	5.8	10.4	325
17	1.4	6.5	13.0	265
18	1.1	5.4	13.4	380
19	1.5	11.6	11.4	250
20	2.3	25.2	24.0	(1450)[1]
21	1.2	3.8	14.0	230
22	1.2	7.6	18.0	275
23	1.4	4.9	15.4	235
24	1.1	4.9	15.4	235
25	1.4	4.2	9.4	300
Mean	1.5	9.4	15.8	371
C.V.	29.4	65.3	23.9	85.5
Critical Level	—	7	5	150

[1] Deleted from Mean

Table 8. Distribution of micronutrients at Jemaa Shaim Station

Sample n°	Fe	Zn	Cu	Mn
	ppm			
1	7.3	0.6	0.6	4.1
2	10.4	0.3	0.4	9.1
3	8.6	0.6	0.4	3.9
4	8.3	0.5	0.4	4.3
5	8.6	0.2	0.5	4.9
6	9.5	0.4	0.4	9.8
7	6.9	0.3	0.4	7.8
8	7.2	0.5	0.4	4.9
9	9.8	0.6	0.4	9.9
10	7.9	0.5	0.4	4.2
11	5.3	0.6	0.4	6.4
12	3.1	0.6	0.4	6.2
13	9.6	0.6	0.4	9.5
14	16.7	0.7	0.5	5.8
15	10.2	0.6	0.4	7.6
16	7.7	1.0	0.4	6.1
17	6.0	0.9	0.4	6.2
18	7.4	3.9	2.5	5.4
19	6.6	0.9	2.5	5.4
20	2.3	1.2	0.4	5.6
21	8.5	0.8	0.5	8.1
22	7.0	0.7	0.4	8.3
23	7.3	0.9	0.5	5.6
24	6.7	1.1	0.5	2.5
25	8.2	1.0	0.5	4.9
Mean	7.9	0.8	0.5	6.3
C.V.	33.8	86.8	88.8	31.8
Critical Level	5.0	0.8	0.2	1.0

Table 9: Distribution of organic matter and major nutrients at Khemis Zemamra Station.

Sample n°	Organic Matter %	NO_3-N	P	K
			ppm	
Irrigated				
1	1.2	4.8	13.4	45
2	1.4	6.4	7.4	95
3	1.5	7.8	15.4	35
4	1.7	4.4	11.4	105
5	1.5	4.8	20.0	60
6	1.7	3.2	12.4	190
Rainfed				
7	1.4	15.4	12.4	145
8	1.5	5.4	11.4	210
9	1.5	6.6	16.0	190
10	2.2	5.2	8.4	195
11	1.7	9.6	20.0	165
12	1.7	10.6	9.4	170
13	1.7	8.0	12.4	175
14	1.7	6.9	14.0	155
15	1.7	8.4	22.0	195
16	2.2	5.6	7.4	140
17	1.7	6.2	8.4	180
18	1.7	6.4	15.4	150
19	2.6	8.6	11.0	185
20	1.5	11.2	22.4	175
21	1.7	5.6	25.4	205
22	1.4	11.6	32.4	165
23	2.5	12.2	13.4	195
24	1.9	6.2	17.0	195
25	1.9	14.2	27.0	215
26	2.3	52.0	68.0	235
27	2.5	26.0	20.0	280
28	2.6	10.9	30.0	225
29	2.3	6.2	8.4	270
Mean	1.8	10.0	17.7	170
C.V.	21.9	12.4	66.9	343
Critical Level	—	7	5	150

Table 10. Distribution of micronutrients at Khemis Zemamra Station

Sample n°	Fe	Zn	Cu	Mn
			ppm	
Irrigated				
1	5.2	0.8	0.6	13.3
2	11.8	0.6	0.5	16.3
3	2.8	0.7	0.5	6.6
4	4.8	0.7	0.4	15.6
5	20.5	0.7	0.2	11.2
Rainfed				
6	8.2	0.7	0.3	8.1
7	8.3	0.7	0.2	6.1
8	5.9	0.7	0.2	4.9
9	7.4	0.6	0.2	4.3
10	6.7	0.7	0.2	4.8
11	6.9	0.5	0.2	4.4
12	8.5	0.6	0.5	2.8
13	7.1	0.7	0.2	7.4
14	7.9	0.7	0.2	9.8
15	6.5	0.7	0.2	5.6
16	6.1	0.7	0.1	5.3
17	6.0	0.6	0.1	2.5
18	6.8	0.6	0.2	3.2
19	7.2	0.6	0.3	10.8
20	6.7	0.7	0.1	3.3
21	8.1	0.7	0.2	7.4
22	9.1	0.9	0.3	6.5
23	7.5	0.7	0.3	5.9
24	12.0	0.8	0.3	19.9
25	5.1	0.9	0.3	11.2
26	63.6	0.7	0.4	7.7
27	8.5	0.7	0.2	4.0
28	7.9	0.8	0.3	7.4
29	3.9	0.6	0.3	3.3
Mean	9.6	0.7	0.3	7.8
C.V.	113.7	12.7	46.1	57.8
Critical Level	5.0	0.8	0.2	1.0

Table 11. Distribution of organic matter and major nutrients at Monnin Lucien Station.

Sample n°	Organic Matter %	NO3-N	P (ppm)	K
1	2.2	13.4	88.0	185
2	2.2	4.6	29.0	130
3	2.2	5.6	24.0	145
4	1.9	5.6	32.4	170
5	1.5	8.6	38.4	170
6	1.5	5.6	32.4	170
7	1.2	6.8	21.0	140
8	1.5	9.6	22.4	185
9	1.1	4.6	19.0	125
10	1.5	6.2	17.4	170
11	2.2	17.2	21.0	175
Mean	1.7	8.0	31.4	160
C.V.	21.9	12.4	66.9	343
Critical Level	—	7.0	5	150

Table 12. Distribution of micronutrients at Monnin Lucien Station

Sample n°	Fe	Zn	Cu ppm	Mn
1	11.7	0.74	0.82	59.0
2	10.0	0.60	0.76	09.0
3	9.6	0.52	0.76	84.0
4	9.2	0.58	0.78	80.6
5	8.6	0.56	0.76	73.2
6	9.4	0.66	0.82	92.6
7	8.4	0.56	0.96	101.6
8	5.6	0.62	0.96	78.4
9	6.6	0.60	0.98	64.8
10	5.8	0.46	0.82	73.4
11	3.0	0.90	0.70	67.2
Mean	8.0	0.6	0.8	78.4
C.V.	29.7	18.2	11.0	15.4
Critical Level	5.0	0.8	0.2	1.0

Table 13. Percentage of sample the critical level for each element[1].

Station	NO_3-N	P	K	Fe	Zn	Cu	Mn
Aïn N'Zagh	58	0	0	25	0	0	0
Sidi El Aydi	0	0	0	79	79	0	5
Monnin Lucien	64	0	0	0	91	0	0
Jemaa Shaim	48	0	0	8	68	0	0
Khemis Zemamra	52	0	24	3	92	10	0

1. Assuming values of 7 ppm NO_3-N, 5 ppm NaHCO3-P, 150 ppm NH4OaC-K, and DTPA – extractable Fe, 5 ppm; Zn, 0.8 ppm; Cu, 0.2 ppm; and Mn, 1.0 ppm.

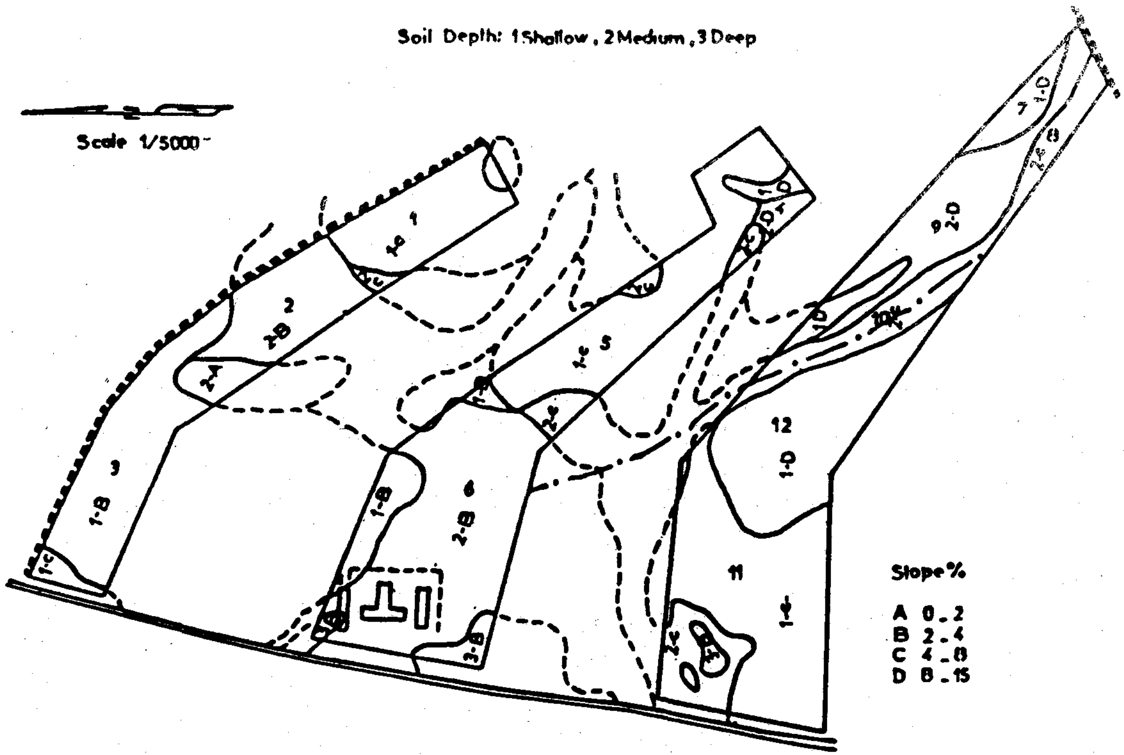
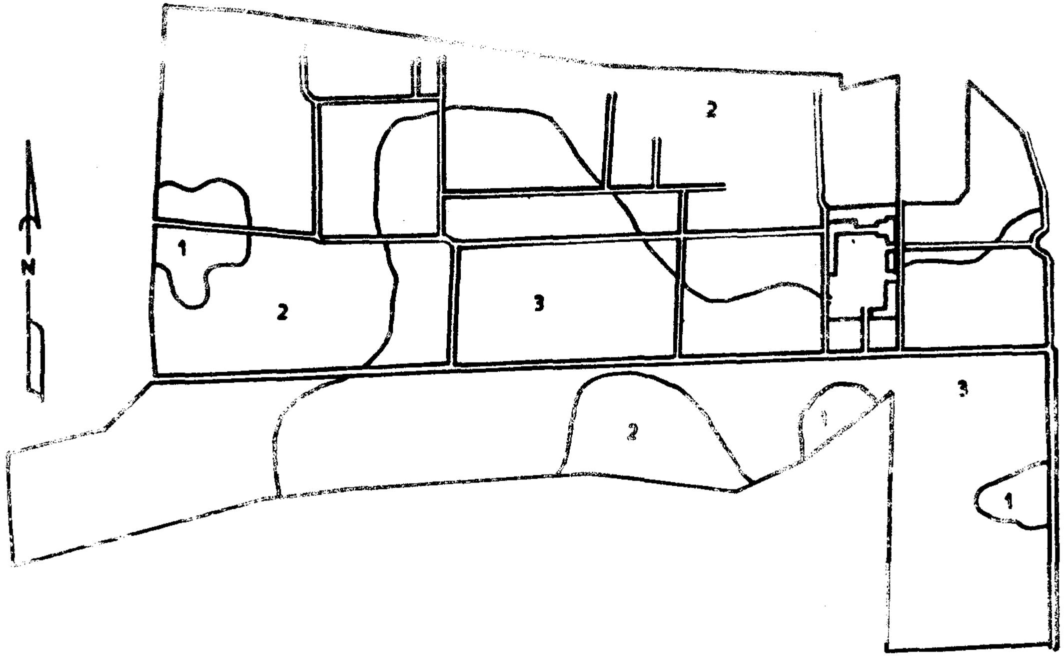


Fig. 2 : Soil sketch for AIn N'Zagh Station.



UNITES	SERIES
1	Peu Profond (< 40cm) Argileux, Calcaire
2	Moyennement Profond (40à60cm) Argileux, Calcaire
3	Tres Profond (>80cm) Argileux, Calcaire

Fig. 3 : Soil map of Sidi El Aydi Station.

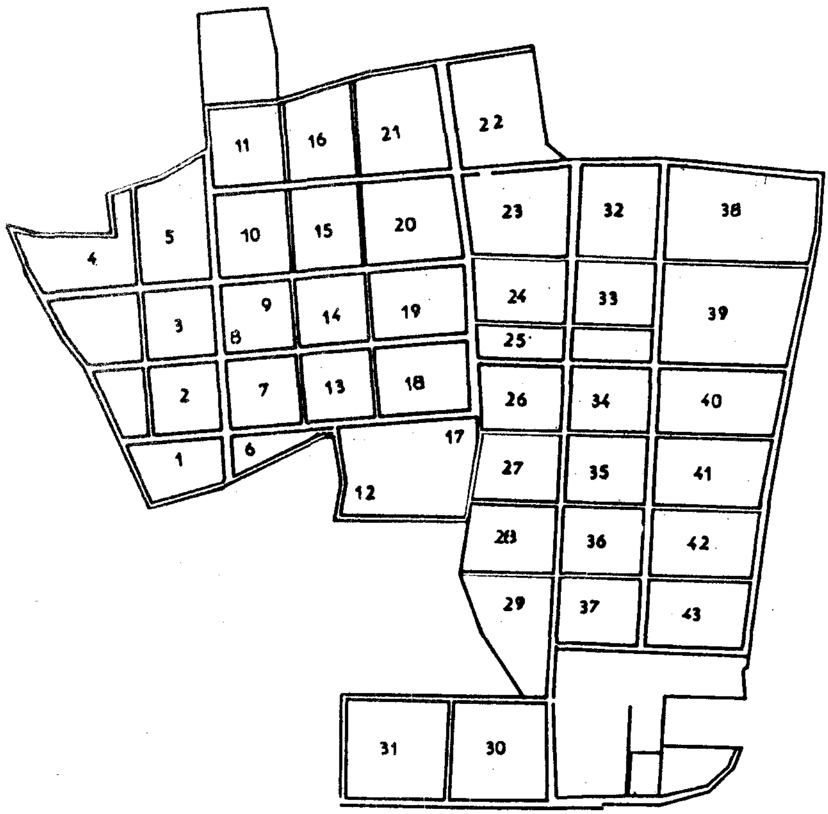


Fig. 4 : Plot sketch at Sidi El Aydi Station.

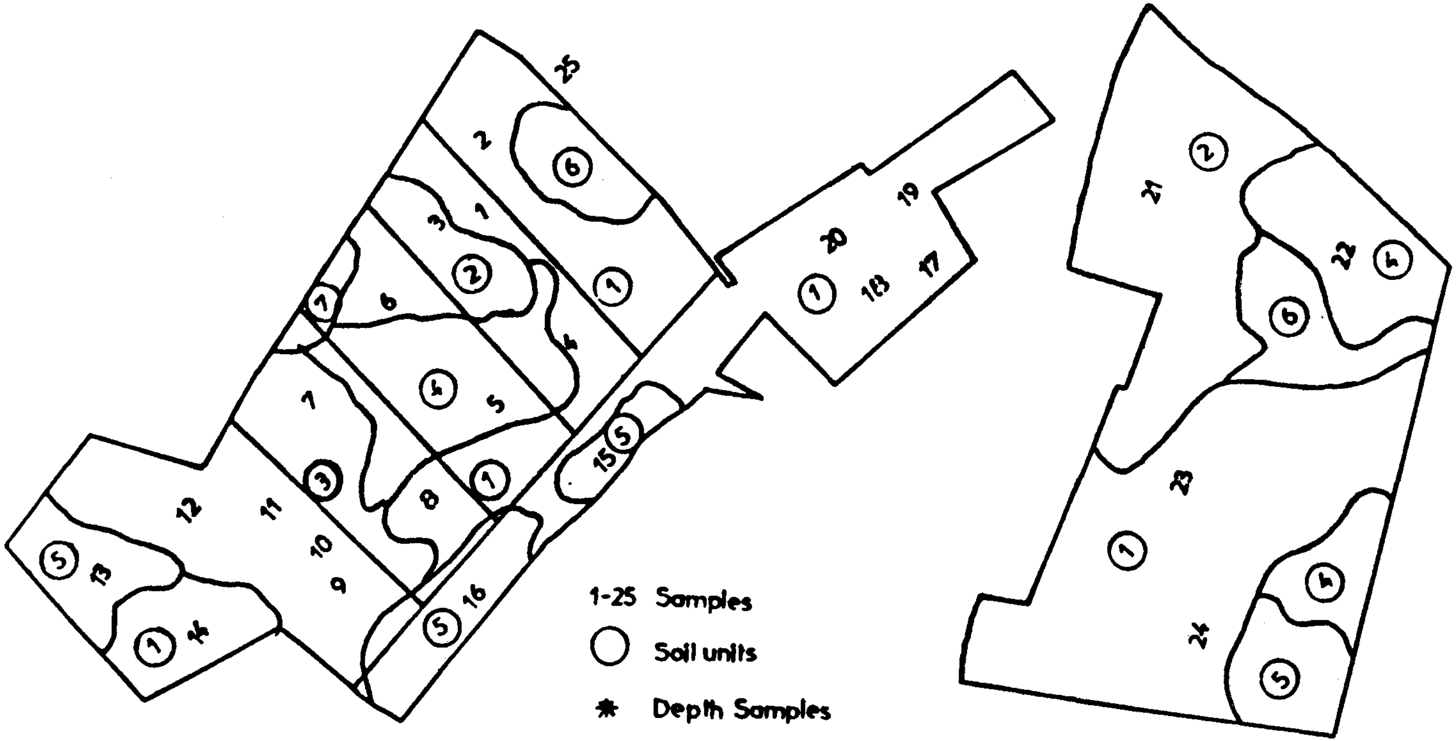


Fig. 5 : Soil and plot sketch of Jemaa Shaim Station.

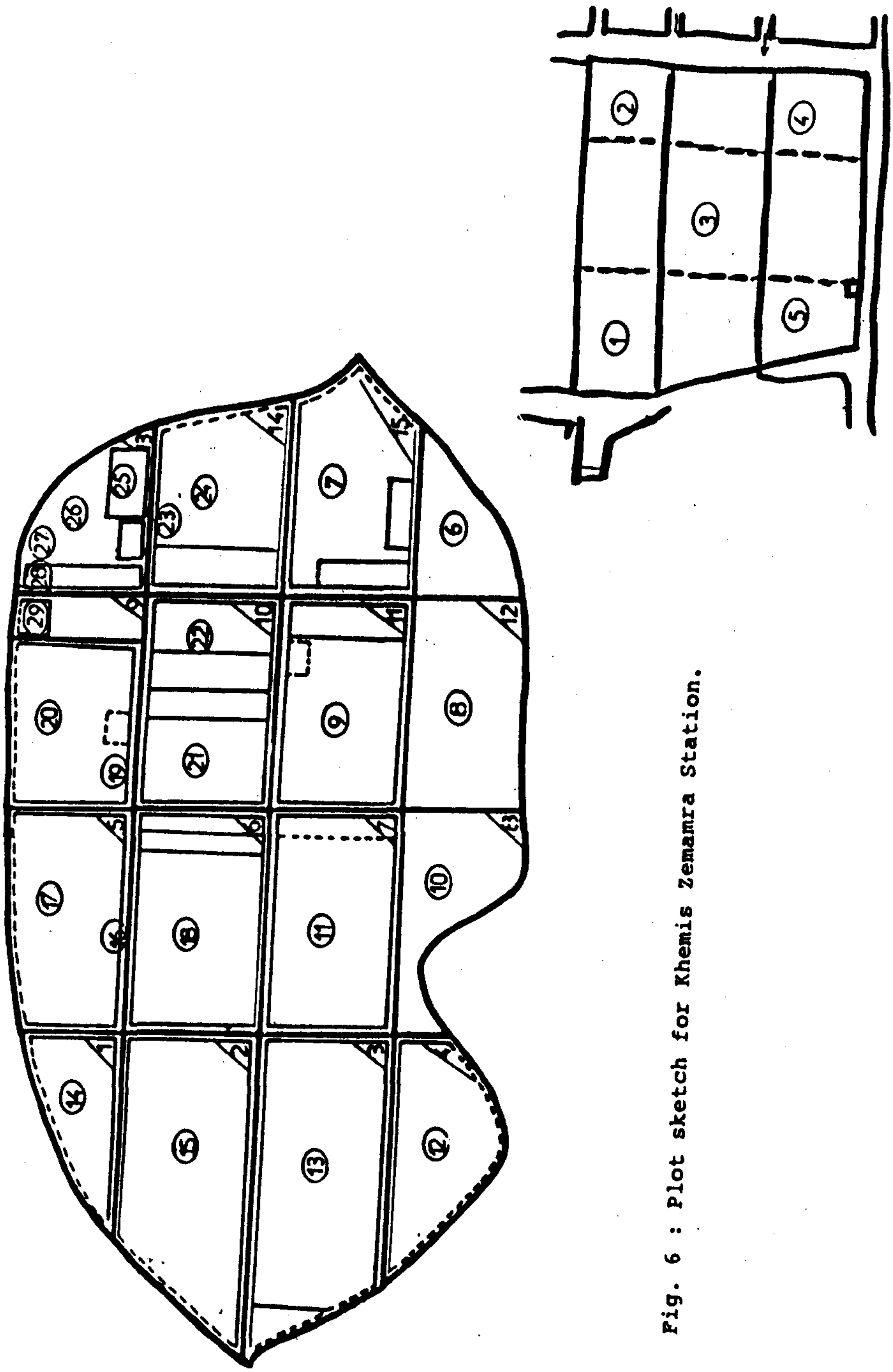


Fig. 6 : Plot sketch for Khemis Zemamra Station.

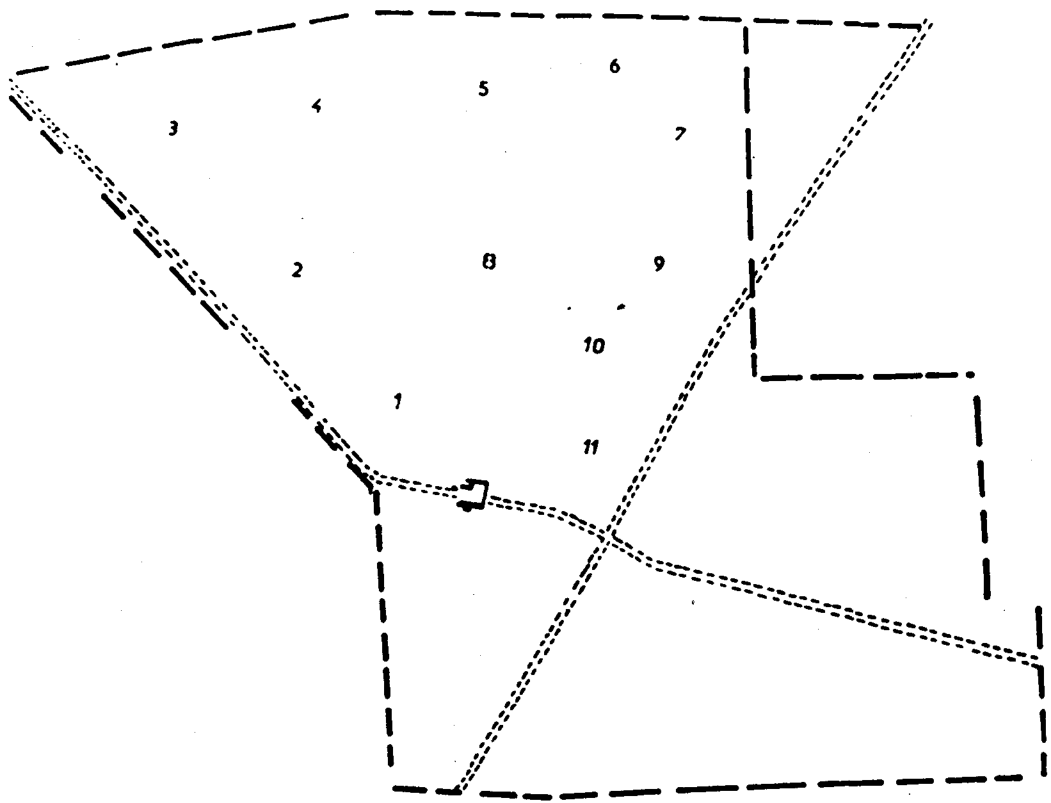


Fig. 7 : Location of composite samples at Monnin Lucien Station.

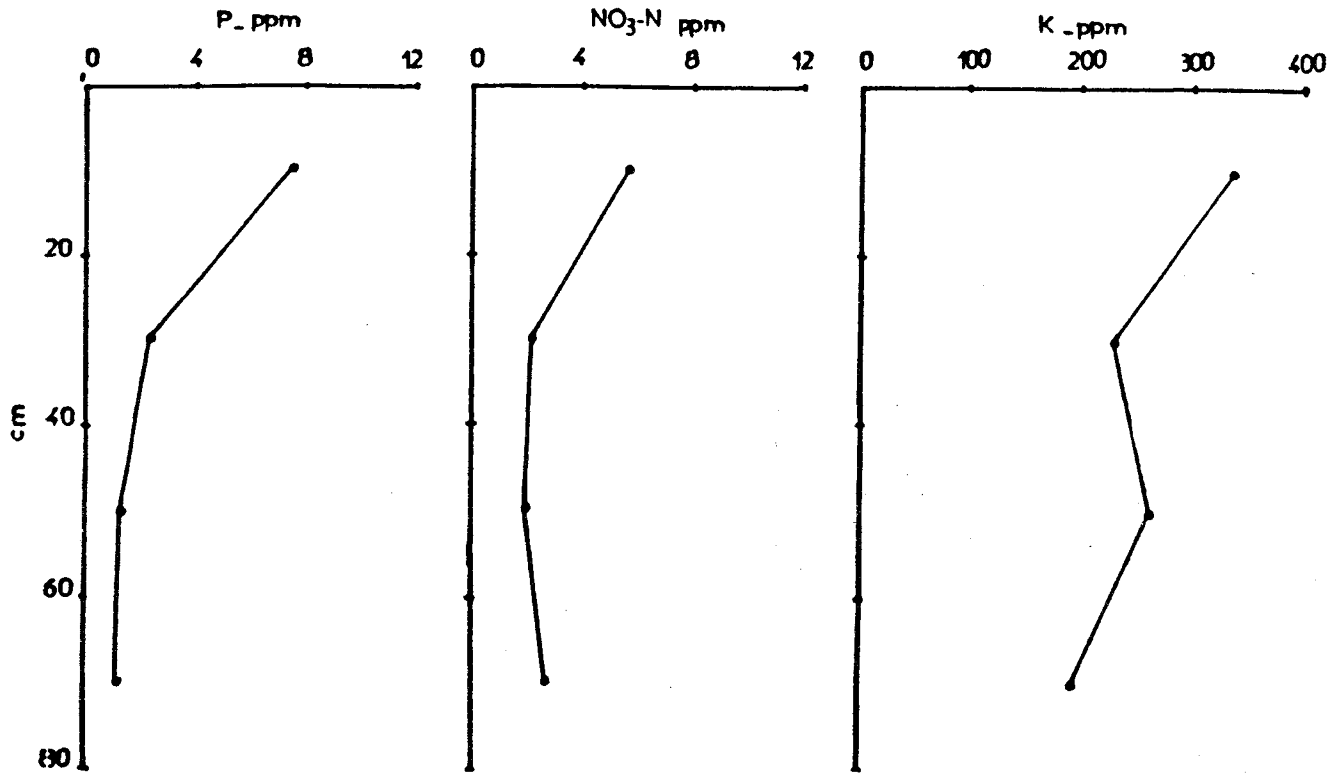


Fig. 8 : Depthwise distribution of nutrients at Jemaa Shaim Station.

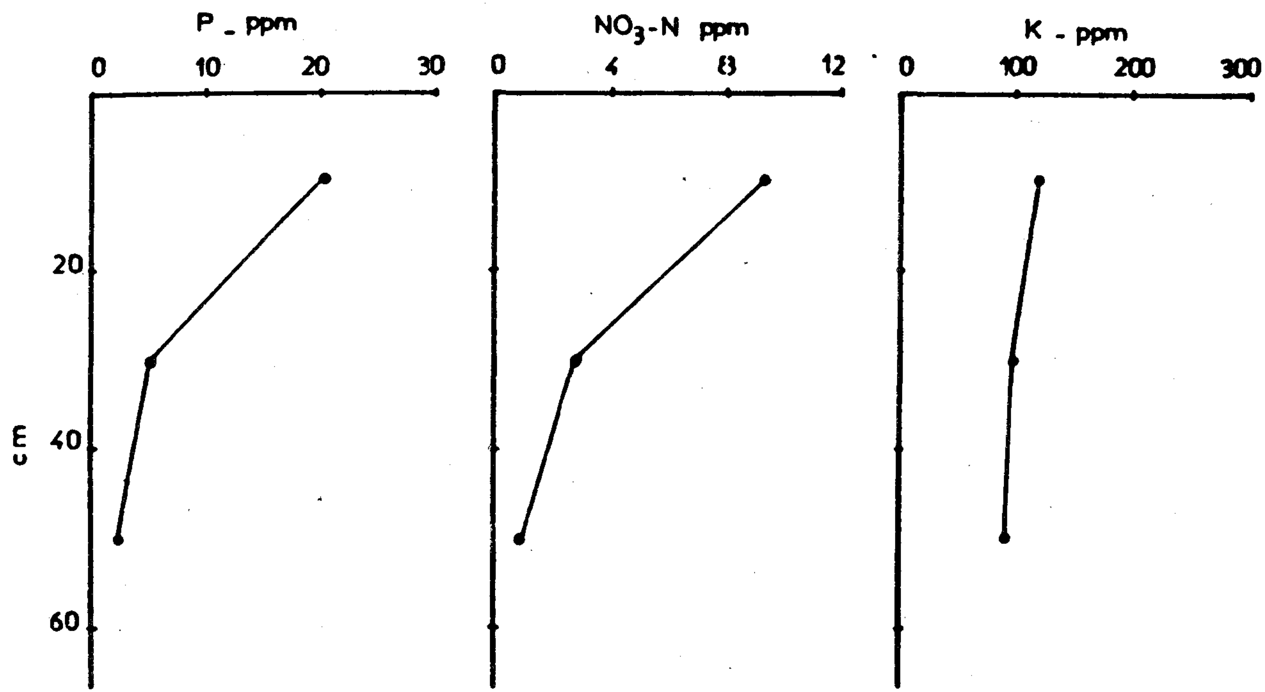


Fig. 9 : Depthwise distribution of nutrients at Monnin Lucien Station.

AZ = Aïn N'Zagh, SE = Sidi El Aydi, JS = Jemaa Shaim,
KZ = Khemis Zemamra, ML = Monnin Lucien

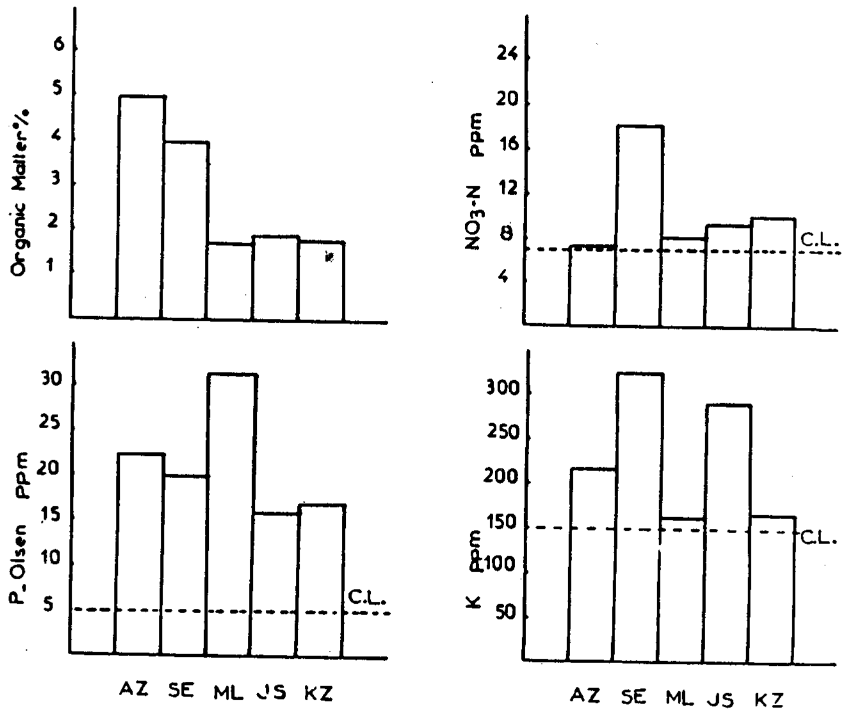


Fig. 10 : Comparison between stations for organic matter and major nutrients.

AZ = Aïn N'Zagh, SE = Sidi El Aydi, JS = Jemaa Shaim,
KZ = Khemis Zemamra, ML = Monnin Lucien

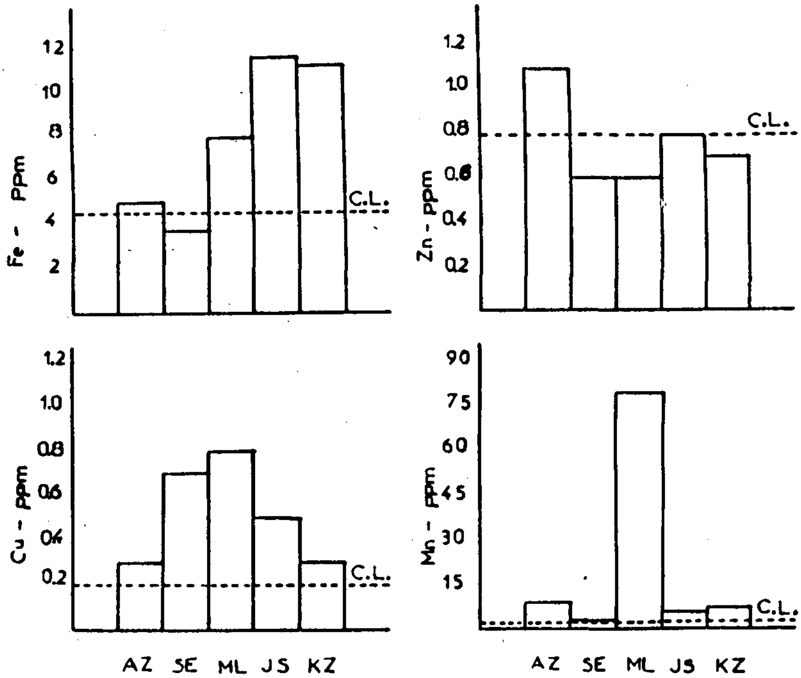


Fig. 11 : Comparison between stations for micronutrients.

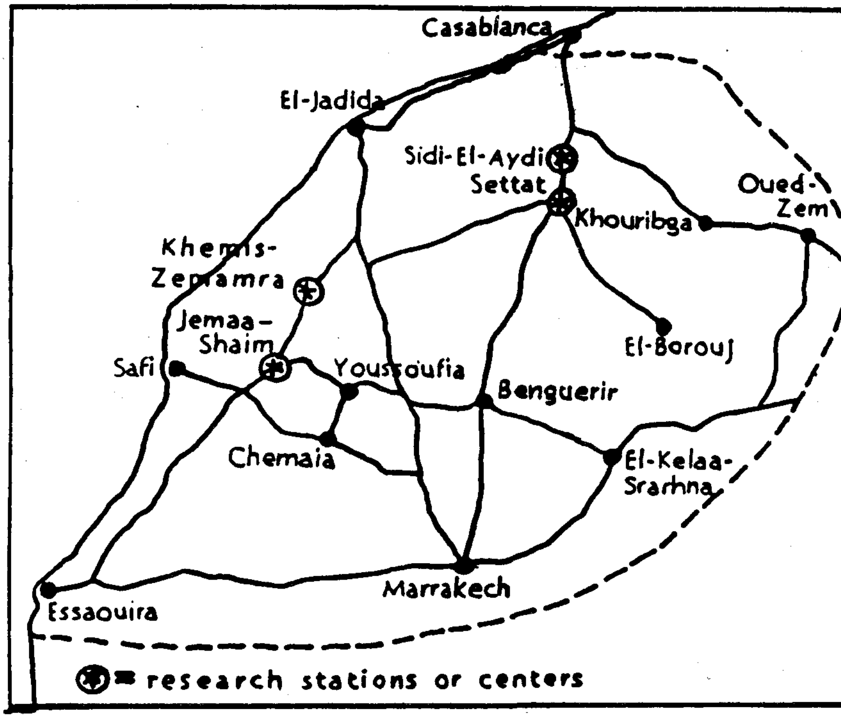


Fig. 1 : Location of agricultural experiment stations in the Aridoculture zone.

حصر لخصوبة التربة في مراكز التجارب الزراعية في مناطق الشاوية وعبدة ودكالة

جوان راين ـ محمد عبد المنعم ومحمد الغاروس

تعتبر مستويات خصوبة التربة ـ سواء كانت ناقصة او زائدة ـ من أهم الخصائص في عمل التجارب الحقلية. فعندما تزداد مستويات المواد المغذية في التربة في مراكز التجارب وذلك نتيجة للاستعمال المستمر للاسمدة فانه من المهم من وقت لاخر لن يتم الكشف عن هذه المستويات وذلك حتى يمكن التحقق من مصداقية النتائج المتحصل عليها والتي سوف يستعملها المزارعون في المنطقة.

وفي هذه الدراسة تم حصر لحالة المادة والمغذيات الكبرى (الازوت ـ الفوسفور ـ البوتاسيوم) وكذلك المغذيات الصغرى (الحديد ـ الزنك ـ المنغنيز ـ والنحاس) وفي بعض الاحيان تم قياس درجة الملوحة في التربة.

ولقد تمت هذه الدراسة في خمس (5) مراكز للتجارب في المناطق الشبه الجافة الممطرة في المغرب، وهي عين نزاع، سيدي العايدي، جمعة سحيم، خميس الزمامرة ومون لوسيان.

من الملامح الهامة لهذه الدراسة هو ارتفاع مستوى الازوت النثراتي في سيدي العايدي وكذلك ارتفاع مستوى الفوسفور في جميع مراكز التجارب. وهذا يرجع الى التسميد المستمر لهذه المراكز ولوحظ ارتفاع مستوى البوتاسيوم ايضا ولكن بالنسبة للحديد والزنك فلقد كانت كافية وفي هذا يتضح اهمية هذا البحث سواء للباحثين أو الاداريين في مجال ادارة مراكز البحوث الزراعية في المغرب.