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EFFECT OF ROW SPACING ON PHOTOSYNTHETIC PRODUCTIVITY OF SUGAR BEET

M.P. VOLOKHA
National Aviation University, Kyiv

The article presents the results on the growth of the effective leaf surface area and net photosynthesis productivity in sugar beet subject to narrowing the row width. It is proved that at stand density 100,000 to 110,000 plants / ha in narrow (30 cm) and combined (3×30cm+1×45cm) rows dry matter weight considerably increases therefore increasing the crop productivity.

Keywords: *sugar beet; row spacing, net photosynthesis productivity, leaf surface area, dry matter weight; yield.*

Introduction. It is know that 95 % of the dry matter in green plants yield has been created due to photosynthesis performed in leaves through absorption of solar radiation energy by chlorophyll, i.e. photosynthesis (*from Greek* “fotos” – “light”) is the organic compounds synthesis with carbon dioxide and water using the energy of sunlight.

The very process of photosynthesis is the separation of hydrogen from water and transferring it to carbon dioxide. According to A. Nychyporovych [1] “photosynthesis is the process of oxidation-reduction, where the water while giving hydrogen and serving as a reducing agent is oxidized itself and carbon dioxide, accepting hydrogen and serving oxidant is restored itself” (Fig. 1).

Ultimately, yield is in close relation with intensity of leaves development, leaf surface area their productivity.

Why is indicator of solar radiation utilisation in photosynthesis low can be explained due to the fact that the leaf area does not reach optimal values (40,000–

50,000 m^2 per ha): closure of leaves between rows is late, especially if crops are thinned and uneven, which results in big share of solar energy passing leaves directly to the soil [2–4].

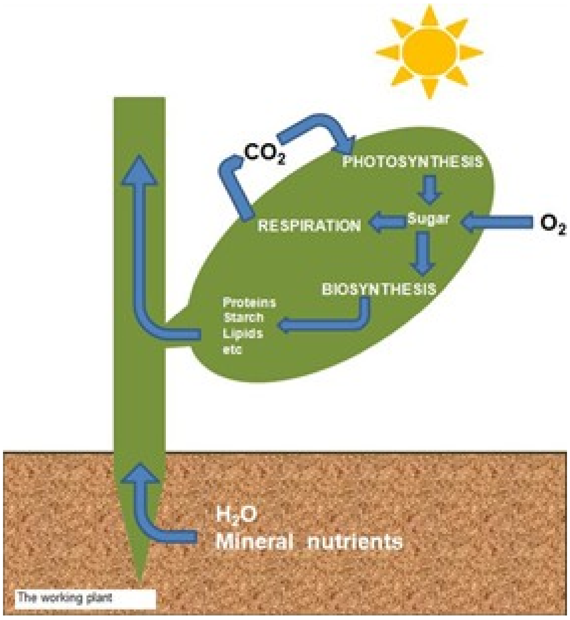

Fig. 1. Scheme of photosynthesis

In this sense narrowed spacing (width less than 45 cm) in sugar beet crops priori positively influence the process of photosynthesis, which is the aim of the study, because until now only effect of the plant stand density in row at inter-row space of 45 cm on photosynthetic productivity in sugar beet has been reported [5–8].

Materials and methods of research. The study was carried out in 2012–2014 in conditions of Experimental Farm "Shevchenkivske" IBCSB situated in the area of unstable wetting in Right-Bank Forest-Steppe of Ukraine.

Sown area was 64.8 m^2, record area 54.0 m^2, and repetition fourfold. To solve the problem of increasing photosynthesis productivity in sugar beet experiments were carried out, which studied photosynthetic productivity depending on the width between rows: 45 cm (typical, check); 3×30cm+1×45cm (combined), 30 cm (narrow width). Seeds of hybrid Shevchenko were sown with drill SST-12B according to relevant scheme to a final stand density of 100,000-110,000 plants per 1 hectare regardless of the inter-row width.

Samples of plants to determine the photosynthesis productivity were selected according to the known method [9], the surface of non-cut leaves was defined by planimetric method [2] according to which their area is calculated through similar geometric shapes (ellipse, triangle, trapezium, etc.).

Results and discussion. Productivity of assimilation system is expressed as net productivity of photosynthesis (NPP), and is calculated with the following formula according to methodology [2]:

$$NPP = \frac{B_2 - B_1}{(Л_1 + Л_2)^1/_2 n},$$

where B_1 and B_2 – dry weight of yield sample at the beginning and end of the test period; $(B_1$ - $B_2)$ – increase in dry weight over test period n days; $Л_1$ and $Л_2$ – leaf area at the beginning and end of the test period; $(Л_1 + Л_2)\,^1/_2$ – mean effective leaf area for this period; n – duration of test period, days.

However, the dependence given can produce accurate results if the growth of leaf area over the entire test period is uniformly and graphically approximated straight line, that is the average effective area for the reporting period can be expressed as half-sum of initial and final figures. However, this case is exceptional because there is a period of most rapid growth of crops with leaf area increasing along the curve rapidly at first, and then damping. For example, leaf area can grow very rapidly during the first 3–5 days and then increase slowly [2]. Then the average leaf area is greater than half-sum of two extreme indicators, and determination of the average effective area for the test period as a half-sum of two extreme indicators does not gives accurate data.

Therefore, to determine NPP we used an improved formula:

$$NPP = \frac{(B_2 - B_1)(\log_e Л_2 - \log_e Л_1)}{n(Л_2 - Л_1)}$$

where $\log_e Л_2$ i $\log_e Л_1$ – natural logarithms of leaf area indicators at the beginning ($Л_1$) and end ($Л_2$) of the test period, while the remaining indicators remain the same.

Phenological observations of sugar beet growth and development have found that emergence is largely dependent on soil moisture and temperature as well as air temperature. Over the research period of “sowing –emergence”, fluctuations in soil moisture and temperature were marked affecting the calculation of plant stand density. Emergence occurred in 8–11 days depending on the year of study.

It was also established over the research years that during the second half of the growing season (after July 10) and for a short period (until 1 August), up to half of the total dry matter weight grew (of that gained at the end of the growing season). Especially when narrow (30cm) and combined (3×30cm+1×45cm) rows. It can be explained with 5–7-days earlier closure leaves between rows, significant growth of leaf area and therefore net photosynthesis productivity.

At the stage of intensive plant development (August 1), a significant leaf area growth was recorded when row spacing 30cm (59.7 m^2/ha) and 3×30 cm+1×45 cm (58.2 m^2/ha) contrary to check row spacing 45 cm (52.7 m^2/ha), LSD_{05} = 4.5 (Fig. 2). Also NPP grew, namely 8.1g of dry matter per 1 m^2 of leaf area per day, and 8.0 g against 6.9 g, respectively (LSD_{05}= 1.0) (Fig. 3).

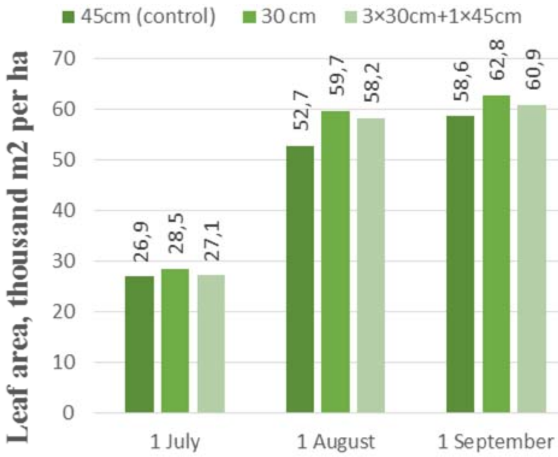

Fig. 2. Leaf area (mean of 2012/14) subject to row spacing and check date

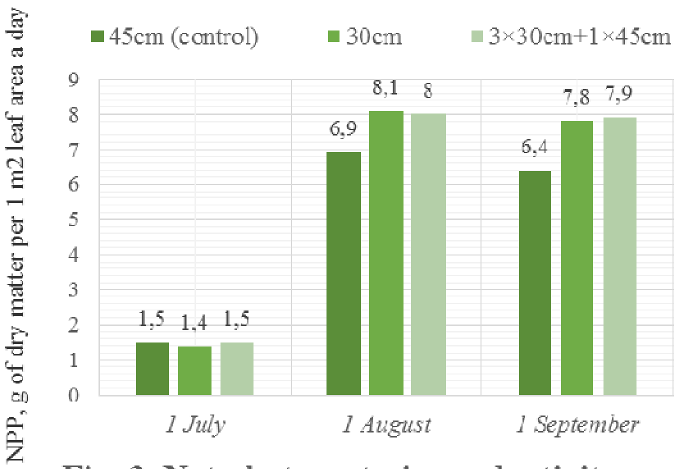

Fig. 3. Net photosyntesis productivity (mean of 2012/14) subject to row spacing and check date

As of September 1, leaf area grew less rapidly and there were no significant differences in this indicator between the test variant found. NPP index dropped slightly in narrowed and combined row-spacing, and significant reduced in check (row width of 45cm): 7.8, 8.0 and 6.4g of dry matter per $1m^2$ of leaf surface per day, respectively, LSD_{05}= 1.2).

CONCLUSIONS

1. When combined and mainly narrow rows in sugar beet crops the effective leaf area increases much intense, especially in the second half of the growing season due to an earlier closure of leaves between rows. The most rapid increase in dry matter weight has been recorded at the same period as compared with typical row spacing.

2. The biological yield of sugar beet when combined (3×30cm+1×45cm) and narrow (30cm) rows increases significantly (up to 6 t/ha) and the possibility of mechanization for this production practice in sugar beet has been proved [10].

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ВПЛИВ ШИРИНИ МІЖРЯДЬ НА ФОТОСИНТЕТИЧНУ ПРОДУКТИВНІСТЬ БУРЯКІВ ЦУКРОВИХ

М.П. ВОЛОХА

Національний авіаційний університет, м. Київ

У статті викладені результати росту робочої листкової поверхні буряків цукрових і продуктивності фотосинтезу залежно від звуження ширини міжрядь. Доведено, що за умови густоти стояння рослин 100–110 тис/га при вузьких (30см) і комбінованих (3×30см+1×45см) міжряддях суттєво збільшується маса сухої речовини і, відповідно, урожайність культури.

Ключові слова: *буряки цукрові, ширина міжрядь, чиста продуктивність фотосинтезу, площа листкової поверхні, маса сухої речовини, урожайність.*

ВЛИЯНИЕ ШИРИНЫ МЕЖДУРЯДИЙ НА ФОТОСИНТЕТИЧЕСКУЮ ПРОИЗВОДИТЕЛЬНОСТЬ САХАРНОЙ СВЕКЛЫ

Н.П. ВОЛОХА

Национальный авиационный университет, г. Киев

В статье изложены результаты роста рабочей листовой поверхности сахарной свеклы и продуктивности фотосинтеза в зависимости от сужения ширины междурядий. Доказано, что при густоте стояния растений 100–110 тыс/га при узких (30 см) и комбинированных (3×30 см+1×45 см) междурядьях существенно увеличивается масса сухого вещества и, соответственно, урожайность культуры.

Ключевые слова: *сахарная свекла, ширина междурядий, чистая продуктивность фотосинтеза, площадь листовой поверхности, масса сухого вещества, урожайность.*