Micro Environment Study under Different Colour Shade Nets and its Effects on Biophysical Parameters in Spinach (*Spinacia Oleracea*)

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Abstract

A study was under taken at research farm of IARI, New Delhi for investigating the effects of microenvironment under different colour shade nets on the growth and development of the spinach (Spinacia oleracea). Spinach crop were sown under four different colour shade nets namely white, black, red and green with 40% mesh size along with control (without shade nets). Results showed that the microenvironment was changed under different colour shade nets in both the season but the difference was more in summer than rainy season. The air temperature, wind speed, soil temperature, canopy temperature, light intensity, radiation and different accumulated heat indices such as GDD, PTU, HTU, PTI was found to be lower under different colour shade as compared to the corresponding value under control. However the relative humidity and soil moisture had higher value under colour shade nets than corresponding value in control. The percentage reflectance as well as value of NDVI and VI was found to be more in green followed by red, black, control and white. The heat use efficiency had higher value under green shade nets followed by red, white, black and control. Biomass, leaf area, chlorophyll content, yield as well as radiation use efficiency and water use efficiency was found to be higher in the colour shade net as compared to corresponding value in the control. The yield was found highest under green as well as red followed by white, black and control.

Keywords: Spinach, Leaf area, colour shade net, water use efficiency, radiation use efficiency

1. INTRODUCTION

Agriculture production is suffered due to increase in air temperature and intensity of solar radiation because of the climate changes and urbanization. One of the ways to cope with this trend is by protecting the crops. Colour shade nets is an effective solution, because it improved plant microenvironment, protect crop from environmental hazards (e.g., excessive solar radiation, temperature, wind, hail etc.), pests (birds, fruit-bats, insects), cheaper and less energy-consuming. All physiological processes, from the emergence of seedlings to fruit development and maturity depend on the quantity and quality of the light. Improving the utilization of solar radiation by vegetables crops is based on selective filtration of the light by different colour shade nets with

special optical properties that modify the quality of natural radiation. In cut flower crops, the colour shade nets differentially affected flowering time and flower quality (Oren-Shamir *et al*., 2001, Shahak *et al*., 2002, Priel 2001). Leaf area values depend on the quality of light and vary amongst species. Increases in leaf area and reductions in the thickness of the leaf blade under shading conditions are common alterations that confer functional advantages to plants grown in environments with low light intensity (Buisson and Lee, 1993).

Coloured shade netting not only exhibit special optical properties that allow the control of light, but also have the advantage of influencing the microclimate to which the plant is exposed to (Oren Shamir *et al*., 2001) and offer physical protection against excessive radiation, insect pests and environmental changes (Shahak *et al*., 2004). In modern agriculture, shade is essential for the success of the crops, both from the agro-technical point of view and the farmer's economic accomplishment. In spinach no work has been done for effect of change in micro-environment due to different colour shade nets on growth parameters, yield, water and radiation use efficiency. Therefore present studies were done to determine the effect of change in microenvironment under different coloured shade nets on growth, yield, water and radiation use efficiency in spinach crop.

2. MATERIALS AND METHODS

Field experiments were conducted during summer (April-June) and rainy (July-September) 2012 at research farm of IARI, New Delhi, India. Four different colour shade viz. green, red, black and white were selected for testing. For studying the effect of microenvironment under different colour shade nets on spinach crop, Pusa Bharati variety was sown under different colour shade nets along with control (without shade nets). Different weather parameters (temperature, relative humidity and wind speed), light intensity, percentage reflectance, canopy temperature, photosynthetically active radiation, soil moisture, soil temperature, crop growth parameters (leaf area, biomass, leaf length, chlorophyll content) and radiation interception were measured at different growth stages in both the season. Radiation use efficiency, water use efficiency and different heat indices were computed. Biomass was taken after oven drying three plants from each plot and then taking average. Total leaf area was measured using leaf area meter.

The leaf length was calculated by taking average of length of three plants from each treatment and then taking average of it. The above measurements were taken at different crop growing period. Leaf water potential of leaf in each treatment was measured using pressure bomb apparatus. Chlorophyll content in fresh leaf was calculated using DMSO methods. Chlorophyll concentration index was measured using SPAD meter. Yield was calculated after harvesting the crop. Statistical analysis viz., computation of correlation coefficients, critical difference and student t test was carried out using Excel and SPSS packages (Version 10.0).

3. RESULTS

Due to different colour shade nets, light intensity varies under net, which play significant role in modify microclimate under nets. Under white shade temperature was 1.6-5^{o}C, under red shade net 1.3-3.6^{o}C, under green shade net 1.2-3.4^{o}C, under black shade net 0.4-1.9^{o}C lower than control. In rainy season temperature difference under colour shade and control was lower then summer. Under white shade net temperature was 1.1-3.6^{o}C lower than control, followed by red 0.9-2.5^{o}C, green 0.4-1.3^{o}C, black 0.1-1.1^{o}C. Relative humidity was found to be higher in colour shade nets than control. In summer season variation in relative humidity is more under white shade net 3.8-10.4% higher than control, under red shade net 2.5-9.5%, under green shade net 0.5-7.2%, under black shade net it was 0.2-3.1% higher than control. In rainy season variation in RH under white net was 1.5-6.7%, under red shade net 0.8-3.4%, under green shade net 0.59-2.4%, under black shade net 0.2-1.5% higher than control. Wind speed was measured under different colour shed nets and control. Result showed that wind speed under control is more then colour shade nets in both the season.

Light intensity under colour shade nets is lower then outside condition. In rainy season light intensity was found to lower as compared to summer season. In summer under white shade net incoming light intensity was 47.8-67.1% lower then control followed by red shade net 55.4-72.5%, green shade net 63.7-74.3% and black shade net 62-82.7%. In rainy season under white shade net light intensity was 44-60%, under red shade net 32-58%, under green shade net 48-68%, under black shade net 72-84.6% lower as compared to corresponding value in control. Photo synthetically active radiation in summer under different color shades found to be lower than control. Under white shade net it was 33.4-42.7% of control, followed by red shade net 26.7-36.1%, green shade net 19.4-32.5% and black shade net had 17.2-20.1% of control. In summer maximum photosynthetically active radiation was under white followed by red, green and minimum under black colour shade nets. In rainy season maximum photosynthetically active radiation was under white followed by red, green and black. Under white shade net it was 38.7-46.7%, under red shade net 37.2-40%, under green shade net 34-35% and under black shade net 16.2-16.6% of control. Radiation reflected by canopy under different colour shade net was found to be lower as compared to the control. In summer season radiation reflectances under white net was 59.6-70%, under red 64.5-77.5%, under green 75.6-80.7% and under black 86.3-88% lower than control. In rainy season radiation reflected from canopy under white was 25-41%, under red 16-34%, under green 53.8-65.2% and under black 72- 81% lower than control. Total dry biomass of plants cultivated under control was significantly lower than that of those maintained under different colour shade. Biomass produced under different colour shade nets in summer season was found to be nearly double as compared to that of control. In colour shade nets maximum biomass production was under green shade nets followed by red, white and black shade net. The percentage increase in biomass as

compared to control was 20-22% under white shade net, 29-33% under black shade net, 48-59% under red shade net and 63-67% under green shade nets. However in rainy season biomass was found to be lower in black and white as compared to control. The percentage increase in biomass was found to be 20-48% in red shade nets and 28-57% in green shade nets.

Leaf area is an important parameter for the crop growth studies since it is useful in interpreting the capacity of a crop for producing dry matter in term of the intercepted utilization of radiation and amount of photosynthesis synthesized. Leaf area affected by colour shed nets due to change in light characteristics. Leaf area measured under different colour shade nets showed that in summer season it was found lowest value in control, followed by white shade net, black shade net, red shade net and green shade net. The percentage increase in leaf area was 26.8-35.5 % under white colour shade net, 41-57.2% under black shade net and 71.3-86.4% under red shade net as compared to control and nearly double under green shade net. In rainy season leaf area was found to be highest value in green followed by red, control, white and black shade nets.

Plant grown under different colour shade nets had different growth. Different type of light affects leaf, root length and number of leaves in spinach crop. In summer season which is off season for spinach, crop showed poor growth under control due to high temperature, but under colour shade nets had favourable environment therefore crop had good growth compared to control. Plant grown under green shade net had maximum growth. Under green shade net leaf length was found to be nearly double as compared to control. Under red shade net leaf length was 62-93% higher as compared to control. Plant grown under black shade net had 15-40% higher value. White shade net had 8-17% higher value as compared to control. In rainy season the root length, leaf length and total length was found to be more in control followed by green, red, white and black shade nets.

Percentage increase in root length as compared to control was 46 to 71% under red colour shade net, 37 to 59% under green shade net, 24 to 47% under black colour shade net and 10 to 32% under white shade net. In rainy season under green shade net root length was 7.5-16.7% lower as compared to control. Plant grown under red shade net had 11-38 % lower value. White shade net had 16-40 %, black shade net had 36-48 % lower value as compared to control. Total length was also found to be maximum in the plants under green, followed by red, black, white and control in summer season. Plant grown under green shade net had 77 to 98% more growth, under red shade nets had 65 to 84% more growth, under black shade net had 27 to 33% more growth and under white shade net 14 to 17% more growth as compared to control. In rainy season under green shade net total length was 8-16% lower as compared to control. Plant grown under red shade net had 13-25 % lower value. White shade net had 13-25 %, black shade net had 33-43% lower value as compared to control. Number of leaves was also found more under colour shade nets then compared to control in summer season. This means colour shade nets provide favourable

environment for plant growth than control in off season or in extreme weather condition. But in rainy season numbers of leaves were found to be more in control followed by red, green, black and white shade nets.

Leaf water potential measured in the leaf of the plant grown under different colour shade nets during summer season was found to be higher in green followed by red, white, black colour shade nets and control. Leaf water potential measured the stress in the plant. This showed that due to higher temperature in control plants are in more stress than the plant grown under colour shade nets, because other agronomic practices such as fertilizer, irrigation water was same in all treatments. In rainy season no significant difference in water potential under different colour shade nets and control because of higher moisture content due to rainfall. Similar to leaf water potential the relative water content measured in the plant grown under different colour shade nets during summer season was found to be more in green followed by red, white, black shade nets and control. During rainy season there was no significant change in relative water content in plant grown under different colour shade nets.

Chlorophyll content depends on light. Colour shade nets modified light concentration under different colour shade nets, which affect the chlorophyll concentration. Chlorophyll content measured by the DMSO method showed that plant grown under black colour shade had 12 to 31% more chlorophyll, under white shade net had 19 to 35% more value, under green shad net had 52 to 62% more value and under red shade net 54 to 67% more value as compared to control. In rainy season control had more chlorophyll content then colour shade net. Chlorophyll concentration index measured by the SPAD meter during summer season showed that red shade net had 10.7% more value, green shade net had 9.9% more value, white had 6.8% more value and black shade net had 4.4% more value of chlorophyll concentration index as compared to corresponding value in control.

Under colour shade net water use efficiency (WUE) and yield was found to be more than control. In summer season water use efficiency was found to be more than rainy season in all the colour shade nets including control (Table 1). Radiation use efficiency under different colour shade net had more value as compared to control. In summer, result showed that under white, percentage increase in radiation use efficiency was 9.1 to 14.3 as compared to control, under black 27 to 57 percentage more than control. In red and green colour shade nets radiation use efficiency was nearly double as compared to control. In rainy season radiation use efficiency was lowest under control, than black, white, red and green shade net (Table 2). In summer season result showed that yield under green colour shade net had nearly 66.4% more, red had 59% more, black had 23.8% more and white had 22.1% more yield than control (Table 3).

4. CONCLUSION

The present studies concluded that the biomass, leaf area and yield were found to be higher in the colour shade net as compared to corresponding value in the control. In rainy season the yield was reduced as compared to summer season under all the colour shade nets as well as control because during rainy season due to excess humidity and rainfall the crop was damaged. Radiation and water use efficiency was also found higher value under colour shade nets as compared to the corresponding value under control. The yield was found highest value under green shade nets followed by red, white, black and control. This study showed that crop grown under colour shade particularly green and red shade nets had great potential during adverse weather condition. From the above studies it can be concluded that colour shade nets provide a new, multi-benefit tool for crop protection. It changes the light intensity and radiation, which influence microenvironment and crop production.

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Table 1: Water use efficiency (kg/ha/mm) in control and different colour shade nets during Summer and Rainy Season.

Season	Control	Black	White	Red	Green
Summer (April-June)	4.12 ± 0.03	4.57±0.06	5.07±0.17	6.01±0.09	6.27±0.05
Rainy (July-September)	2.7±0.13	2.92±0.09	3.4±0.11	5.8±0.23	6.3±0.29

Table 2: Radiation use efficiency (g/MJ) at different growth stage under different colour shade nets

Days after sowing	Control	Black	White	Red	Green
Summer season (April-June)					
11	0.07±0.0032	0.11±0.0071	0.08±0.0023	0.25±0.0049	0.28±0.001
23	0.1±0.0021	0.12±0.0027	0.11±0.0020	0.19±0.0018	0.2±0.0027
31	0.11±0.0076	0.14±0.0021	0.12±0.0013	0.18±0.0011	0.19±0.003
Rainy season (July-September)					
13	0.22±0.0077	0.4± 0.0015	0.59±0.0018	0.6± 0.0015	0.62±0.0028
25	0.23±0.0062	0.25±0.0043	0.31±0.0027	0.42± 0.002	0.44± 0.006
37	0.19 ± 0.008	0.21±0.002	0.28±0.006	0.31± 0.008	0.33± 0.004

Table 3: Yield (kg/ ha) under different colour shade nets

Season	Control	White	Black	Red	Green
Summer	8951±256	10931±146	11078±183	14233±256	14893±330
Rainy	2525±64	1530±34	1465±30	2605±96	3580±94