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Research Paper

Effect of shades on growth, yield and quality of cherry tomato in Indonesia

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ABSTRACT

This study aimed to assess the effect of shade treatments on growth, yield, and fruit quality in two tomato varieties (cherry ruby and cherry sweet ruby). Treatments included the use of UV plastic shade, as well as its combination + 25% and 50% paranet. Parameters observed included light intensity, temperature, growth rate, plant height, number of leaves, leaf area, number of fruits, fruit weight, vitamin C content, and sweetness (Brix). Results showed that the addition of paranet significantly reduced light intensity and stabilised temperature, which had a positive impact on growth and vitamin C content but reduced sweetness. The cherry ruby variety showed superior performance in vegetative growth, fruit number and weight, and vitamin C content, while cherry sweet ruby excelled in sweetness. The combination of UV plastic shade + 25% paranet gave the best results in creating a balance between growth, yield, and quality. This study shows the importance of shade management in tomato cultivation in the tropics to optimise productivity and fruit quality.

Keywords: Cherry tomato, Light intensity, Shade treatments, UV plastic shade, Paranet shade

Agriculture is one of the vital sectors in meeting the needs of food and the global economy (Hidayah *et al.,* 2022). In the context of agriculture, fruits are one of the most important commodities, not only because of their high nutritional value, but also because of their contribution to human health and great economic potential. Among the various types of fruits cultivated, tomato play an important role in the global fruit market (Wales *et al.,* 2023). Cherry tomatoes have a special appeal due to their distinctive sweet flavour, bright red colour, and abundant nutritional content (Febrianto *et al.,* 2019). Both have become a favourite choice for planters and consumers in various parts of the world. However, to maximise their production potential, an in-depth understanding of the environmental factors that affect fruit growth and yield is essential.

One of the environmental factors that play a key role in plant growth is light intensity (Miao *et al.,* 2023). Sunlight is the main source of energy in the process of photosynthesis, which is the cornerstone of food production and plant growth (Fauziah *et al.,* 2019). Appropriate light intensity can stimulate vegetative and reproductive growth of plants, including fruit formation and development. Shade regulates the amount of light that plants receive (Wei *et al.,* 2023). Cherry tomatoes require sufficient light intensity to perform the photosynthetic process optimally. Shade that is too thick can reduce the amount of available light, which in turn can inhibit plant growth, development and fruit production (Abbasnia Zare *et al.,* 2019).

Shade can also affect the temperature and humidity of the microenvironment around the plant (Manoj *et al.,* 2021). If the shade is too dense, the temperature may become lower and humidity may increase. These conditions may not be ideal for cherry tomato growth and development, especially if temperatures become too low for optimal photosynthetic activity. Shade can also affect the transpiration rate of plants. If the shade is too dense, transpiration may be reduced due to decreased temperature and higher humidity. Improper regulation of transpiration can disrupt the gas exchange processes necessary for photosynthesis and healthy plant growth. Inappropriate or extreme shading can cause stress to plants, which in turn can reduce vegetative growth and reproduction and reduce the quality and number of fruits produced. Plant stress can also make plants more susceptible to diseases and pest attacks. Although many studies have been conducted on the effect of light intensity on fruit crops, there is still a need for more in-depth research, especially in the context of cherry tomato varieties. Previous research has shown

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that plant responses to light intensity can vary depending on the species and variety (Manoj *et al.,* 2021).

In that context, this study aimed to investigate the impact of light intensity on fruit growth and yield in cherry tomato varieties, with the hope of making a significant contribution to the development of sustainable agriculture and increased fruit productivity globally.

MATERIAL AND METHODS

This research was conducted from March to June 2024 in the experimental garden of the University of Muhammadiyah Sidoarjo, using a nested design with two factors, namely two cherry tomato varieties (cherry ruby and cherry sweet ruby) and three light intensities (UV plastic shade, UV plastic + 25% paranet, UV plastic + 50% paranet) with four replications. The experiment was conducted in a greenhouse with light intensity regulation using paranet for one growing season until harvest, which is ± 90-120 days. Materials used included seeds of tomato varieties cherry ruby and cherry sweet ruby, planting media in the form of cocopet, and AB mix nutrients. The tools used include a paranet for light intensity regulation, a digital lux meter equipped with quantum sensor for light measurement, an analytical balance, a pH meter, a refractometer, and a spectrophotometer, and a UV-Vis for fruit phytochemical testing. Plant samples observed in this study were taken randomly from each experimental unit to represent the treatments given. From each experimental unit, three healthy plants with uniform growth were selected for observation.

The experiment started with the preparation of planting media and seed sowing until the seedlings were 2-3 weeks old, then transferred to polybags. Light intensity treatment was given by installing paranet according to the treatment to obtain light intensity, namely UV plastic without paranet, UV plastic + 25% paranet, UV plastic + 50% paranet, which was measured periodically using a lux meter. Plant maintenance was carried out routinely, including watering, fertilizing, and controlling pests and diseases. Observations of light intensity and temperature in different shades were taken. Observations were made on agronomic parameters, namely plant height, number of leaves, leaf area, and plant yield in the form of number and weight of fruits per plant. In addition, observations of the physicochemical quality of the fruit were made by measuring the level of sweetness (°Brix) using a refractometer, and vitamin C content using a spectrophotometer. Data from the study were analysed using analysis of variance (ANOVA) to determine the effect of treatment. If there was a significant effect, the analysis was continued with Tukey's honestly significant difference (HSD) at the 5% level.

RESULTS AND DISCUSSION

Light intensity and temperature under shades

Table 1 shows that the light intensity (μmol m^{-2} s^{-1}) and air temperature (°C) in three different types of shade treatments at three observation times (09:00, 12:00, and 15:00). In general, the highest light intensity was recorded in UV plastic shade, where no additional paranet reduced light ingress. In contrast, UV plastic shade + 50% paranet showed the lowest light intensity, indicating that the use of netting was significant in reducing the amount of light entering. This difference was more striking at noon (12.00), when light intensity peaked.

Table 1: Variation of light intensity and temperature under shades

Treatment	Time	Light intensity (μmol m^{-2} s^{-1})	Temperature (^{o}C)
UV plastic shade (N1)	9 am	40530	39.2
	12 am	86340	38.4
	03 pm	68800	35.5
UV plastic shade + 25% paranet (N2)	9 am	21770	38.5
	12 am	30830	37.0
	03 pm	34660	35.5
UV plastic shade +50% paranet (N3)	9 am	15220	36.0
	12 am	29560	36.8
	03 pm	28740	35.5

Temperature showed that the use of paranet in UV plastic shade + 25% paranet and UV plastic shade + 50% paranet slightly lowered the temperature compared to UV plastic shade, especially during the day. At 12.00pm, the temperature in UV plastic shade reached 38.4°C, while in the more shaded UV plastic shade + 50% paranet it was only 36.8°C (Table 1). This decrease in temperature was caused by the reduced light intensity, as the paranet was able to block most of the light radiation, resulting in a lower ambient temperature underneath. This shows that the use of paranet in shading systems is not only effective in reducing light intensity, but also plays a role in maintaining cooler temperatures, which can be important in hot environmental conditions.

Effects of shades on growth parameters of cherry tomato

The plant growth parameters namely growth rate, plant height, number of leaves, and leaf area, in two tomato varieties, cherry ruby and cherry sweet ruby with different shade treatments are presented in Table 2. The treatments applied include the use of UV plastic shade, as well as a combination of UV plastic + 25% and 50% netting. Each parameter was tested using HSD (Honest Significant Difference) analysis at the 0.05 significance level to identify significant differences between treatments.

The growth rate (in grams per day) varied depending on the variety and type of shade. The cherry ruby variety showed higher growth rates than the cherry sweet ruby in all shade treatments. This suggests that cherry ruby is more responsive to shade treatments compared to cherry sweet ruby variety. UV plastic shade + 25% paranet produced the highest growth rate in cherry ruby (1.11 g per day), while cherry sweet ruby remained low with the peak value of only 0.86 g per day. Plant height also exhibited different patterns between varieties. Cherry ruby was consistently taller than cherry sweet ruby in all treatments. The combination of UV plastic shade + 50% paranet produced the highest plant height for cherry ruby variety (97.88 cm), while cherry sweet ruby only reached 62.00 cm. This treatment indicates that cherry ruby variety has better adaptation to certain shade intensities. Cherry ruby tended

Table 2: Growth parameters of tomato varieties as influenced by shade treatments

Treatments			Growth rate (g per day)	Plant height (cm)	Number of leaves (blade)	Leaf area (cm^2 per plant)
Shades	Variety					
UV plastic shade	Cherry Ruby		1.29b	85.13b	26.40b	787.25b
	Cherry Sweet Ruby		0.86a	47.13a	24.20a	671.95a
		HSD (0.05)	0.100	8.37	1.60	75.02
UV plastic shade + 25% paranet	Cherry Ruby		1.11b	85.63b	28.05b	863.25b
	Cherry Sweet Ruby		0.72a	51.38a	26.55a	722.25a
		HSD (0.05)	0.10	8.37	1.60	75.02
UV plastic shade + 50% paranet	Cherry Ruby		0.88a	97.88b	24.25b	711.50b
	Cherry Sweet Ruby		0.80a	62.00a	22.00a	635.00a
		HSD (0.05)	0.10	8.37	1.60	75.02

to have a greater number and area of leaves than cherry sweet ruby in almost all treatments. For example, in the UV plastic shade + 25% paranet treatment, cherry ruby variety had 28.05 leaves and 863.25 cm² leaf area, while cherry sweet ruby variety only reached 26.55 leaves and 722.25 cm² leaf area (Table 2). This difference may reflect the photosynthetic efficiency and adaptability of the varieties to environmental conditions. HSD analysis results showed that differences between varieties and treatments were significant at the 5% level for all parameters. This means that the shade treatment had a significant impact on plant growth, with cherry ruby showing superior performance under various conditions.

Shading serves to reduce the light intensity received by plants, which can reduce heat stress and increase photosynthetic efficiency, especially in high-light-sensitive varieties (Fan *et al.,* 2013)R. Cherry ruby variety, with better adaptation, showed a positive response to shade treatment compared to cherry sweet ruby. The difference in response between the two varieties to shade treatment could be due to genetic factors, such as photosynthetic capacity and resource use efficiency. Varieties with wider leaves tend to be more efficient at absorbing light for photosynthesis. The combination of UV plastic shade with paranet can create an optimal microclimate, including more stable temperatures and higher humidity levels, thus favouring vegetative growth of plants (Kisman *et al.,* 2007). This was seen in cherry ruby variety, which showed the best performance in the combination of UV plastic shade and 25% paranet. These findings suggest that proper variety selection and shade treatment can increase plant productivity, especially in tropical environments with high light intensity. Cherry ruby is a more recommended variety for certain shade treatments in resource-efficient cultivation systems.

Effects of shades on yield attributes of cherry tomato

The effect of shade treatments on the average number of fruits and fruit weight in two tomato varieties is shown in Table 3. Treatments included UV plastic shade and a combination of 25% and 50% plastic shade cloth. HSD analysis at the 0.05 significance level showed that the differences between treatments were significant for both parameters.

Cherry ruby variety consistently produced more fruit than cherry sweet ruby in all treatments. The UV plastic shade treatment produced the highest number of fruits on cherry ruby (55.50 fruits), while cherry sweet ruby variety produced 46.50 fruits. With the addition of 50% plastic shade, there was a decrease in the number of fruits in both varieties, but cherry ruby remained superior with 37.75 fruits compared to cherry sweet ruby, which had only 29.00 fruits. The fruit weight of cherry ruby was also greater than that of cherry sweet ruby in all treatments. The UV plastic shade + 25% paranet treatment produced the highest fruit weight in cherry ruby (865.50 g), while cherry sweet ruby reached 735.00 g. In the UV plastic shade + 50% paranet treatment, the fruit weight of cherry ruby decreased slightly to 839.33 g, but was still higher than that of cherry sweet ruby (693.33 g). The combination of UV plastic shade + 25% paranet increased the fruit weight compared to UV plastic shade alone. However, the addition of paranet up to 50% caused a decrease in fruit number, although fruit weight remained relatively high (Table 3). This suggests that lower light intensity due to excessive shading can reduce fruit formation, although fruit size is still quite large (Yadav *et al.,* 2017).

Light intensity affects the photosynthetic process, which has a direct impact on fruit formation and weight (Bogor and Bogor, 2012). Optimal shading can increase light use efficiency without causing high or low light stress (Hermanwati and Suminarti, 2018). The Cherry ruby variety showed better adaptation to low light intensity than the cherry sweet ruby. This difference can be attributed to cherry ruby's ability to utilise light for photosynthesis and fruit formation more efficiently. The combination of UV plastic shade with paranet can create microclimate conditions that favour fruit growth (Rifky *et al.,* 2020). The 25% shade provides a balance between sufficient light intensity and reduced environmental stress, resulting in the best fruit weight (Wada *et al.,* 2006). These findings confirm the importance of shade management in improving tomato productivity, especially in the tropics. UV plastic shade with the addition of 25% paranet is recommended to maximise fruit weight, especially in the cherry ruby variety, which is more adaptive to these conditions.

Effects of shades on quality of cherry tomato

Average vitamin C content and sweetness (Brix) of two

Table 3: Number of fruits and fruit weight of tomato varieties as influenced by shade treatments

Treatments		Number of fruits	Fruit weight (g)
Shades	Variety		
UV plastic shade	Cherry Ruby	55.50b	742.50b
	Cherry Sweet Ruby	46.50a	522.00a
	HSD (0.05)	2.95	73.65
UV plastic shade + 25% paranet	Cherry Ruby	54.50b	865.50b
	Cherry Sweet Ruby	41.75a	735.00a
	HSD (0.05)	2.95	73.65
UV plastic shade + 50% paranet	Cherry Ruby	37.75b	839.33b
	Cherry Sweet Ruby	29.00a	693.33a
	HSD (0.05)	2.95	90.20

Table 4: Vitamin C and sweetness of tomato varieties as influenced by shade treatments

Treatments		Vitamin C (mg per 100g)	Sweetness (Brix)
Shades	Variety		
UV plastic shade	Cherry Ruby	19.50b	7.75a
	Cherry Sweet Ruby	14.00a	8.75b
	HSD (0.05)	2.95	0.65
UV plastic shade + 25% paranet	Cherry Ruby	22.25b	7.50a
	Cherry Sweet Ruby	17.75a	8.25b
	HSD (0.05)	1.35	0.65
UV plastic shade + 50% paranet	Cherry Ruby	23.75b	6.50a
	Cherry Sweet Ruby	19.25a	8.25b
	HSD (0.05)	1.35	0.65

tomato varieties under various shade treatments are shown in Table 4. Results were tested by HSD (Honest Significant Difference) analysis at a 0.05 significance level to determine significant differences between treatments. Ruby cherry had a higher vitamin C content than sweet ruby cherry in all treatments. The UV plastic shade + 50% paranet treatment produced the highest vitamin C content in cherry ruby (23.75 mg per 100 g) and cherry sweet ruby (19.25 mg per 100 g). The addition of shade seemed to increase vitamin C content, especially in cherry ruby, which may be due to protection against vitamin degradation caused by high light intensity. In contrast, sweet ruby cherry variety showed higher sweetness (Brix) than ruby cherry in all treatments. The highest sweetness was found in cherry sweet ruby with UV plastic shade (8.75 Brix), while cherry ruby only reached 7.75 Brix in the same treatment. The addition of plastic shade up to 50% caused a slight decrease in sweetness in both varieties, especially Cherry Ruby.

The addition of shade (paranet) tends to increase vitamin C content but decrease sweetness (Casals *et al.,* 2019). This suggests that the microclimatic conditions created by shade have a greater effect on vitamin C synthesis than on sugar accumulation in the fruit. Based on HSD, differences in vitamin C content and sweetness between varieties and treatments were significant at the 5% level. Ruby cherry variety was superior in vitamin C content, while sweet ruby cherry variety was better in sweetness, indicating specific advantages of each variety that can be utilised in selection for specific purposes.

Vitamin C content in fruits increases at low light intensity due to light stress, which triggers an increase in secondary metabolites, including ascorbic acid (Panigrahy *et al.,* 2019). This explains why shade treatments, especially 50% shade, resulted in higher vitamin C content. The level of sweetness is influenced by the process of photosynthesis and the allocation of sugars into the fruit (Garrido *et al.,* 2023)including stems, roots, flowers, fruits and seeds, may exhibit photosynthetic activity. There is still a lack of a coherent and systematized body of knowledge and consensus on the role(s. High light intensity generally increases sugar accumulation (El-Dawayati *et al.,* 2020), whereas excessive shading can reduce this process, especially in less adaptive varieties such as cherry ruby. Shading can reduce fruit surface temperature, which in turn prevents enzymatic damage and preserves vitamin C quality (Ilić *et al.,* 2012). However, it can also inhibit sugar synthesis, resulting in a discrepancy between vitamin C content and sweetness level. These results suggest that ruby cherry variety is more suitable for markets that prioritise nutritional content, such as vitamin C, while sSweet ruby cherry variety is superior in terms of sweetness. Shade treatment combinations can be adjusted to meet specific market needs, such as choosing 25% shade for a balance of nutrients and flavour.

The relationships between growth, yield, and quality in this study were closely interrelated and influenced by the shade treatment. Optimal vegetative growth, such as plant height, leaf number, and leaf area, provides a strong basis for a productive fruit set. Yield parameters, such as fruit number and weight, are influenced by photosynthetic efficiency that depends on microclimatic conditions, which are regulated by the light intensity and temperature of the shade treatment. Fruit quality, including vitamin C content and sweetness, is the result of metabolic processes influenced by these environmental factors. For example, the addition of shade cloth increases vitamin C content by reducing excess light stress, but decreases sweetness due to reduced sugar synthesis. Thus, shade treatments not only affect growth and yield, but also determine the nutritional quality and flavour of the fruit, both of which are very important in terms of agronomic and market value.

CONCLUSION

The use of shade, either UV plastic alone or in combination + 25% and 50% netting, significantly affected microclimatic conditions, vegetative growth, fruit productivity, and nutritional and flavour qualities in cherry ruby and cherry sweet ruby tomato varieties. The addition of paranet reduced light intensity and stabilised temperature, which increased vitamin C content but tended to decrease sweetness. Cherry ruby performed better in growth rate, plant height, leaf number, leaf area, fruit number, fruit weight, and vitamin C content, while cherry sweet ruby excelled in sweetness. The combination of UV plastic shade + 25% netting produced the best balance between microclimatic conditions and agronomic performance for both varieties, with cherry ruby being more adaptive to the treatment.

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REFERENCES

Abbasnia Zare, S. K., Sedaghathoor, S., Padasht Dahkaei, M. N., and Hashemabadi, D. (2019). The effect of light variations by photoselective shade nets on pigments, antioxidant capacity, and growth of two ornamental plant species: Marigold (*Calendula officinalis* L.) and violet (Viola tricolor). *Cogent Food Agric.,* 5(1): https://doi.org/10.1080/23311932.2019.1650415

Bogor, B., and Bogor, K. P. H. (2012). Intensitas Cahaya, Suhu, Kelembaban Dan Perakaran Lateral Mahoni (Swietenia Macrophylla King.) Di Rph Babakan Madang, Bkph Bogor, Kph Bogor. *J. Silvikultur Tropika*, 3(1): 8-13.

Casals, J., Rivera, A., Sabaté, J., del Castillo, R. R., and Simó, J. (2019). Cherry and fresh market tomatoes: Differences in chemical, morphological, and sensory traits and their implications for consumer acceptance. *Agronomy*, *9*(1). https://doi.org/10.3390/agronomy9010009

El-Dawayati, M. M., El-Sharabasy, S., and Gantait, S. (2020). Light intensity-induced morphogenetic response and enhanced β-sitosterol accumulation in date palm (Phoenix dactylifera L. cv. Hayani) callus culture. *Sugar Tech*, 22(6): 112-1129.

Fan, X. X., Xu, Z. G., Liu, X. Y., Tang, C. M., Wang, L. W., and lin Han, X. (2013). Effects of light intensity on the growth and leaf development of young tomato plants grown under a combination of red and blue light. *Sci. Horticul.,* 153: 50-55. https://doi.org/10.1016/j.scienta.2013.01.017

Fauziah, A., Bengen, D. G., Kawaroe, M., Effendi, H., and Krisanti, M. (2019). Hubungan Antara Ketersediaan Cahaya Matahari Dan Konsentrasi Pigmen Fotosintetik Di Perairan Selat Bali. *Jurnal Ilmu Dan Teknologi Kelautan Tropis*, 11(1): 37-48. https://doi.org/10.29244/jitkt.v11i1.23108

Febrianto, M., Sutoto, S. B., and Suwardi. (2019). Efektivitas Pemberian Giberelin Terhadap Pertumbuhan dan Hasil Tomat Ceri (Lycopersicon esculentum var. cerasiforme) pada Berbagai Jenias Media Tanam dengan Sistem Hidroponik Substrat. *Agrivet*, 25(1): 25-37. http://eprints.upnyk.ac.id/id/eprint/17988

Garrido, A., Conde, A., Serôdio, J., De Vos, R. C. H., and Cunha, A. (2023). Fruit Photosynthesis: More to Know about Where, How and Why. *Plants*, 12(13): 1–29. https://doi.org/10.3390/plants12132393

Hermanwati, V. R., and Suminarti, N. E. (2018). Pengaruh Tingkat Naungan pada Pertumbuhan dan Hasil Tiga Varietas Stroberi (Fragaria sp.) yang Ditanam di Wilayah Dataran Menengah. *PLANTROPICA J. Agric. Sci.,* 3(1): 70-77.

Hidayah, I., Yulhendri, and Susanti, N. (2022). Peran sektor pertanian dalam perekonomian negara maju dan negara berkembang. *J. Salingka Nagari*, 1(1): 28-37. https://jsn.ppj.unp.ac.id/index.php/jsn/article/view/9

Ilić, Z. S., Milenkovic, L., Stanojevic, L., Cvetkovic, D., and Fallik, E. (2012). Effects of the modification of light intensity by color shade nets on yield and quality of tomato fruits. *Sci. Horticul.*, 139: 90–95. https://doi.org/10.1016/j.scienta.2012.03.009

Kisman, Khumaida, N., Trikoesoemaningtyas, Sobir, and Sopandie, D. (2007). Karakter Morfo-Fisiologi Daun, Pendiri Adaptasi Kedelai terhadap Intensitas Cahaya Rendah. *Buletin Agronomi*, 35(2): 96-102.

Manoj, K.N., M.R. Umesh, N. Ananda, and Shantappa D. (2021). Effects of low light intensity on radiation use efficiency and productivity of tropical pulses. *J. Agrometeorol.,* 23(3): 249-256. https://doi.org/10.54386/jam.v23i3.19

Miao, C., Yang, S., Xu, J., Wang, H., Zhang, Y., Cui, J., Zhang, H., Jin, H., Lu, P., He, L., Yu, J., Zhou, Q., and Ding, X. (2023). Effects of Light Intensity on Growth and Quality of Lettuce and Spinach Cultivars in a Plant Factory. *Plants*, 12(18): 1-18. https://doi.org/10.3390/plants12183337

Panigrahy, M., Ranga, A., Das, J., and Panigrahi, K. C. S. (2019). Shade tolerance in Swarnaprabha rice is associated with higher rate of panicle emergence and positively regulated by genes of ethylene and cytokinin pathway. *Sci. Reports*, 9(1): 1-17. https://doi.org/10.1038/s41598-019-43096-8

Rifky, S.N., Nasution, I. S., and Ichwana, I. (2020). Analisis Intensitas Cahaya, Suhu Dan Kelembaban Pada Bangunan

Rumah Kaca Menggunakan Arduino Uno Studi Kasus Di Fakultas Pertanian Universitas Syiah Kuala. *Jurnal Ilmiah Mahasiswa Pertanian*, 5(1): 541-550. https://doi.org/10.17969/jimfp.v5i1.13642

Wada, T., Ikeda, H., Matsushita, K., Kambara, A., Hirai, H., and Abe, K. (2006). Effects of shading in summer on yield and quality of tomatoes grown on a single-truss system. *J. Japanese Soc. Horticul. Sci.,* 75(1): 51-58. https://doi.org/10.2503/jjshs.75.51

Wales, S., Tulung, S. M. T., and Mamarimbing, R. (2023). Growth and Production of Tomato (*Solanum lycopersicum* L.) on several types of growing media. *Jurnal Agroekoteknologi Terapan*, 4(1): 84-93. https://doi.org/10.35791/jat.v4i1.44124

Wei, Y., Wang, S., and Yu, D. (2023). The Role of Light Quality in Regulating Early Seedling Development. *Plants*, 12(14): 1-15. https://doi.org/10.3390/plants12142746

Yadav, B., Mukherjee, J., Sehgal, V. K., Das, D. K., and Krishnan, P. (2017). Effect of dimming of global radiation on morphology and yield of wheat crop in Delhi. *J. Agrometeorol.*, 19(4): 323–327. https://doi.org/10.54386/jam.v19i4.599