FRI-9.2-1-EC-02

INFLUENCE OF ARTIFICIAL LIGHT ON TOMATO PRODUCTIVITY IN GREENHOUSE CONDITIONS IN SOUTH EAST KAZAKHSTAN

Phd student Indira Belgitayeva
Department of horticulture and nuts growing
Kazakh National Agrarian University, Kazakhstan
Tel+77017536610
E-mail: b.indi@mail.ru

Assoc. Prof. Kussainova Gulzhan
Department of horticulture and nuts growing
Kazakh National Agrarian University, Kazakhstan
Tel: +77025988995
E-mail: gulzhan56@yandex.ru

Abstract: *The paper reviews influence of different lightning level on tomatoes productivity in greenhouse conditions in Kazakhstan. Few lightning levels and LED lightning was used to study efficiency of each options.*

In order to gain more insight into the influence on production, was performed an experiment in green house conditions in the east Kazakhstan, were greenhouses more developed. In total used 5 lightning options - on beef type tomato ("Torero") from 22 July 2017 to 20July 2018. 5 lightning treatment were applied, in one greenhouse, in the similar conditions: control without lightning (1),top lightning HPS-15000lux(2), top lightning HPS-10000lux(3), top lightning Led white (4), top lightning LED-blue red(5). A strong good crop was developed under HPS (2), under LED light we noted long and thin steam, and very small fruits settled per truss. But if to tell about taste of tomatoes, the best were under LED lamps (5). Economic efficiency on HPS much higher compare to other options. So, using artificial light in greenhouses of Kazakhstan profitable, and necessary.

Keywords: *Energy use, greenhouse climate, lightning, HPS lamps, LED lamps.*

INTRODUCTION

Growing tomatoes under artificial light during crossing turnover developing very well in Kazakhstan. Research in this field is very important for Kazakhstan. The main limiting factor for growing tomatoes in greenhouses during the winter is light. Most of physiological damages which lead to decrease plant productivity and deterioration in the quality of vegetables are associated with a deficiency of light. The light deficiency is reflected in various life processes of plants, since the majority of physiological and biological transformations in a plant organism are associated with the absorption of light energy. The first is the suppression of the photosynthetic activity of the leaves. In this regard, the determination of the influence of the time of sowing and planting in the substrate with various degrees of illumination on fruiting is the most important task in the development of the technology of growing tomato in winter greenhouses. The physiological reasons of the lightning induced injury in tomato remain unclear. Recently, by combining previous experimental evidence with the current understanding of plant physiology, we proposed a set of hypotheses that aim to explain the induced injury, and re-discovered that wild-tomato species were reported as tolerant to artificial light more than 45 years ago (Velez-Ramirez et al., 2011). Modern tools like quantitative analysis, molecular marker assisted breeding and gene expression profiling should allow the breeding of a tolerant tomatoes to artificial light. Although a light tolerant tomato genotype is an important achievement, it would guarantee an increase in greenhouse tomato yield by its own. For that, a better understanding of crop ecology and the mechanism by which continuously lightning injures tomato will be also needed. Or main task to get results in this field and discuss the expected challenges, regarding greenhouse technology and crop ecology, in cultivating tomatoes under artificial light.

EXPOSITION

To compensate the deficiency of fresh vegetables in the off-season, it is necessary to grow them in the greenhouse during the winter. Equally important is the quality and yield of grown products. Currently, to obtain a high-quality crop in greenhouses in the near and far abroad during the growing season, farmers using additional lightning. However, it is known that all greenhouse plants where additional lighting is used are located in different light zones. South-east of Kazakhstan on the tributary of PAR (by Vashchenko) is in the seventh light zone. PAR light year by year with influence of global warming became less and less, 2018 darker compare to the similar period of 2017(Fig. 1, 2).

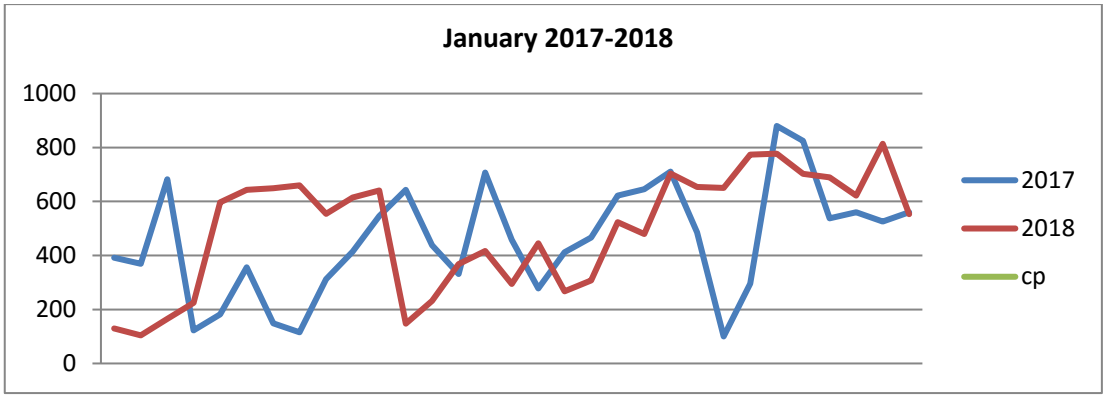

Fig. 1. Radiation in darkest moths January 2017/2018, J/cm

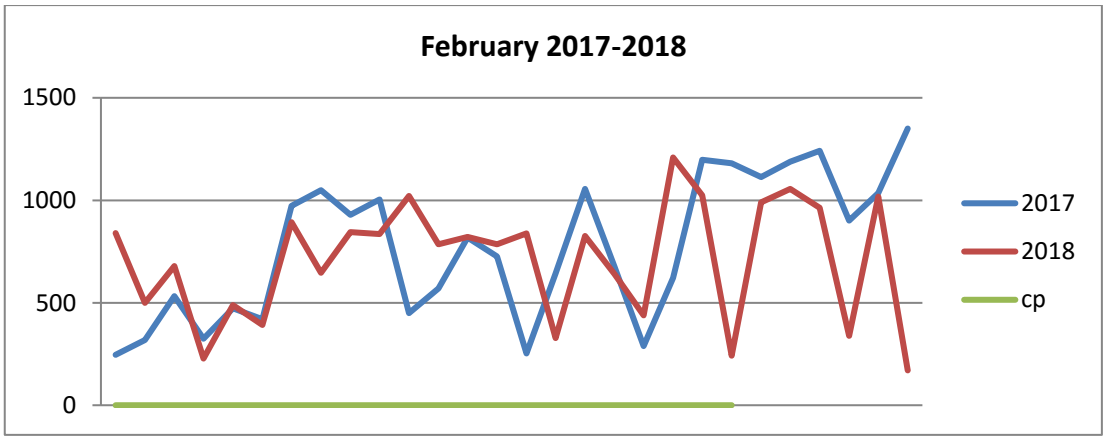

Fig. 2. Radiation in darkest moths February 2017/2018, J/cm

With using artificial light, darkest period is the Winter if we compare climate in January and February of 2017/2018, we have quite big difference-18%, what means we used more hours of light in 2018, and product self cost is higher for this amount of used hours. This point should be discussed in economic feasibility article.

Tomatoes is most important vegetable, fruits contains a lot of vitamins C, B, A, sugars, apple and lemon acids, and very sensitive to light. Tomatoes very important vegetable in every day human's consumption.

Actual problem at that moment is growing tomatoes with artificial lightning (A.Somos). Artificial light is new for Kazakhstan, all what we use w have to find ourselves: climate data, hours of lightning, irrigation setting etc. Research started in 2016 in Kazakhstan, with different type of light, and different intensity of lightning. Last few years many scientists researching influence of different kind of light:

Yellow light more used in greenhouses, as main source of photosynthesis energy;

Red light (600-700 nm) more effective for photosynthesis process;

Blue light (400-500 nm) many cultures need blue light for stabile growing of plants;

Red-blue combination is effective for transformation of energy to photosynthesis;

White light (700-80 nm) phosphor covered lamps, transmitting blue to red or green, and sometimes to infrared light.

Treatment took place in the greenhouse, located in Kazakhstan, Almaty city, used variety of tomatoes - Torero F1 hybrid, big beef tomato, with average fruit weight 220-280 gramm, red color, good shape, with long shelf life, for consumption fresh. Torero - indeterminate hybrid, not sensitive for light deficit, steady for diseases. Good variety for growing in high-tech greenhouse with artificial light. In greenhouse we keep similar climate conditions for all 5 treatments: 10000 lux; 15000 lux; LED white; LED red&blue; Control (without lighting). Sowing seeds 22 July, planted to greenhouse 9 of September. Growing media - rockwool Each of treatment- department with 200 sq meter, covered by white plastic to divide treatment from each other, but with open top, to have possibility of using outside sun light.

Table 1. Biometric registration of tomato plants under different treatment

№ 1 control - no artificial light											
biometric data	***unit***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
stem length	sm	20,0	23,0	27,0	24,0	22,0	23,0	25,0	19,0	19,0	19,0
leave length	sm	37,0	39,0	34,0	42,0	39,0	32,0	38,0	37,0	36,0	39,0
stem thikness	mm	11,0	10,0	10,0	10,0	10,0	10,0	10,0	10,0	10,0	10,0
amount of fruits	per truss	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
harvested truss	weight	132,0	130,0	156,0	135	140	128	155	152	180	177
№ 2 15000 lux HPS											
biometric data	***unit***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
stem length	sm	21,3	18,8	17,3	16,8	16,0	17,9	16,3	19,8	22,4	20,4
leave length	sm	39,6	33,3	36,3	32,0	34,6	37,1	36,9	37,8	36,7	35,9
stem thikness	mm	11,7	12,2	11,2	12,2	11,1	12,2	12,7	12,8	11,1	12,0
amount of fruits	per truss	4,0	4,0	3,8	2,6	3,4	4,0	3,0	3,7	4,0	3,7
harvested truss	weight	254,0	433,0	719,0	194,0	251,0	263,0	674,0	452,0	619,0	589,0
№ 3 10000 lux HPS											
biometric data	***unit***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
stem length	sm	19,2	23,9	26,0	22,3	20,5	22,8	24,0	20,2	21,3	17,9
leave length	sm	35,7	34,6	39,0	37,1	39,3	37,3	35,0	35,6	31,4	38,2
stem thikness	mm	11,0	11,0	11,7	10,7	10,6	11,3	11,7	12,0	11,6	11,1

amount of fruits	per truss	2,8	3,0	3,1	2,1	2,7	3,0	3,5	3,5	3,9	3,5
harvested truss	weight	254,0	250,0	519,0	170,0	201,0	203,0	474,0	452,0	519,0	390,0
№ 4 LED white											
biometric data	***unit***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
stem length	sm	21,7	21,0	19,1	19,6	22,5	23,2	20,3	20,4	23,3	21,6
leave length	sm	38,0	33,7	36,9	34,1	36,6	36,2	38,6	37,5	38,2	36,1
stem thikness	mm	10,1	11,6	10,5	11,7	10,8	10,6	11,8	10,7	10,7	11,7
amount of fruits	per truss	3,6	3,6	3,3	2,6	4,0	4,0	3,0	3,7	4,0	3,8
harvested truss	weight	254,0	196,0		161,0		455,0		217,0	205,0	219,0
№ 5 LED red&blue											
biometric data	***unit***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
stem length	sm	20,7	20,7	16,7	18,0	21,8	23,0	19,7	19,8	21,2	19,4
leave length	sm	33,7	33,7	38,4	33,3	36,3	36,0	38,0	37,1	35,5	34,2
stem thikness	mm	11,6	11,6	11,9	11,9	11,0	11,9	11,6	11,7	10,7	12,0
amount of fruits	per truss	3,7	3,1	3,9	3,9	3,9	4,0	3,0	3,9	3,6	3,8
harvested truss	weight	272,0	240,0	230,0		213,0	507,0	244,0	260,0	222,0	219,0

Control without lightning (Tab. 1) dark days 27 sm growth of stem per week, with sunny days 19 sm growth, influence of outside radiation 8 sm in this variant. After dark week, you can find very long, thin leaves 42 sm. Stem thickness 10 mm, no changes. Only 3 flower developed, but 2 of them settle fruit in some plants, that is why harvested so less. Stem length (Tab. 1), optimal grows on 2 treatment 19,85 sm (mean) growth per week. Leave length 32-34 sm, that means good plant balance, with stem thickness 11,7-12,2 can create good strong flowering truss with 3,8-4 fruits. Harvest every day 254, 433 gram per week. Treatment № 3 stem growth 19-25 sm per week, mean 21,92 sm, stem thickness 11-12 mm, can create good flower truss, with 2-3 flowers and fruits. Treatment № 5 - mean is 20,3 sm closer to optimal, plants growth, light sufficient, but still not enough. Rest is too long grows, that meant not enough light, stem thickness optimal 11,3 (mean), on the 2 treatment (Tab. 1). Stem thickness 10 mm (№ 1, № 4), means too weak stem, weak flowering truss, loose of quality because of not sufficient artificial light № 5. Leave length haven't difference between treatments, there is only difference you can feel, not measure, length of leaves similar but HPS treatment leaves have nice dark color, and wider compare to other treatments. Amount of fruits per truss 4 on number 2, control 3, but with low quality, harvest only 1 fruit per truss. 2,6 on number 3.Rest of treatments less than 3 per truss.

Harvested data's we give below in (Tab. 2).

Table 2 - Total harvested tomatoes kg per sq/m

№	Treatment	Kilo/sg.m	% of good quality	Fruit weight average
1.	№ 1 control - no artificial light	24,3	64	70-96
2.	№ 2 15000 lux HPS	76,4	97	242-320
3.	№ 3 10000 lux HPS	58,7	92	189-234
4.	№ 4 LED white	48,3	73	157-183
5.	№ 5 LED red&blue	54,2	83	179-212

As given data in (Tab. 2), total per year harvested tomatoes with artificial light treatment - 76,4 kilo per sq meter of greenhouse (Fig. 3). Influence of HPS lamps for quality of tomato very high, because tomatoes from this treatment with good shape, real beef as mention per seed company, fruit average weight 220-280 gramm. Tomatoes, which grow without light, fruit sizes 70-96 gramm, and % of good quality 64, that means 36 % was waste. Treatment № 2, good quality tomatoes, fruit sizes 242-320 gramm even bigger than declared by seed company, need trial with even higher light capacity. № 3 compare to № 2 more yield for 31 %, good fruit quality, fruit sizes also acceptable. № 4 more soft fruits, white light not enough for goo quality of tomatoes 27 % wasted, because too soft. № 5 still possible to grow with blue red light, but need to investigate more deep in this field. On the Fig. 3 you can see harvest and % of quality, the best results given by 2 treatment, 3 treatment acceptable, possible to grow in case of energy economy.

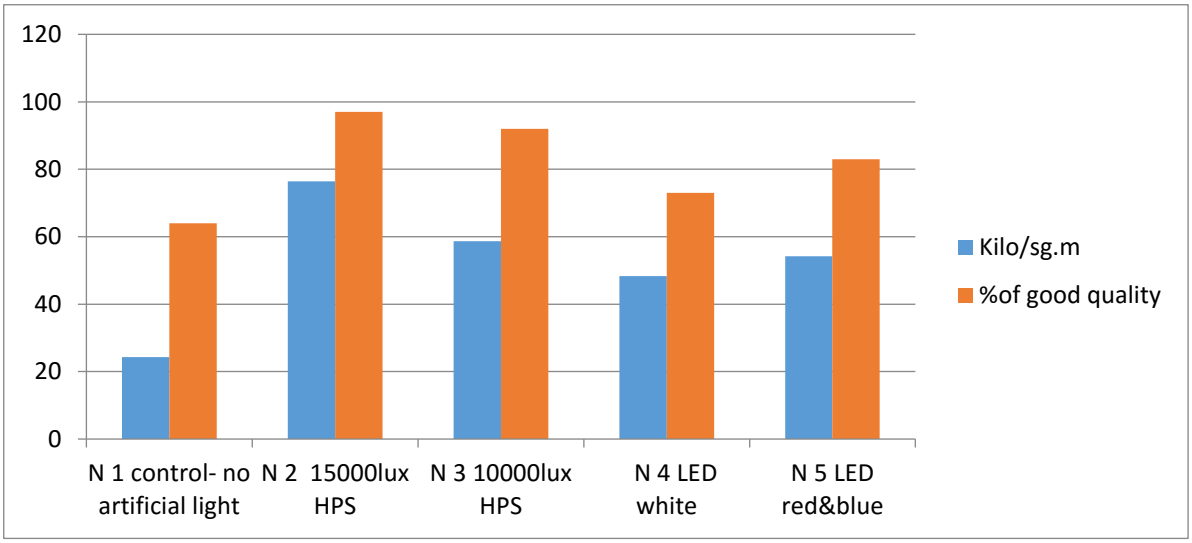

Fig.3. Harvest in kilo per sq meter/quality of harvested tomatoes

CONCLUSION

According to results of research growing tomatoes without artificial light impossible, tomatoes developed 11-12 truss, and stop to settle trusses, only very thin stem is growing during winter time, when light is limited. Then starting to grow in the end of February, March, but anyway, not good plants, lost plant balance, not settled good flower truss, quality and shape of flowers not good, that will not good standard tomato.

Optimal for high tech greenhouses is HPS lamps with 15000 lux capacity. Good tomato shape, optimal sizes of tomato, good shape for sale, long shelf life, good tomato for transporting for a long distances, what is also important.

Treatment 3-10000 lux lightning not enough to get high results, but still possible to use.

White LED not possible to use for growing tomatoes, too sick stem, too weak plant, quality of tomatoes not sufficient for sales, small sizes of fruits, too soft, less sugar and dry matter content not enough.

Combined red and blue light possible to use, good plant balance, but 22 kilo too much to loose compare with HPS lamps, treatment 2. Combined lamps gives best taste of tomatoes, and more sugar content compare with all other variants, but need to research a little more place of lamps f.e.

REFERENCES

Institute of Electrical and Electronic Engineering (IEEE): IEEE Recommended Practices and Requrements for Harmonic Control in electrical power systems, *Std.IEEE* 519-1992, 1993

C.Dilouie, Advanced Lightning Controls: Energy Savings, Productivity,Technology and Applications, *first ed. Georgia*, United State, 2005.

Hogewoning, S.W., Douwstra, P., Trouwborst, Van Ieperen, W. and Harbinson, J. 2010b. An aritificial solar spectrum substantially alters plant development compared with usual climate room irradiance spectra. *Journal of Experimental Botany* 61:1267-1276.

Trouwborst, G., Oosterkamp, J., Hogewoning, S.W., Harbinson, J. and Van Ieperen, W. 2010. The responses of light interception, photosynthesis and fruit yield of cucumber to LED-lighting within the canopy. *Physiologia Plantarum* 138:289-300.

Paradiso, R., Meinen, E., Snel, J.F.H., De Visser, P., Van Ieperen, W., Hogewoning, S.W. and Marcelis, L.F.M. 2011. Spectral dependence of photosynthesis and light absorptance in single leaves and canopy in rose. *Scientia Horticulturae* 127:548-554.