УДК 635.65:[581.1.03:539.16.04+631.59] (477)

INFLUENCE OF PHOTOSYNTETICALLY ACTIVE RADIATION ON THE PRODUCTIVITY OF VEGETABLE BEANS UNDER THE CONDITIONS OF FOREST-STEPPE OF THE UKRAINE

Vira KUTOVENKO, Nataliya GAVRYLYUK
National University of Life and Environmental Sciences of Ukraine

Abstract. Potential capacities of vegetable bean sorts and actual harvest losses are elucidated depending on summarized photosynthetically active radiation during vegetative period in Forest-Steppe Zone of the Ukraine. We found that potential yield of vegetable beans was depending on summarized PAR during vegetative period. Potential harvest of the sorts of vegetable beans under 2% of PAR's use would be 57.25-59.3 t/ha, which was 2.2-3.6 times more than their actual harvest. The lesser losses of actual harvest compared to potential one were recorded for the sorts Bartoli and Windsor (2.2-2.3 times).

Key words: Vegetable beans; Sorts; Photosynthetic active radiation; Potential productivity; Actual productivity

INTRODUCTION

Biological potential of vegetable cultures might be high theoretically, however hard to achieve under practical conditions. Potential capacities of any certain culture are determined not only by biological peculiarities, but also by the environmental factors and financial possibilities of every farm. Optimization of growth conditions using technological measures during critical growth phases of any vegetable culture helps to reach its biological potential.

Even small climatic changes lead to big harvest losses. Solar radiation is one of the key factors affecting the yield. However, the plants don't absorb the whole spectrum of solar energy but only its photosynthetic active radiation (PAR), which influences the future harvest of the culture. Therefore study of the influence of photosynthetic active radiation (PAR) on the yield of the sorts of vegetable beans is an interesting and actual question nowadays (Barabaš, Î.Ű, Taranenko, L.K. 2005; Syč, Z.D. 2005; Syč, Z.D. 2008).

Theoretical coefficient of PAR's use accounting the total biomas of vegetable plants is 9.5-10.5% in average. It is impossible to reach these theoretically high potential productivity because of the absence of optimal growth conditions. Also, optimum of these factors changes depending on the growth phases and development of vegetable plants. It is possible to evaluate these factors only studying their morphogenesis (Syč, Z.D. 2008; Syč, Z.D. 2004; Marčenko, O.V. 2003).

PAR efficiency is closely related to the biology of vegetable cultures, geographical location of the region and field conditions of every given plantation. Average PAR efficiency for different vegetable cultures is ca. 2% in Forest-Steppe zone of the Ukraine, lesser in Polissya and greater in Steppe (Bobos', I.M. 2008; Bobos', I.M. 2011; Syč, Z.D. 2008; Syč, Z.D. 2004).

Practically the coefficient of PAR (K_{PAR}) can reach 3%, but under modern conditions this value can not regulated by farmers. Currently its value is just 1% under usual growth conditions. For example, cucumber plants use PAR only for 1.14% in the Forest-Steppe zone of the Ukraine, including the first fruiting for just 0.25% (Bobos', I.M. 2008; Syč, Z.D. 2008; Syč, Z.D. 2004).

The aim of our research was the study of the influence of photosynthetic active radiation on potentially possible productivity of the sorts of vegetable beans under the conditions of Forest-Steppe of the Ukraine.

MATERIALS AND METHODS

Research were conducted during 2009-2011 in NDP "Fruit and vegetable orchard" in NUBiP of the Ukraine, which is located in the northern part of Forest-Steppe of the Ukraine on sod-mediumpodzolic soils, following the method of research in vegetable production (Bondarenko, G.L., Âkovenko, K.I. 2001) and method of field experiments edited by B.A. Dospehov (Dospehov, B.Ŕ. 1979).

Four sorts of vegetable beans including Karadag (control) were the objects of study. Four repetitions with plot randomization were made. Surface of study spots was 5 m^2. Fourty plants were sampled –

10 for each repetition. Beans were grown as in commercial production (Lihackij, V.I. 1996; Syč, Z.D., Kutovenko, V.B. 2011). The records were taken for such stages of vegetation: final seedlings, buttons, flowering, start of technological maturity and biological maturity of beans. Duration of vegetative period was calculated started with the day of seedling appearance above ground to the biological maturity. The plantating scheme was 70×20 cm. Height of the plants was measured before the harvest using measuring ruler in five equally remoted locations of the plot.

Summarized PAR for the whole vegetative season, value of potential yield according to actual PAR, biomas output regarding standard moisture and potential, and actual yield of the sorts of vegetable beans were determined after harvest.

To determine the potential productivity we have used the reference materials for northern climatic-geographic region where Kyiv oblast belongs. Under the conditions of the Ukraine the distribution of the sums of PAR for the vegetative period with average day temperature above 5 ^{0}C fits the natural-climatic zones except mountain regions of Carpathy, Crimea and Donetsk regions. Summarized PAR changes insignificantly each year. This value was calculated for the whole vegetative period – from fully appeared seedlings to the last harvest. For Kyiv oblast the average monthly PAR in April contained 22.2; May – 30.2; June – 32.3; July – 32.3; kJ/cm^2 (Syč, Z.D. 2004; Syč, Z.D., Kutovenko, V.B. 2011).

The value for potentially possible production (PP, t/ha) was calculated using formula:

$$PP = K_{PAR} \times \Sigma Q_n : q,$$

were: K_{PAR} – coefficient of PAR utilization; "Q_n – summarized PAR during the vegetative period for each sort; q – calories per one unit of dry organic matter of the vegetable culture. Energy value of the main production of vegetable beans for the absolute dry matter (q) is 15072 cal/kg.

Biomas yield was calculated accounting the standart water conent using the formula:

$$P_c = 100 \times (PP: (100 - M_n) \times a), \text{ where}$$

PP – value of potential productivity (t/ha); M_c – standard moisture content (80% for vegetable beans); a – ratio of main production to side production (1:1,5 for vegetable beans).

Having biomas productivity and knowing the ratio between main and side production, we determined the potential productivity for the sorts of vegetable beans using the formula:

$$PP_k = P_c : a,$$

where P_c – biomas productivity (t/ha); a – ratio between main and side productivity (Dospehov, B.A. 1979; Bondarenko, G.L., Âkovenko, K.¸. 2001; Syč, Z.D. 2004).

RESULTS AND DISCUSSION

Our results show that seedlings of all studied sorts appeared above ground uniformly. However, their biological maturity occured one-two days later comparing to the control sort Karadag. Date of biological maturity influenced the summarized PAR income (table 1) during vegetative period. The highest summarized PAR was calculated for the sort Winzor and the lowest for the sort Karadag. Biological maturity of the sort Karadag occured two-three days earlier as in other sorts.

Potential productivity for the sorts of vegetable beans was dependent on the summarized PAR during the vegetative period. The potential productivity of all sorts was 0.26-0.41 t/ha higher than control using PAR value.

Table 1. *Potential productivity of the sorts of vegetable beans for sumarized PAR (the average for 2009-2011)*

Sort	Appearance of full seedlings	Sumarized PAR for vegetation period, kJ/cm^2	Potential productivity of PAR, t/ha
Karadag (control)	21.04	86.3	11.45
Bartoli	21.04	88.3	11.71
Winzor	21.04	89.4	11.86
Karestino	21.04	88.3	11.71

Regarding the ratio between main and side production, potential productivity of the sorts of vegetable beans was 57.25 – 59.30 t/ha (Table 2). The highest productivity was recorded for the sort Winzor – 2.05 t/ha higher than in control.

Actual productivity was the highest for the sorts Bartoli – 26.93 t/ha and Winzor – 26.07 t/ha, which is higher on 11.15 and 10.29 t/ha comparing to the sort Karadag (control). Actual productivity for the sort Karestino was 0.72 t/ha higher than in the sort Karadag.

Table 2. *Potential and actual productivity of the sorts of vegetable beans for 2% of PAR use*

Sort	Biomas productivity to standart moisture content, t/ha	Potential productivity of beans, t/ha	Actual productivity of vegetable beans, t/ha	Actual loss of producti-vity, t/ha
Karadag (control)	143.13	57.25	15.78	41.47
Bartoli	146.75	58.70	26.93	31.77
Winzor	148.25	59.30	26.07	33.23
Karestino	146.75	58.70	16.50	42.20

The lowest actual loss of productivity we observed in the sort Bartoli – 31.77 t/ha, which is 9.7 t/ha lower as of the sort Karadag. Relatively small loss of productivity we found in the sort Winzor – 33.23 t/ha, which is 8.24 t/ha smaller than in the control. The highest actual loss of productivity we calculated for the sort Karestino – 42.2 t/ha, which 0.73 t/ha higher than in control.

CONCLUSIONS

Potential productivity of the sorts of vegetable beans accounting possible 2% of PAR use was 57.25 – 59.30 t/ha, which is 2.2 – 3.6 times greater comparing to their actual productivity. The smallest loss of actual productivity were recorded for the sorts Bartoli and Winzor (in 2.2 – 2.3 times). Lowest productivity was recorded in the sorts Karadag and Karestino– 3.6 times smaller comparing to their potential productivity.

REFERENCES

1. BARABAŠ, O.Ű., TARANENKO, L.K., SYČ, Z.D., 2005. Biologičeskie osnovy ovoŝevodstva. Kiev: Aristej, s. 119-132.

2. BOBOS', I.M., 2008. Vliânie fotoaktivnoj radiacii na urožajnost' sortov morkovi v zavisimosti ot srokov poseva v usloviâh Lesostepi Ukrainy. V: Ovoŝevodstvo i bahčevodstvo, s. 54.

3. BOBOS', I.M., KONONOV, A.A., 2011. Potencial'naâ i faktičeskaâ urožajnost'korneplodov sortov morkovi *(Daucus carota L.)*. NUBiP Ukrainy, Nr 5 (27). Disponibil: http://www.nbuv.gov.ua/e-journals/Nd/2011_5/11bim.pdf

4. BOBOS', I.M., 2008. Vliânie fotoaktivnoj radiacii na urožajnost' sortov morkovi v usloviâh Lesostepi Ukrainy. V: LNAU, s. 22-28.

5. BONDARENKO, G.L., ÂKOVENKO, K.I., 2001. Metodika opytnogo dela v ovoŝevodstve i bahčevodstva. Har'kov: Osnova. 369 s.

6. DOSPEHOV, B.A., 1979. Metodika polevogo opyta. Moskva: Kolos. 416 s.

7. HARČENKO, O.V., 2003. Osnovy programmirovaniâ urožaev sel'skohozâjstvennyh kul'tur. Sumy: Universitetskaâ kniga. 296 s.

8. LIHACKIJ, V.I. et al., 1996. Ovoŝevodstvo. Kiev: Urožaj. T. 2. 357 c.

9. SYČ, Z.D., 2008. Poka ležit sneg – ocenite potencial'nye vozmojnosti ovoŝnogo polâ. V: Ovoŝevodstvo, ą 1, s. 24-28.

10. SYČ, Z.D., 2004. Programmirovanie i prognozirovanie urožaev ovoŝnyh kul'tur. Kiev: NUBiP. 19 s.

11. SYČ, Z.D., Kutovenko, V.B., 2011. Rekomendacii po tehnologii vyraŝivaniâ boba ovoŝnogo. Kiev: NUBiP. 12 s.

Data prezentării articolului: ***25.09.2013***
Data acceptării articolului: ***21.10.2013***