Water use efficiency of soybeans

The availability of fresh water is under enormous pressure, not only in South Africa, but worldwide. Consequently, the management and use of water is becoming more and more contentious. It has been estimated that approximately 86% of all fresh water in the world is used for food production.

Therefore, the water footprint of products will become increasingly important. The water footprint of 1 kg of animal protein has been estimated at 1,6 to two times more than the production of vegetable protein.

Soybeans (*Glycine max*) are one of the most important sources of oil and protein in the world. Soybean production in South Africa has increased noticeably over the past number of years due to, among other things, the increased crushing capacity (2 300 000 tons) that was developed. The production of soybeans is mainly for use in the animal feed industry, driven by the demand for animal protein.

Soybean production in South Africa exceeded the 1 million ton mark for the first time during the 2015 production season. During the 2015/2016 season, production declined drastically due to the serious drought. This led to a lower production per hectare, but was also due to 26,8% less surface area being planted.

According to the Crop Estimates Committee, only 502 800 ha had been planted, with an expected total production of 691 750 tons. Only about 50 000 ha (± 10%) of the total planting is cultivated under irrigation.

The popularity of soybeans as part of a crop rotation system is increasing due to the nitrogen-fixation quality of soybeans, as well as the improved soil structure characteristic of the extended root system of soybeans.

It is important for planning purposes to know the total water requirement of soybeans, and to make the management decisions accordingly. The water-use efficiency of soybeans varies between 4 kg and 7 kg of grain per hectare per mm water usage.

Lower yields usually go hand in hand with a low water-use efficiency, while higher yields have a high water-use efficiency. Therefore, in the case of higher yields, more soybeans are produced per mm water usage than is the case with low yields.

Water requirements of soybeans

Like with all crops, the seasonal water usage of soybeans is determined by the atmospheric evaporation demand and the availability of water in the soil profile. If the evaporation demand is to exceed the supply of water (rain and irrigation), soybeans will only use the water readily available.

The shortage causes the crop to develop a water deficiency – something experienced regularly in dryland cultivation in South Africa, and resulting in yield losses.

The water requirement of soybeans will vary throughout the season according to the weather conditions and the growth stage of the plant, which requires more or less water. Approximately 6 kg per hectare per mm water can be assumed for planning purposes for seed production.

Therefore (3 000 kg per ha/6 kg per ha per mm water) = 500 mm water will be needed to produce a yield of 3 000 kg per ha. Keep in mind that atmospheric demand has an effect on water-use efficiency. Water requirements are therefore higher in areas with high evaporation figures.

By definition, evapotranspiration is the transpiration of water from plants, as well as evaporation of water from the ground. Transpiration in itself is very important, because yield shows a linear correlation with the amount of water a soybean plant transpires.

Knowledge regarding soybeans' water requirements ensures better irrigation scheduling and also enables the producer to make the right cultivar choice where dryland cultivation is concerned.

Factors affecting evapotranspiration

The water usage of soybeans is affected by the weather conditions as well as by the growth stage of the plant. Factors to take into account are:

Weather conditions

Evapotranspiration is affected by the prevailing air temperature, relative humidity, wind and radiation. High temperatures, low humidity, clear skies and strong wind speed up the evapotranspiration process.

Type of soil

Water-holding capacity of the soil and the current water content in the soil profile. The plant-available water that the soil can hold (plant-available water capacity) is the maximum water available to the plant when the specific soil has reached field capacity.

Factors affecting plant-available water capacity are the soil type, organic matter, root depth and the density of the roots. Soils with a higher clay content and finer texture can hold more water, but are scarcer during times of drought. Therefore, plants' water usage is maximised at field capacity.

The crop can be planted in a variety of soils, knowing that the risk of root knot nematodes (eelworms) increases in sandy soils. Root knot nematodes prevent the plant from properly absorbing nutrients and water through the root system, with consequent crop losses.

Soybean roots are less sensitive than maize to soil acidity and therefore soybeans can survive drought strain in acid soils better than maize. Soils with a shallow water table also increase the risk for waterlogging, because soybeans are more susceptible to waterlogging in the early growth stage.

Growth stage of the plant

The water requirements of the plant vary according to the growth stage of the plant. Young plants transpire less due to the smaller leaf surface.

Soybeans' water requirements are the highest from flowering to seed filling stage. The middle to late reproductive stages are therefore very sensitive to any moisture strain. It is very important to make the correct cultivar choice with respect to the maturity grouping on the basis of the expected rainfall pattern of the area where the planting will be done.

The crop factor indicates the water requirement of the crop at different growth stages. Water stress in soybeans is visible when the youngest terminal leaves, and in time all the leaves, turn upwards.

Growth period

The growth period of the soybean cultivar is indicated by the maturity grouping. Cultivars with a high maturity grouping of, say, 6,5 will need more water in their total growth period than a cultivar with a maturity grouping of, say, 4.

Although cultivars with a higher maturity grouping require more water, they also have