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NEW REFERENCES FOR THE FERTILISATION OF WHEAT, SUGAR BEET, AND SUNFLOWER IN DOUKKALA AND GHARB IRRIGATED PERIMETERS IN MOROCCO

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Introduction

Soil fertility management for intensive cropping systems under irrigation is a major component of sustainable agricultural development in the Mediterranean countries. Although, irrigation permits good yields in arid and semi arid Mediterranean regions like Morocco, water use efficiency needs to be improved by using adapted and efficient agricultural techniques such as fertilisation.

Balanced fertilisation of the major crops should be based on soil testing. The interpretation of soil tests needs regional crop and soil specific critical levels obtained from field experiments. In addition, data on soil nutrients supplying capacity and crop nutrient requirements are needed to estimate the amount of fertilisers to be used by farmers.

In the framework of a large programme dealing with the improvement of the large scale irrigation scheme performance (PAGI), a sub-programme was set up to support the agricultural development in irrigated areas of Morocco (PSDA). Soil fertility management for the major crops under irrigation was one of the adaptive research components of the PSDA. Diversity of crops, soil types, and climatic conditions make fertilisers recommendations very difficult. Non adapted general fertiliser formulas have been used for a long time with no monitoring of soils fertility changes.

With the development of laboratory facilities to perform soil test for farmers, reference critical levels to interpret the results are becoming necessary. In fact, local soil test interpretation data are needed for the major crops and soil types. The objective of this paper is to present a synthesis of the major results obtained from field trials in the Doukkala and Gharb agricultural regions of northwestern Morocco.

The specific objectives of the trials were: i) to determine critical levels for the interpretation of soil tests specific for each region, soils types, and crops, ii) to evaluate the soil supplying capacities of N, P2O5, and K2O, iii) to evaluate the crop requirements of N, P_2O_5, and K_2O for potential yields in each region, iv) to calculate the amount of fertilisers based on soil test for farmers who can afford to make soil analyses before planting, and v) to suggest new regional fertilisers formulas to be used by those farmers who can not afford to pay for making soil analyses before planting.

Materials and Methods

Doukkala and Gharg regions are two of the nine large-scale irrigation systems of Morocco. The potential irrigable land is evaluated about 380,000 ha, from which 190,000 ha (50 %) are effectively irrigated. Sugar beet, wheat, and sunflower are the major crops cultivated in these regions. Chromoxerets (Tirs), Calcixerolls (Tirs and Hamri), Xerochrepts (Faid), and Xeralfs (Hamri and Rmel) are the major soil types occurring in the Doukkala semi arid region. In the Gharb region, which is located in a sub-humid Mediterranean type of climate, the major soil types are Pelloxererts (Tirs), Haploxerolls (clayey Dehs), Xerochrepts (loamy Dehs), and Calcixerolls (Hamri).

Seventy field experiments testing the response of the crops (sugar beet, wheat, and sunflower) to fertilisers (N, P_2O_5 and K_2O) additions were performed in Doukkala and Gharb regions between 1995 and 2001. The experiments were performed according to a completely randomised block design with 4 replicates and 2 treatments each time (NxP, NxK, PxK).

Relative yield and crop response coefficient was used to assess the response of the crops to fertilisers. Crop response curves were used to estimate the optimal rates of fertilisers. The crop uptake of N, P_2O_5, and K_2O at maturity stage was considered to be the minimum soil supplying capacity of these 3 nutrients. The nitrogen, phosphorus, and potassium use efficiencies and the apparent fertiliser use coefficient by the crops were calculated.

Results and Discussions

Response to fertilisers

Because of the high spatial and temporal variability of mineral nitrogen in the soils before planting, no correlation was found between the response of wheat, sugar beet, and sunflower to nitrogen fertiliser. Response to nitrogen occurred even for high soil mineral nitrogen plots. So, no critical levels were set to interpret soil nitrogen fertility (Table 1 to 4). In other words, in these irrigated areas, we can not use initial mineral nitrogen to assess the nitrogen fertility of the soils.

Wheat responded to the addition of phosphorus in the Gharb and Doukkala regions. However, the critical level is different in the 2 regions. Wheat responded to phosphorus in Doukkala region in plots testing less than 17.5 mg P_2O_5 Olsen/kg of soil (Table 1). In the Gharb region, the response limit is only 16 mg P_2O_5 Olsen/kg of soil (Table 2). Presently it is very exceptional to find soils having less than these values in the two regions because of P fertiliser overuse by farmers for more than 20 years.

Sugar beet and sunflower responded also to phosphorus fertiliser when the soil P-Olsen test is less than 12.2 and 21.6 mg P2O5 /kg of soil, respectively (Tables 3 and 4).

This is the first time in Morocco that wheat responded to potassium fertiliser. The response occurred in Doukkala region when the yield obtained is higher than 5 t/ha and only on non-clayey soils (Hamri, Rmel, and Faid). The critical level under which the response was observed is 260 mg K_2O/kg of soil (Table 1). Since the Gharb region posses younger soils,

rich in K bearing minerals like illite and intestratified illite/smectite, the response of wheat to potassium was not observed.

Sunflower crops, which need more K than wheat, responded to potassium fertilisation. The critical level in the Gharb region is 149 mg K2O/kg. However, very few plots have less than this value in this region. Sugar beet is a very highly potassium demanding crop. The response to potassium addition in the Doukkala region was systematic on all soil types including the Tirs soils, which are clayey. An exchangeable potassium interpretation scheme was established for sugar beet taking into consideration the clay content (Figure 1).

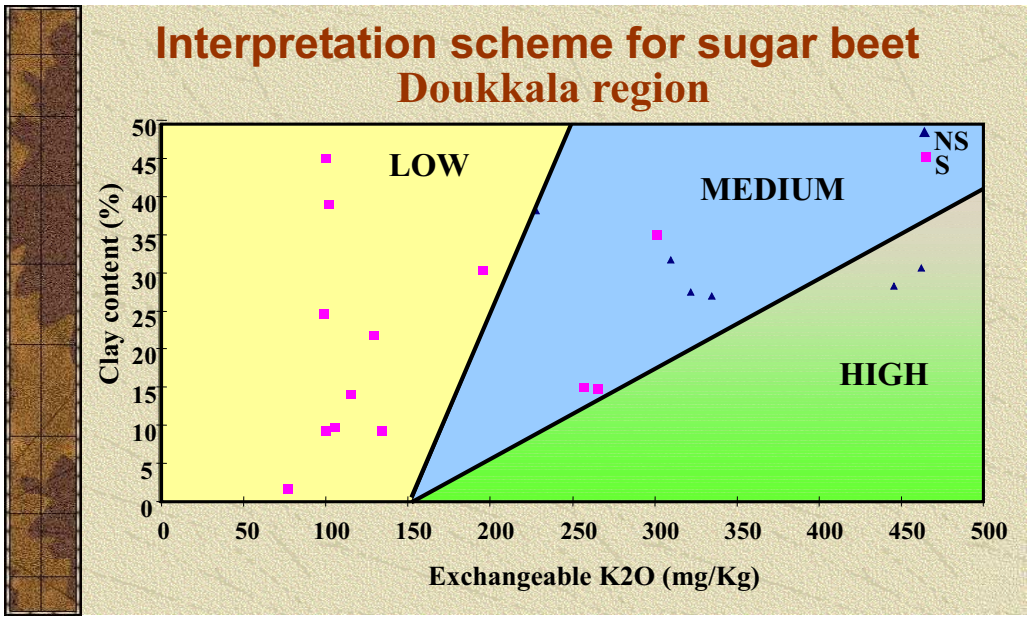

Figure 1. Soil Exchangeable Potassium interpretation scheme for sugar beet in the irrigated perimeter of Doukkala, Morocco

Table 1. Critical levels, nutrient use efficiency, and apparent fertiliser use for wheat under irrigation in Doukkala region

Nutrient	Critical level	Nutrient use efficiency (kg/100 kg grains)	Apparent fertiliser use coefficient	Observations
Nitrogen	No critical level	3.50	0.65	Soil nitrogen supplying capacity can be estimated using the max. Yield without N addition and organic matter content
Phosphorus	< 17.5 mg P2O5/kg soil.	0.60	-	-
Potassium	< 260 mg K2O/kg soil for Hamri, Rmel and Faid soil series. No response on Tirs soil series	1.54	-	No addition of K2O if the yield < 5 tons/ha.

Table 2. Critical levels, nutrient use efficiency, and apparent fertilizer use for wheat under irrigation in Gharb region

Nutrient	Critical level	Nutrient use efficiency (kg/100 kg grains)	Apparent fertiliser use coefficient	Observations
Nitrogen	No critical level	3.95	0.60	Soil nitrogen supplying capacity can be estimated using the max. Yield without N addition. No correlation between N soil test and crop response to N fertiliser.
Phosphorus	< 16 mg P2O5/kg soil.	0.74	0.165	Critical level for Dehs soil series only. Needs to be determined for Tirs soil series.
Potassium	No response to K2O addition.	3.00	-	Soils have a very high potassium supplying capacity. No K fertiliser required.

Crop nutrient requirements

The amounts of N, P_2O5, and K_20 required to produce 1 quintal (100 kg) of the harvested crops are presented in tables 1 to 4. These quantities are referred to as nutrient use efficiency. They are needed to calculate the amount of fertiliser to be added in order to get a given yield.

Table 3. Critical levels, nutrient use efficiency, and apparent fertiliser use for sugar beet under irrigation in Doukkala region

Nutrient	Critical level	Nutrient use efficiency (kg/1000 kg)	Apparent fertiliser use coefficient	Observations
Nitrogen	No critical level.	3.14	0.56	Soil nitrogen supplying capacity can be estimated using the max. Yield without N addition. No correlation between N soil test and crop response to N fertiliser.
Phosphorus	< 12.2 mg P2O5/kg soil.	1.40	-	Very few plots have less than 12 mg P2O5/kg.
Potassium	See soil test K interpretation scheme in relation to clay content.	6.00	-	Low: add crop requirement x 1.2. Medium: add crop requirement High: no K2O addition.

Wheat needs to take up 3.5 kg N to produce 1 quintal in the Doukkala region. In the Gharb region, this quantity is 3.95 kg N/quintal produced. For sugar beet the mean N use efficiency in the Doukkala region is 3.14 kg/tone of fresh beets. To produce one quintal of sunflower seeds in the Gharb region, the crop absorbs 3.47 kg N.

Wheat needs 0.6 kg P_20_5/quintal in the Doukkala region and 0.74 kg P_20_5/quintal in the Gharb region. Sugar beet requirement in phosphorus is 1.4 kg/tone of beets. Sunflower needs only 0.67 kg P_20_5/quintal.

Sugar beet and sunflower require large quantities of potassium; 6 kg K_20/ton of beets and 7.23 kg K_20/quintal of seeds. Only 1.54 kg K_2O/quintal is required by wheat in the Doukkala region. The K use efficiency by wheat in the Gharb region is exceptionally high because of the natural uptake from very high K fertility soils.

The recovery of fertilisers by the crops is expressed by the apparent fertiliser use coefficient (Tables 1 to 4). The results show that between 50 and 65 % of fertiliser nitrogen are taken up by the crops. The use of P and K fertilisers is very low. The remaining fertilisers in the soils can be used by the following crops. It was found that fixation and release processes complicate the understanding of the fertiliser's recovery. The uses of 15N labelled techniques are necessary to better understand the recovery of nitrogen fertiliser by the crops.

Table 4. Critical levels, nutrient use efficiency, and apparent fertiliser use for sunflower under irrigation in Gharb region

Nutrient	Critical level	Nutrient use efficiency (kg/100 kg)	Apparent fertiliser use coefficient	Observations
Nitrogen	No critical level.	3.47	0.53	Soil nitrogen supplying capacity can be estimated using the max. Yield without N addition. No correlation between N soil test and crop response to N fertiliser.
Phosphorus	21.6 mg P2O5/kg soil.	0.67	0.21	Critical level for Dehs soil series only. Needs to be determined for Tirs soil series..
Potassium	149 mg K2O/kg soil.	7.23	0.44	Low: add crop requirement x 1.2. Medium: add crop requirement High: no K2O addition.

Conclusions

Recommendations for new fertilisers formulas

A survey of soil fertility status was performed in the Doukkala and Gharb regions. Taking into account the results obtained in this study, we were able to suggest general fertiliser formulas adapted for the majority of the farmers.

Table 5 presents the quantities of nutrients needed to make better use of water in the Gharb and Doukkala irrigated perimeters. Farmers who can afford to make soil analysis before planting can use the data presented in tables 1 to 4 to compute the amount of fertilisers to be added to each plot. For those who are not yet able to do soil analysis, the quantities to be added depend on the region, the crop, soil types, and the targeted yield.

The Doukkala and Gharb agricultural development services are presently promoting the use of these formulas. They are also building their laboratory capacities to make soil test for the farmers. Similar experiments are being done for other crops, especially orchards and sugar cane in the Gharb region and sunflower in the Doukkala region.

Table 5. Recommended fertilisers formulas for wheat, sugar beet, and sunflower in the Gharb and Doukkala irrigated regions in Morocco

Crop	Region	Soil type	Yield (t/ha)	N (kg/ha)	P2O5 (kg/ha)	K2O (kg/ha)
Wheat	Doukkala	Tirs	5	153	23	0
		Hamri, Faid, Rmel	5	153	23	75
		Hamri, Faid, Rmel	< 5	153	23	0
	Gharb	Dehs, high in P2O5	5	120	0	0
		Dehs low in P2O5	5	120	80	0
Sugar beet	Doukkala	All types high in P2O5	80	220	0	360
		All types low in P2O5	80	220	53	360
Sunflower	Gharb	Dehs high in P2O5	4	120	0	0
		Dehs low in P2O5	4	120	70	0

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