Effect of Stand Density on Formation of Leaves and Leaf Area of Sugarbeet Under Irrigation

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ABSTRACT

The study of the effect of stand density (number of plants per ha) and irrigation showed that in the first year, under Yugoslavia conditions (semihumid to semiarid climate), sugareet variety Dana formd an average of 53 leaves and 31 leaves died during the growing period. Averaged over stand density, the number of leaves per plant was 54.0 under irrigation and was 51.4 without irrigation. The largest differences between irrigated and not irrigated was with 90,000 plant/ha where irrigated plants produced 55.3 leaves and non-irrigated produced 49.5. The number of dead leaves per plant was similar with or without irrigation.

The number leaves formed negatively correlated with stand density. However, stand density was positively correlated with leaf area. Under irrigation, average leaf area index ranged from 2.9 ha/ha with 60000 plants/ha to 4.2 ha/ha with 120000 plant/ha. The average leaf area index in 1992, a dry year, was increased by 81% by irrigation while irrigation in 1991, a wet year, only increase leaf area index by 5%.

Additional key words: Number of leaves, Leaf area index, Irrigation, Sugarbeet, Stand density.

Leaf area and its photosynthetic activity is a primary factor in productivity of sugarbeet. Numerous reports indicate that reduced leaf area reduces the yield of sugarbeet root. The factors affecting the formation, growth and duration of leaf area affect sugarbeet yield. Okanenko (1968) found a high correlation (0.9) between leaf area and yield of sugarbeet root. However, according to other research, the highest photosynthetic activity of sugarbeet is at an optimum leaf area and additional leaf area is not beneficial. Kastori and Petrović (1992a) claimed that, for efficient utilization of light energy , leaf area index should range from 3.5 to 4.0. At optimum conditions, this leaf area may daily synthesize 30 g of sugar per 1 m^2,(300 kg per ha). Similar results were achieved by Shulz (1963) and Storer et. al. (1970) who indicated that optimum leaf area index of sugarbeet ranges from 3 to 4. Lomis and Williams (1969) also claimed that leaf area index of sugarbeet should be about 4. However, Folleth et al (1970) found that the optimum leaf area index of sugarbeet ranges from 4.2 to 5.5.

Sugarbeet develops leaf mass in the first year and under the favourable environmental conditions such as soil moisture, air temperature, light, soil fertility, the leaf mass will increase during the entire growing period. Leaf formation and the duration of leaf area of sugarbeet depends on weather conditions, varietal characters, applied cultural practices, etc. The increase of leaf area is affected by stand density, i.e., number of plants per area unit. The increase of leaf mass is also significantly affected by available water and irrigation practices. The influence of the effect of these factors on the formation of leaves and leaf area of sugarbeet are the subject of this paper.

MATERIALS AND METHODS

The effect of stand density on the formation and dying off of leaves and the dynamics of the increase in leaf area under irrigation and non-irrigation were investigated. The study was conducted at the experiment field of the Institute of Field and Vegetable Crops Novi Sad at Rimski Šančevi from 1991 through 1994.

The treatments studied were:

A. Stand density:
a^1 - 60000 plants ha^{-1} (50 * 32-33 cm)
a^2 - 75000 plants ha^{-1} (50 * 26-27 cm)
a^3 - 90000 plants ha^{-1} (50 * 21-22 cm)
a^4 - 105000 plants ha^{-1} (50 * 18-19 cm)
a^5 - 120000 plants ha^{-1} (50 * 16-17 cm)

B. Irrigation
b_1 - irrigation
b_2 - no irrigation

Other cultural practices (soil tillage, fertilization, sowing, cultivating, protection, etc.) were the same as for comercial sugarbeet production. The experiment had four replicates. Plot size for one variant and one replicate was 24 m^2.

The measurement of sugarbeet leaf area, variety 'Dana', was performed five times during the growing season (June 5, July 5, July 25, August 20, September 20) according to the method of leaf dimension measuring (length x width) and multiplied by the coefficient 0.75.

RESULTS AND DISCUSSION

Leaf area is a basic factor of photosynthesis productivity and thereby, plant productivity. Additionally, the increase of leaf area of sugarbeet is affected by stand density and water supply to the plant.

Sugarbeet intensively forms leaves and leaf area in the early part of growing season, generally reaching the maximum leaf area in the middle of July. The period needed to form maximum leaf area depends on environment conditions, applied cultural practices and characters of the varieties. Stanaćev (1969) determined maximum leaf area on August 1, and Djordjević (1965) from July 1 to 15. Dragović (1973 and 1978) found the maximum leaf index area in irrigation at the end of June and beginning of July. We found that under Rimski Šančevi, Yugoslavia conditions, maximum leaf area in all stand densities in irrigation was achieved on July 25 and, with no irrigation from July 5 to 25, (Figure 1).

The variation in leaf area development depends on the conditions for sugarbeet development. Sugarbeet stand density influenced average leaf area index under irrigated and non-irrigated conditions. Under irrigation the leaf area index increased linearly from 2.9 with 60,000 plants/ha to 4.2 with 120,000 plants/ha. Similar results were obtained without irrigation (Figure 2). Irrigation increased leaf area index in all years and at all populations by an average of 36%.

Stand density also influenced maximum leaf are index. Under irrigation, maximum leaf area index was 4.0 with 60,000 plants/ha to 6.3 with 120,000 plants/ha, a 61% increase. Without irrigation, maximum leaf area index ranged from 3.1 to 5.4, an increase of 58%, from 60,000 to 120,000 plants/ha (Figure 3).

Irrigation increased the average leaf area index by 81% in 1992, a dry year, while irrigation increased leaf area index by only 5% in 1991, a wet year, as compared to non-irrigated sugarbeet (data not shown).

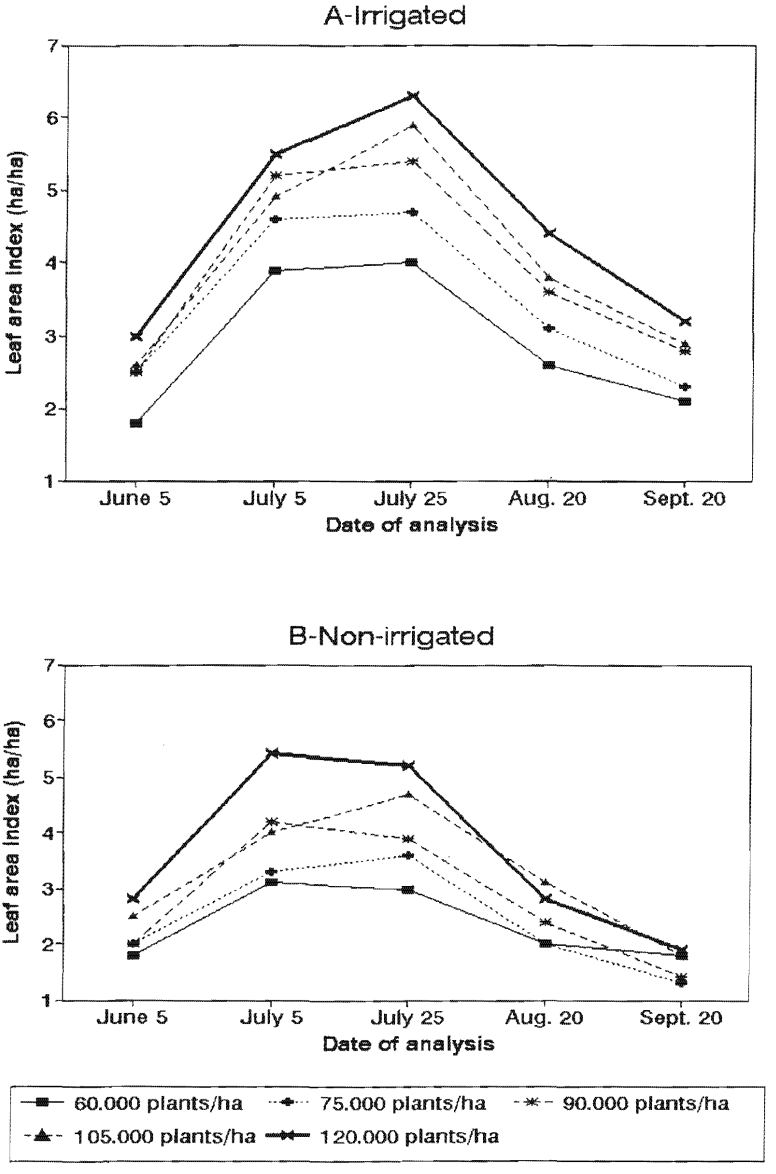

Figure 1. The effect of stand density and irrigation on leaf area index at five dates during the growing season.

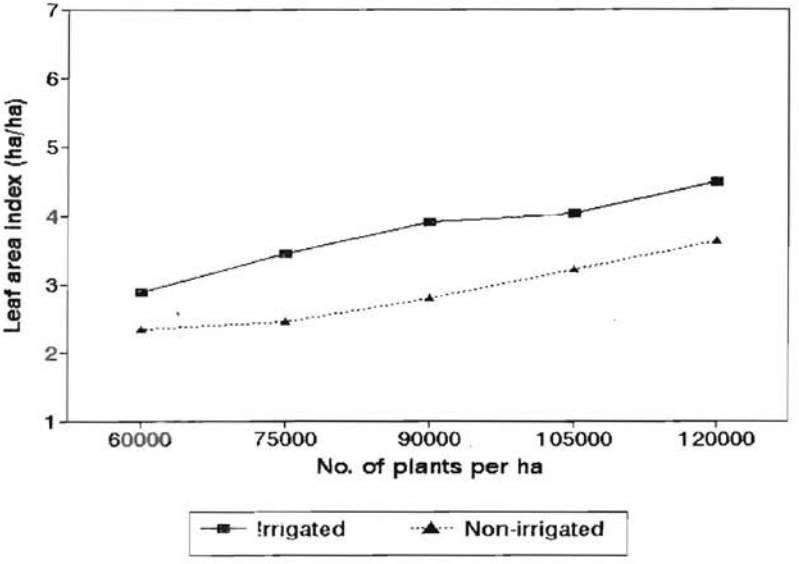

Figure 2. Effect of stand density on average leaf area index in irrigated and non-irrigated sugar beet (average for 1991-1994).

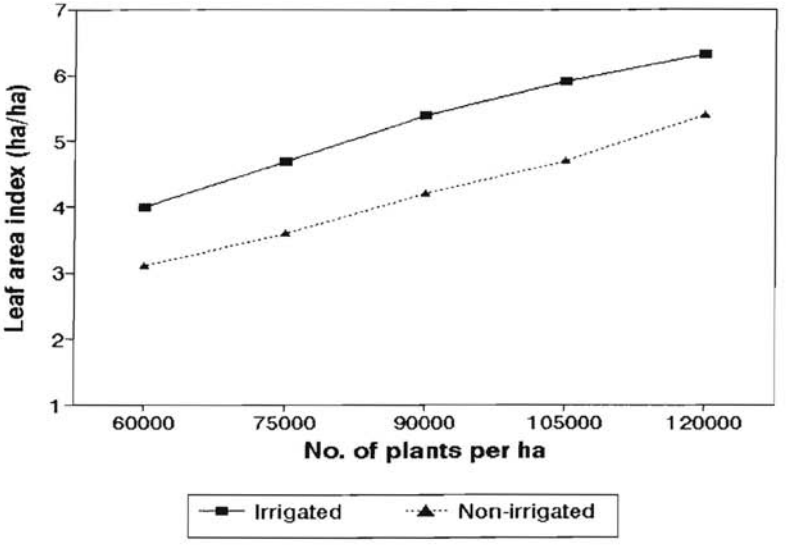

Figure 3. Effect of stand density on maximum leaf area index in irrigated and non-irrigated sugar beet (average for 1991-1994).

Maximum leaf area index was also affected by fluctations in growing conditions from year to year. Maximum leaf area index of 8.1 ha/'ha was achieved on July 25, 1994 with stand density of 105,000 plants/ha. Maximum leaf area index without irrigation was 7.7 ha/.ha with stand density of 120,000 plants/ha at the same date. Similar results were found by Dragović (1973), who achieved a maximum leaf area index of 7.9 under irrigation and intensive application of fertilizer in the trials at Rimski Šančevi. However, the leaf area index was 9.5 in conditions of intensive irrigation for variety 'Almira' in Skopsko polje suggesting varietal differences (Čukalijev, 1995).

The increase in leaf area index with the increase in the number of plants per ha had a significant effect on the yield of variety Dana grown under irrigation. Stand density of 120,000 plants/ha with a leaf area index of 4.2 ha/ha gave a significantly lower root yield than 5.3 ha/ha leaf area index and a stand density of 90,000 plants/ha (Table 1). Without irrigation, leaf area had no significant effect on root yield with any sugarbret stand density. (Dragović and Maksimović, 1995).

Table 1. Effect of irrigation and plant density on the yield of sugar beet variety Dana, t/ha-1 (average for 1991-1994).

Irrigation	Plant density, plants/ha					Average
	60000	75000	90000	105000	120000	
Irrigated	97.6	98.1	99.0	98.2	92.7	97.1
Non-irrigated	52.5	54.0	54.7	56.2	53.3	54.1
Average	75.0	76.0	76.8	77.2	73.0	75.6

LSD:	Irrigation means	Plant Density means	Interaction means
0.05	2.8	4.4	6.2
0.01	3.7	5.9	8.3

Optimum leaf area index of sugarbeet ranged from 3 to 4 ha/.ha, although Dragović (1978) claimed that optimum index of leaf area of sugarbeet is from 4 to 5. Dombroth and Bramm (1980) considered that most of sugarbeet genotypes have higher total leaf area than needed.

According to several published reports, sugarbeet forms a large number of leaves in the first growing season. According Kastori and Petrović (1992), sugarbeet produces from 50 to 90 or even more than 100 leaves annually. The study of Dragović (1973) indicates that the variety 'NS-Poly 2' formed 53 leaves in the first year and the number of leaves was similar under irrigation and non-irrigation. Stanaćev (1969) found 48 leaves produced by the same variety with no irrigation. However, Orlovskij (1963) reported that sugarbeet forms 50 to 60 leaves during the growing season. High leaf area does not necessarilly result in high root yield due to shading of fully developed leaves. Shaded leaves can not achieve potential rates of photosynthesis. Saric (1981) claimed that to achieve maximum intensity of sugarbeet photosynthesis, future idiotypes of sugarbeet need lower leaf area per plant, to minimize leaf shading.

The number of leaves formed by sugarbeet variety Dana averaged 52.7. During the growing season 31leaves died. The number of leaves per plant decreased as the population density increases (Table 2). The decrease of the number of leaves per plant with the increase in stand density was observed both with and without irrigation. Plant density and irrigation had no effect on the number of leaves dying in the growing season.

Table 2. Effect of stand density and irrigation on the number of formed and wilted leaves per plant in the sugar beet variety Dana during the growing season.

Plant	Irrigated		Non-irrigated		Average	
Density	Leaves formed	Dead leaves	Leaves formed	Dead leaves	Leaves formed	Dead leaves
60,000	55.5	30.5	53.5	31.3	54.5	30.9
75,000	55.0	33.8	51.5	31.4	54.2	32.6
90,000	55.3	32.1	49.5	30.3	52.4	31.2
105,000	52.4	30.2	51.2	31.4	51.8	30.8
120,000	52.0	30.0	51.1	30.9	51.5	30.4
Average	54.0	31.3	51.4	31.1	52.9	31.2

The number of leaves per plant under irrigation, averaged over stand densities, was 2.6 leaves per plant higher than without irrigation. The largest difference between irrigated and not irrigated was with 90,000 plants/ha where irrigated plants produced 5.8 more leaves than

non-irrigated plants. Considering the large number of leaves produced in the growing season, the difference between irrigation and non-irrigation was relatively small.

Sugarbeet forms leaves during the entire growing period. Dynamics of leaf formation under irrigation was characterized by formation of higher number of leaves in the first part of growing period (to the beginning of July), less formation in the middle of the growing period (July and August) and more at the end of the growing period (September) (Figure 4).

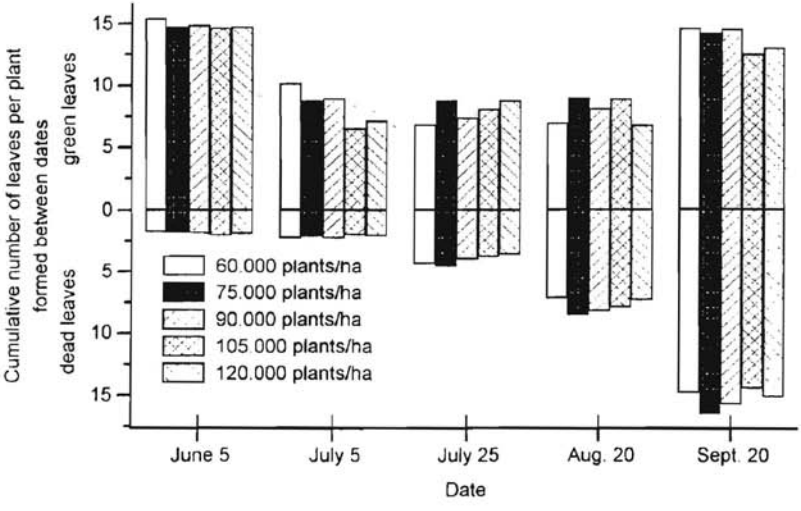

Figure 4. Number of dry and green leaves formed between each date for each plant density over irrigated sugar beet (average for 1991-1994).

Life duration of the leaves varied from 16 to 90 days, while 0.2 to 0.7 leaves were formed per day (Kastori and Petrović, 1992b). In the period from June 5 to September 20 (106 days), 37.4 leaves per plant were formed on average with irrigation, which is 0.35 leaves per day. Without irrigation, 0.33 leaves were formed per day on average.

Dynamics of leaf dying in the growing season under irrigation has a pattern opposite to leaf forming. In the first part of the growing season, leaf dying was minimal at two to three leaves per month. In the middle of the growing season, leaf dying was more extensive while at the end of the growing season, dying was greater. Without irrigation, the dynamics of leaf dying differed from under irrigation. In the middle of growing season, leaf dying was more pronounced while at the end of the growing season it was less (Table 3). Similar results were found in previous studies under similar conditions but with other varieties. (Dragović, 1973).

Table 3. Number of green, dead and newly formed leaves per plant of sugar beet in certain periods under irrigation and non-irrigation (1991 through 1994) averaged over sugarbeet plant densities.

Date	Irrigation				Non-irrigation			
	New (since previous date)	Dead	Green	Growth (per day)	New (since previous date)	Dead	Green	Growth (per day)
June 5	-	1.9	14.8	-	-	1.6	14.6	-
July 5	8.2	2.2	20.8	0.25	8.4	2.4	20.7	0.25
July 25	7.4	4.1	24.1	0.41	6.6	4.7	22.5	0.37
Aug 20	8.1	7.8	24.8	0.31	7.9	9.5	20.9	0.30
Sept 20	13.7	15.3	23.1	0.46	12.3	12.9	20.3	0.40
Total	37.4	31.3		0.35	35.2	31.1		0.33

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