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OA Nirmal
Ph.D. Scholar, Department of Horticulture, College of Agriculture, Dapoli, Maharashtra, India

PC Haldavanekar
Associate Dean, College of Horticulture, Mulde, Maharashtra, India

PC Mali
Associate Professor, Department of Horticulture, College of Agriculture, Dapoli, Maharashtra, India

AA Khot
PG. Scholar, Department of Horticulture, College of Agriculture, Dapoli, Maharashtra, India

YR Parulekar
Assistant Professor, Department of Horticulture, College of Agriculture, Dapoli, Maharashtra, India

MC Kasture
Associate Professor, Department of Soil Science and Agriculture Chemistry, College of Agriculture, Dapoli, Maharashtra, India

Ghavale SL
Assistant Professor, Regional Coconut Research Station, Bhatye, Ratnagiri, Maharashtra, India

Correspondence
OA Nirmal
Ph.D. Scholar, Department of Horticulture, College of Agriculture, Dapoli, Maharashtra, India

Influence of different shade intensities on growth performance of Chilli (*Capsicum annuum* L.) seedlings under Konkan agro-climatic condition

OA Nirmal, PC Haldavanekar, PC Mali, AA Khot, YR Parulekar, MC Kasture and Ghavale SL

Abstract
The experiment was carried out at High-Tech Farm, Department of Horticulture, College of Agriculture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli for investigating the effects of different shade intensities on growth performance of Chilli seedlings. The experiment laid out by randomized block design having seven treatments *viz*., T_1-U shaped tunnel covered with 25% shade net, T_2-U shaped tunnel covered with 50% shade net, T_3-U shaped tunnel covered with 75% shade net, T_4-U shaped tunnel covered with LDP paper, T_5-U shaped tunnel covered with coconut leaves, T_6-U shaped tunnel covered with gunny bags and T_7-U shaped tunnel without coverings and which was replicated by three time. The minimum days required for germination was recorded in the treatment T_4 (7.33 days). Among all the treatments, T_6 significantly influenced growth and health of seedlings and produced the maximum seedling height (32.83 cm), numbers of functional leaves (16.53), leaf area (17.85 cm^2), diameter at collar region (3.93 cm), plant spread (21.77 cm), length of tap root (6.87 cm), numbers of adventitious roots (59.47), fresh weight (6.817 g), dry weight (1.0005 g), absolute growth rate (1.955 $cm \cdot day^{-1}$), relative growth rate (0.045 $cm \cdot cm^{-1} day^{-1}$) and minimum number of weeks (3 weeks) required for transplanting. The considering overall performance of the different shade intensities, it is concluded that the Chilli seedlings performed better in terms of days required for germination and their growth was found best in 'U' shaped tunnel covered with gunny bags under Konkan agro-climatic condition of Maharashtra State.

Keywords: Chilli seedlings, shade intensities, 'U' shaped tunnel, absolute growth rate

Introduction
The Chilli (*Capsicum annuum* L.) is one of the important solanaceous crops grown as mature green as well as red ripe spice crop for its pungency and fascinating natural color throughout the world. At present, India is the largest producer of Chillies in the world with an annual production of about 1983 '000' MT from an area of 170 thousand hectares (Anonymous, 2015 a) [2]. Andhra Pradesh, Telangana, Karnataka, Maharashtra, Orissa, Rajasthan, Tamil Nadu and West Bengal account for 85.8 per cent of the total area and 89.3 per cent of the total output of Chillies in the country. The total area under Chilli cultivation in Maharashtra is 12.29 thousand hectares with annual production of 127.41 thousand metric tonnes. Thus, the share of Maharashtra is 8.4 per cent in annual production (Anonymous, 2015 b) [3]. The major problem is the variation in crop yields from year to year due to variation in environmental stresses which results as the physiological disorders in plants. Growing crops under protection can contribute to overcome these problems in order to get higher yields of good quality (Singh *et al.*, 1999; Ganesan, 2004) [11, 4]. Among different protected structures; a shade net house are popular one can modify environmental conditions. A simple, economical and user-friendly protective covering vary from, dried coconut leaves, gunny bags, shade netting, and simple film plastics on inverted 'U' shaped structures well fitted with optimum size of nursery raised beds. The shade netting not only decreases light quantity but also alters light quality to a varying extent and might also change other environmental conditions (Shahak *et al*., 2004) [10]. The solanaceous vegetables are first raised in nursery and then transplanted in the open field. However, most of the small and marginal farmers raise the seedlings of these transplanted vegetable under uncontrolled open conditions, which adversely affect the seed germination percentage, less vigour, non-uniform growth, finally do not achieve potential yield in the main field. Under such conditions, intensive care during nursery stage is pre-requisite for quality production. Economical and user-friendly protective covering during nursery stage will be solution for small and marginal farmers to protect vegetable nursery against biotic and abiotic stresses.

In view of these facts, the present study was done to determine the effects of different shade intensities on growth performance of Chilli seedlings under Kokan agro-climatic condition.

Material and Methods

The field experiment was conducted at High-Tech Farm, Department of Horticulture, College of Agriculture, Dapoli, Dist. Ratnagiri (MS) during *rabi-summer* season of 2016 laid out by randomized block design with seven treatments *viz*., T_1-U shaped tunnel covered with 25% shade net, T_2-U shaped tunnel covered with 50% shade net, T_3-U shaped tunnel covered with 75% shade net, T_4-U shaped tunnel covered with LDP paper, T_5-U shaped tunnel covered with coconut leaves, T_6-U shaped tunnel covered with gunny bags and T_7-U shaped tunnel without coverings, which were replicated three times. For the purpose of effect of different shade intensities on growth of Chilli, the variety Pusa Jwala was sown under different shade nets along with control (without coverings). Different climatic parameters – atmospheric temperature, relative humidity, soil temperature; crop growth parameters – days for germination, seedling height, diameter at collar region, number of functional leaves, plant spread, leaf area, length of tap root, number of adventitious roots, fresh and dry weight of the seedling and weeks required for transplanting were measured at different growth stages. The crop growth parameters were recorded at an interval of seven days during the course of study. The diameters at collar region were measured with the help of Vernier Calliper. Leaf area was calculated by using LI 3100 area meter (LI-COR) and was expressed in cm^2. The data were analyzed statistically as per the method suggested by Panse and Sukhatme, 1985 using RBD and valid conclusions were drawn only on significant differences between treatment mean at 0.05% level of significance.

Results and Discussion

The various growth aspects of Chilli seedlings as influenced by different shade intensities under Konkan agro-climatic condition of Maharashtra State have been studied and the results of these findings have been presented in this paper.

Days required for seed germination

The minimum numbers of days (7.33 days) required for seed germination were recorded in the treatment T_4 ('U' shaped tunnel covered with low density polyethylene paper), which was at par with T_6 while, the maximum numbers of days (10.33 days) required for seed germination was observed under T_7 – control (Table 1).

Seedling height (cm)

At fifth week, the highest seedling height was observed in T_6 (32.83 cm) which was significantly differed from rest of the treatments. The lowest was recorded in T_7 (15.15 cm) (Table 1). Significantly, the highest seedling height in T_6 might be due to favorable soil and temperature that attributed to active response of seedlings to diffused sunlight inside the coarse and loosely gunny bag and better utilization of environment inside the growing structure resulting in increase of growth variables including seedling height. This may be attributed to profuse vegetative growth due to higher availability of absorb photo-synthetically active radiation under former shade intensity. Analogous observation to these finding were reported by Aclan and Quisumbing (1976) [1] in ginger. Similar result was also reported by Nair (1999) [6] in coriander.

Number of functional leaves

Significantly the maximum number of functional leaves were reported in the treatment T_6 (16.53), while the minimum in T_7 (9.60) (Table 1). The highest number of functional leaves in T_6 might be due to congenial micro climate around the seedling under 'U' shaped tunnel covered with coarse and loosely gunny bag which increased the number of functional leaves per seedling. These results are in conformity with the research findings of Rylski and Spigelman (1986) [9] in *Capsicum annuum.* Similar results were also noticed by Singh (1997) [12] in okra. However, Nair (1999) [6] reported that 50 per cent shade recorded the maximum growth in respect of number of functional leaves followed by gunny bag.

Leaf area (cm^2)

The maximum leaf area of chilli seedlings were found in treatment T_6 (17.85 cm^2) which was found significantly superior over rest while, the minimum was recorded in T_4 (6.43 cm^2) (Table 1). This might be ascribed to availability of more diffused radiation in coarse and loosely gunny bag which might have led to increased absorption of PAR resulting into higher photosynthesis and accumulation of dry matter in terms of increased leaf area per seedling. This might also be due to leaf physiology and thus increased number of stomata and leaf photosynthesis. Present findings are also in accordance with that of Rylski and Spigelman (1986) [9] those reported in *Capsicum annuum.*

Diameter at collar region (cm)

At the fifth week of sowing, the highest diameter (3.93 cm) at collar region was found in the treatment T_6 which was significantly superior over the rest while, the lowest diameter (1.96 cm) at collar region was found in treatment T_1 (Table 2). This might be due to favorable soil and climatic conditions. However, the result was in contrast to the findings of Thapa *et al.* (2013) [13] in sprouting broccoli and Hindalekar, (2015) [5] in okra.

Plant spread (cm)

Highest plant spread (21.77 cm) was observed in T_6 and was significantly superior to rest of the treatments whereas, the lowest plant spread (12.37 cm) recorded in T_4 (Table 2). This might be attributed to the favorable temperature for enhancing leaf expansion and consequently increasing the plant spread. Present findings are also in accordance with that of Nair (1999) [6] in coriander crop.

Length of tap root (cm)

The treatment T_6 recorded the highest tap root length (6.87 cm), which was significantly superior over all the treatments whereas, the lowest tap root length (3.19 cm) was observed in T_4 (Table 2). As soil provides nutrients with good water holding capacity and drains of excess water and coarse and loosely gunny bag provide congenial micro-climate might have supported maximum length of tap roots. Similar results were reported by Renuka (2015) [8] and Thomas *et al.* (2003) [14] in carnation.

Number of adventitious roots

The maximum numbers of adventitious roots were observed in T_6 (59.47), while the minimum was observed in T_5 (34.27). The treatment T_6 recorded maximum number of adventitious roots (Table 3); it might be due to favorable micro-climate with combination of soil might have provided suitable environment for development of more number of adventitious

roots. Contradictory finding was reported by Renuka, (2015) [8] in carnation.

Fresh weight of seedling (g)

The highest fresh weight of seedlings was found in T_6 (6.817 g) whereas, the lowest was found in treatment T_4 (2.952 g) (Table 3). This might be due to more vigor of Chilli seedling in terms of seedling height, leaf area and other growth parameters under study. Further, congenial micro-climate developed under coarse and loosely gunny bag shade might have resulted better photo-synthetically active radiation, light use efficiency and photosynthetic rate contributed to better fresh weight of seedling. Similar results were obtained by Nair (1999) [6] in coriander crop.

Dry weight of seedling (g)

The treatment T_6 recorded the highest dry weight (1.0005 g) of chilli seedlings, which was significantly superior over all the treatments. The lowest dry weight (0.3668 g) was observed in T_4 (Table 3). It might be due to congenial micro-climate developed under coarse and loosely gunny bag shade helps for more absorbed photo synthetically active radiation, light use efficiency and photosynthetic rate, which had resulted into significant improvement in dry matter production in chilli seedlings. Similar results were obtained by Nair (1999) [6] in coriander crop.

Absolute growth rate (AGR) (cm·day^{-1})

Mean values of absolute growth rate based on plant height obtained at various crop growth stages during the crop period are illustrated in Fig.1. Highest absolute growth rate of Chilli seedlings were observed in T_1 (1.955 cm·day^{-1}), while that of the lowest absolute growth rate (0.964 cm·day^{-1}) was recorded in T_7 (control). The figure illustrated that AGR based on plant height was minimum between 0-3rd weeks after sowing and thereafter it was increased gradually.

Relative growth rate (RGR) (cm·cm^{-1}day^{-1})

Data computed on mean relative growth rate at various crop growth stages are illustrated in Fig.2. Highest relative growth rate of Chilli seedlings were found in T_1 (0.041 cm·cm^{-1}day^{-1}), while the lowest was in treatment T_6 (0.021 cm·cm^{-1}day^{-1}). The figure illustrated that RGR was very slow during 0-2rd weeks after sowing and then after increased gradually.

Weeks required for transplanting

The growth performance of Chilli seedling was also found satisfactory in the treatment T_6 followed by T_1. The treatment T_4 showed the least performance followed by T_7 (Table 1). Variation in weeks required for transplanting in Chilli might be due to variation in soil temperature and other growth related environmental factors under different shade intensities.

Table 1: Effect of different shade intensities on days required for seed germination, no. of weeks required for transplanting, seedling height (cm), no. of functional leaves and leaf area (cm^2) of the chilli seedling

Treatments	Days required for seed germination	No. of weeks required for transplanting	Seedling height (cm) After period of sowing						Number of functional leaves After period of sowing					Leaf area (cm^2) After period of sowing			
			1st week	2nd week	3rd week	4th week	5th week	1st week	2nd week	3rd week	4th week	5th week	1st week	2nd week	3rd week	4th week	5th week
T_1	9.33	4	2.55	6.01	9.21	15.76	29.45	3.87	5.20	5.40	11.07	12.20	0.55	2.55	5.47	10.11	15.58
T_2	8.33	3	2.53	4.94	10.56	16.77	27.61	4.73	4.87	6.00	9.33	10.67	0.56	1.57	8.46	6.54	13.09
T_3	8.66	4	2.49	2.68	8.55	16.96	26.32	3.47	5.00	5.13	8.73	10.00	0.53	3.89	6.74	9.05	14.56
T_4	7.33	4	2.53	3.88	6.68	10.37	17.95	3.60	4.80	5.60	10.00	11.47	0.53	0.70	2.50	4.27	6.43
T_5	9.66	4	2.55	4.33	6.22	11.85	20.29	4.33	6.27	6.40	11.80	13.80	0.56	1.44	4.18	8.67	9.21
T_6	7.66	3	2.50	5.45	11.32	23.33	32.83	3.20	5.60	7.20	14.80	16.53	0.53	2.09	11.52	15.01	17.85
T_7	10.33	5	2.44	2.46	7.17	8.40	15.15	3.07	4.53	4.80	8.87	9.60	0.52	0.94	3.11	3.18	7.64
Range	7.33-10.33	3 – 5	2.44-2.55	2.46-6.01	6.22-11.32	8.40-23.33	15.15-32.83	3.07-4.73	4.53-6.27	4.80-7.20	8.73-14.80	9.60-16.53	0.52-0.56	0.70-3.89	2.50-11.52	3.18-15.01	6.43-17.85
Mean	8.76	3.85	2.51	4.25	8.53	14.78	24.23	3.75	5.18	5.79	10.66	12.04	0.54	1.88	6.00	8.12	12.05
Result	SIG	-	NS	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	NS	SIG	SIG	SIG	SIG
S.Em ±	0.53	-	0.04	0.11	0.06	1.26	0.28	0.10	0.18	0.15	0.25	0.36	0.01	0.02	0.06	0.15	0.30
CD @ 5%	1.65	-	0.12	0.33	0.19	3.88	0.86	0.30	0.54	0.46	0.77	1.11	0.04	0.07	0.19	0.47	0.92

Table 2: Effect of different shade intensities on diameter at collar region (cm), plant spread (cm) and length of the tap root (cm) of chilli seedling

Treatments	Diameter at collar region (cm) After period of sowing					Plant spread (cm) After period of sowing					Length of the tap root (cm) After period of sowing				
	1st week	2nd week	3rd week	4th week	5th week	1st week	2nd week	3rd week	4th week	5th week	1st week	2nd week	3rd week	4th week	5th week
T_1	0.38	0.85	1.67	1.54	1.96	2.93	6.53	8.67	13.63	19.44	2.13	2.25	2.33	5.06	5.31
T_2	0.47	0.94	1.76	2.48	2.74	3.23	5.28	7.55	14.51	20.50	1.66	1.67	2.77	5.74	5.79
T_3	0.34	0.72	1.44	1.33	2.44	2.26	3.97	9.66	12.42	18.16	1.52	2.90	2.51	4.18	4.41
T_4	0.28	0.57	1.15	1.39	2.33	1.94	3.26	4.91	11.51	12.37	1.34	1.55	1.82	3.01	3.19
T_5	0.29	0.68	1.54	1.90	2.62	2.14	4.73	6.03	6.86	15.86	1.44	1.63	1.70	3.33	4.91
T_6	0.32	0.72	1.85	2.65	3.93	2.50	5.47	10.59	16.91	21.77	1.70	2.42	3.53	6.35	6.87
T_7	0.25	0.49	1.26	1.85	2.53	1.76	4.92	5.54	7.49	14.83	1.56	2.46	1.92	4.82	3.85
Range	0.25-0.47	0.49-0.94	1.15-1.85	1.33-2.65	1.96-3.93	1.76-3.23	3.26-6.53	4.91-10.59	6.86-16.91	12.37-21.77	1.34-2.13	1.55-2.90	1.70-3.53	3.01-6.35	3.19-6.87
Mean	0.33	0.71	1.52	1.88	2.65	2.40	4.88	7.56	11.90	17.56	1.62	2.13	2.37	4.64	4.90
Result	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.Em ±	0.002	0.003	0.006	0.009	0.010	0.04	0.01	0.01	0.01	0.17	0.02	0.04	0.03	0.07	0.06
CD @ 5%	0.005	0.008	0.020	0.027	0.032	0.14	0.04	0.04	0.03	0.52	0.06	0.11	0.10	0.21	0.19

Table 3: Effect of different shade intensities on number of adventitious roots, fresh weight (g) and dry weight (g) of the chilli seedling var. Pusa Jwala

Treatments	Number of adventitious roots After period of sowing						Fresh weight (g) After period of sowing					Dry weight (g) After period of sowing				
	1st week	2nd week	3rd week	4th week	5th week	1st week	2nd week	3rd week	4th week	5th week	1st week	2nd week	3rd week	4th week	5th week
T_1	4.00	5.40	20.27	47.27	56.40	0.052	0.329	0.587	1.661	6.317	0.0213	0.0624	0.1153	0.2412	0.9135
T_2	3.40	6.60	22.40	43.07	53.67	0.052	0.245	0.713	2.042	4.313	0.0215	0.0995	0.1311	0.6429	0.6908
T_3	3.00	9.47	14.33	40.53	51.93	0.053	0.215	0.465	1.366	5.157	0.0213	0.0865	0.0893	0.2018	0.7555
T_4	2.80	4.60	4.87	26.73	46.07	0.053	0.121	0.355	1.074	2.953	0.0209	0.0423	0.0686	0.1531	0.3668
T_5	2.13	4.40	7.07	21.47	34.27	0.055	0.099	0.241	0.829	3.284	0.0213	0.0320	0.0485	0.1250	0.4193
T_6	3.80	6.80	24.80	51.53	59.47	0.055	0.235	0.744	3.637	6.817	0.0222	0.0774	0.1558	0.9203	1.0005
T_7	2.53	3.60	5.47	32.00	39.13	0.053	0.042	0.091	0.769	3.395	0.0211	0.0335	0.0257	0.0971	0.5451
Range	2.13-4.00	3.60-9.47	4.87-24.80	21.47-51.53	34.27-59.47	0.052-0.055	0.042-0.032	0.091-0.744	0.769-3.637	2.952-6.817	0.0209-0.0222	0.0320-0.0995	0.0257-0.1153	0.0971-0.9203	0.3668-1.0005
Mean	3.10	5.84	14.17	37.51	48.70	0.053	0.184	0.457	1.625	4.605	0.0214	0.0619	0.0906	0.3402	0.6702
Result	SIG	SIG	SIG	SIG	SIG	NS	SIG	SIG	SIG	SIG	NS	SIG	SIG	SIG	SIG
S.Em ±	0.13	0.34	0.62	0.99	1.27	0.001	0.005	0.010	0.012	0.012	0.0005	0.0006	0.0014	0.0193	0.0094
CD @ 5%	0.41	1.05	1.90	3.05	3.91	0.002	0.014	0.029	0.037	0.038	0.0017	0.0017	0.0044	0.0596	0.0289

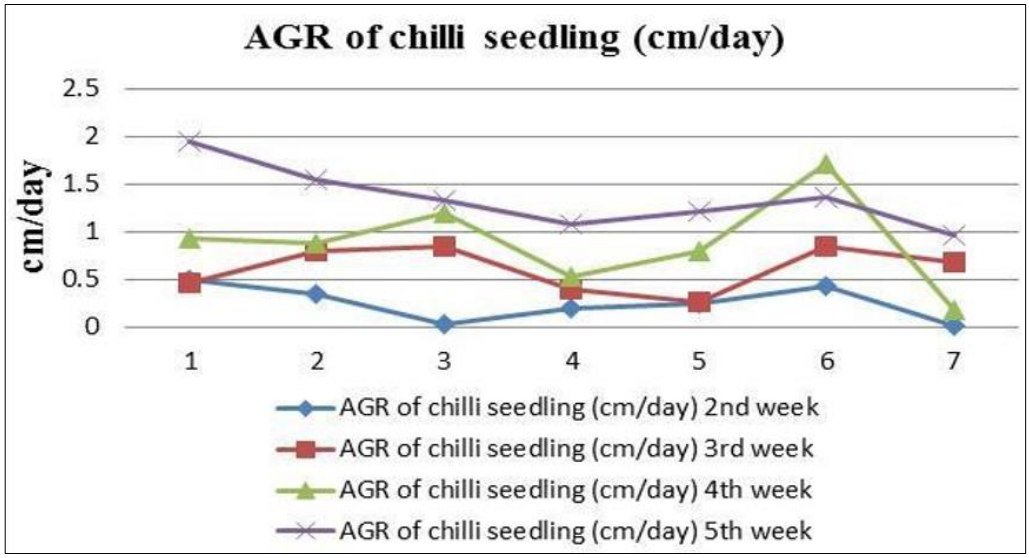

Fig 1: Influence of different shade intensities on Absolute growth rate ($cm \cdot day^{-1}$) of the chilli seedling

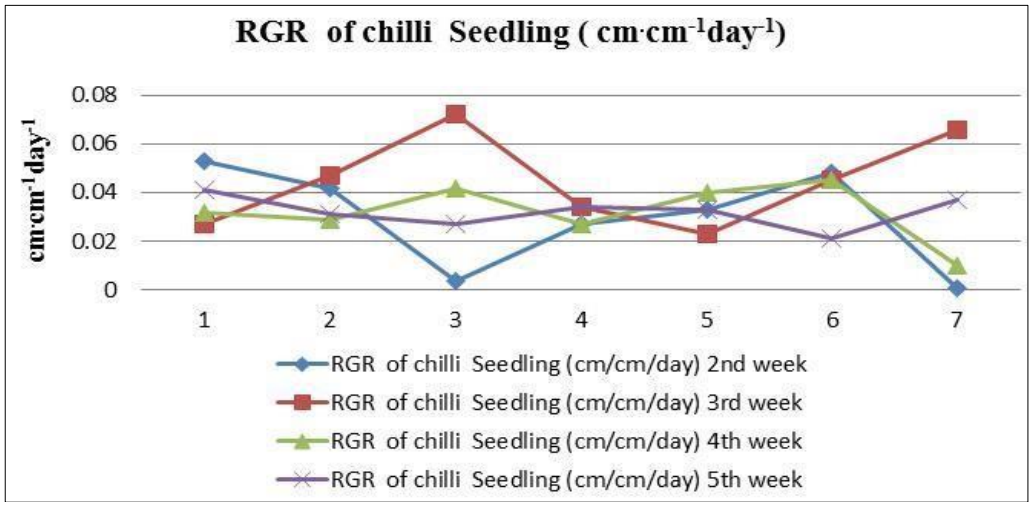

Fig 2: Influence of different shade intensities on Relative growth rate ($cm \cdot cm^{-1} day^{-1}$) of the chilli seedling

Conclusion

Considering the overall performance of different shade intensities, it can be concluded that the growth performance of chilli seedling was found best in shade intensities treatment of 'U' shaped tunnel covered with gunny bag with minimum weeks required to attain the stage of transplanting.

Thus, the 'U' shaped tunnel covered with gunny bag gave the optimum shade intensities during *rabi-summer* season under Konkan agro-climatic condition.

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