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THE INFLUENCE OF FERTILIZER NITROGEN AND BLUE-GREEN ALGAE ON GROWTH AND YIELD OF RICE (*ORYZA SATIVA* L.) UNDER DIFFERENT SOIL MOISTURE REGIMES*

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It is well known that nitrogen is limiting among the plant nutrients in the rice soils of India and at the same time the most needed nutrient for successful crop production. Nitrogen fertilizers are the largest and costly fossil energy dependent input in agricultural production. There exists a widening gap between supply and demand of nitrogen fertilizers. Biological nitrogen fixation through the inoculation of blue-green algae has been found to be a cheap and efficient technology assuming importance in tropical rice fields. Experiments in general have revealed that an increase in bound nitrogen occurs in water-logged soils containing abundant blue-green algal bloom which are capable of supplementing upto 30 kg/ha of the nitrogen requirement of rice (Venkataraman, 1973J. However, the performance of blue-green algae in combination with water and fertilizer, the two costly inputs in rice production, has not been properly investigated. Hence, the present study was taken up to determine the influence of fertilizer nitrogen and blue-green aigae on growth and yield of rice under different soil moisture regimes.

Materials and Methods

The field experiment was conducted for two consecutive Kharif seasons (June to October) of 1978 and 1979 at the Indian Agricultural Research Institute, New Delhi. The soil of the experimental plot was loam in texture with moderate water holding capacity, bulk density ranging from 1.51 to 1.54 g/cm^3 and almost neutral in reaction. The organic carbon and total nitrogen contents were low and available phosphorus and potassium were medium. The saturated hydraulic conductivity (K) of unpuddled surface soil was 191 mm per day. The experiment was laid out in a split plot design with four replications. There were 12 main plot treatments and two sub-plot treatments Combinations of three soil moisture regimes viz., I_1 = saturation to 0.3 bar tension at 15 cm soil depth throughout (alternate wetting and drying), I_2 = submergence (5 cm) to saturation from tillering (45th day) to flowering and saturation to 0.3 bar tension at 15 cm soil depth during the remaining period (partial submergence) and I_3 = submergence (5 cm) to saturation throughout (continuous submergence) and four levels of nitrogen (0, 30, 60 and 90 kg N/ha) were assigned to the main plots and two levels of algae (without algal inoculation and with algal inoculation @ 10 kg/ha of soil based culture) were allotted to the sub-plots. Nitrogen was applied through urea (46% N) in

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three split doses (50 per cent as basal and the remaining was given in two equal doses at 15 and 40 days after transplanting). A uniform dose of 40 kg each of P_2O_5 and K_2O per hectare was applied at the time of final field preparation. The mixed culture of algae contained five species viz., *Aulosira fertilissima, JolypQthrix tenuis, Nostoc* sp, *Anabaena* sp. and *Plectonema* sp. The algal culture was thoroughly mixed with water and the suspension was uniformly sprinkled in the plots on the seventh day of planting after maintaining 5 cm of standing water. Twenty five to twenty six day old seedlings of rice variety Pusa 2-21 were transplanted at a spacing of 15 cm x 15 cm at the rate of two seedlings per hill.

The rainfall during the crop season from July to October was [illegible]11.2 mm in 1978 and 262.4 mm in 1979. The mean air temperature ranged between 14.2 and 35.5 during 1978 and between 15.6 and 38.3 during 1979. The water table varied between 17.2cm to 177.5 cm during 1978 and between 143.6 cm to 230.2cm during 1979 from ground surface.

Results and Discussion

The 1979 crop season as compared to 1978 was less favourable to rice due to low rainfall, high temperature, low relative humidity, high rate of evaporation and deep water table conditions.

Grain and straw yields were favourably influenced by higher levels of irrigation (Table 1). Characters which [illegible] mainly to grain yield viz., number of effective tillers per hill, number of filled grains per panicle and thousand grain weight (Table 2) were improved substantially with increase in soil wetness. The favourable influence of submergence on grain to straw ratio was observed only during 1979. The effect of submergence was more pronounced during [illegible] which was a comparatively dry year. Continuous submergence (I_3) brought about an increase of [illegible] and [illegible] per cent in grain yield and 19.3 and 32,0 per cent in straw yield over alternate wetting and drying (I_1) during 1978 and 1979 respectively. This is in general agreement with the findings of Dastane *et al.* (1967), Pillai (1971) and Rajput (1979). According to Ponnamperuma (1972, [illegible]) flooding the soil sets in motion a series of physical, chemical and microbial processes, which profoundly affect the nutrient absorption, growth and yield of the rice plant. Ghildyal (1971) stated that [illegible] transpiration due to increased hydrostatic pressure of water in the soil coupled with evaporative demand and increased leaf porosity seem to be important factors favourably influencing the growth of flooded rice. When the transpirational transfer of water is high, the rate of nutrient uptake as a result of mass transfer of ions through transpirational stream also increases. The favourable microclimate formed inside the crop canopy and its influence on various chemical and biological activities in the soil as well as the soil temperature also needs special emphasis. Soil water stress reduced the tiller production (Table 2} and might have adversely affected the reproductive physiology by interfering with pollination and fertilization resulting in decreased grain yield.

Nitrogen application gave appreciable increase in grain and straw yield consistently during both the years (Table 1). Nitrogen at 30, 60 and 90 kg/ha increased the grain yield over no nitrogen by 5.4, 12.3 and 16·3 q/ha respectively during 1978. The corresponding values in the year 1979 were 4.6, 9.3 and 11.9 q/ha. Higher response to applied nitrogen during 1978 is attributable to the favourable weather conditions which might have helped the plants to utilize the applied nitrogen more efficiently. Similar trend in grain and straw yields due to nitrogen application in Pusa 2-21 has been reported by Reddy and Prasad (1977). The yield components viz., number of effective tillers per hill, number of filled grains per panicle and 1000 grain weight were favourably influenced fay nitrogen (Table 2) which ultimately reflected in the grain yield. The significance of nitrogen in the improvement of photosynthetic functions and grain development has been well recognised.

Inoculation of blue-green algae resulted in 7.7 and 6.4 per cent increase in grain yield and 5.0 and 5.7 per cent increase in straw yield over no inoculation during 1978 and 1979 respectively. The algal effect was marked on the number of effective tillers per hill and the number of grains per panicle. The beneficial effect of blue-green algae can be ascribed to their capability to fix atmospheric nitrogen and the possible synthesis of metabolites stimulatory to rice plant (Venkataraman, 1978).

Blue-green algae interacted significantly with irrigation in respect of grain and straw yields during 1979 with markedly higher yields under continuous submergence (Table 3). Thus, it is evident that the algal growth and contribution to soil nitrogen and grain and straw yields are favoured under flooded than under upland conditions in a comparatively dry season.

Differential response of algal inoculation at different levels of nitrogen (Table 4) indicated the pronounced effect of algal inoculation under no nitrogen application. A decline in response to algal inoculation with increase in the level of nitrogen brought out the fact that the maximum benefit of algal inoculation could be derived only under low levels of fertility (Kannaiyan *et al.*, 1979),

The response functions worked out under inoculated and uninoculated treatments indicated that the nature of response in general was quadratic except under no algal inoculation in 1978 (Table 5). In both the years constant coefficient was higher under algal inoculation. It is apparent that the maximum and economic optimum dose of nitrogen could be brought down by algal inoculation. In the year 1979 when the response functions were quadratic under inoculated and uninoculated treatments algal inoculation could bring down the economic optimum dose of nitrogen by 22,8 kg/ha without appreciable reduction in yield. Thus inoculation of blue-green algae proved to be effective in bringing down the optimum dose of nitrogen.

Table 1

Effect of soil moisture regimes, nitrogen levels and blue-green algae on grain yield, straw yield and grain to straw ratio

	Grain yield (q/ha)			Straw yield (q/ha)			Grain straw ratio	
	1978	1979	Pooled	1978	1979	Pooled	1978	1979
Soil moisture regimes								
I_1	39.77	31,34	35.56	48.80	39.43	43.95	0.830	0.796
I_2	43.91	36.21	40.06	52.58	44.02	48.30	0.844	0.822
I_3	48.16	43.84	46.00	57.86	52.11	54.98	0.831	0.838
SEm+	1.136	0.464	0.867	1.127	0.533	0.882	—	0.004
C.D. (0.05)	3.148	1.336	2,403	3.123	1.478	2.444	N.S.	0,012
Nitrogen (kg/ha)								
0	35.46	30.67	33.06	43.62	38.60	41.11	0 810	0.792
30	40.88	35.28	38.08	47.50	41.68	44.59	0.859	0.843
60	47.74	39.96	43.85	55.98	47.44	51,71	0.869	0.840
90	51.70	42,62	47.16	67.79	53.03	58.91	0.802	0.801
SEm +	1.312	0.537	1.002	1.302	0.616	1.018	0.008	0.005
C. D. (0.05)	3.636	1.488	2.777	3.608	1.707	2.821	0.022	0.014
Blue-green algae								
A_0	42.32	35.97	39.15	51.69	48.93	47,81	0.826	0.815
A_1	45.57	38.29	41.93	54.25	46.45	50.35	0.844	0.822
SEm+	0.320	0.187	0.263	0.392	0.207	0.309	0.003	—
C, D. (0.05)	0.887	0.518	0.729	1.086	0.574	0.856	0.008	NS

Table 2

Effect of soil moisture regimes, nitrogen levels and blue-green algae on height of plant, effective tillers per hill, filled grains per panicle and 1 QOOgrain weight

Treatments	Height of plant (cm)		No. of effective tillers per hill		No. of filled grains		1000 grain weight (g)	
	1978	1979	1978	1979	1978	1979	1978	1979
Soil moisture regimes								
I_1	56.0	50.5	5.73	4.57	99.1	91.0	19,66	18.85
I_2	57.8	53.4	6.13	5.61	105.6	99.2	19.1	19.17
I_3	59.8	56,5	6.53	6.26	105.3	105.5	20.08	19.71
SEm+	0.518	0.512	0.038	0.062	0.8S6	1.108	0,121	0.090
C. D. (0 05)	1.436	1.419	0.244	0.172	2.455	3.071	0.335	0.249
Nitrogen (kg N/ha)								
0	53.2	47.7	5.13	4.62	95.3	85.9	19.45	18.92
30	56.6	52.0	5.82	5.22	106.0	96.8	19.81	19.12
60	59.8	56.2	6.62	5.81	109.1	104.5	19.71	19.38
90	61,8	57.9	6.95	6.21	108.4	106.9	20.38	19,57
SEm+	0.598	0.591	0.102	0.072	1,022	1.279	0,167	0.104
C. D. (0.05)	1.657	1.638	0.283	0.199	2.832	3.545	0.463	0.288
Blue-green algae								
A_0	57.7	52.8	5.99	5.35	103.7	97.3	19.85	19.20
A_1	58.6	54.1	6.27	5.61	105.7	99.8	19.91	19.29
SEm+	0.206	0-166	0.033	0.034	0.439	0.638	—	—
C. D, (0.05)	0.571	0.460	0.091	0.094	1.217	1.768	N. S.	N. S.

Table 3

Mean grain and straw yields (q/ha) as affected by the interaction between soil moisture regimes and blue-green algae (1979)

	Grain yield			Straw yield		
	I_1			I_1		1.
	31.18	35.23	41.51	39,10	43.09	49.60
A!	31 .50	37.20	46.16	39.70	44.96	54.61

	Grain yield SEm+	Grain yield CD (0.05)	Straw yield SEm+	Straw yield CD (0.05)
For comparing I means at the same level of 'A' means	0,518	1.436	0.591	1.638
For comparing 'A' means at the same level of I means	0.598	1 .659	0.682	1.890

Table 4

Mean grain and straw yields (q/ha) as affected by the interaction between nitrogen levels and blue-green algae

		Grainyield				Straw yield			
		NO	N.	N	N	NO	N_{30}	N_{60}	N_{90}
1978	A_0	32.90	38.83	46.06	**51.47**				
	A_1	38.03	42.92	49.42	551.92	—	—		—
1979	A_0	28.64	33.68	39.28	42.29	36.32	40.31	46.66	52.43
	A_1	32,70	36.87	40.64	42.94	40.88	43.05	48.22	53.63

	1 978		1 979		1979	
For comparing 'N' means at the same level of 'A' means	SEm +	CD (0.05)	SEm +	CD (0.05)	SEm ±	CD (0.05)
	0.556	1.541	0.325	0.901	0.358	0.992
For comparing 'A' means at the same level of N means	0.641	1.776	**0.376**	1.042	0,413	1,145

Table 5

Response functions, predicted maximum and optimum nitrogen doses and corresponding grain yields under algal treatments

Treatments		Functions	Dose of N giving max. yield (kg/ha)	Maximum grain yield (q/ha)	Eco. opt. dose of N (kg/ha)	Yield at economic opt. dose of N (q/ha)
1978	AO	$Y = 32.87 + 0.21\ N$			—	—
	A1	$Y = 37.69 + 0.22\ N + 0.0007\ N^2$	166.0	57.68	123.9	54.20
1979	AO	$Y = 28.42 + 0.21\ N - 0.0006\ N^2$	178.0	46.79	136.2	45.89
	A1	$Y = 32.60 + 0.16\ N - 0.0005\ N^2$	152.0	45.37	113.4	44.31

Summary

Studies on the influence of fertilizer nitrogen and blue-green algae on growth and yield of rice variety Pusa 2-21 under different soil moisture regimes revealed that submergence was essential to obtain maximum grain yield under Delhi conditions. The crop responded well upto 90 kg N/ha. Inoculation of blue-green algae was effective in increasing the grain yield of rice comparable to that obtained with 30 kg N/ha. The full benefit of algal inoculation could be derived only under continuous submergence in a comparatively dry year. Effect of algal inoculation was pronounced under lower levels of nitrogen.

സംഗ്രഹം

വ്യത്യസ്ത ജലസേചന രീതികളിൽ പാക്യജനകവും, നീലഹരിത പായലും പൂസാ 2–21 എന്നയിനം നെല്ലിന്റെ വളർച്ചയേയും, വിളവിനേയും എങ്ങനെ സ്വാധീനിക്കുന്നു എന്നതിനെപ്പററി പഠനം നടത്തുകയുണ്ടായി. തുടർച്ചയായി വെള്ളം കെട്ടി നിർത്തിക്കൊണ്ടുള്ള കൃഷിരീതിയും ഹെക്ടറിന് 90 കി. ഗ്രാം വരെ പാക്യജനകം നൽകുന്നതും വിളവു വർദ്ധിപ്പിക്കുവാൻ സഹായകരമാണെന്നു കണ്ടു. നീലഹരിത പായൽ ചേർത്തതു മൂലം ഹെക്ടറിന് 30 കി. ഗ്രാം പാക്യജനകം നൽകുന്നതിനു തുല്യമായ പ്രയോജനം സിദ്ധിച്ചു. വരണ്ട കാലാവസ്ഥയിൽ നിലത്തിൽ തുടർച്ചയായി വെള്ളം കെട്ടിനിർത്തിയാൽ മാത്രമെ നീലഹരിത പായലിന്റെ പരമാവധി പ്രയോജനം ലഭിക്കുകയുള്ളൂ. കുറഞ്ഞയളവിൽ പാക്യജനകം നൽകിയപ്പോൾ നീലഹരിത പായലിന്റെ പ്രയോജനം വർദ്ധിച്ച തോതിൽ ദൃശ്യമായി.

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