Irrigation of lupin

An experiment in Greece

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White lupin (*Lupinus albus*) is a good source of protein for animal feed and stands out as an alternative to soybean in the local market. However, the cultivation of the crop has declined in Greece mostly due to farmers opting for more profitable crops with better yields. The warm and dry climate in Greece leads to a drought impacting on lupin cultivation. This is the main agronomic risk. Precision irrigation combined with the good adaptation of domestic cultivars to local conditions can increase yields, thus revitalising lupin production. We conducted an experiment using a precision irrigation system to achieve the optimum yield and identify the irrigation needs based on field trial.

Maturing white lupin plant. Photograph: THESGI Coop

Applicability

Topic: Irrigation in lupin cultivation

For: Farmers

Where: Lupin cultivation

Equipment: Data collection sensors

Follow-up: No follow-up action required

Impact: Optimum yield with precision irrigation

Our experiment has shown that well-managed irrigation reduces the risk of low yield in lupin production and has multiple benefits. Precise irrigation increases yield by up to 70% and reduces the risk of fungal diseases. Cost-efficient precision irrigation increases the final farmer's income and could make lupin production a competitive crop choice.

Lupinus albus cultivation

Lupin is a promising crop for Greece. It can play a role in livestock feeding in particular. Lupin seeds have a high protein content (up to 44%) and they are also a rich source of calcium, iron, magnesium and phosphorus. Due to its nutritional profile, lupin represents a significant alternative to soybean. White lupin originates from the Mediterranean countries. It has the longest history of cultivation for human consumption of any lupin species, dating back to pre-Roman and Greek times. In the past, a cultivar of white lupin that was bitter was mainly cultivated in Greece. The bitterness is due to alkaloids which are toxic to humans and animals. Lupin seeds were immersed in the sea or were roasted to reduce the alkaloids. Sweet and semi-sweet cultivars with low levels of alkaloids (<0.05%) are now used. The most widely grown cultivar in Greece is the locally adopted cv. Multitalia which is semi-sweet.

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Climate and soil

Spring-sown white lupin is well-adapted to the cool season. Lupin thrives in a temperature range from 14 to 25°C over a 110–125 day growing period. In warm climates such as in Greece, autumn sowing after the first rains is recommended. Sowing can continue until the end of November. Autumn sowing extends the growing season by about 60 days and brings the harvest forward so that the crop escapes severe mid-summer droughts and heat stress. This approach increases and stabilises yield. Autumn sowing of lupin also allows Greek farmers to grow two crops per year where there is irrigation.

White lupin requires slightly acid soils (pH 6–6.5), with an active calcium content of less than 3%. It has low demands in nutritional elements. Its deep root system forms large nodules where soil microorganisms (rhizobium bacteria) work symbiotically with the plant to fix atmospheric nitrogen and so enable plants to grow. Part of this nitrogen remains in the soil with legume residues for the next crop contributing further to the sustainability of crop rotations by reducing the need of synthetic nitrogen fertilizer.

Water

Under Mediterranean conditions, lupin grows in areas with rainfall of 380–450 mm. White lupin is quite drought tolerant, however the prolonged dry periods and high temperatures may cause significant yield reduction. Water supply from the soil at flowering and pod filling is critical for the plant development. Flood or overhead irrigation which results in water logging and soil flooding leads to problems with diseases. The optimum strategy for managing water is to gradually recharge the soil water reserve before severe drought strikes. For the best results, the cultivation strategy should tend towards recharging the soil moisture before depletion. This is where precision irrigation plays a role.

Testing precision irrigation

We conducted an experiment from November 2019 to May 2020 near Larissa in Greece, looking at five different irrigation plans to determine the optimal irrigation protocol for lupin cultivation. Soil analysis before sowing provided information on soil texture and the supply of nutrients. These facts are needed because they can influence the irrigation scheduling and the final yield. For example, sandy soils need to be irrigated earlier than clay soils while soils richer in nutrients such as phosphorus and potassium can amplify a better yield.

The selected fields had similar climate conditions, were of similar soil composition and nutrient concentration. We used the exact same fertilisation and cultivation techniques. The fields were sowed in mid-October, using the cultivar Multitalia. The crop stand developed well. There were long periods of drought during the winter and the total amount of rain was not enough to cover crop needs.

Sensors in each field collected data on air temperature, wind, rainfall, external humidity, soil moisture, etc. The Drill and Drop type and Enviroscan type ground sensors measured soil moisture in different depths e.g., 10 cm, 20 cm, etc. Data are easily accessible via a web application where farmers see the parameters of interest and act accordingly. These sensors cover a large area, thus providing data for several fields minimising the cost of use.

Young white lupin. Photograph: THESGI Coop

Lupinus albus grains. Photograph: THESGI Coop

Table 1. The yield of white lupin as affected by irrigation and the associated soil water contents

	Rain (mm)	Irrigation (mm)	Water content of soil (% w/w)* at 200 mm below soil surface**	Yield (t/ha)
Field 1	330	0	-	2.60
Field 2	370	30	31	3.10
Field 3	370	20	22	3.40
Field 4	380	40	20	3.40
Field 5	380	50	13	2.90

Crop responses

We applied irrigation at different times according to soil humidity, making sure that the total amount of water was approximately the same (Table 1).

Irrigation increased yield significantly from 11.5% to 30.76%, compared to the non-irrigated field. Field 1 was the control field and no irrigation was applied. Rain did not cover the crop needs and total yield was quite low at 2.6 t/ha. The treatments differ in the scheduling of the irrigation. Field 2 was irrigated to keep soil moisture levels high while fields 3 and 4 were irrigated to keep soil water levels at about 20% at 200 mm. This moderate water supply prevented extreme drought stress, maintained crop growth and avoided diseases associated with excessive irrigation. Field 5 was irrigated at the stage where plants were stressed due to a lack of adequate soil humidity. Despite receiving the biggest total amount of water, plants did not recover from the drought stress and the yield was lower than expected.

Key practice points

- Lupin thrives in a temperature range from 14 to 25 oC for a period of 110–125 days from spring sowing and about 180 days from autumn sowing.
- In Greece, October sowing is recommended in order to avoid the high summer temperatures.
- Soil analysis helps determine the nutrient availability.
- Irrigation strategy should tend towards recharging the soil water before depletion impacts on the crop.
- Data from sensors covering a large area can be easily accessed via the web.
- Understanding what happens in the plants` root system enables us to make better decisions.
- In case of low winter rainfall, lupin needs irrigation to produce a high and economically viable yield.
- Excessive water accumulation during flowering stage can stress the plants. Irrigation where soil water contents are high is not advised.
- Irrigation should be used in advance to prevent extreme drought stress. Crops that have been subject to extreme drought stress do not recover fully when irrigated.
- Improved water use efficiency saves resources.

Further information

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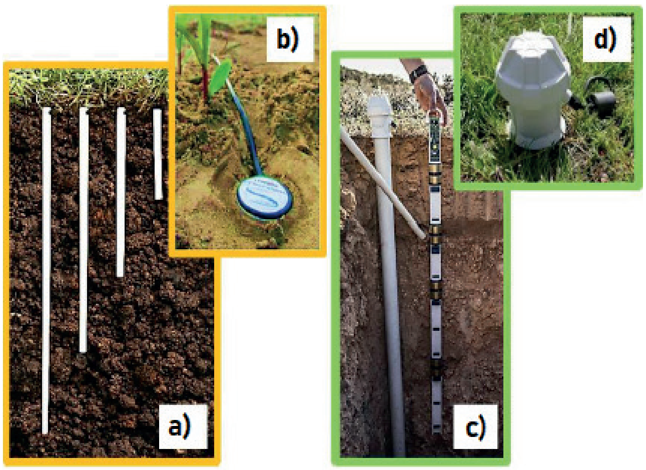
Table 2. Web panel view. End-user interface is hourly updated. Focus on soil moisture by 10cm, 20cm and 30cm. Photograph: THESGI Coop

Ημερομηνία	Σχετική Υγρασία Φύλλου 1 (%)	Σχετική Υγρασία Φύλλου 2 (%)	Σχετική Υγρασία (%)	Υγρασία (%) Εδάφους 10cm [DND]	Υγρασία (%) Εδάφους 20cm [DND]	Υγρασία (%) Εδάφους 30cm [DND]	Υγρασία (%) Εδάφους 40cm [DND]	Υγρασία (%) Εδάφους 50cm [DND]	Υγρασία (%) Εδάφους 60cm [DND]	Υγρασία (%) Εδάφους 70cm [DND]	Υγρασία (%) Εδάφους 80cm [DND]	Υγρασία (%) Εδάφους 90cm [DND]	Υγρασία (%) Εδάφους 10cm	Υγρασία (%) Εδάφους 20cm	Υγρασία (%) Εδάφους 30cm	Υγρασία (%) Εδάφους 40cm
2019-07-17 04:00:00	99.5	98.17	97.0	46.34	44.96	45.73	45.08	50.99	50.29	53.0	54.71	54.9	50.38	43.47	46.3	52.05
2019-07-17 03:00:00	99.0	98.33	97.0	46.31	44.95	45.71	45.09	50.98	50.29	53.0	54.71	54.9	50.27	43.42	46.31	52.07
2019-07-17 02:00:00	99.0	97.0	95.5	46.51	44.95	45.75	45.12	50.99	50.29	53.0	54.72	54.9	50.22	43.37	46.32	52.08
2019-07-17 01:00:00	99.0	97.67	96.17	46.79	44.93	45.79	45.12	50.97	50.3	53.0	54.71	54.89	50.22	43.3	46.33	52.1
2019-07-17 00:00:00	99.0	97.83	96.83	47.14	44.93	45.74	45.14	50.98	50.3	53.0	54.7	54.9	50.23	43.2	46.34	52.11
2019-07-16 23:00:00	99.0	97.0	95.67	47.59	44.9	45.71	45.12	50.99	50.31	53.0	54.71	54.91	50.18	43.08	46.34	52.13



Soil sensors Drill and Drop (a,b) Enviroscan (c,d). Photograph: Gaia Sense

Sources

Part of the information was obtained from the Greek and the international literature listed above. The approach of the irrigation protocol presented for the first time here is the result of Greek agronomists and lupin producers' efforts to optimise yield while protecting resources.

The main sources for soil monitoring are the ground sensors in the field (figure on the left) for monitoring the plant condition every hour. Data are accessible by a terminal device in a form of table (Table 2).

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