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Research Paper

Phenology, growth and productivity of rice (*Oryza sativa* l.) under reduced sunlight intensity and foliar nitrogen application

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ABSTRACT

The field experiments related to the study were conducted at Punjab Agricultural University, Ludhiana and Krishi Vigyan Kendra, Bahowal. There were 20 treatment combinations comprising of four levels of sunlight intensity [control (full sunlight), 50% reduction in sunlight light intensity during 15-45(R_{15-45}), 46-75(R_{46-75}) and 76-105(R_{76-105}) DAT] and five levels of foliar nitrogen application [control (only recommended nitrogen, no foliar spray), spray of 3% urea before (N_B), midway(N_M), afterwards(N_A) and midway-afterwards(N_{MA}) the reduction in sunlight intensity in addition to the recommended nitrogen application]. Radiation level of R_{15-45} significantly preponed (2-5 days) the occurrence of phenological stages from maximum tillering to physiological maturity. Similarly, R_{46-75} significantly preponed (3-9 days) the occurrences of flag leaf initiation to physiological maturity. The nitrogen level of N_B, significantly delayed the occurrence of flag leaf initiation to physiological maturity stages (2-5 days), N_M delayed flag leaf initiation to physiological maturity (2-4 days), N_A delayed anthesis to physiological maturity (1-4 days) and N_{MA} delayed panicle emergence to physiological maturity (2-5 days). Plant height of rice was significantly increased due to R_{15-45} (5.21-5.26%) and R_{46-75} (6.95-7.61%) and also with foliar nitrogen application levels of N_B, N_M, N_A and N_{MA} by 9.95-9.89, 9.65-10.06, 8.06-7.57 and 9.65-9.29 per cent, respectively. Number of tillers m^{-2} was significantly reduced (4.71-15.99%) under low light conditions and was increased (5.59-23.34%) with foliar nitrogen application. Yield attributes were affected by the reduced sunlight intensity and foliar nitrogen application. Grain yield was significantly reduced as a result of R_{15-45} (9.19-11.41%), R_{46-75} (14.29-16.35%) and R_{76-105} (8.15-10.67%) and foliar nitrogen application levels of N_B, N_M and N_{MA} resulted in significant increase the grain yield by 9.32-10.19, 5.74-6.38 and 4.59-5.74 per cent respectively, as compared to control.

***Key words*:** Rice, growth, yield, sunlight intensity, nitrogen

Rice (*Oryza sativa* L.) is the most important cereal crop in India as well as in Punjab. Yearly variation in crop growth and yield is mainly due to the weather variability (Banerjee *et al.,* 2018). Rice is mainly grown as a rainy season crop in the southeast Asia, and is, therefore, often exposed to reduced sunlight intensity during its life cycle. Low light stress has emerged as a major constraint for rice production in some of the rice-growing regions, especially in southeast. Asia and China In several south Asian countries including India, most of the rice (around 80%) is grown during the monsoon season, when light intensity is about 40-60% less as compared to dry season (Panda *et al.,* 2019). Moreover, during the *kharif* season in Punjab, a decrease in the duration of bright sunshine hours at the rate of 0.04 hr $year^{-1}$ had been observed at Ballowal Saunkhri as well as Ludhiana. A significant positive correlation of solar radiation with the grain yield of rice was reported by many studies, such as during the vegetative phase (Karuna and Dhaliwal, 2020), vegetative phase and the entire growing season (Sandhu *et al.,* 2013), during the reproductive phase (Sun *et al.,* 2012), during the ripening phase (Chen *et al.,* 2019) or during both reproductive and ripening phases (Nagarajan *et al.,* 2010). Photosynthetic rate is reduced under low light conditions which leads to reduced tiller number during the vegetative phase, increased male sterility at the time of flowering and reduced starch accumulation during the grain filling stage resulting in poor rice yield and quality (Liu *et al.,* 2014).

Nitrogen (N) is an important nutrient, which is applied in most of the rice-producing areas and its application during different

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growth stages is well documented. The radiation interception by the canopy is increased by increasing the tiller number, which can be increased by nitrogen application and top dressing of nitrogen at tillering stage (San-oh *et al.*, 2002).

Thus, it is evident that reduced sunlight intensity affects performance of rice. The information on foliar nitrogen application to rice as a strategy to mitigate the harmful effects of reduced sunlight intensity is lacking in literature. Therefore, a study was planned to quantify the effects of reduced sunlight intensity on the performance of rice and secondly to evaluate the role of foliar nitrogen application in alleviating the harmful effects of reduced sunlight intensity in rice.

MATERIAL AND METHODS

A multilocation field experiment was conducted at Punjab Agricultural University (PAU), Ludhiana (30°54' N latitude and 75°48' E longitude and 247 m above mean sea level) and Krishi Vigyan Kendra (KVK), Bahowal (31°31' N latitude and 75°54' E longitude and 296 m above the mean sea level), district Hoshiarpur. These sites are situated in two different agro-climatic zones of Punjab, i.e. Ludhiana in the central plain zone and Bahowal in sub-mountain undulating zone.

The soil of the experimental fields was loamy sand in texture and normal in reaction at both the locations. The organic carbon, available nitrogen, available phosphorus, available potassium, EC and pH of 0-15 cm layer of soil was 0.44%, 302.9 kg ha^{-1}, 20.4 kg ha^{-1}, 169.4 kg ha^{-1}, 0.21 dS m^{-1} and 6.6 at Ludhiana and 0.84%, 489.3 kg ha^{-1}, 15.5 kg ha^{-1}, 155.0 kg ha^{-1}, 0.51 dS m^{-1} and 7.8 at Bahowal, respectively. Thus, the soil was medium in organic carbon and available nitrogen at Ludhiana and high in organic carbon and available nitrogen at Bahowal and medium in available phosphorus and potassium at both the locations.

The nursery (variety PR 122) was sown on 23rd and 25th May 2019 at Ludhiana and Bahowal, respectively. The 30 days old seedlings were transplanted at a spacing of 20 x15 cm on 24th and 26th June 2019 at Ludhiana and Bahowal, respectively. The doses of fertilizers as recommended by PAU, Ludhiana were applied at the rate 105 kg N ha^{-1} for medium fertility soil at Ludhiana and 78.75 kg N ha^{-1} for high fertility soil at Bahowal. 30 kg P_2O_5 ha^{-1}, 30 kg ha^{-1} K_2O and 40 kg ha^{-1} of zinc sulphate monohydrate were applied at both the locations. All the agronomic practices recommended by PAU, Ludhiana were followed during experimentation.

The experiment was conducted in randomized block design with three replications. Sunlight intensity was reduced by covering the plots from top (leaving the sides open) with green shade net capable of reducing 50% of sunlight intensity. The treatments comprised of four levels of sunlight intensity: full sun light intensity (Control), 50% reduction in sunlight intensity during 15-45 (R_{15-45}), 46-75 (R_{46-75}) and 76-105 (R_{76-105}) DAT (days after transplanting) and five levels of foliar N application [Control (only recommended nitrogen, no foliar spray), spray of 3% urea before (N_B), midway (N_M), afterwards (N_A) and midway & afterwards (N_{MA}) the reduction in sunlight in addition to the recommended nitrogen application]. The PAR (photosynthetically active radiation) was measured with Line quantum sensor (Apogee Instrument) at 15 days interval from top of the canopy. The measurements were done from control (full sunlight) as well as from the plots covered with green shade net capable of reducing the PAR by 50 per cent. Average values of PAR above the respective plots were calculated and presented in Table 1.

RESULTS AND DISCUSSION

Intensity of photosynthetically active radiation

It is evident that, covering the plots with green shade net resulted in almost 50% reduction in incident PAR (Table 1). The reduction in PAR was only for a period of 30 days and during these days PAR values in plots covered with green shade net was about 50% of that under open conditions. Before and after the period of the 30 days the plots received same PAR as received by the uncovered plots.

Crop phenology

At Ludhiana (Table 2), averaged over nitrogen levels the rice crop took 146 days to reach physiological maturity stage under full sunlight conditions. The physiological maturity was attained in 5 and 9 days earlier as compared to full sunlight, as a result of reduction in sunlight under R_{15-45}, and R_{46-75}, respectively. Similarly, averaged over sunlight intensity levels at Ludhiana, rice crop matured in 141, 144, 143, 143 and 144 days under N_0, N_B, N_M, N_A and N_{MA}, respectively (Table 3).

At Bahowal (Table 2), averaged over nitrogen levels the rice crop took 151 days to reach physiological maturity stage under full sunlight conditions. The physiological maturity was attained in 5 and 9 days earlier as compared to control as a result of reduction in sunlight under R_{15-45}, and R_{46-75}, respectively. Similarly, averaged over sunlight intensity levels at Bahowal, rice crop matured in 144, 149, 148, 148 and 149 days under N_0, N_B, N_M, N_A and N_{MA}, respectively (Table 3).

Averaged over nitrogen levels at both locations (Table 2), the R_{15-45}, resulted in statistically significant early occurrence of phenological stages from maximum tillering to physiological maturity stages by 2-5 days as compared to control. Similarly at both locations, the R_{46-75} resulted in statistically significant early occurrence stages from flag leaf initiation to physiological maturity 3-9 days as compared to control (Table 2). The effect of R_{76-105} on occurrence of different phenological stages was found to be statistically non-significant.

At Ludhiana, averaged over sunlight intensity levels, N_B resulted in statistically significant delay in occurrence of phenological stages from flag leaf initiation to physiological maturity by 2-3 days, while N_M delayed the occurrence of these stages by 2 days as compared to the control (Table 3). The N_A resulted in statistically significant delay in occurrence of anthesis, milky and physiological maturity stages by 1, 2 and 2 days, respectively. The N_{MA} resulted in statistically significant delay in occurrence of panicle emergence to physiological maturity stages by 2-3 days.

At Bahowal, averaged over sunlight intensity levels, N_B resulted in statistically significant delay in occurrence of flag

Table 1: Photosynthetically active radiation (µ mol m^{-2} s^{-1}) recorded at both locations

Data recorded at	PAR under unshaded (control) conditions	PAR in plots shaded during 15-45 DAT	PAR in plots shaded during 46-75 DAT	PAR in plots shaded during 76-105 DAT
		Ludhiana		
15 DAT*	1683	781	1671	1695
30 DAT	1660	762	1678	1618
46 DAT	1640	1662	784	1662
60 DAT	1489	1501	703	1485
76 DAT	1330	1310	1329	638
90 DAT	1095	1090	1071	558
105 DAT	1015	1038	1025	514
		Bahowal		
15 DAT	1151	569	1131	1182
30 DAT	796	393	782	773
46 DAT	1411	1459	704	1433
60 DAT	1403	1401	678	1407
76 DAT	1390	1385	1368	688
90 DAT	1128	1134	1129	552
105 DAT	1066	1078	1061	518

*DAT: Days after transplanting

Table 2: Influence of sunlight intensity on days taken to attain different phenological stages from nursery sowing of rice crop

Phenological stages	Ludhiana					Bahowal				
	Sunlight intensity levels				CD (0.05)	Sunlight intensity levels				CD (0.05)
	Control	R_{15-45}	R_{46-75}	R_{76-105}		Control	R_{15-45}	R_{46-75}	R_{76-105}	
Transplanting	30	30	30	30	NS	30	30	30	30	NS
Start tillering	45	45	45	45	NS	45	45	45	45	Ns
Maximum tillering	81	79	80	81	1.33	83	81	82	83	1.09
Flag leaf initiation	85	81	82	85	0.94	87	83	84	87	0.54
Booting	107	102	101	107	1.88	110	105	104	110	2.18
Panicle emergence (50%)	112	107	104	111	2.66	115	110	107	114	2.72
Anthesis	116	111	107	114	2.11	120	115	111	118	2.17
Milky	125	120	116	124	2.82	129	124	120	128	1.80
Soft dough	134	129	125	134	1.44	139	134	130	139	2.83
Hard dough	142	137	133	142	2.37	147	142	138	147	1.88
Physiological maturity	146	141	137	146	1.63	151	146	142	151	2.72

leaf initiation to physiological maturity stages by 2-5 days as compared to control (Table 3). While N_M delayed the occurrence of stages from flag leaf initiation to physiological maturity by 2-4 days as compared to the control. The N_A resulted in statistically significant delay in occurrence of anthesis to physiological maturity by 1-4 days, as compared to control. Similarly, the N_{MA} resulted in statistically significant delay in occurrence of panicle emergence to physiological maturity by 2-5 days.

Plant height

Among the solar radiation levels, the R_{46-75} resulted in maximum plant height (Table 4) and it was significantly higher than that under control and was statistically at par with the plant height under R_{15-45} at both the locations. Nag (2017) also observed an increase in the plant height under the low light as compared to the normal light.

Among nitrogen levels, N_B resulted in maximum plant height and it was statistically at par with all other foliar nitrogen application treatments and was significantly more than control, at both the locations (Table 4). Behera *et al.* (2019) also reported higher plant height under higher doses of nitrogen application.

The relationship between the plant height and sunlight intensity (Table 5) during R_{15-45} and R_{46-75} at Ludhiana within a PAR range of 772-1672 and 744-1565 µ mol m^{-2} s^{-1} and at Bahowal within a PAR range of 481-974 and 691-1407 µ mol m^{-2} s^{-1} was found to be linear and statistically significant, respectively. The plant height got increased by 0.003 and 0.005 cm at Ludhiana and by 0.006 and 0.006 cm at Bahowal in response to decrease in 1 unit of PAR during R_{15-45} and R_{46-75}, respectively.

Table 3: Influence of foliar nitrogen application on days taken to attain different phenological stages from nursery sowing of rice crop

Phenological stages	Ludhiana						Bahowal					
	Nitrogen levels					CD (0.05)	Nitrogen levels					CD (0.05)
	N_0	N_B	N_M	N_A	N_{MA}		N_0	N_B	N_M	N_A	N_{MA}	
Transplanting	30	30	30	30	30	NS	30	30	30	30	30	NS
Start tillering	45	45	45	45	45	NS	45	45	45	45	45	NS
Maximum tillering	80	81	81	80	80	NS	82	83	83	82	82	NS
Flag leaf initiation	82	84	84	83	83	1.15	84	86	86	85	85	1.49
Booting	103	106	105	104	104	1.63	106	109	108	107	107	1.69
Panicle emergence 50%)	107	110	109	108	109	1.82	110	113	112	111	112	1.88
Anthesis	110	113	112	111	112	0.94	114	117	116	115	116	0.81
Milky	119	122	121	121	121	1.24	123	126	125	125	125	1.33
Soft dough	129	132	131	131	131	2.05	132	137	136	136	136	1.62
Hard dough	137	140	139	139	140	2.20	140	145	144	144	145	2.53
Physiological maturity	141	144	143	143	144	0.81	144	149	148	148	149	0.94

Table 4: Effect of sunlight intensity and foliar nitrogen application on plant height and number of tillers m^{-2} of rice at harvest

Treatments	Plant height (cm)		Number of tillers m^{-2}	
	Ludhiana	Bahowal	Ludhiana	Bahowal
Reduced sunlight intensity				
Control	64.06	64.63	349.35	352.13
R_{15-45}	67.40	68.03	321.99	335.55
R_{46-75}	68.51	69.55	293.50	306.80
R_{76-105}	64.95	65.05	328.47	338.89
CD (0.05)	1.39	1.52	28.14	18.55
Foliar nitrogen application				
N_0	61.63	62.21	285.10	300.33
N_B	67.76	68.36	351.64	358.34
N_M	67.58	68.47	343.83	348.92
N_A	66.60	66.92	302.33	317.12
N_{MA}	67.58	67.99	333.74	342.01
CD (0.05)	1.55	1.69	31.46	20.73

Number of tillers m^{-2}

Maximum number of tillers m^{-2} at harvest was observed under full sunlight intensity and it was significantly higher than that produced in R_{46-75} but was statistically at par with number of tillers m^{-2} under R_{15-45} and R_{76-105} at both the locations (Table 4). Reduction in light intensity might have reduced the net photosynthesis resulting in reduced supply of assimilates for tiller emergence and thus the number of tillers decreased.

Among nitrogen levels, N_B resulted in maximum number of tillers m^{-2} and it was statistically at par with those under N_M and N_{MA} at both the locations (Table 4). Behera *et al.* (2019) also reported higher number of tillers $hill^{-1}$ under higher doses of nitrogen as compared to lower doses.

The relationship between the number of tillers m^{-2} at harvest and sunlight intensity (Table 5) during R_{46-75} at Ludhiana and Bahowal was found to be linear and statistically significant within a PAR range of 744-1565 and 691-1407 µ mol m^{-2} s^{-1}, respectively. The reduction in PAR by 1 unit resulted in a reduction in the number of tillers m^{-2} by 0.068 and 0.063 tillers m^{-2} 46-75 DAT at Ludhiana and Bahowal, respectively.

Panicle length

Maximum panicle length was observed under full sunlight and it was significantly higher by 8.8 and 5.3% than that under R_{46-75} at Ludhiana and Bahowal, respectively, but it was statistically at par with panicle length under R_{15-45} and R_{76-105} (Table 6). Ling *et al.* (1994) observed that 20 days before heading stage is the critical stage of panicle initiation and it affects the panicle length to a great extent and in the present study 46-75 DAT corresponded with this period.

The nitrogen level of N_B resulted in the maximum panicle

Table 5: Linear corelation parameters between crop parameters at harvest and PAR during different treatments of reduction in sunlight intensity

Reduced sunlight intensity	Parameter	Plant height (cm)		No of tillers m^{-2}		Panicle length (cm)		Wt. of grains $panicle^{-1}$ (g)		Grain yield (q ha^{-1})	
		LDH	BAH	LDH	BAH	LDH	BAH	LDH	BAH	LDH	BAH
R_{15-45}	Slope	-0.003	-0.006	0.03	0.033	0	0.001	0	0	0.007	0.011
	R^2	0.919	0.796	0.458	0.608	0.372	0.98	0.079	0.178	0.983	0.944
	F-value	17.01	5.85	1.26	2.32	0.89	73.5	0.13	0.32	86.73	25.28
	P	0.02	0.09	0.39	0.24	0.497	0.0028	0.883	0.745	0.0022	0.013
	PAR range*	772-1672	481-974	772-1672	481-974	772-1672	481-974	772-1672	481-974	772-1672	481-974
R_{46-75}	Slope	-0.005	-0.006	0.068	0.063	0.002	0.001	0	0	0.011	0.013
	R^2	0.952	0.883	0.977	0.902	0.889	0.949	0.266	0.473	0.829	0.86
	F-value	29.75	11.32	63.71	13.806	12.01	27.91	0.54	1.35	7.27	9.21
	P	0.01	0.04	0.003	0.03	0.037	0.011	0.628	0.382	0.071	0.052
	PAR range	744-1565	691-1407	744-1565	691-1407	744-1565	691-1407	744-1565	691-1407	744-1565	691-1407
R_{76-105}	Slope	-0.001	0	0.036	0.021	0.001	0	0	0	0.01	0.008
	R^2	0.239	0.047	0.83	0.462	0.361	0.327	0.686	0.795	0.99	0.823
	F-value	0.47	0.07	7.323	1.288	0.85	0.73	3.28	5.82	148.5	6.97
	P	0.66	0.93	0.07	0.39	0.51	0.552	0.175	0.092	0.001	0.074
	PAR range	570-1147	586-1195	570-1147	586-1195	570-1147	586-1195	570-1147	586-1195	570-1147	586-1195

*PAR (µ mol m^{-2} s^{-1}) range used for developing the respective equations

Table 6: Effect of sunlight intensity and foliar nitrogen application on the yield attributes and yield of rice

Treatments	Panicle length (cm)		Weight of grains per panicle (g)		Grain yield (q ha^{-1})	
	Ludhiana	Bahowal	Ludhiana	Bahowal	Ludhiana	Bahowal
Reduced sunlight intensity						
Control	24.75	25.28	3.40	3.60	58.22	62.35
R_{15-45}	24.14	24.68	3.33	3.47	51.58	56.62
R_{46-75}	22.73	23.99	3.21	3.31	48.70	53.44
R_{76-105}	24.06	24.77	3.07	2.90	52.01	57.27
CD (0.05)	0.85	0.64	0.23	0.30	2.63	2.98
Foliar nitrogen application						
N_0	22.79	24.16	2.80	2.95	50.53	55.04
N_B	24.96	25.37	3.59	3.61	55.68	60.17
N_M	24.54	24.81	3.44	3.48	53.43	58.55
N_A	23.39	24.46	3.10	3.15	50.65	55.14
N_{MA}	23.91	24.61	3.33	3.42	52.85	58.20
CD (0.05)	0.96	0.72	0.26	0.34	2.94	3.33

length and it was significantly higher than control by 9.5 and 5.0% at Ludhiana and Bahowal, respectively, and it was statistically at par with the panicle length under N_M (Table 6). This might be due to the beneficial effect of nitrogen on the vegetative growth of rice resulting in increased source leading to an increase in accumulation of photosynthates and transfer to the sink, resulting in increased panicle length.

The relationship between the panicle length and sunlight intensity (Table 5) during R_{46-75} at Ludhiana within a PAR range of 744-1565 µ mol m^{-2} s^{-1} and at Bahowal during R_{15-45} and R_{46-75} within a PAR range of 481-974 and 691-1407 µ mol m^{-2} s^{-1} was found to be linear and statistically significant, respectively. The panicle length at Ludhiana got decreased by 0.002 cm in response to decrease in 1 unit of PAR during R_{46-75} and by 0.001 cm at Bahowal in response to decrease in 1 unit of PAR during both R_{15-45} and R_{46-75}, respectively.

Weight of grains panicle^{-1}

The weight of grains $panicle^{-1}$ is directly related to grain yield of rice. Maximum weight of grains $panicle^{-1}$ was observed under full sunlight intensity and it was significantly higher by 10.75 and 24.14 % as compared to that under R_{76-105}, at Ludhiana and Bahowal respectively, but was statistically at par with weight of grains $panicle^{-1}$ under R_{15-45} and R_{46-75} (Table 6). Reduction in grain weight $panicle^{-1}$ might be attributed to the reduced supply of current photosynthates due to reduction in sunlight intensity. Similar results in rice were also reported by Sandhu *et al* (2012).

At both locations, the N_B resulted in maximum weight of grains panicle^{-1} and it was significantly higher than control and N_A, however, it was statistically at par with N_M and N_{MA} (Table 6). This might be due to the reason than foliar nitrogen application might have increased the photosynthetic rate which might have increased the weight of grains panicle^{-1}.

The relationship between the weight of grains panicle^{-1} and sunlight intensity at both locations was found to be statistically non-significant at 5% level of significance (Table 5).

Grain yield

Grain yield was significantly reduced with reduction in sunlight intensity (Table 6). Full sunlight resulted in highest grain yield and it was significantly higher as compared to all the treatment with reduced sunlight intensity at both the locations. The reduction in sunlight under R_{15-45}, R_{46-75} and R_{76-105} resulted in 11.41, 16.35 and 10.67 per cent reduction in grain yield at Ludhiana and by 9.19, 14.29 and 8.15 per cent at Bahowal, as compared to control, respectively. The foliar nitrogen application levels of N_B, N_M and N_{MA} resulted in an increase in the grain yield at Ludhiana by 10.19, 5.74 and 4.59 per cent and at Bahowal by 9.32, 6.38 and 5.74 per cent as compared to control, respectively. Panda *et al.* (2019) also found a significant reduction in the grain yield in rice under low light stress. Sattar *et al.* (2017) reported that daily bright sunshine hours of 7 to 8 hours during flowering phase is required for higher rice productivity. Kumar *et al*. (2017) also reported from Uttar Pradesh that in rice, an increase in sunshine duration and solar radiation led to an increase in grain yield. Reduction in grain yield might be attributed to the decrease in the number of effective tillers m^{-2}, grain weight and number panicle^{-1}.

Maximum grain yield was observed under N_B and it was significantly higher as compared to control and N_A but was statistically at par with N_M and N_{MA} at both the locations (Table 6). The nitrogen application levels of N_B, N_M and N_{MA} resulted in a significant increase in grain yield by 10.19, 6.38 and 5.74 per cent at Ludhiana and by 9.32, 5.74 and 4.59 per cent at Bahowal as compared to control, respectively. Higher grain yield with foliar application of nitrogen might be due to higher values of growth parameter which might have resulted in higher capture of solar energy and hence led to enhanced values of yield attributing characters, that ultimately resulted in higher grain yield. Similar results were also reported by Behera *et al.* (2019).

The relationship between the grain yield and sunlight intensity during R_{15-45} and R_{76-105} at Ludhiana was found to be linear and statistically significant (p=0.05) within a PAR range of 772-1672 and 570-1147 µ mol m^{-2} s^{-1}, respectively (Table 5). At Ludhiana, the grain yield got decreased by 0.007 and 0.010 q ha^{-1} in response to decrease in 1 unit of PAR during R_{15-45} and R_{76-105}, respectively. At Bahowal, the relationship between the grain yield and sunlight intensity during R_{15-45} was found to be linear and statistically significant (p=0.05) within a PAR range of 481-974 µ mol m^{-2} s^{-1}. At Bahowal, the grain yield got decreased by 0.011 q ha^{-1} in response to decrease in 1 unit of PAR during R_{15-45}.

CONCLUSION

The present study, revealed that reduced sunlight intensity and foliar nitrogen application significantly increased the plant height of rice, whereas, other parameters, i.e. number of tillers m^{-2}, yield attributes including panicle length, number of grains panicle^{-1} and weight of grains panicle^{-1} and grain yield were significantly reduced under low light but were increased with the foliar application of nitrogen. Maximum reduction was caused when the sunlight intensity was reduced during R_{46-75} and in case of foliar application, highest increase was observed when foliar nitrogen was applied before the reduction in the sunlight intensity (N_B). So, the present study revealed that rice productivity is significantly reduced due to reduction in the sunlight intensity and this decrease can be compensated with the foliar application of nitrogen.

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