

# Fertilizer best management practices in the dryland Mediterranean area – concepts and perspectives

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## Abstract

While globally fertilizers have had a major impact on food production for the past half-century, the general use of chemical fertilizers in the semi-arid areas of the world is a more recent development. This is particularly true of the Mediterranean region, especially in North Africa and West Asia. Traditionally, the cropping system involved growing cereals (barley and wheat) in rotation with fallow to conserve moisture; sheep and goats were an integral part of the low-input system. Drought was a constant constraint on crop yields. In the past few decades, significant developments have occurred to increase agricultural output; new high-yielding disease resistant varieties; mechanization; irrigation; pest control; and particularly the use of chemical fertilizers as a supplement to the limited animal manures available. Research at the International Center for Agricultural Research in the Dry Areas (ICARDA) in collaboration with the national agricultural systems in the mandate countries of the region has made significant strides in fertilizer research. While much has been achieved in terms of best fertilizer management practices, much remains to be done. This presentation examines the use of fertilizers under the headings of the best management practice concept; right source, right application rate, right time of application, and right place. As fertilizer use will expand in the Mediterranean region, efficiency of use will be an underlying consideration.

As agricultural land on a global level is finite, with limited possibilities to expand cultivation, the increasing population of the world has correspondingly increased the needs for food and fibre. An inevitable development has been intensification of land use, particularly in developing countries of the world, leading to poverty and increased concerns about food security (Borlaug 2007). Pressure on land has been particularly acute in the arid and semi-arid regions, which are characterized by drought and land degradation.

The lands surrounding the Mediterranean have been cultivated for millennia and are the site of settled agriculture and the center of origin of some of the world's major crops, especially cereals and pulses. Much development efforts have centered on the West Asia- North Africa (WANA) area, which is characterized by a Mediterranean climate and where drought is the main production constraint (Smith and Harris 1981).

## Rainfall and Cropping Systems

Under typical Mediterranean conditions, rainfed cropping is only possible during the cool, wet "winter" season (late fall-early summer) with growth dependent on the amount of rainfall which is variable between and within years. In addition, fallowing, or cropping in alternate yields (Harris 1995), has been a hedge against drought in order to increase the likelihood of an economically harvestable crop, especially in below-average rainfall years. Limited summer cropping can occur when there is carryover of sufficient moisture, while a full range of crops can be grown where irrigation is available. Typical rainfall and temperature conditions that dictate rainfed cropping are illustrated in Figure 1. The normal rainfed pattern varies from year to year and within season. As a consequence, drought is invariably a constraint on crop production.

In addition to inherent agroecological constraints associated with this region (Kassam 1981), such as a wide range of soil types of varying fertility and depth (Matar *et al.* 1992), there are numerous socioeconomic obstacles to sustainable agricultural development. The cropping system that has evolved under low rainfall conditions of the Mediterranean climate is centered on dryland or rainfall cereals (Cooper *et al.* 1987), with bread wheat (*Triticum aestivum*) and durum wheat (*T. durum*, var *turgidum*) in the more favorable rainfall zones (350-500 mm) and barley (*Hordeum vulgare*) being dominant in the lower rainfall areas as it is relatively drought-tolerant. Both food legumes, such as chickpea (*Cicer arietinum*), lentil (*Lens culinaris*) and faba bean (*Vicia faba*), a pasture and forage legumes such as vetch (*Vicia sativa*) are significant in maintaining the agriculture of the region. Crop rotations involving legumes are an alternative to fallow and continuous cropping, both economically and biophysically (Ryan *et al.* 2008a). The typical Mediterranean conditions involve cereal production integrated with livestock, mainly sheep

Agroecological conditions across the Middle East range from deserts and rangeland in arid areas (less than 200 mm) to barley-based systems (200-350 mm) and then wheat based systems (350-500 mm) and wider cropping options above that.

### *The Changing Context*

Agriculture in the WANA region has greatly changed in the past few decades, with a shift from traditional agriculture to more intensive cropping, particularly in terms of chemical inputs, especially fertilizers. Most countries of the region have had increased use of nitrogen (N) and to a lesser extent phosphorus (P), reflecting the crop needs, but little potassium (K) use due to high available K reserves in the soils. Micronutrients are rarely used.

### **Methodology**

As our concern is fertilizer best management practices, we briefly indicate the relevance of components of such practices. These are based on numerous soil fertility/agronomy/plant nutrition studies as reported in various reviews of N (Ryan *et al.* 2009), P (Matar *et al.* 1992; Ryan *et al.* 2008b), and micronutrients (Rashid and Ryan 2008).

### Results

#### *Right Time*

- Due to limited rainfall and thus leaching losses, there was generally little difference between fall and spring application of N fertilizers. However, topdressing in spring allowed more flexibility in relation to rainfall.

#### *Right Place*

- Response to N fertilizer was related to increasing rainfall and soil moisture availability. In Syria, responses were highest where rainfall was favorable (350-500mm) and minimal below 250 mm. Responses to N were highest after fallow and lowest after continuous wheat.
- Responses to P were related to fields where soil test levels for P were low; in areas where P had buildup from regular fertilization, there was little or no response to fertilization. Hence, the importance of soil testing in identifying areas of likely fertilizer response is illustrated.
- Responses to N are also conditioned by the level of soil organic matter, which in turn are related to the particular crop rotation that has been practiced in the area or field (Ryan *et al.* 2010).
- Similarly, crop responses to N and P fertilization only occur where there are no deficiencies of micronutrients, such as zinc or iron, or toxicities, such as that of boron.

#### *Right Source*

- While urea has become the dominant N fertilizer, it is prone to volatile loss, however, if mixed into the soil or applied under cooler conditions or topdressed before or during spring rains, loss is minimal (Abdel Monem *et al.* 2010).

#### *Right Application Method*

- While all soluble P sources are “fixed” by calcareous soils, efficiency is improved by banding. Buildup can occur quickly and efficiency may be higher if the long-term is considered. Conservation or minimum tillage and irrigation require modifications in fertilizer application methods.

#### *Right Application Rate*

- Numerous soil test calibration studies from countries of the WANA region identified appropriate application rates for N and P for various crops under rainfed and irrigated conditions, being higher in the latter conditions. Nutrient levels were identified to give optimum crop yield response, but avoid excess nutrient use, especially for N.

### **Conclusions**

Fertilizer use will increase in the cropping systems of the region. Given the costs of the materials and the environmental implications, efficiency of nutrient use will assume major importance. This can only be achieved by considering the various site-specific factors (rainfall, soil types, nutrient test levels, the particular crop, method of tillage, irrigation) that affect efficient nutrient use.

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