Effect of light quality and intensity on emergence, growth and reproduction in *Chromolaena odorata*

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Abstract. *Chromolaena odorata* is a perennial weed which invades forest areas cleared for developing plantations, nurseries, young plantations, and wastelands, but is conspicuously absent in the interior of dense forests or established plantations with closed canopy. The fresh seeds of *C. odorata* were found to be photoblastic; however, storage and washing substituted for light. 150 lux was sufficient to promote seed germination to a maximum of 68%. Higher intensities were less effective and those higher than 1500 lux were inhibitory. White and red light were promontory, while blue, far red and green were inhibitory. Light passing through leaf canopy was more inhibitory than far red light. Emergence of chromolaena was favored by low light intensity but for optimal seedling growth, higher intensities of 3000 to 3500 lux were found essential. Besides the light intensity, the quality of light had a very specific effect on the plant growth of *C. odorata*. Red and white light favored growth while blue, green and far red inhibited. Besides this, only those plants exposed to red and white light completed their life cycle by producing flowers. This study reflects on the strong light requirement of chromolaena for germination, seedling growth and seed production.

Key words: fresh seeds, storage, closed canopy, light intensity, light quality, leaf canopy, germination, seedling growth.

Introduction

Chromolaena odorata (L.) King and Robinson (Asteraceae) is an aggressive weed reported to be established all along the humid tropics. A survey undertaken as a preamble to the present study revealed that this species preferred open sunny habitats and was conspicuously absent in dense forests and plantations with a closed canopy. The partially/fully open areas, nurseries and young plantations in the same locality are observed to support a luxuriant growth of the weed. However, in the established plantations with a completely closed canopy, this weed was confined to the outskirts. Even if a few plants happened to grow in the interior of the plantations, they eventually developed a straggling habit, sending their branches atop the trees. The influence of environmental factors on seedling growth in *C. odorata* was earlier studied in detail under conditions existing in forests and plains of Karnataka, India by Ambika (2002). There are also reports stating that *C.odorata* is a secondary succession species rapidly colonizing forest clearings (Norbu, 2004). In this paper the results of the study on the influence of light on the life of *C. odorata* right from the seed germination stage is reported.

Materials and Methods

The cypsela collected from the teak plantations and nursery at Malnad areas of Shimoga, Karnataka, India during the month of April were stored in brown card board boxes, in the laboratory at temperatures varying from 22°C to 32°C, where the relative humidity ranged between 45 to 90%, and were drawn periodically for experimentation as outlined below.

Test.1: Effect of light intensity on seed germination and seedling growth
Seeds stored for 16 weeks were set for germination in five replications. Fifty seeds (ten seeds / Petri plate) each were subjected to 50, 150, 1000, 1500, 2500, and 4500 lux in the growth chamber where the temperature and relative humidity were fixed at 25°C and 85%, respectively. Ten seedlings each were grown under these intensities for 60 days. Their linear growth, number of leaves, fresh and dry matter accumulation were recorded.

Test.2: Influence of storage on germination under different light conditions
The seeds stored for 4 and 20 weeks were set for germination under continuous light (Intensity 150 to 200 lux), continuous darkness and far red irradiations (spectra obtained following Hillman, 1962) in the growth chamber. During the experimental period the temperature was maintained at 25°C and relative humidity at 85%.

Test. 3: Seed germination under different light Quality
Seeds stored for 16 weeks were set for germination under blue, green, yellow, red and far red irradiations (spectra obtained following Hillman, 1962), full spectrum of light (white light) in a growth chamber and under the canopy of *Musa sp.* and *Ficus sp.* During the experiment, the temperature and relative humidity in the growth chamber were 25°C and 85%, respectively.

Test.4: Plant growth in C. odorata under different light Quality
Chromolaena odorata plants were grown from seedlings in polyhouses maintained in the garden of the Botany Department, Bangalore University, Bangalore. Four polyhouses filtering more of blue, red, far red and a complete spectrum of light were constructed and these polysheets were replaced with fresh sheets if they faded. Fifty *C. odorata* plants were maintained in rows in each of the polyhouses. The light intensity and other growth factors were maintained at optimum (light intensity ranged between 3500 to 6000 lux, the temperature and relative humidity ranged from 22 to 28°C and 65 to 80%, and the available moisture ranged between 60 and 100%, respectively). Twenty plants each sixty days-old, were harvested to study their linear growth, number of leaves, and fresh and dry matter accumulation. The remaining plants were left to record the flowering under different light conditions.

Results and Discussion

Light had a profound effect on the emergence, growth and reproduction in *C. odorata.* Fresh seeds of this species needing light for germination were earlier reported by Ambika and Jayachandra (1980). Light intensities ranging from 50 – 4500 lux supported good germination, however, maximum germination occurred at 150 lux. It remained good up to1500 lux, and with further increase in the intensity, the percent germination came down (Fig.1).

The Multiple line charts for percentage germination gives the mean readings along with standard deviation and 95% upper and lower confidence levels. It is clear from the chart that good germination took place for light intensities up to1500 Lux. However, maximum as well as a good pattern of germination took place at 150 Lux. It is also interesting to note that the germination pattern is almost similar for 1000 and 1500 Lux (Fig.2).

The promotory effect of light was less evident with increase in storage duration. Freshly harvested seeds and seeds stored for a short duration exhibited a preference to light quality (spectrum of light) for germination. They preferred full spectrum of light to a result in 72.5% germination, followed by red irradiation, giving 62.5%. The germination percent was less by 51-61% in yellow, far red and green irradiation. The germination inhibition was complete under the blue irradiation and sunlight was filtered through the canopy of *Musa species* and *Ficus sp* (Figs.2 & 3). However, the inhibitory effect of far red light on seed germination decreased with storage. The germination percent in far red light increased from 5 to 40% in 5 months duration (Fig.3). The promotory effect of white and red light and the inhibitory effect of far red light on germination of light sensitive species are well documented (Flint and Mc Allister, 1937; Toole *et. al.*, 1956; Evenari, 1956 and Mayer and Poljakoff-Mayber, 1965). Soerohaldoko (1975) also recorded a similar observation of light quality on germination of *C. odorata* from Indonesia.

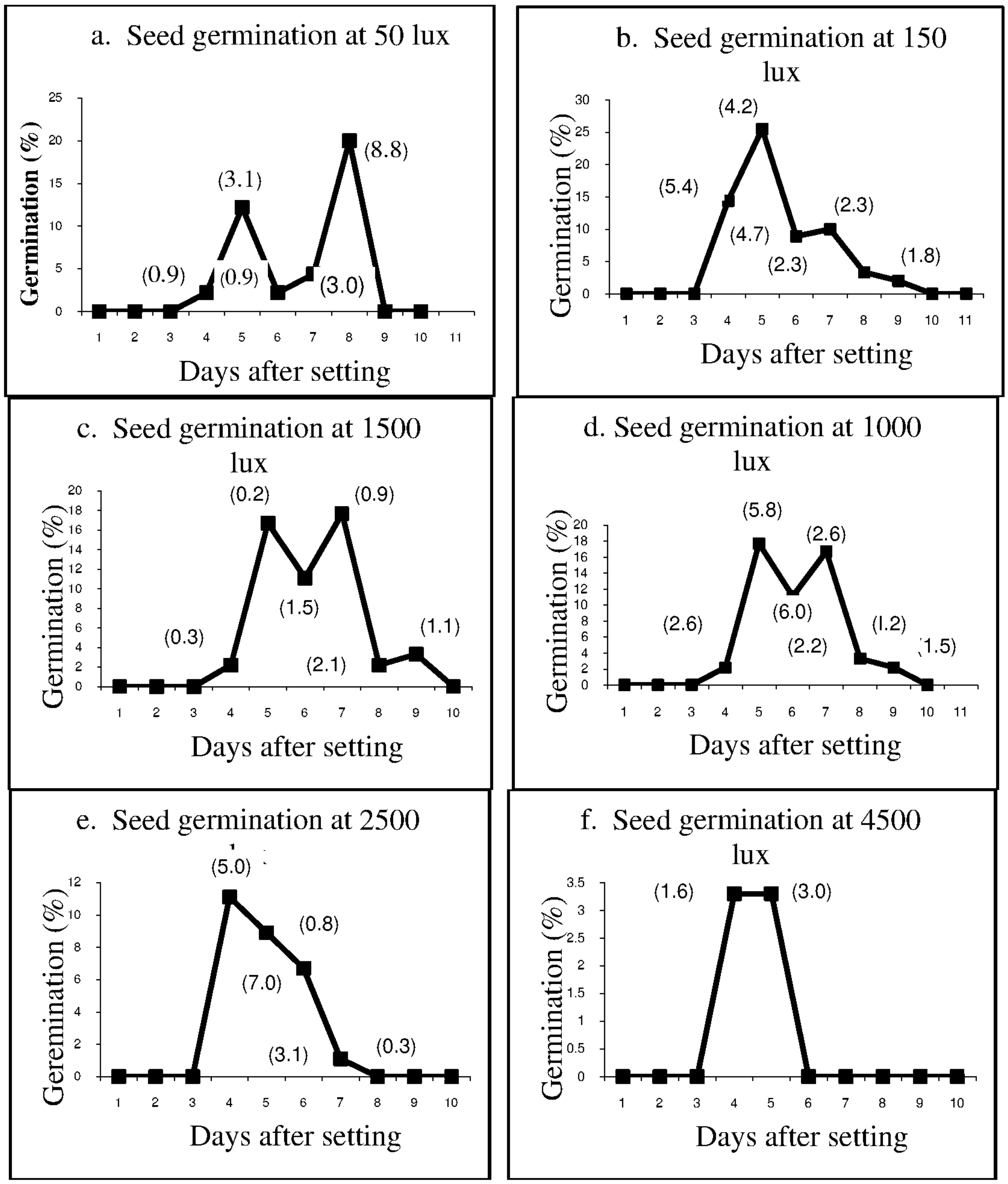
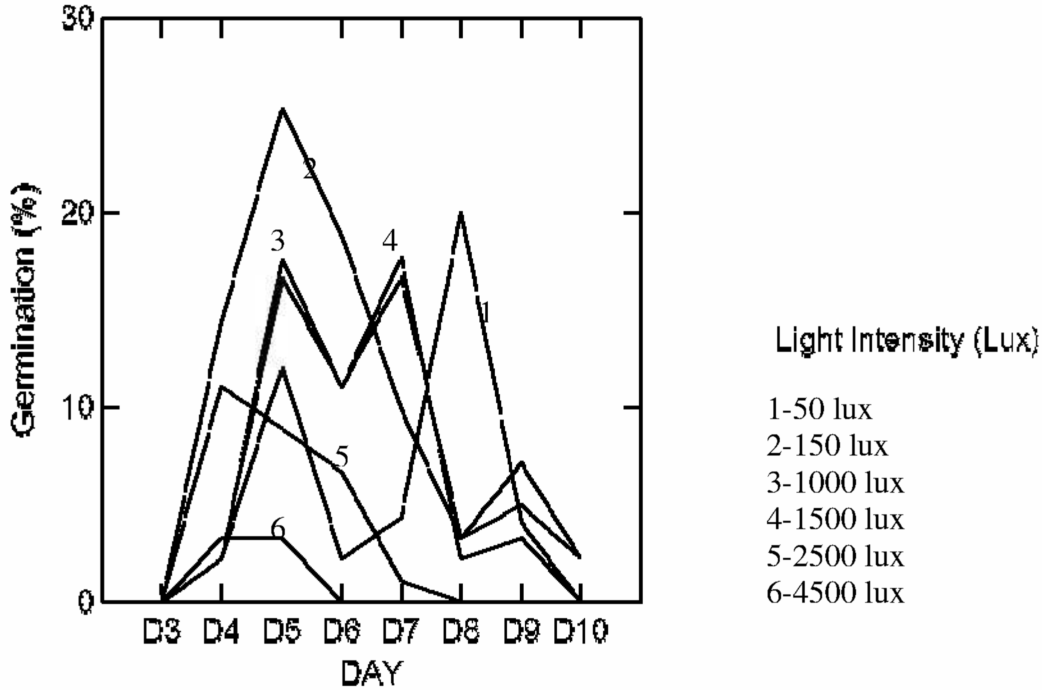
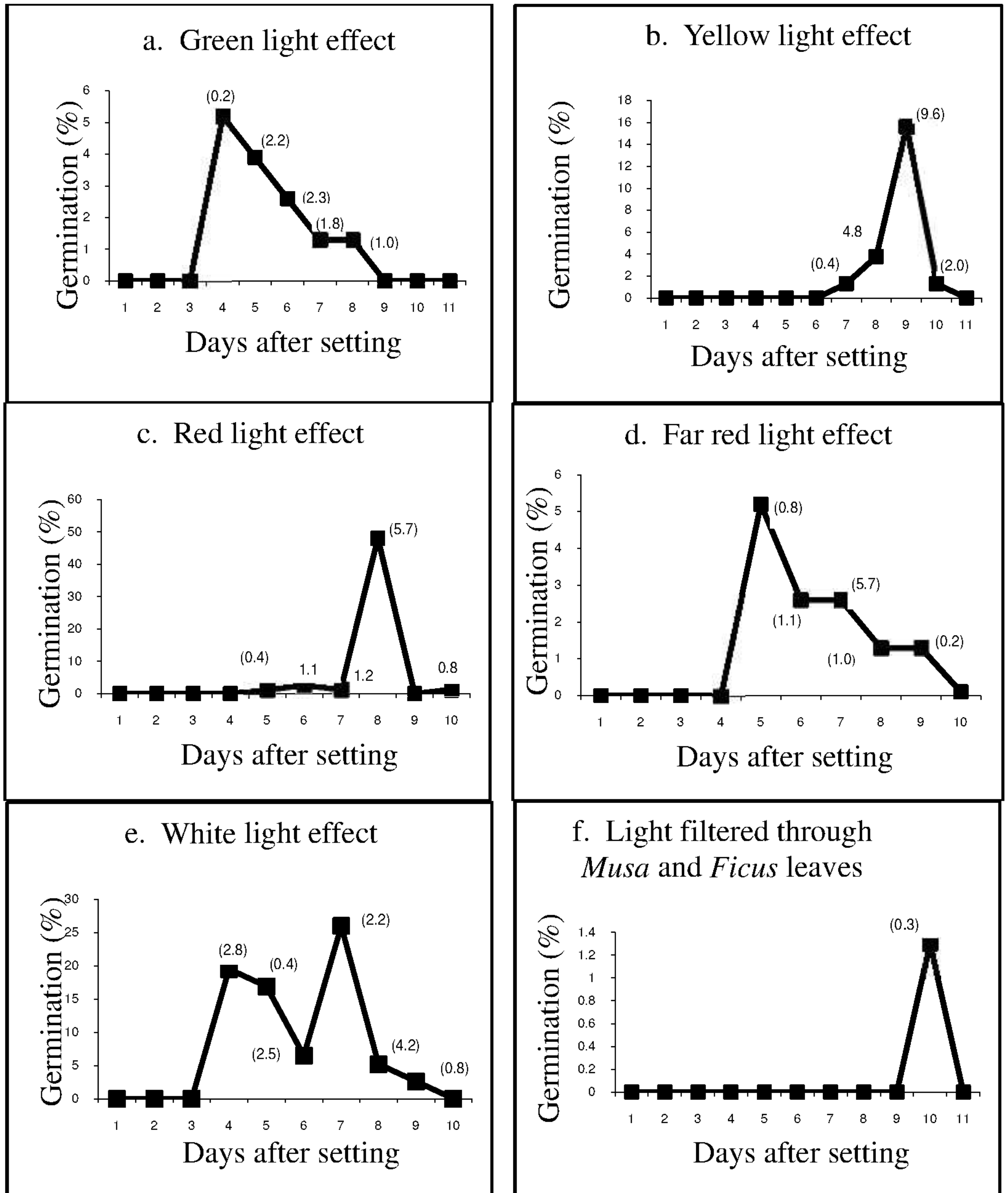


Figure 1. Influence of light intensity on seed germination in *Chromolaena odorata*



Intensity	50 lux	150lux	1000lux	1500lux	2500lux	4500lux
Mean	6.443	11.629	8.314	7.6	3.971	0.825
95% CI upper	13.027	19.493	14.599	14.476	8.409	2.102
95% CI Lower	-0.142	3.764	2.03	0.724	-0.466	-0.452
Standard deviation	7.119	8.503	6.795	7.435	4.798	1.528

Figure 2. Daily pattern and total germination percentage at different light intensities in *Chromolaena odorata* seeds



	L S D 5%	
Between light qualities	Between days after setting for germination	Interaction
2.3	**1.98**	**1.3**

Figure 3. Influence of light quality on seed germination in *Chromolaena odorata*

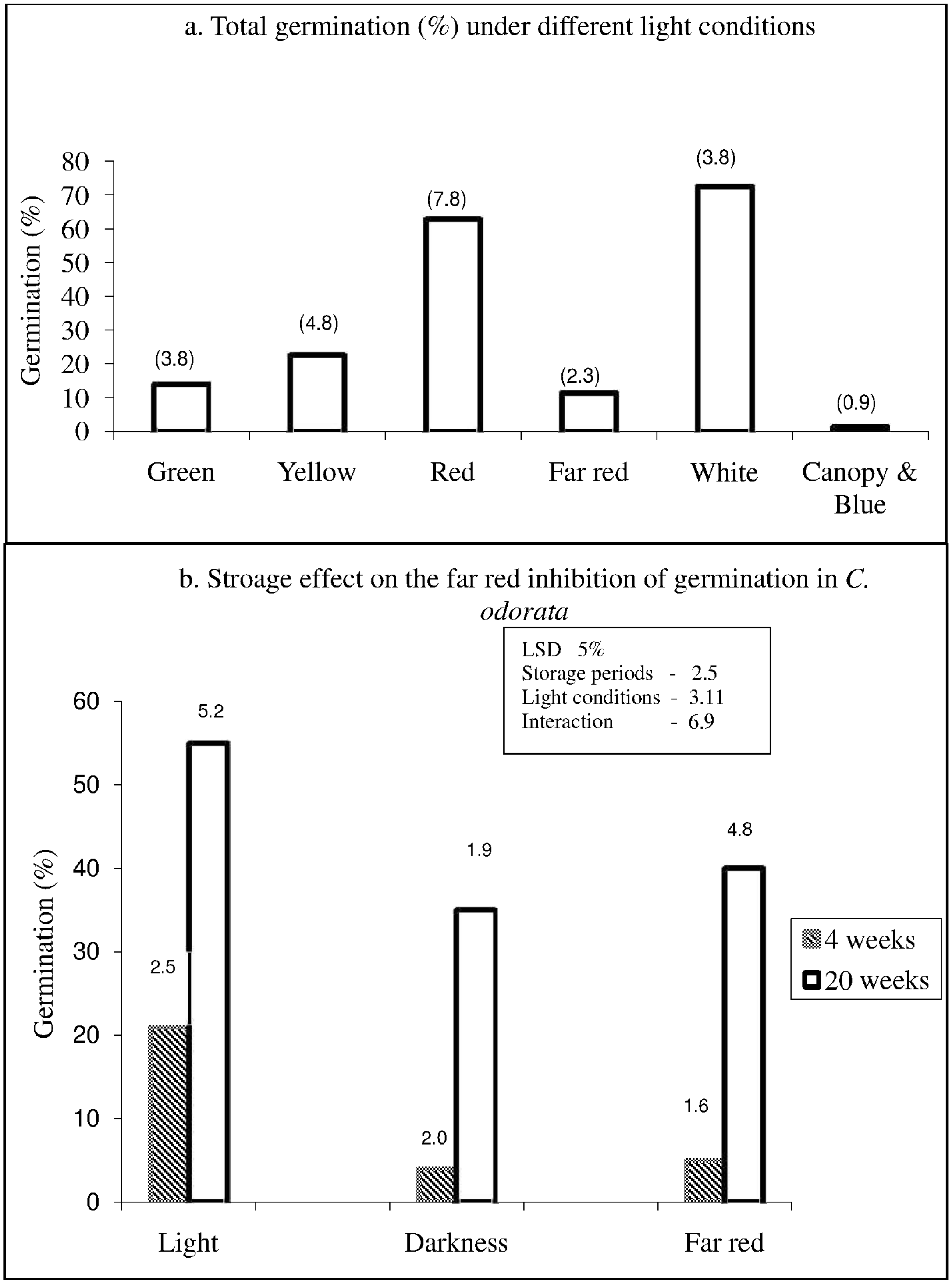


Figure 4. Light quality and storage on seed germination in *Chromolaena odorata*

Canopy light is known to be rich in the content of far red (Cumming, 1963) and this could be the reason for the total inhibition of germination under this condition. Similar reports have been made for *Digitalis purpurea, Chamaerion angustifolium, Calotropis procera* and *Ruellia tuberosa* (Van der veen, 1970). But in *C.odorata* this inhibition was found to be greater than due to far red alone (Fig.4); this was probably due to the combined effect of other inhibitory wavelengths such as green.

To know whether light intensity and light quality affect the germination process, the nonparametric analysis known as Kruskal-Wallis H test was used. The p-value suggests that at 5% level of significance the average germination across the light intensities and quality are stastically significant. Though maximum germination occurred in red light, the seeds preferred white light for affecting better pattern of germination.

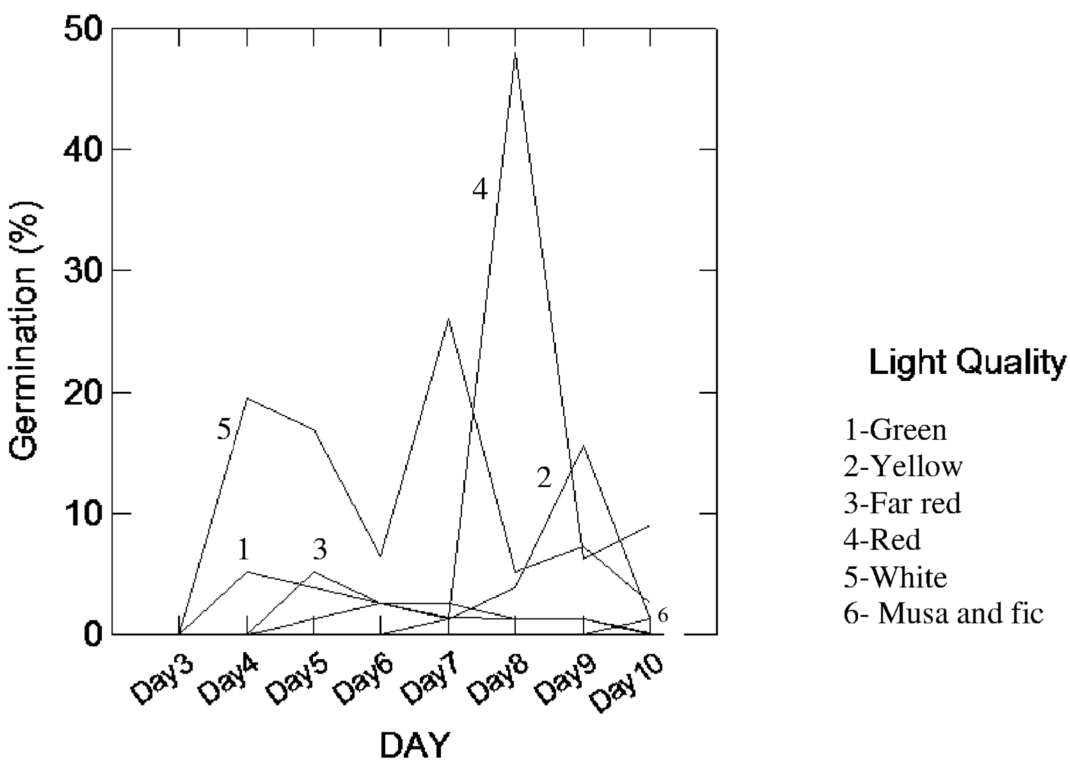


Figure 5. Daily pattern and total germination percentage at different light quality in *Chromolaena odorata* seeds

The inhibition in germination due to far red was less with the stored seeds. As by Ambika and Jayachandra (1989) washing was found to supplement storage in this regard (Fig.5). The spider diagram representing the percentage of germination in *C. odorata* after storage is given below. Good germination took place at 20 weeks storage and maximum germination occurred under white light (Fig. 6).

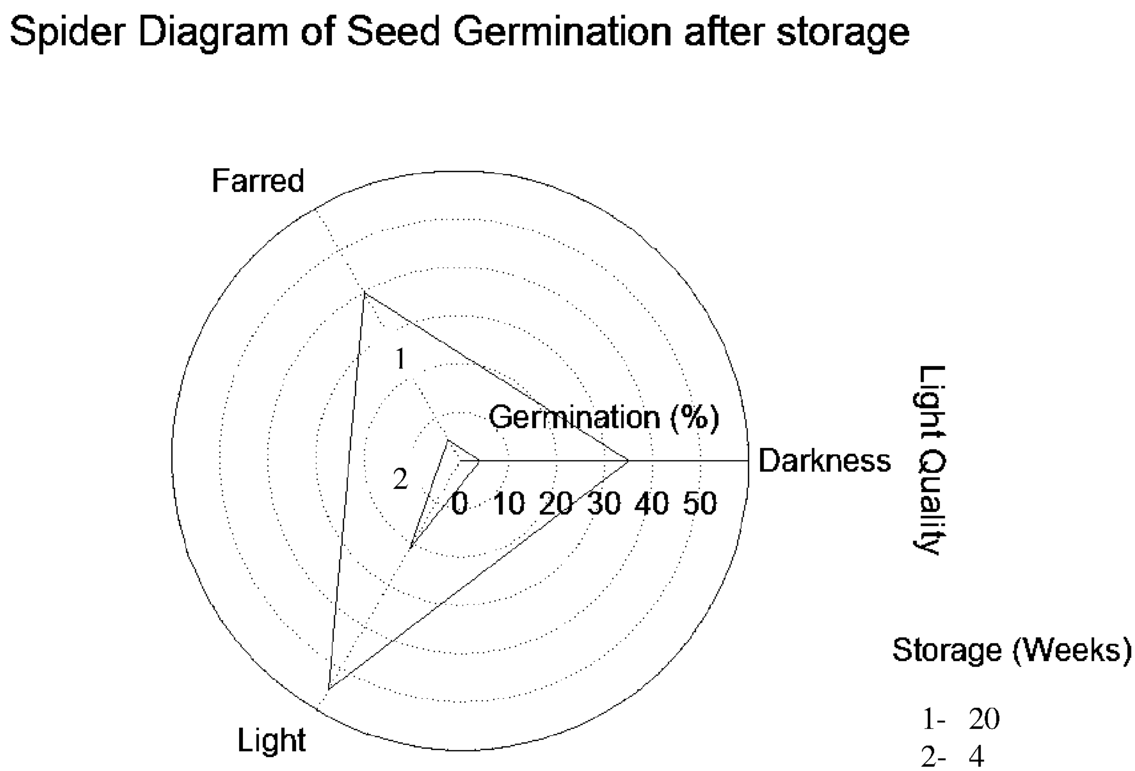


Figure 6. Seed germination percentage in *Chromolaena odorata* after Storage

	Green	Yellow	Far red	Red	White	Musa and fic
Mean	2.247	3.157	1.871	9.774	11.993	0.186
95% CI upper	3.897	8.391	3.536	25.637	20.123	0.64
95% CI Lower	0.598	-2.077	0.207	-6.088	3.863	-0.269
Standard deviation	1.784	5.659	1.8	17.152	8.791	0.491

These data show that the inhibitory effect of far red may not find expression to any significant degree in nature. As mentioned earlier, light is not an absolute requirement for the germination of this species. The promotory effect of light may find expression only in the case of the fresh cypsela that happened to be shed or deposited in a habitat where the soil moisture was high enough to favor germination. Thus, either the non-availability of sufficient light or the content of the inhibitory radiations in the light passing through the leaf canopy does not impose considerable limitation on seed germination in *C.odorata* and hence, the influence of these factors at the germination stage of the species cannot account for its conspicuous absence in the shaded areas such as the interior of the "closed forests".

However, it is quite evident from the data in Fig. 7 & 9 that the limiting influence of light could operate at later stages of its life. The findings from the studies on the influence of light on seedling growth in *C.odorata* show that though the emergence in the species was favored by low intensities of light (Fig.1), higher intensities above 3000 lux were required for the optimal growth of the seedlings (Fig.7).With the decrease in intensity from 3000 lux to 150 lux, the dry matter content of the shoot was reduced by over 31 – 95%. This drastic effect found expression in the height, and leaf number ant root depth; all of which were reduced by a significant degree.

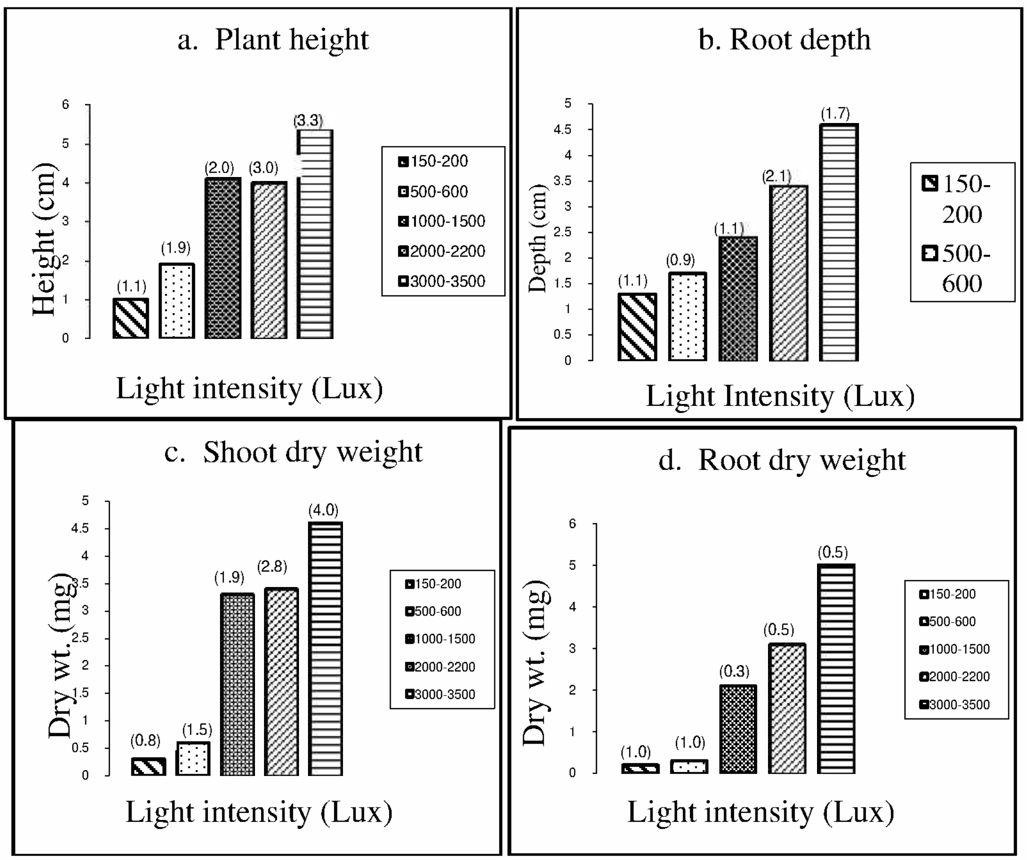


Figure 7. Seedling growth in *C. odorata* (45 days - old) under different light intensities.

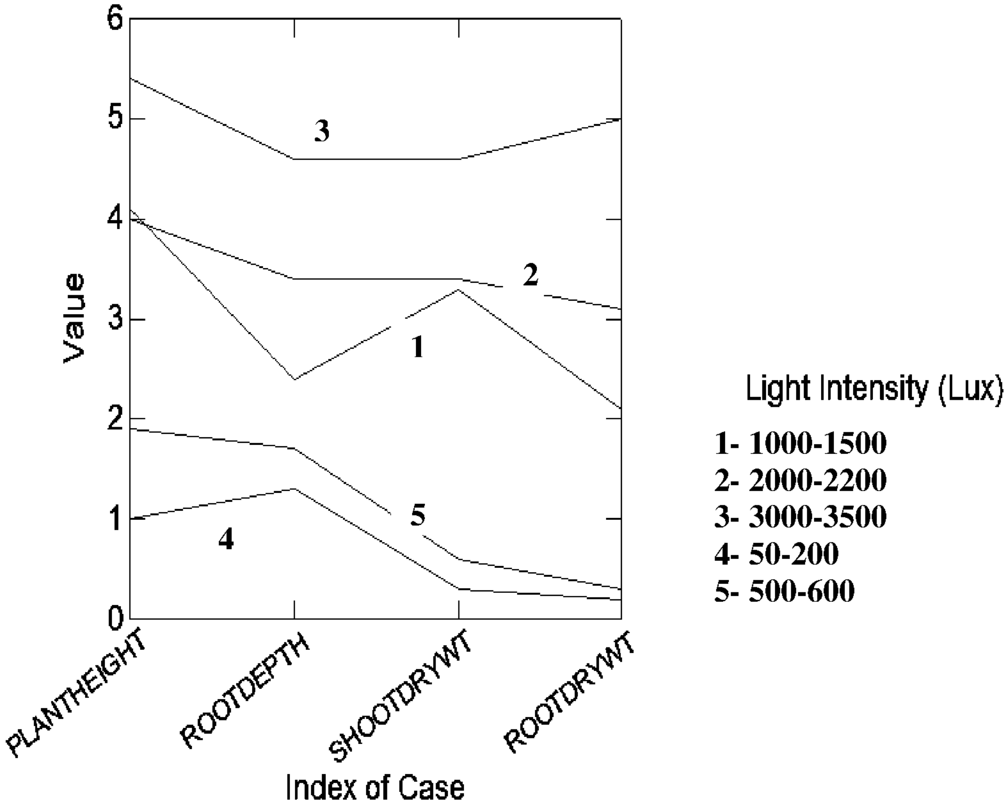


Figure 8. Growth of *Chromolaena odorata* seedlings at different light intensity

Light quality had a specific effect on seedling growth in *C.odorata* as evident from the data given in Fig.9. Though under laboratory conditions, there was some seed germination in green light, however, under field conditions in green poly houses there was no seedling emergence. Red and white light favored seedling growth in this species, but far red and blue inhibited growth in terms of linear, number of leaves and dry matter accumulation. Though the seedlings grew in blue and far red irradiation, they remained slender and unhealthy and did not flower even after one year, while those in red and white houses started flowering after only three months.

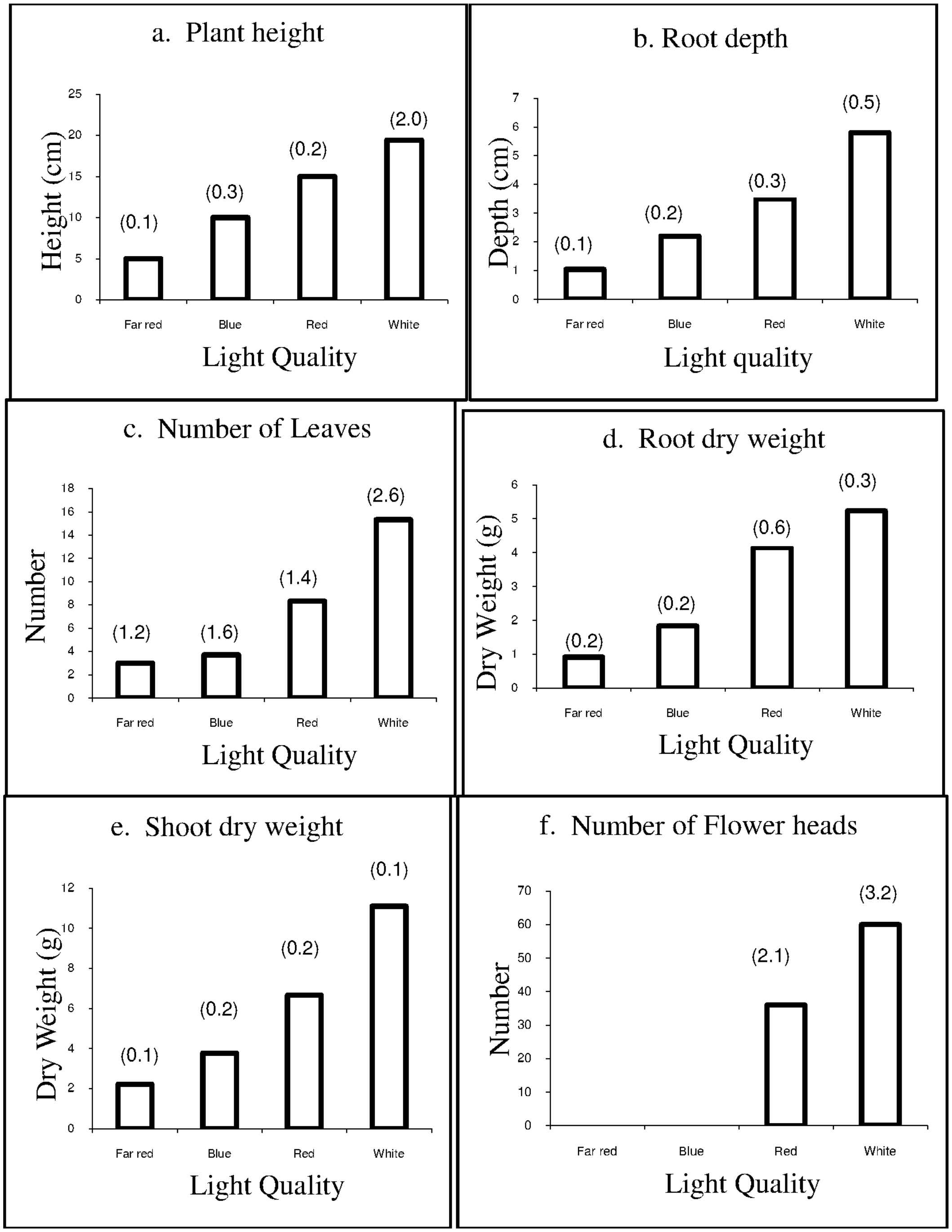


Figure 9. Growth of *Chromolaena odorata* for 60 days at different light quality in playhouses.

The parallel coordinate display represents how plants behave across light intensity and quality. Plants have greater growth at 3000- 3500 lux and respond very well in white light (Fig. 8 and 10).

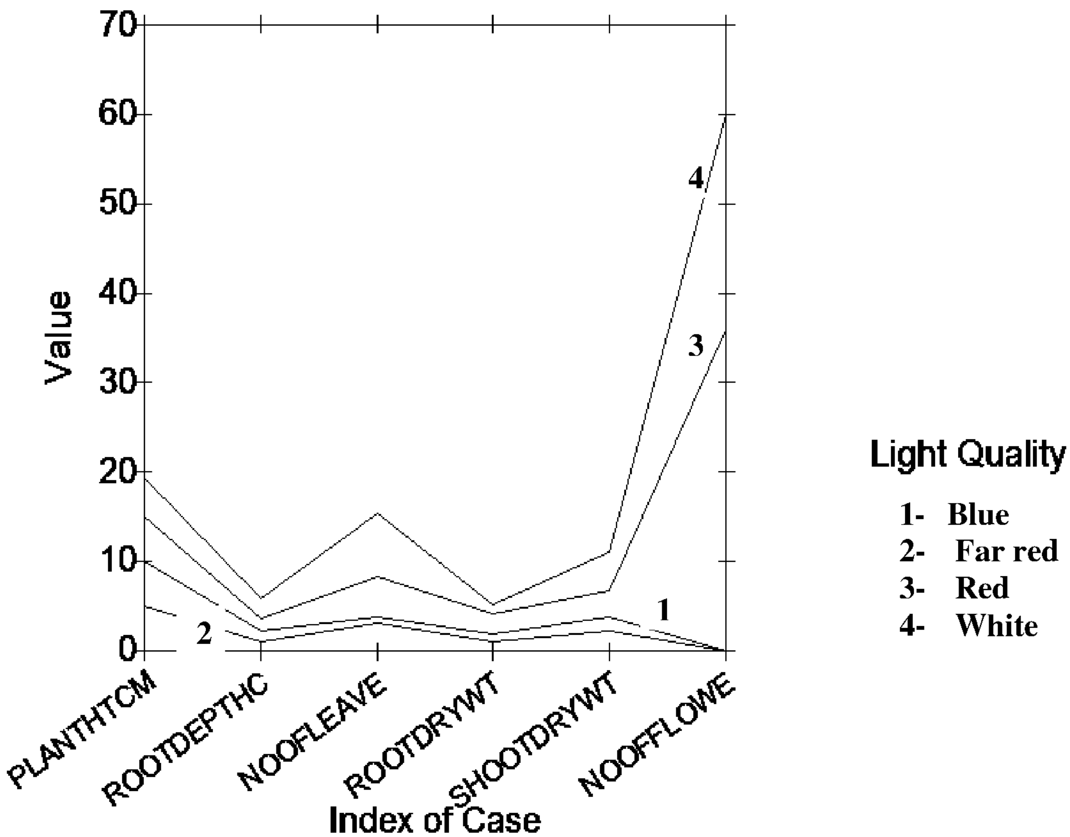


Figure 10. Growth of *Chromolaena odorata* seedlings at different light quality

Conclusions

The foregoing data reflect on the strong light requirement (in terms of quality and quantity) of *Chromolaena* for the seedling growth and for reproduction. In malnad regions of Karnataka (India), though the days are cloudy during the rainy season, light intensity in open areas would be adequate enough to support good growth of the species. However, in the forest interior with a dense canopy, the low light intensity along with canopy filtered light, rich in far red, and less in blue and red light, cannot support maturations of these plants beyond the seedling stage, and they remain as non-reproductive populations. Results from studies on similar invasive shrub species (*Lantana camara*) indicate that even plants which have grown beyond the seedling stage do not set flower when found under low light intensity levels in dense canopy forests (Duggin and Gentle, 1998).

Hence, the conspicuous absence of *C. odorata* in dense forests and plantations with a closed canopy is due to its light requirement for germination, seedling growth, flowering and fruiting, while the partially/fully open areas, nurseries and young plantations in the same locality support luxuriant growth of this weed. The fact that seedlings in the interior of plantations develop a straggling habit, sending their branches atop trees to produce flowers and seeds, also testifies its light requirement.

References

Ambika, S.R. and Jayachandra. 1980. Influence of light on seed germination in *Eupatorium odoratum* L. *Indian Forester* 106: 637-640.

Ambika, S.R. and Jayachandra. 1989. Influence of storage on seed germination in *Chromolaena odorata*. *Seed research* 17: 143-152.

Ambika, S. R. 2002. The influence of Environmental factors on seedling growth in *Chromolaena odorata.* In: C. Zachariades, R. Muniappan and L.W Strathie, (eds.), *Proceedings of the fifth international workshop on Biological control and Management of* Chromolaena odorata. ARC-PPRI Durban, South Africa, pp. 106-117.

Cumming, B .G. 1963. The dependence of germination on photoperiod light, quality and temperature, Chromolaena species. *Canadian Journal of Botany* 41: 1211-1233.

Duggin, J.A. and Gentle, C. 1998. Experimental evidence on the importance of disturbance intensity for invasion of *Lantana camara* L. in dry rain forest-open forest ecotones in north eastern NSW, Australia. *Forest Ecology and Management* 109: 279-292.

Evenari, M. 1956. Light and seed dormancy. In: W. Ruhland, (ed.), *Encyclopedia of Plant Physiology*. Springler-Verlag, Berlin, Germany.

Flint, L. H. and Mc Allister, E.D. 1937. Wavelengths of radiation in the visible spectrum promoting the germination of light-sensitive lettuce seed. *Smithsonian Institute Collection* 96: 1-8.

Hillman, W. S. 1962. *Physiology of flowering*. Hold Reinert and Winston. New York.

Mayer, A .M. and Poljakoff- Mayber. 1965. *The germination of seeds*. Pergamon Press, Oxford.

Norbu, N. 2004. Invasion success of *Chromolaena odorata* in Terai of Nepal. *Thesis submitted to the International institute of Geo-information, science and earth observation. Enschede,* The Netherlands.

Soerohaldoko, S. 1975. The after effect of filtered sunlight through green leaves on the seed germination of *C. odorata* (L.) King and Robinson compared with that of sunlight and darkness. In: *Proceedings of the third Indonesian Weed Science Conference. Bandung,* pp. 12-17.

Toole, E. H., Hendricks, S.B., Borthwick, H.A. and Toole, V. K .1956 Physiology of Seed germination. *Annual Review of Plant Physiology* 7: 299-324.

Van der Veen, R. 1970. The importance of red, far red in Photoblastic seed. *Acta Botanica Neerlandica* 19: 809-812.