Journal of Agroecology and Natural Resource Management
Print ISSN: 2394-0786, Online ISSN: 2394-0794, Volume 2, Number 1; February-March 2015 pp. 45-47

http://www.krishisanskriti.org/janrm.html

Study on Change in Heat Indices under different Colour shade Nets and its Relation to Yield of Spinach (*Spinacia oleracea* L.)

Rekha Kumari Meena, Ananta Vashisth, Ravender Singh[1] Balraj Singh[2] and K.M. Manjaih[3]

Division of Agricultural Physics, IARI, New Delhi 110012
[1]NRCSS, Ajmer
[2]Soil Science & Agricultural Chemistry, IARI, New Delhi

Abstract—*A study was undertaken at research farm of IARI, New Delhi to study the effect of change in the microenvironment under different colour shade nets during summer and rainy season, of 2012 on yield of spinach. Spinach crop was sown under different colour shade nets such as red, green, black, white along with control (without shade net) during summer and rainy season. Crop duration from sowing to harvesting was 62 days in summer and 58 days in rainy season. Different heat indices were calculated under different colour shade nets along with control. The heat indices were calculated and it was found that the value of different heat indices such as GDD, PTU, HTU, PTI were higher in control followed by black, green, red and white colour shade nets in both season. The heat use efficiency was found to be more value in different colour shade nets than control.*

Keywords: *Spinach, heat indices, heat use efficiency, colour shade nets.*

1. INTRODUCTION

India is second largest producer of vegetable in world, with annual growth rate of 2.9%. Consumer preference have also shifted away from cereal and moved toward high value agricultural produce like vegetable. Spinach (*Spinacia oleracea* L.) is vegetable crop, grown in winter season. During summer season (off season) crop encounter various stresses such as extreme temperature, high light intensity, humidity, wind speed etc. Crop production is reduced due to increased air temperature and intensity of solar radiation caused by climate changes.

Crop grown in open condition also affected from various pests and diseases. Nets are commonly used to protect agricultural crops from excessive solar radiation, extreme temperature and pests. In recent period, nets are used for specific modification of sunlight, improving microenvironment, and providing physical protection. Colour shade nets represent a new agro-technological concept, which aims at combining the physical protection, together with differential filtration of the solar radiation. They are based on the incorporation of various chromatic additives, light dispersive and reflective elements into the netting materials during manufacturing. Netting is frequently used to protect agricultural crops from excessive solar radiation (shade-nets), improving the thermal climate (Kittas *et al*., 1999), sheltering from wind and hail and exclusion of bird and insect-transmitted virus diseases (Teitel *et al*., 2005).

In our study it was found that the temperature under shade nets was found to be lower than control. Smith *et al*. (1984) observed that under shade nets the air temperature was lower than that of the ambient air, depending on the shading intensity. Temperature plays a key role in determining the sowing time and consequently the duration of different phenophases, which affect the crop productivity (Tewari and Singh, 1993). It is one of the most important climatic factors affecting the growth, development and yield of crops. Thermal time is an independent variable to describe plant development. (Dwyer and Stewart,1986). Wang (1960) reported that the duration of a particular stage of growth was directly related to temperature and this duration of particular species could be predicted using the sum of daily air temperature. The agroclimatic indices, namely, growing degree days, heliothermal units and photothermal units, phenothermal index and heat use efficiency. These can be used as a tool for characterizing thermal responses in different crops. Pal *et al*. (1996) reported in their studies that the growing degree-days and photothermal unit requirement differ from crop to crop and also from genotype to genotype. Further, it was also

found that in general a progressive delay in sowing causes a decrease in GDD and PTU requirement of constituent phenophases as well as for the crop duration. A photothermal index (PTI) was calculated by summing the ratio of day length per 24-h period multiplied by the total heat units (Masle *et al*., 1989**). *Relative Temperature Disparity*** (RTD) is a linear or direct relationship between ***temperature*** and

growth of the plants. Heat use efficiency (HUE), i.e. efficiency of utilization of heat in terms of dry matter accumulation, depends on crop type, genetic factors and sowing time and has great practical application (Rao *et al*., 1999). The index heliothermal unit (HTU) serves to be effective in taking into account and expressing the effect of varying ambient temperature on the duration between the phenological events for comparing the crop response to the ambient temperature between phenological stages (Rajput, 1980). Keeping the above point in view the present study was done to investigate relation between different heat indices and yield under different colour shade nets.

2. MATERIALS AND METHODS

A Field experiment was conducted on the sandy loam soil of research farm of IARI, New Delhi during 2012 with Spinach crop. The crop was grown during summer and rainy season with drip irrigation under different colour shade nets for generating different microenvironment along with control (without shade nets). These colour shade nets (white, black, red, green) having distinct transmittance spectra in the visible range, and no modification under control (without shade net) condition. The knitting density of each net was designed to provide 40% shading in the photosynthetically active radiation region.

Heat indices

Different thermal indices were calculated under different colour shade nets along with control (without shed nets) as given by the method in table 1.

Table 1: Method for calculation of different heat indices

SN	Indices	Computation	Reference
1	Growing degree days (GDD)	=∑(Tmax-Tmin)/2-Tb	(Iwata,1984)
2	Helio thermal units (HTD)	=∑GDD× SSH	(Rajput,1980)
3	Photo thermal units (PTU)	=∑GDD× Day length	(Major et al.1975)
4	Realtive temperature disparity (RTD)	=∑ Tmax-Tmin /Tmaxx 100	(Rajput,1980)
5	Heat use efficiency (HUE)	=Yield/GDD	(Haider et al.2003)
6	Photo thermal index (PTI)	GDD/Growing day	(Haider et al.2003)

3. RESULT

Heat indices measured under different colour shade nets

Heat indices under different colour shade nets was estimated and it was found that all heat indices for both season such as growing degree days, helio thermal units, photo thermal units, photo thermal index were found to be higher in control followed by black, green, red and white. However the value of Relative temperature disparity was found to be higher in white followed by red, green, black and control. The heat use efficiency was found to be more in red followed by white, green, black and control in both the season. The value of Growing degree days 9.6% lower than control under white, followed by red 6.2%, green 5.3%, black 2.9%. Similarly for Helio thermal units, photo thermal index and Photo thermal units, the values were found to be lower under colour shade nets as compared to control.

Table 2: Different heat indices under control and different colour shade nets during summer season

Heat indices	Control	White	Black	Red	Green
Growing degree days (GDD)	1726.2	1561.2	1674.6	1620.6	1633.8
Helio thermal units (HTU)	12773.9	11552.9	12392.0	11992.4	12090.1
Photo thermal units (PTU)	97585.3	88257.5	94668.2	91615.5	92361.7
Realtive temperature disparity (RTD)	28.3	30.3	28.9	29.5	29.4
Heat use efficiency (HUE)	5.2	7.0	6.7	8.8	6.9
Photo thermal index (PTI)	29.3	26.5	28.4	27.5	27.7

Heat use efficiency was found to be more under colour shade nets. Under black shade net 29.9% higher, under green 33.1%, under white 35% and under red net 69.3% higher than control. Relative temperature disparity under white was 7.3%, under red was 4.6%, under green was 4% and under black was 2.2% higher than control (Table 3).

In rainy season growing degree days, helio thermal units, photo thermal units and photothermal index had similar trend as that of summer season. Result showed that the value of growing degree days under white had 6.5% lower value then control, followed by red 4.5%, green 2.5% and black 1.4%. Halio thermal units, photo thermal index and photo thermal unit had similar trends as that of growing degree days. Highest

value of GDD, HTU, PTU and PTI was found in control followed by black, green, red and white. Heat use efficiency under nets was more than control, under white it was 85.1% more than control, under black it was 6.1%, under red it was 86.9%, more than control. Under green it was more than double. Relative temperature disparities under white 5.8%, under red 4%, under green 2.1% and under black 1.2% lower than control (Table 4).

Table 4: Different heat indices under control and different colour shade nets during rainy Season

Heat indeces	Control	White	Black	Red	Green
Growing degree days (GDD)	1473.9	1377.8	1452.9	1408.0	1437.7
Helio thermal units (HTU)	8548.7	7991.2	8426.5	8166.6	8338.8
Photo thermal units (PTU)	65307.1	61048.1	64374.0	62388.0	63704.0
Realtive temperature disparity (RTD)	24.8	26.2	25.1	25.7	25.3
Heat use efficiency (HUE)	0.010	0.018	0.011	0.019	0.025
Photo thermal index (PTI)	27.8	26.0	27.4	26.6	27.1

Yield under different colour shade nets

Under different colour shade net yield had higher value than control. In summer season result showed that yield under green colour shade net had nearly 66.4% more yield than control, red had 59%, black had 23.8% and white had 22.1% more yield than control condition. In rainy season black and white shade nets had lower yield than control (Table. 5).

Table 5:Yield (kg/ ha) under different colour shade nets

Season	Control	White	Black	Red	Green
Summer	8950.5±256	10931.4±146	11078.1±183	14232.8±256	14893.1±330
Rainy	2525±64	1530±34	1465±30	2605±96	3580±94

4. CONCLUSION

The microenvironment was changed under different colour shade nets. The different accumulated heat indices such as growing degree days, helio thermal unit, photo thermal unit, and photo thermal index were found to be lower under different colour shade as compared to the corresponding value under control. The heat use efficiency had higher value under colour shade nets as compared to control. The yield was found highest value under green shade net followed by red, black, white and control in summer season, but in rainy season control had more yield then white and black shade net.

5. ACKNOWLEDGEMENT

The author thanks Post Graduate School, Indian Agricultural Research Institute, New Delhi for financial assistance. Thanks are due to Director, IARI, New Delhi for providing the facilities.

REFERENCES

[1] Dwyer, L.M. and Stewart, D.W. (1986). Leaf area development in field grown maize. *Agron.J*. **78**: 334-348.

[2] Haider, S.A. M.Z. Alam, M.F. Alam and N.K. Paul, (2003). Influence of different sowing dates on the phenology and accumulated heat units in wheat. *J. Biological Sci*. **3**: 932-939.

[3] Iwata, F., (1984). The heat unit concept of crop maturity. In: U.S. Gupta (Ed.), physiological aspects of dryland farming. Oxford & IBH Publishing Co., New Delhi, pp. 350-370.

[4] Kittas, C., Baille, A. and Giaglaras, P. (1999). Influence of covering material and shading on the spectral distribution of light in greenhouses. *Journal of Agricultural Engineering Research*. **73**: 341 – 351.

[5] Major, D.J., D.R. Johnson, J.W. Tanner and I.C. Anderson, (1975). Effect of day length and temperature on soybean development. *Crop Sci*., **15**: 174-179.

[6] Masle J, Doussinault G, Farquhar GD, Sun B (1989). Foliar stage in wheat correlates better to photothermal time than to thermal time. *Plant Cell Environ* **12**:235-247.

[7] Pal, S. K., Verma, V. N., Singh, M. K. And Thakur, R. (1996). Heat unit requirement for phonological development of wheat (*Triticum aestivum* L.) under different levels of irrigation, seeding date and fertilizer. *Indian Journal of Agricultural Sciences*. **66**: 397-400.

[8] Rajput, RP. (1980). Response of soybean crop to climate and soil environments. Ph D thesis. Indian Agricultural Research Institute, Pusa, New Delhi.

[9] Rao, V.U.M., Singh, D. and Singh, R. (1999). Heat use efficiency of winter crops in Haryana. *Journal of Agrometeorology* **1**(2): 143-8.

[10] Smith, I.E., Savage, M.J. and Mills, P. (1984). Shading effects on greenhouse tomatoes and cucumbers. *Acta Hort*. **148**: 491-500.

[11] Teitel, M., Tanny, J., Ben-Yakir, D. and Barak, M. (2005). Airflow patterns through roof openings of a naturally ventilated greenhouse and their effect on insect penetration. *Biosystems Engineering*. **92** (3): 341-353.

[12] Tewari, S. K. and Singh, M., (1993). Yielding ability of wheat at different dates of sowing. a temperature development performance. *Indian Journal of Agronomy*. **38**: 204-209.

[13] Wang, J.Y. 1960. A critique of the heat units approach to plant response studies. *Ecology*. **41**: 785-90.