Journal of Tropical Agriculture 40 (2002): 67-70

SHADE RESPONSE OF UPLAND RICE CULTIVARS *(ORYZA SATIVA* L.) AS INFLUENCED BY SILICA APPLICATION

Intercropping rice with other upland crops is a viable alternative. Many scientists have reported the possibility of intercropping rice with other crops. Study conducted by the Kerala Agricultural University revealed the possibility of raising rice in coconut garden (KAU, 1984).

Rice is a known silicon (Si) accumulator. Several beneficial effects have been attributed to silicon in the physiology of the rice plant. It is found that silicon gets deposited on the cell walls of the stem, thereby increases culm strength and prevents the tendency to lodge. The increase in silicon content of the cells also results in increased resistance of the plant to the attack of pests and diseases. Further more silicon is said to regulate the rate of transpiration, thereby enable the plant to withstand drought conditions better. Since upland cultivars are more susceptible to lodging and drought situations, the role of silicon, which imparts resistance to lodging and tolerance to water stress, has to be assessed.

In the present investigation, a field experiment was conducted at the College of Agriculture, Trivandrum in kharif season to study the effect of varying intensities of solar radiation and different levels of silica on the yield and yield attributes in upland rice; to assess the suitability of different rice cultivars for shaded upland situation; to study the effect of silica on growth and productivity of upland rice; and to study the impact of silica on upland rice in shaded situation.

The treatments included three shade levels (0, 20 and 40 per cent), two levels of silica (no silica and 100 kg ha^{-1} silica) and four varieties (Swarnaprabha, A4-4-2, A4-1-3 and Mattatriveni). Shade was imposed by using shade nets of appropriate shade levels and silica was applied as sodium silicate. In order to compensate the effect of sodium in sodium silicate, sodium carbonate was applied in other plots on equivalent basis. The experiment was laid out in split-split plot design with shade levels allotted in main plots, silica levels in subplots and rice cultivars in sub-subplots; the number of replications was three. Observations like total grain yield, straw yield, length of panicle, weight of panicle and other yield contributing characters like number of productive tillers per hill, number of grains per panicle, number of filled grains per panicle and 1000-grain weight were taken. For assessing the role of silica in preventing lodging, culm strength was measured by employing the procedure of Atkins (1938).

Effect of solar radiation on upland rice

Results of this study revealed significant influence of solar radiation on the productivity of upland rice (Table 1). Maximum grain yield was realized under open situation. A reduction in grain yield was observed with the increase in shade level (reduction in the intensity of solar radiation). Grain yield was significantly reduced by 41 and 80 per cent at 20 and 40 per cent shade levels, respectively (Table 1). This reduction in grain yield with increase in shade level is the direct reflection of the inhibitory effect of shade on various growth and yield attributes of upland rice. The results of this study corroborate with the findings of Viji (1995), in the study conducted at Coimbatore, which showed a significant decrease in grain yield in rice cultivars with the increase in shade level.

Growing the plants at 20 per cent shade level resulted in a significant reduction in various yield attributes as compared to that of open situation (Table 1). About 7 per cent reduction was observed in the number of filled grains per panicle compared to 0 per cent shade level and this has resulted in an increase in the percentage of chaff at this level of shade. Chaff content increased by 19 per cent compared to open situation (Table 1). Thangaraj and Sivasubramanian (1990) and Viji (1995) reported enhanced spikelet sterility under low light situation.

At forty per cent shade level also a more or less similar response was observed. But the extent of reduction in growth and yield attributes was much higher than that observed at 20 per cent shade level (Table 1). Similar reduction in the

Table 1. Effect of shade and silica levels on yield and yield attributes of upland rice cultivars and performance of rice cultivars in upland situation

Treatments	Grain yield, kg ha^{-1}	Length of panicle, cm	Weight of panicle, g	No. of productive tillers hill^{-1}	No. of spikelets panicle^{-1}	No. of filled grains panicle^{-1}	1000-grain weight, kg ha^{-1}	Chaff percentage
0 % shade	2763	22.6	2.66	6.2	120.2	97.6	24.66	21.76
20 % shade	1641	23.2	2.53	5.5	118.2	90.4	24.85	24.25
40 % shade	568	21.5	1.83	3.2	96.9	70.4	22.03	28.89
SE	27.24	0.31	0.07	0.39	1.49	1.74	0.31	0.51
CD (0.05)	106.95	1.21	0.28	1.52	5.84	6.83	1.22	2.02
No SiO_2	1495	22.1	2.23	5.0	107.0	81.8	23.98	26.11
SiO_2 100 kg ha^{-1}	1820	22.8	2.45	4.9	116.5	90.4	23.72	23.81
SE	34.82	0.29	0.06	0.24	1.61	1.73	0.30	0.59
CD (0.05)	109.72	NS	0.18	NS	5.02	5.45	NS	1.86
Swarnaprabha	1534	22.9	2.35	4.5	116.2	87.6	23.70	29.71
A4-4-2	1793	22.5	2.30	5.0	108.7	82.4	23.81	24.86
A4-1-3	1598	21.8	2.40	4.8	110.9	87.2	24.77	20.55
Mattatriveni	1705	22.6	2.31	5.6	111.3	87.3	23.11	24.75
SE	55.65	0.36	0.08	0.24	3.45	2.71	0.37	1.14
CD (0.05)	158.57	1.03	NS	0.69	NS	NS	1.05	3.24

Table 2. Effect of shade and silica levels on straw yield and growth parameters of upland rice cultivars and performance of rice cultivars in upland situation

Treatments	Straw yield, kg ha^{-1}	Height of plant at harvest, cm	No. of tillers hill^{-1} at harvest	Culm strength, mg cm^{-1}	Harvest index
0 % shade	4107	81.9	7.3	35.10	0.311
20 % shade	4585	109.6	6.4	27.17	0.308
40 % shade	2723	96.7	4.7	18.29	0.222
SE	156.17	1.31	0.38	0.90	0.010
CD (0.05)	613.11	5.14	1.51	3.51	0.040
No SiO_2	3576	94.9	5.9	26.62	0.250
SiO_2 100 kg ha^{-1}	4034	97.2	6.3	27.08	0.311
SE	158.52	0.83	0.27	0.64	0.011
CD (0.05)	499.48	2.21	NS	NS	0.034
Swarnaprabha	4384	108.7	5.7	25.98	0.234
A4-4-2	3401	83.2	6.3	25.63	0.302
A4-1-3	3764	98.0	5.8	28.15	0.290
Mattatriveni	3672	94.5	6.6	27.65	0.295
SE	170.29	1.72	0.30	0.83	0.014
CD (0.05)	485.26	4.89	NS	2.36	0.040

productivity under low light intensity has been earlier reported by Vijayalekshmi *et al.* (1987), Thangaraj and Sivasubramanian (1990) and Viji (1995).

The effect of shade on straw yield was also significant, but the trend was not in line with that of grain yield (Table 2). Straw yields recorded at 0 and 20 per cent shade levels were on par,

but at 40 per cent shade level a significant reduction in straw yield as compared to open situation was noticed. The similar effect on straw yield at 0 and 20 per cent shade levels could be explained by evaluating the influence on plant height, culm strength and other growth attributes. Lincy (1986) has reported a 14 per cent increase in straw yield in maize grown under partial shade situation. The culm strength was reduced by 23 per cent at 20 per cent shade level.

Performance of rice cultivars in upland situation

Significant difference in the performance of rice varieties was observed in upland situation. The rice cultivar A4-4-2 recorded maximum grain yield of 1.8 t ha^{-1}, which was on par with Mattatriveni, which were significantly superior to the other rice cultivars (Table 1). The better performance of Mattatriveni and A4-4-2 was mainly due to the higher number of productive tillers and the increase in panicle length observed in these varieties. The number of productive tillers per hill in these varieties was about 14 per cent higher than that recorded in Swarnaprabha and A4-1-3.

Maximum straw yield was observed in Swarnaprabha, which was significantly superior to all the other three cultivars, which themselves were statistically similar in this character (Table 2). This better straw yield recorded in Swarnaprabha is mainly due to the tall nature of this particular cultivar, which recorded a height of 110 cm at the time of harvest, which was significantly superior to all other cultivars in this character and the height ranged from 83 to 98 cm. But this superiority of Swarnaprabha, in straw yield, was not reflected in grain yield, which indicates poor translocation of photosynthates from source to sink in this cultivar, which in turn is evident from the higher percentage of chaff and lower harvest index recorded in this cultivar.

The cultivar A4-4-2, which produced maximum grain yield and the lowest straw yield was found to have the higher grain:straw ratio i.e. higher harvest index. The dwarf nature of A4-4-2 with better translocation of photosynthates might have resulted in this.

Effect of silicon nutrition on upland rice

Result of this study revealed significant influence of silica on upland rice. Both grain and straw yields increased significantly with the application of silica. It is found that silicon gets deposited in the cell wall of the stem and thereby increases culm strength and also imparts increased resistance to the incidence of pests and diseases. In this study also a favourable increase in culm strength (1.7 per cent) was observed with silicon nutrition. Silica application resulted in an increase in the number of spikelets per panicle (9 per cent), filled grains per panicle (10.5 per cent) and panicle weight (10 per cent) (Table 1). This superiority in yield contributing characters might be due to better translocation of assimilates, as evidenced from better harvest index (24 per cent increase as compared to control). Miyoshi and Ishii (1960) reported better translocation of photosynthates from straw to earhead by the application of silica. Better filling of grains by the application of silica was earlier reported by Vijayakumar (1977) who found an increase in thousand-grain weight by the application of silica.

This significant increase might be the cumulative effect of better spikelet number per panicle ($r = 0.509$), filled grains per panicle ($r = 0.622$) and weight of panicle ($r = 0.610$). Straw yield also increased significantly by 18 per cent with the addition of silica. The study also reveals the possibility of enhancing productivity of upland rice by applying SiO_2 @ 100 kg ha^{-1}.

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REFERENCES

Atkins, I. M. 1938. Studies on lodging in cereals. *J. Am. Soc. Agron.* 30 : 309

KAU. 1984. *Annual Research Report 1983-1984.* Kerala Agricultural University, Thrissur, 641p

Lincy, X. 1986. Response of maize varieties to graded levels of nitrogen grown under open and partial shade conditions. M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, 137p

Miyoshi, H. and Ishii, H. 1960. Effect of silicic acid and silicic slag on paddy rice: IV. Effect of silicic acid on P metabolism of paddy rice. *J. Sci. Soil Tokyo* 31: 146-148

Thangaraj, M. and Sivasubramanian, V. 1990. Effect of low light intensity on growth and productivity of irrigated rice (Oryza *sativa* L.) grown in Cauvery delta region. *Madras agric. J.* 77: 220-224

Vijayakumar, K. 1977. Use of indigenous source of magnesium silicate as a soil amendment. M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, p. 78

Vijayalakshmi, C., Natarajarathinam, N. and Sreerangasamy, S. R. 1987. Effect of light stress on yield attributes in rice. *Madras agric. J.* 74: 550-512

Viji, M. M. 1995. Molecular, physiological and biochemical aspects of low light stress tolerance in rice (*Oryza sativa* L.). Ph.D. thesis, TNAU, Coimbatore, p. 198