

Effect of Night Temperature on Plant Growth and Dry Matter Production in Poppies (*Papaver* spp.)

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ABSTRACT

Night temperature has a significant impact on the plant growth and dry matter production by altering the metabolites between the membrane systems. Optimum day/night temperature is required for poppy plant to increase the potential yield of the crop. This experiment was done to test the effect of night temperature on the growth and dry matter production in poppy plants. Experiment were conducted in growth cabinets at Horticulture Research Centre (HRC) with two varieties (V1, V4), each with two replications under three different night temperature treatments (2.5°C, 7.2°C, 12°C). Plant measurements were recorded each week and the plant dry matter was observed against different treatments. Plants subjected to low temperature yielding less capsule weight due to chilling injury and high dry weight of leaves and stem due to internodal elongation. The increase in the capsule weight at 12°C is due to the increase in metabolic activities and also the genetic makeup of the variety. Difference between the dry matter content in between the varieties is due to the genotype interaction of the plants with the environment. V4 is found to be effective variety when compared to V1.

Key words: Temperature, Yield components, Metabolites, Chilling, Photoperiod.

INTRODUCTION

Temperature has profound effects on growth and development in majority of crops, controlling the rate of development through multitude of metabolic process⁹. Depending on the sensitivity of crop, temperature highly affects flower initiation, development, anthesis, and fruit development. The optimum temperature range for many cultivated crops is 5-8°C and is usually in between 20-30°C¹.

Bernáth and Tétényi², found that when a differential day/night temperature is imposed, low night temperatures favours growth of the plant rather than low day temperature. In

studying the temperature effect on opium poppy, they also noticed that the low temperature program 12.5/7°C prolonged the growth period resulting in taller plants with more dry matter partitioning of dry matter to leaves when compared to the high temperature program. The study by Bernáth and Tétényi strongly indicates that poppy is a cool season plant. Photoperiod is another important factor that plays a vital role in flower development. In poppy plants, flowering usually occurs in long photoperiods and the critical photoperiod has not been precisely determined but is between 14 and 16 hours.

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The poppy plants did not initiate flowering when the photoperiod length is less than 12hours³.

The purpose of this work was to increase the understanding of how poppy plants respond to different night temperature with constant day temperature and photoperiod length so that it is easy to predict effects of geographical location and temperature during the growing season. The main objectives were to determine the influence of three night temperatures on the growth, dry matter production and alkaloid content of two poppy varieties. Unfortunately, due to the mixed maturity of the capsules, the alkaloid content was not determined.

MATERIAL AND METHODS

The trials were conducted at Horticulture Research Centre (HRC), University of Tasmania(S 42° 54.306,E 147° 19.467 at an elevation of 55m) in 2017.Two poppy varieties V1 and V4 were obtained from Tasmanian Alkaloids at vegetative and pre-flowering stage respectively. Two replications of each variety were allowed to grow in the growth cabinets at a night temperature treatment of 2.5 °C, 7.2 °C (optimum) and 12 °C with a relative humidity of 38%, 51% and 55% respectively. A total of three treatments, each with 2 replications was arranged in a completely randomized design (CRD). By using refrigerated cooling and thermostatically controlled elements, a constant day temperature of 20±1°C was maintained in all the cabinets. Artificial lighting within the

cabinets was used to maintain a constant daylength of 16 hours throughout the growth period. A photon flux density of 30.2µmol.m⁻². s⁻¹ was provided with the use of fluorescent and mercury bulbs⁶.

The plants were grown in pots (6-8inch) containing potting mix with peat, sand and pine bark in the ratio of 1:2:7 at a planting density of 70plants/m². Slow release Osmocote® granules (330g/50L),iron sulphate (25g/50L), dolomite lime (330g/50L), and Micromax® 20g/50Lwere used as a fertiliser composition in potting mix⁶. After the exhaustion of Osmocote granules, Hoagland's solution (0.83litres/pot) was applied. The pots were labelled and growth parameters such as plant height, number of leaves, and number of capsules were recorded each week. Plants were watered regularly with automated drip irrigation system and monitored for any pest growth,

The capsules, leaves and stems were harvestedseparately, and oven dried at 55 °C for 8 hours. Then, the dry weight wasrecorded, and thedata was analyzed with ANOVA using general linear model procedure of IBM SPSS (Version 24). For comparison of means, Fishers least significant difference (LSD) was calculated at 0.05 probability level.

RESULTS

Overall observations revealed that there were differences between the varieties in both the dry matter yield of capsules, and leaves and stems under different night temperature treatments.

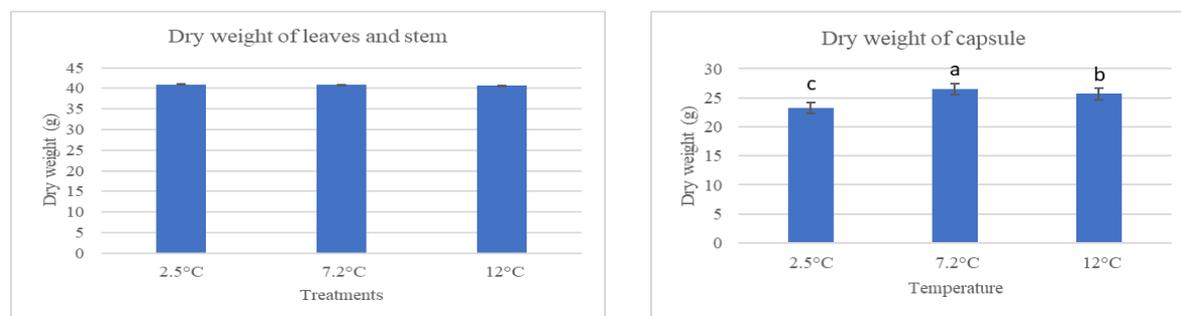


Fig. 1: Effect of night temperature (°C) treatments on dry yield of leaves and stems (A) and capsules (B) in V4. Bars represent ±2SE

It is evident from the figure 1A that the night temperature treatments did not have a significant effect on the dry matter production in leaves and stems of V4 variety. The treatments had a significant difference on the

dry weight of the capsule in V4 ($p < 0.001$). As expected, the capsule yield was high under optimum night temperature and low when the temperature was 2.5°C (figure 1B).

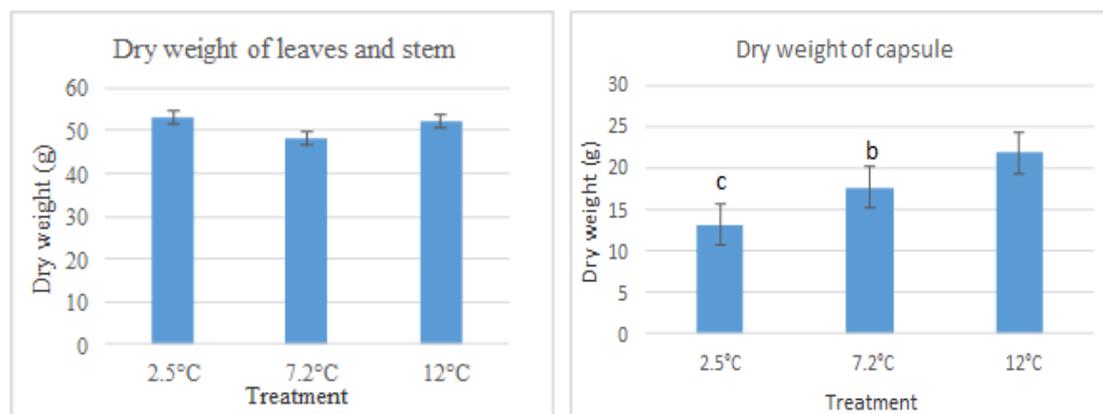


Fig. 2: Effect of night temperature ($^{\circ}\text{C}$) treatments on dry weights of leaves and stems (A) and capsules (B) in V1. Bars represent $\pm 2\text{SE}$

Figure 2 clearly indicates that there is a significant effect of night temperature on the dry matter production in leaves, stems and capsules ($p < 0.001$). The capsules of V1 yielded a high dry weight when the plants were exposed to a night temperature of 12°C and low dry weight was recorded when exposed to 2.5°C .

In contrary to the capsule weight, the dry weight of leaves and stems was noticed to be high at a night temperature of 2.5°C in both the varieties. In V1 the dry weight of leaves and stems was noticed to be low under optimum night temperature (7.2°C). On a whole, V4 variety yielding more dry weight of capsules when compared to V1.

DISCUSSION

The capsule yield was decreased at low temperature because of a number of mechanisms associated with the chilling injury. Though poppy is a cool season crop, it can tolerate low temperatures up to a certain extent. As the temperature is lowered, the lipid membranes begin to solidify and contract which causes cracks or channels leading to the augmented permeability. This sudden effect on permeability causes an ion imbalance resulting in the ion leakage due to chilling in tissues⁴. As the temperature decreases, glycolysis and

the enzymes associated with mitochondrial respiration decreases until the critical temperature. Below the critical temperature, the metabolites accumulate in between glycolysis and mitochondrial system⁵. Similar changes occur in the chloroplast resulting the chilling injury symptoms and death of the tissue due to the inability of the cells to withstand the increasing metabolite concentrations⁸.

The dry weight at low temperature is high to due to prolonged photoperiod. When the temperature is lowered, the plant growth phase increases resulting in elongated plants with more number of leaves³. The dry weight of the capsules in V1 was found to be increased at a high night temperature due to the increase in metabolic activities with increase in temperature⁷, and genetic makeup of that particular variety. V4 plants contain high concentration of alkaloids than V1 due to more dry weight of capsules. The variation in the dry matter yield of capsules between both the varieties is due to the genotype \times environment interaction⁷.

CONCLUSION

Although optimum night temperature for poppy is not precisely known, the response of the plants was different at different treatments.

Photoperiod and temperature play a vital role in the dry matter partitioning. Poppy plants cannot tolerate a temperature less than 5°C which results in the chilling injury. Prolonged photoperiod along with low night temperature increase the internodal length and number of leaves in poppy plants. Differences between the varieties occur due to the genotypic differences in relation to the environment. From this work, it can be concluded that V4 is effective variety than V1 when the dry weights were compared.

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