Germination and Growth Responses of Important Summer Weeds to Different Light Intensities

Rashid A. Shad, Karimullah Beg and M. Altaf Sher*

ABSTRACT

Studies were conducted to determine the germination and growth responses of *Sorghum halepense, Cyperus rotundus, Trianthema portulacastrum* and *Dactyloctenium aegyptium* to different light intensities such as natural sunlight, 2000 lux, 1000 lux, 500 lux, and below 500 lux. Although different weed species responded differently to natural as well as reduced light yet all the four started germination earlier under reduced light conditions as compared to natural sunlight. Total germination percentage was higher in case of natural sunlight for grasses. Under light intensities below 500 lux, only *C. rotundus* survived. All the weed species grew taller under 2000 lux light intensity as compared to natural sunlight. Significant reduction in weed biomass in case of *S. halepense. C. rotundus, T. portulacastrum* and *D. aegyptium* occurred only when the light intensities reduced beyond 1000 lux, 500 lux, 1000 and 2000 lux, respectively. Studies revealed the possible role of light management in weed management technology.

* Principal Scientific Officer, Trainee Scientist and Scientific Officer respectively, National Agricultural Research Centre, Islamabad.

INTRODUCTION

Light is one of the most important primary factors which govern plant growth and hence the potential competitivability of crop plants and the associated weeds. Because light requirement of different plants are different for their growth and development, weeds and crop plants respond differently to natural as well as reduced irradiance. The effect of shading could thereiore, be explored as an important tool in weed management.

Responses of weed plants to irradiance have not been thoroughly and properly investigated and the comparative studies on the light responses to weeds are very few. Patterson (1982) has reviewed the effects of light on crops and weeds.

In an other study on show-crotalaria (*Crotalaria - spectabilis*), shading significantly reduced height, dry matter accumulation, leaf production, leaf area expansion, auxiliary branch development, reproductive development and partitioning of plant biomass in the stem. However shading in this study increased the partitioning of plant biomass into leaves and the leaf area ratio (Patterson, 1982).

Similarly, Boyd and Murray (1982) found that dry matter production of night-shade (*Solanum elaeagnifolium*) declined markedly with increasing shade levels from 0 through 92 percent

and the chlorophyll a/b ratio of the 92 percent shaded plants was significantly less than with other treatments. They reported that leaf area increased with the increasing shade but leaf weight per unit area decreased because of thinner leaves.

Sorghum halepense, Cyperus rotundus (perennials), *Trianthema portulacastrum* and *Dactyloctenium aegyptium* (annuals) are most important weeds of upland crops in Pakistan. They cause serious problems for the farmers in maize, sugarcane, cotton, orchards, vegetables and other crops of summer season.

The objective of this study was to determine the germination and growth responses of these four weed species under natural and reduced light.

MATERIALS AND METHODS

Laboratory experiments were conducted on four summer weeds namely *Sorghum halepense, Cyperus rotundus, Trianthema portulacastrum* and *Dactyloctenium aegyptium.*

Except *Cyperus rotundus*, seeds of all the other species were planted 1 cm deep in small plastic pots. In case of *Cyperus rotundus* bulbs were planted 2 cm deep in the similar pots.

The pots with weed seeds were arranged in a complete randomized design with 5 replications under different light intensities. At night, lights were switched off. Different light intensities included in this study were, natural sunlight, 2000 lux, 1000 lux, 500 lux and below 500 lux artificial tube lights.

Data were recorded on the number of emerged seedlings, active germination span, total germination span, plant height, number of leaves, shoot biomass, root biomass, and number of tubers (in case of *C. rotundus* only).

RESULTS AND DISCUSSION

Germination behavior

Weed species responded differently to various light intensities. In general, germination of all the weeds started earlier under reduced light as compared to natural sunlight. However, total germination percentage of all the weed species except *T. portulacastrum* (a broad leaf weed) was higher under sunlight as compared to reduced light. Meyer and Anderson, (1952) also observed that the germination of grasses is enhanced on exposure to strong light.

Natural sunlight:

None of the weed species showed emergence upto 7th day after seeding (Table 1). On the 7th day *S. halepense* followed by *D. aegyptium* showed the highest number of emergents, whereas *C. rotundus* and *T. portulacastrum* species were the least in number to emerge. After the 7th day, emergence of *C. rotundus* started sharply and it completed more than 95% of its emergence on the 15th day (Fig. 1).

Similarly *S. halepense*, also a perennial, showed gradual increase in seedling emergence and completed 60% of its germination by 13th day. After that the germination rate slowed down and no seedling emerged after 15th day ending finally with 62% germination (Fig. 1).

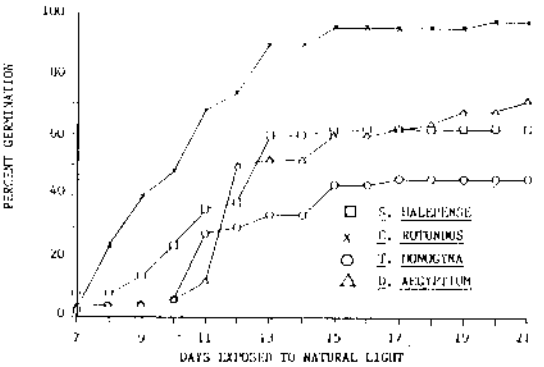

Fig 1 Germination of different weeds under natural light

Germination rate of *T. portulacastrum* remained slow in the beginning with only 6% germination on the 10th day. Between 10th and 15th day after seeding, the germination rate was the highest with 44% germination on the 15th day. After that germination rate slowed down and complete germination of 48% was obtained on the 18th day which remained constant afterwards (Fig. 1).

D. aegyptium showed similar behaviour as that of *T. portulacastrum* for 10 days. There was sharp increase in germination during the next two days so that a germination of 50% was obtained on the 12th day. After that, a slow but gradual increase in seedling number continued showing a long germination span spreading upto 21 DAS. The final germination of 72% was recorded on the 21st DAS (Fig. 1).

It could be concluded from these data that under natural sunlight complete emergence of *C. rotundus, T. portulacastrum* and *D. aegyptium* occurs within about 11-14 days, whereas *S. halepense* takes only 8 days. However active germination span extends to 3-4 days in case of annuals such as *T. portulacastrum* and *D. aegyptium* and 5-6 days in case of perennials such as *S. halepense* and *C. rotundus* (Table 2). An interesting point to be noticed during this study is that most of the summer season crops such as corn with whom these weeds are associated emerge within 5 days after seeding in the field where as the weeds in this experiment emerged after 7 days and that too in the pots where enough soil moisture was

Table 1. Percent germination of different weeds as affected by different light intensities 5 and 6 days after seeding (DAS).

	Weed Species							
Light intensities	*Sorghum halepense*		*Cyperus rotundus*		*Trianthema portulacastrum*		*Dactyloctenium aegyptium*	
Treatments	5 DAS	6 DAS	5DAS	6 DAS	5 DAS	6 DAS	5 DAS	6 DAS
Natural light	0	0	0	0	0	0	0	0
2000 lux	14	16	30	44	0	4	0	0
1000 lux	12	12	20	36	0	10	6	6
500 lux	16	16	24	44	0	10	4	4
Below 500 lux	30	36	30	30	44	50	51	52

Table 2. Final germination percentage (FGP), active germination span (AGS) and total germination span (TGS) of different weed species under different light intensities.

Light intensities	Weed Species											
	Sorghum halepense			*Cyperus rotundus*			*Trianthema portulacastrum*			*Dactyloctenium aegyptium*		
	FGP	AGS *–**	TGS *–**	FGP	AGS	TGS	FGP	AGS	TGS	FGP	AGS	TGS
Sun light	62	8-13	7-15	98	7-13	7-20	48	9-12	7-18	72	11-15	7-21
2000 lux	56	6-12	5-18	68	5-9	5-17	58	6-11	6-15	36	8-12	6-18
1000 lux	26	6-10	5-16	70	5-9	5-12	62	6-11	6-20	40	8-11	5-11
500 lux	46	6-10	5-21	90	5-10	5-17	64	6-11	6-12	48	5-10	5-13

* Days after seeding, the germination started
** Days after seeding, the germination completed.

available. In the field their emergence could be still later. Measures to control these weeds in field crops should therefore, be planned keeping in view these data.

Reduced light:

As in case of sunlight, weed species showed different germination behaviour under reduced light too. Percent germination of all the weeds except *T. portulacastrum* decreased under reduced light. There are also previous reports that germination of some weed species is retarded under reduced light. Not only the germination started earlier but also the active germination spans were found different under reduced light.

The germination of *S. halepense* started on the 5th DAS under 2000 lux and 1000 lux light intensities. Under 2000 lux, seedlings continued emerging without any regular interval and germination span spread from 5-18 days after seeding with the constant germination of 56% obtained on the 18th day. In case of 1000 lux, germination span spread at 5-16 DAS with the final germination of 26% whereas the active germination span was only for 4 days i.e. 6-10 DAS. Under 500 lux intensity although the active germination span was 6-10 DAS but the seedlings continued to emerge upto 21 days with the final germination of 46 percent (Table 2, Fig. 2).

Generally *Cyperus rotundus* showed a better germination percentage than other species both under natural as well as reduced light. However the germination percentages in case of reduced light particularly 2000 and 1000 lux, were considerably less as compared to natural light. In case of 2000 lux, germination continued up to 17th DAS starting 5th DAS although the active germination span persisted for 5-9 days

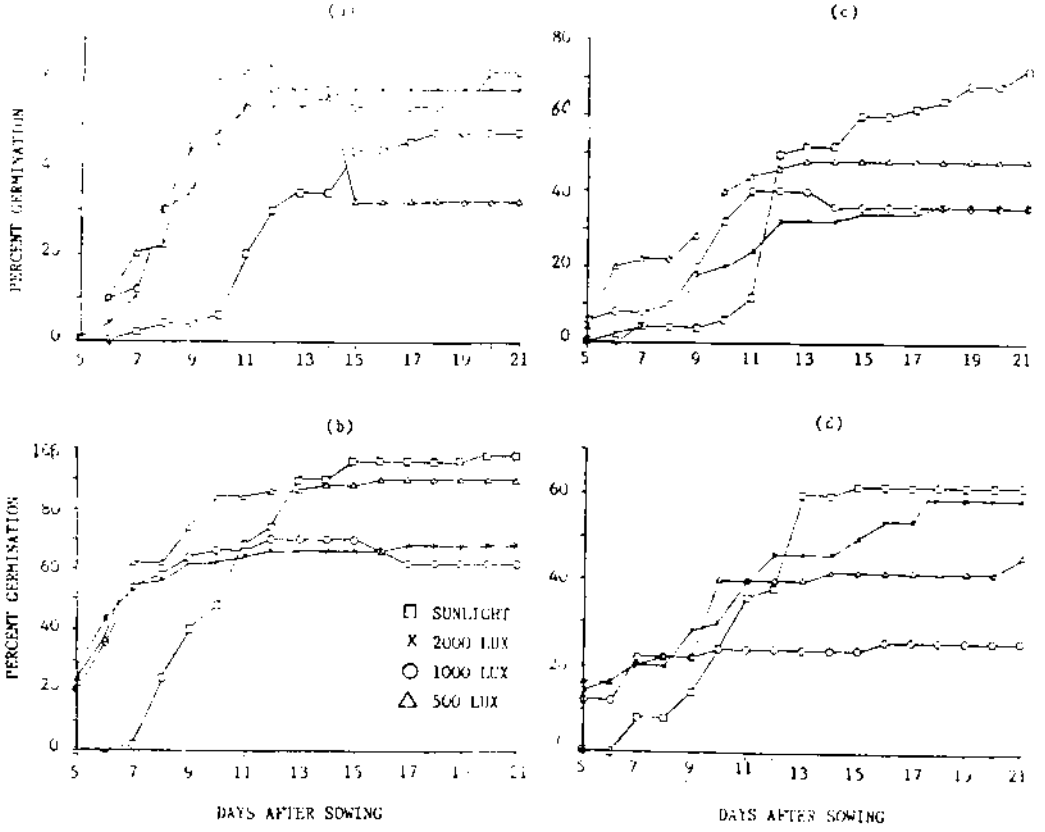

Fig. 2 Germination behaviour of Trianthema monogyna (a), [illegible] (b), [illegible] (c) and Sorghum halepense (d) under different light intensities.

after germination. In case of 1000 lux, germination span prolonged upto 12 days starting 5th DAS and obtained 70% seedlings on the 12th day. Some of the seedlings died later bringing the final count to 62% on the 21st day. Among the reduced light treatments, germination percentage was the highest i.e. 90% in case of 500 lux intensity. Germination span under this light intensity was 5-17 DAS whereas the active germination span prolonged from 5-10 DAS (Table 2, Fig. 2).

Germination of *T. portulacastrum* was higher under reduced light as compared to natural light. Germination spans in case of 2000, 1000, and 500 lux were 6-15, 6-20 and 6-12 DAS respectively, whereas the active germination persisted 6-11 DAS in case 2000, 1000 and 500 lux. In case of 1000 lux some of the seedlings died after 15 days and some emerged on the 20th day (Table 2, Fig. 2).

Unlike *T. portulacastrum* germination of *D. aegyptium* was found to be less under all intensities of reduced light as compared to natural light with the 500 lux showing higher gemination percentage than others i.e. 2000 and 1000 lux.

In 2000 lux the maximum percentage of germination i.e. 36% was obtained on the 18th day starting 6th DAS whereas the maximum (40%) in case of 1000 lux was recorded on the 11th day (Table 2, Fig. 2). These data reveal that interventions such as increased plant population, use of suitable varieties and cover crops which can provide early shading can be helpful in weed management.

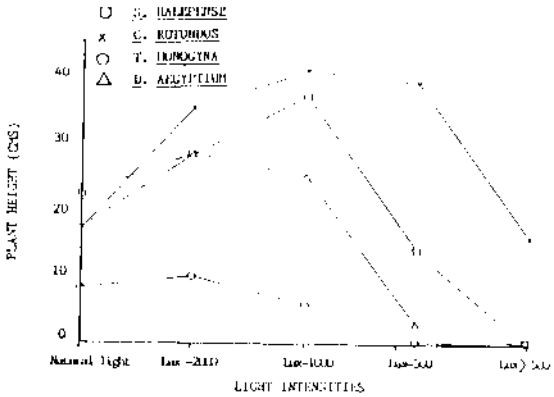

Fig 3 Plant height (CMS) of different weed species as affected by light (60 DAS)

Growth characteristics

Plant height

Plant height also showed sensitivity to varying light intensities. All weed species grew less taller under natural sunlight as compared to 2000 lux artificial light. *Sorghum halepense* and *Cyperus rotundus* attained the maximum height under 1000 lux whereas *T. portulacastrum* and *D. aegyptium* under 2000 lux. With the further reduction in light intensities after these, reduction in plant height also occured to the extent that at light intensity below 500 lux a sharp fall in plant height was observed but not in case of *C. rotundus* (Fig. 3). This is in accordance with the observation that most of the weed species have the tendency to grow taller under reduced light until the photosynthate production becomes a limiting factor (Patterson, 1979). These data show that *C. rotundus* is the least sensitive weed species to etiolation and can even survive under light as low as below 500 lux. The other weed species can be best controlled by shading with an irradiation of 1000 lux or below (Fig. 3).

Number of leaves

Sorghum halepense produced about similar number i.e. 6, 7, and 8 leaves per plant under natural sunlight, 2000 lux and 1000 lux, respectively. At 500 lux

Table 3. Number of leaves of different weeds under different light intensities 60 days after seeding.

	Weed Species			
Light intensities	*S. halepense*	*C. rotundus*	*T. portulacastrum*	*D. aegyptium*
Natural sunlight	6 ab	13 a	15 a	16 a
2000 lux	7 a	7 b	14 ab	7 b
1000 lux	8 a	9 b	8 bc	8 b
500 lux	4 b	6 bc	1 cd	4 bc
Below 500 lux	0 c	3 c	0 d	0 c

Means followed by same letters are not significantly different at 5% level.

Table 4. Fresh shoot weight in grams of different weeds as affected by different light intensities 60 days after seeding.

	Weed species			
Light intensities	*S. halepense*	*C. rotundus*	*T. monogyna*	*D. aegyptium*
Natural sunlight	0.320 ab	0.616 ab	0.812 a	0.736 a
2000 lux	0.338 ab	0.674 ab	0.716 a	0.618 a
1000 lux	0.696 a	0.836 ab	0.158 ab	0.286 c
500 lux	0.030 b	0.466 ab	0.002 b	0.004 c
Below 500 lux	0.000 b	0.096 b	0.000 b	0.000 c

the number reduced to 4 and below 500 lux the plants did not survive. *C. rotundus* and *D. aegyptium* on the other hand produced the highest number of leaves under natural light and with the reduction in light intensity a sharp decrease in the number of leaves occured. However unlike other weed species *C. rotundus* survived under the most reduced light i.e. below 500 lux and produced 3 leaves per plant (Table 3).

T. portulacastrum was not much affected by reduction in light up to 2000 lux and about a similar number of leaves (14-15) was recorded under natural sunlight and 2000 lux. However after this a decrease occured with only 8 leaves under 1000 lux, one under 500 lux and none beyond that (Table 3).

Shoot/root biomass

Both perennial weeds i.e. *S. halepense* and *C. rotundus* did not differ significantly in terms of shoot biomass under natural, 2000 lux and 1000 lux light intensities although the highest biomass was gathered by these two species under 1000 lux light intensity. Further reduction in light intensity to 500 lux and beyond decreased the biomass significantly and ultimately to a negligible level (Table 4). In case of annual weeds *T. portulacastrum* and *D. aegyptium*, shoot biomass decreased significantly under reduced light as com-

Table 5. Fresh root weight (gm) of different weeds under different light intensities 60 days after seeding.

	Weed species			
Light intensities	*S. halepense*	*C. rotundus*	*T. portulacastrum*	*D. aegyptium*
Natural sunlight	0.326 a	0.910 a	0.186 a	0.361 a
2000 lux	0.053 b	0.576 a	0.042 b	0.045 b
1000 lux	0.071 a	0.758 a	0.053 b	0.018 b
500 lux	0.004 b	0.664 a	0.000 b	0.001 b
Below 500 lux	0.000 b	1.710 a	0.000 b	0.000 b

pared to natural sunlight and a sharp decrease was observed at 500 lux and below.

Root biomass in case of *S. halepense, T. portulacastrum and D. aegyptium* reduced gradually with reduction in light intensities and almost no root development at 500 lux and below took place. On the contrary root biomass of *C. rotundus* did not suffer significantly because of low irradiation, rather the highest biomass was recorded under light intensity below 500 lux (Table 5).

Number of bulbs/plant of C. rotundus:

Interestingly the highest number of bulbs was recorded in case of lowest light intensity i.e. below 500 lux. In case of other light intensities including sunlight, the number of bulbs remained almost the same. (Table 6). It indicates that reduced light can not suppress the vegetative propagation of *C. rotundus*.

Table 6. Number of bulbs/ plant in *Cyperus rotundus* under different light intensities 60 days after seeding (DAS).

Light intensities	No. of bulb/plnat
Natural sunlight	1.27
2000 lux	1.3
1000 lux	1.48
500 lux	1.56
Below 500 lux	3.16

From these data it can be concluded that control of the some weed species such as *T. portulacastrum, D. aegyptium* and *S. halepense* could be possible by reducing the light through shading which can be achieved through increased plant population, use of suitable varieties and cover crops. On the other hand *C. rotundus* seems to be a difficult weed to be controlled through such ecological techniques. This finding is contradictory to the report by Mercado (1980) who has recorded *C. rotundus* as one of the weed species which show sensitivity to light.

REFERENCES

Boyd, J.W. and Murray, B.S. 1982. Effects of shade on silverleaf nightshade (*Solanum elaeagnifolium*) Weed Sci. 30: 264-269.

Mercado, B.L. 1979. Introduction to Weed Science. South East Asian Regional Centre for Graduate study and Research in Agriculture. Laguna, Philippines 292 pp.

Meyer, B.S. and Anderson, D.B. 1952. Plant Physiology. Maruzen Company, limited, Tokyo, Japan 784 pp.

Patterson, D.T. 1979. Effect of shading on the growth and development of itchgrass (*Rottboellia exalata*). Weed Sci. 27. 549-553.

Patterson, D.T. 1982. Effect of light and temperature on weed/crop growth and competition. In Biometerology in Integrated Pest Management. (J.L. Hatfield and I.J. thomason eds) Academic Press, New york, London, pp. 407-420.