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THE EFFECT OF SHELTER BELTS AND IRRIGATION ON WATER USE IN A DRY REGION

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This article describes an investigation of irrigation and water use in an area with wooden shelter belts. Soil moisture was measured using a neutron moisture probe and tensiometers. The soil is deep and the water holding capacity is very high. Values of actual evapotranspiration on irrigated and non-irrigated plots are presented.

The principal purpose of this paper is to describe and give the results of a water balance investigation on irrigated and non-irrigated plots. The investigation, which is part of the national IHD program, was carried out in Lesja, a location 550 m.a.s.l. in North Gudbrandsdal, one of the most arid areas in Norway. Average yearly precipitation is 300–400 mm.

The research area at Brendjord is also unique because of the use of wooden shelter belts across the valley and the prevailing wind direction. The shelter belts are used mainly to accumulate snow, to prevent wind erosion and to protect the plants against the heavy wind. The shelter belts are mostly 60 cm high and 8–15 m apart.

The soil at the research area is deep and consists of deposits of glaciofluvial and fluvial origin. The dominating soil particle fraction is silt, 0.06–0.002 mm, which amounts to 80–90 %. The content of sand is 5–15 %, and the clay fraction about 5 %.

A soil texture range of this composition results in a very high water holding capacity. The water infiltrated from precipitation and even from snow melt close to the shelter belts in the spring is all stored in the upper 1 m layer of the soil.

A soil water tension of pF ≡ 2.0 and pF ≡ 4.2 is used to represent field capacity and wilting point, respectively. Using these limits the plant available water in the upper 1 m of the profile amounts to approximately 45 % on a volume basis.

Neutron-probe measurements were performed 18 times on the research plots in the period May 2 – Dec. 12.

These soil moisture measurements were carried out in eight profiles, four on irrigated and four on non-irrigated plots. On each water treatment two profiles were located close to the shelter belts and two midway between. The distance between the shelter belts was 8 m.

The actual water content expressed in mm of water in the profile 0–130 cm is given in Fig. 1. The deviations between the two parallel soil moisture observations at the four locations were moderate. The total water content in the profiles on irrigated plots ranged from 480–580 mm. Based on pF-curves, the water content of the profile at field capacity is estimated to be about 620 mm. On irrigated plots, the water content was kept fairly constant throughout the

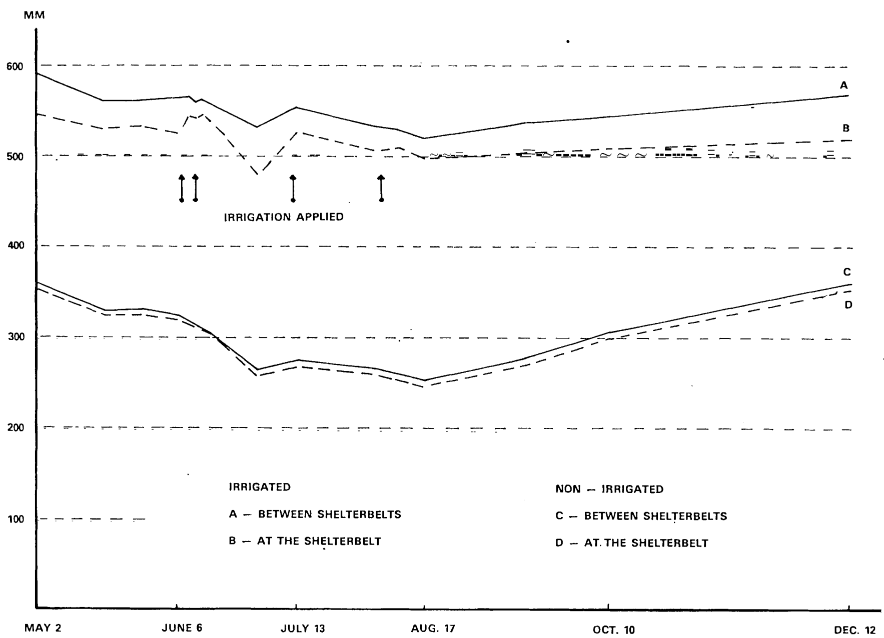

Fig. 1.
Soil moisture content, mm, in profiles 0–130 cm on different locations.

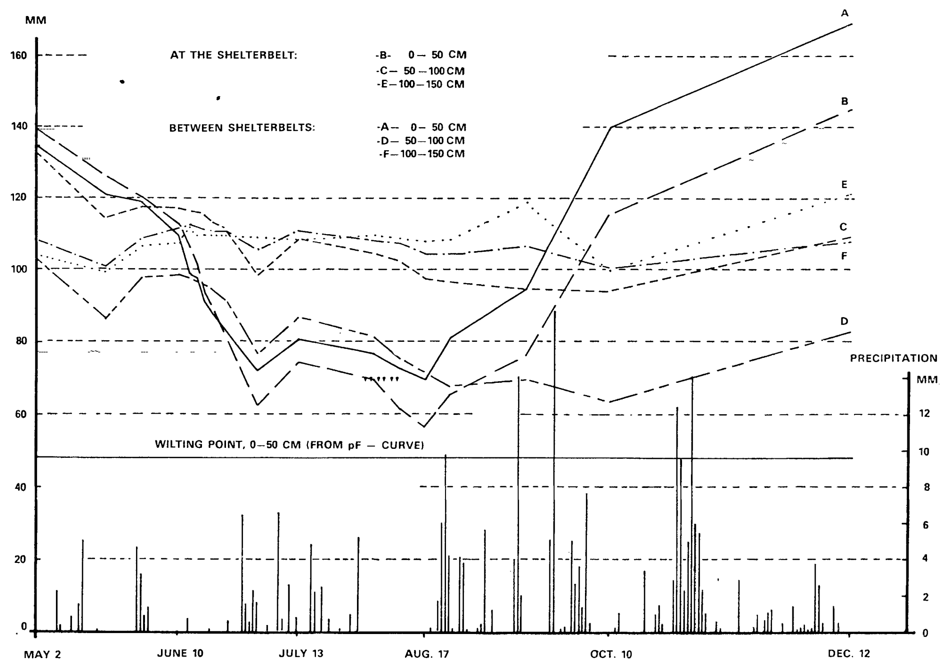

Fig. 2.
Soil moisture, mm, in different horizons on non-irrigated plots.

observation period. The variation in water content on non-irrigated plots was more pronounced, with a minimum in the period July to mid-August. The water content in the profiles also was considerably lower, in the range of 200 to 400 mm. The difference in water regime on irrigated and non-irrigated plots in the spring is due to irrigation practice in the research area during previous years.

Water content in different horizons on non-irrigated fields is shown in Fig. 2. In the upper 50 cm, the water content has decreased from 135 mm in early May to approximately 70 mm in the period July to mid-August. The water content at the wilting point in the 0–50 cm horizon is estimated to be 50 mm, based on pF-curves. The plant roots are distributed mainly in this horizon.

At a lower water content, the water potential is high and the turgor pressure in the plant tissue is decreasing. Transpiration and water uptake, as well as the production of plant tissue (grass), are reduced considerably. This situation occurs even at a moderate water potential in the soil when the transpiration rate is high. Due to slow water movement and incomplete root distribution in the soil mass, not all the defined available water actually is readily available. On non-irrigated plots the water status in the 0–50 cm horizon in the most intense growing period has been close to the wilting point, and therefore drying stress most probably has occurred on these plots.

The water content in the horizon 50–100 cm is somewhat decreased during the growing season, with a slight increase during late fall. The yearly variation is modest. At 100–150 cm depth the water content is practically constant throughout the observation period.

The soil moisture content in the horizon 0–50 cm was highest near the shelter belts until mid-June. During the remaining observation period the water content was higher on plots midway between the shelter belts and this difference increased towards the end of the period.

The accumulation of snow causes a higher initial soil moisture content close to the shelter belts. However, the plant cover is more densely developed near the shelter than further away, partly due to the shelter effect. The more completely developed plant cover close to the shelter belts has a more efficient root system and a higher transpiration, and the quantity of grass harvested also is higher here.

Soil moisture content in the horizon 50–100 cm was 25–30 mm higher near the shelter belts throughout the observation period. This is also an effect of the

Table 1.

Period	Irrigated fields			Non-irrigated fields		
	East of shelter belts	Midway between shelter belts	West of shelter belts	East of shelter belts	Midway between shelter belts	West of shelter belts
1969						
May 26–July 2	105	135	121	131	156	135
July 2–Aug. 1	70	96	83	79	96	85
Aug. 1–Sept. 3	98	123	88	121	133	105
Sept. 9–Sept. 27	29	35	32	33	43	38
1970						
June 14–June 30	48	60	48	59	67	64
July 1–July 31	24	40	36	44	49	46
Aug. 1–Aug. 31	61	73	57	60	64	56

Evaporation from Andersson evaporimeter, mm.

snow accumulation. Since the difference is maintained throughout the growing season, it is assumed that the root distribution in this horizon is poor and of less importance for the water uptake.

The effect of the shelter belts on evapotranspiration is examined using Anderson's evaporimeter.

Maximum evaporation occurred midway between the shelter belts. The wind direction in the periods in Table 1 was predominant westerly, which explains the higher evaporation on the western side of the shelter belts. The evaporation was highest on the eastern side of the shelter belts in August, when the wind direction was predominantly easterly.

The actual water consumption is calculated using the difference between successive neutron probe measurements, precipitation on non-irrigated plots, and precipitation plus irrigation on irrigated fields. The variation in soil water content is expressed in mm water in the profile 0–130 cm.

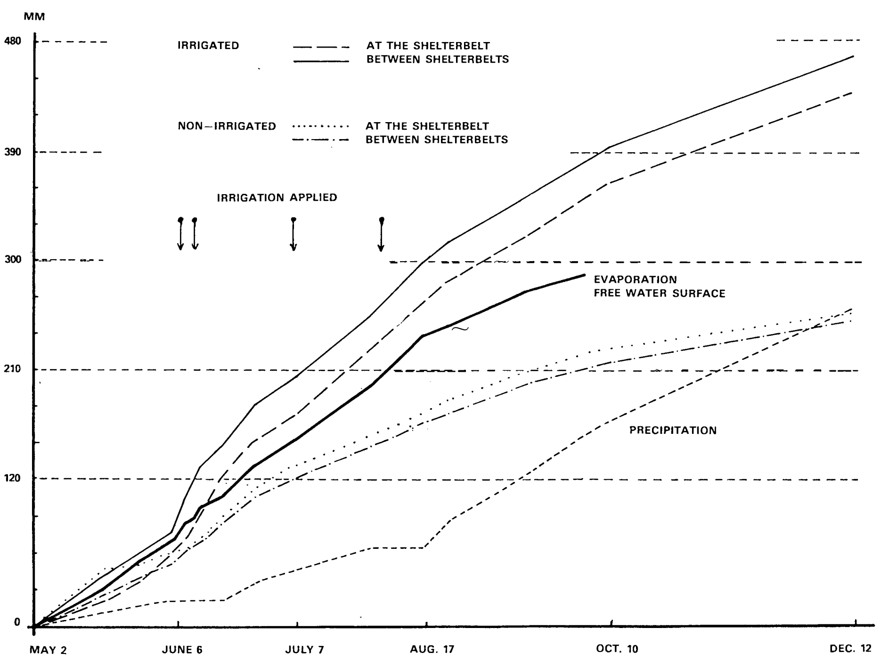

Fig. 3.
Precipitation, evaporation from free water surface and actual water use on irrigated and non-irrigated plots.

The calibration of the neutron meter may result in some inaccuracy as to absolute water content. However, the water use is calculated by using the relative values, which seems to be reliable since the difference between parallel observations is negligible.

The water use observed on irrigated fields in this investigation is expected to be close to the potential evapotranspiration in this region. This assumption is made because of the very high soil moisture capacity for plant available water and because the application of irrigation water has maintained a soil moisture potential in the range of 0.4 to 0.5 bar.

The actual water use on non-irrigated and irrigated plots, compared to the evaporation from free water surface (Thorsrud evaporimeter) and precipitation is given in Fig. 3. The Figure gives the cumulative values.

Actual water use by the plant cover on non-irrigated plots is lower than the evaporation from a free water surface, and the difference increases with time.

The difference in water use by the vegetation near the shelter belts and midway between the shelter belts is small on non-irrigated plots. However, there is a tendency towards higher water use close to the shelter belts, due to a more complete plant cover.

The water use by the vegetation on irrigated plots exceeds the evaporation from a free water surface, as shown in Fig. 3. Lesja is a district exposed to heavy wind, which causes an intense and efficient ventilation of the plant cover, and the plant cover as well as the root system are extremely well developed. The yield of dry hay on irrigated plots was 12 940 kg per hectare, averaged over 3 years. On non-irrigated plots the total yield in the same period was 6810 kg per hectare. Thus a remarkable increase in yield was obtained by optimal irrigation.

The actual evapotranspiration under the conditions in Lesja is obtained on non-irrigated plots.

Evapotranspiration on irrigated and non-irrigated plots during the period May 2 to October 7 is illustrated in Table 2.

Table 2.

Treatment	Near shelter belt	Midway between shelter belts
Irrigated	363	394
Non-irrigated	231	219

Water use on irrigated and non-irrigated plots, mm, during the period May 2–Oct. 10.

On irrigated fields the evapotranspiration is higher midway between shelter belts than at the shelter belts. The plant cover is well developed on all irrigated plots. The effect of shelter belt on yield is about 10 % on irrigated plots.

The climate in the area is characterized by a low humidity and a high wind speed. This may cause some oasis effect on the water use on irrigated plots.

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