OBSERVATIONS ON THE RÔLE OF BLUE-GREEN ALGAE ON RICE YIELD COMPARED WITH THAT OF CONVENTIONAL FERTILIZERS*

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BOTH field and pot experiments in progress since 1961 at the Central Rice Research Institute with emphasis on the former, to study the rôle of blue-green algæ in the nitrogen enrichment of the soil as well as conditioning of the soil for their proper manifestation such as addition of chemical nutrients, *e.g.*, lime, superphosphate and sodium molybdate (trace) together (*no nitrogenous fertilizers employed*), definitely indicated the beneficial rôle of blue-green algæ in increasing grain yield to the extent of 82% over no manure control. Some of the results have already been published (Relwani, 1963; Relwani and Subrahmanyan, 1963).

Based on the above findings, a replicated conventional organic manures and fertilizers such as farm-yard manure, green manure, urea field experiment was conducted during the main crop season of 1963 (July-December) with a popular high-yielding variety of paddy, *T 141* (145 days' duration), to test the efficiency of blue-green algæ *alone* and in combination with and ammonium sulphate to supply 20 kg. N/ha. over a no manure control, all treatments being superimposed over a basal dressing of lime at 500 kg., superphosphate at 20 kg. P_2O_5/ha. and sodium molybdate at 0·28 kg./ha. Four species of blue-green algæ—*Nostoc sphæricum, N. amplissimum, Tolypothrix campylonemoides* and *Westiella* sp.—grown in the laboratory by one of us (R. S.) and tested for their nitrogen-fixing capacity, were used for field inoculation. It may be mentioned in this connexion that a mixture of known nitrogen fixers is more efficient than inoculation of a single species (Subrahmanyan and Sahay, 1964, in press).

The results are presented in Table I. The data show that inoculation of blue-green algæ alone increased the grain yield significantly by about 30% over the corresponding control (no manure) treatment and this is found to be statistically on the same level as 20 kg. N/ha. applied in the forms of farm-yard manure, urea and ammonium sulphate. None of the manures or fertilizers was found to enhance significantly the efficiency of blue-green algæ except urea. It may be observed that the response of blue-green algæ is not as high as that obtained with green manure possibly because this is the first year of the inoculation of the algæ. Experimental evidence indicates that the population of blue-green algæ can be strengthened by successive inoculation during a few more crop seasons by which time these algæ can get well acclimatised to the environment and cause progressive increases in crop yield (unpublished data). The observations of De and Sulaiman (1950) based on pot culture experiments lend support to this view mentioned above; they found that

TABLE I

Yield and post-harvest biometrical data (average of four replications) pertaining to the main crop season of 1963—variety T. 141 (field experiment)

Treatment (over basal dressing of lime, superphosphate and sodium molybdate)	Grain yield (Kg./Ha.)		Straw yield (Kg./Ha.)		Height (cm.)		Effective tillers per hill	
	A	B	A	B	A	B	A	B
Check (No manure) ..	2615 (100)	3403 (130)	2496 (100)	3657 (147)	131·4 (100)	137·9 (105)	3·60 (100)	5·51 (153)
Farm-yard manure @ 20 Kg. N/Ha. ..	3392 (130)	3537 (137)	3483 (140)	3657 (147)	137·6 (105)	139·2 (106)	4·64 (129)	5·12 (142)
Green manure (*Sesbania speciosa*) @ 20 Kg. N/Ha. ..	3907 (149)	3902 (149)	4238 (170)	4412 (177)	140·7 (107)	145·9 (110)	5·42 (151)	5·80 (161)
Ammonium sulphate @ 20 Kg. N/Ha. ..	3431 (131)	3472 (132)	3588 (144)	3861 (155)	139·2 (106)	140·9 (107)	4·81 (134)	4·98 (138)
Urea @ 20 Kg. N/Ha. ..	3366 (129)	3585) (137)	3454 (138)	3715 (149)	136·0 (104)	141·2 (108)	4·74 (132)	4·93 (137)
C.D. (0·05) per hectare ..	215		..		..		..	
C.D. (0·10) per hectare ..	291		..		..		..	

(Figures in brackets represent per cent. increases over check). A—Without blue-green algæ. B—With blue-green algæ.)

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the fourth and fifth year in a five-year course of experiments in the presence of algæ gave a much higher yield than those in which no algæ were present as well as than those at the start of the experiments.

The expression of algæ in conjunction with organic manures and ammonium sulphate is not evident, presumably due to the fact that as nitrogen in the form of ammonia is readily available for its growth most forms do not fix atmospheric nitrogen. It may be noted here that ammonia is the key intermediate in nitrogen fixation by blue-green algæ (Fogg, 1963). Differential behaviour with urea resulting in significant response needs confirmation before a satisfactory explanation can be offered.

Further, the significantly higher yield of crop with green manure over other popular manures may be attributed to the fact that though, on equal nitrogen basis, green manure produces similar yield as ammoniacal fertilizers (Nair, 1953); its efficiency is always more with superphosphate (Vivekanandan and Raja, 1964) and still more with addition of lime which helps the mineralization process of the green manure (Jochim in Mukherjee and Agarwal, 1950).

The trend observed in respect of biometrical data recorded from various treatments conforms to the trend of the grain and straw yield of the respective treatments (Table I).

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RAMAN MASER ACTION WITH ACOUSTIC WAVES—STIMULATED BRILLOUIN SCATTERING

STIMULATED Brillouin scattering of an intense maser beam, involving coherent amplification of a hypersonic lattice vibration and a scattered light wave, has been detected in quartz and sapphire. This has been reported in a communication to *Phys. Rev. Letters* (25 May, 1964) by R. Y. Chiao, C. H. Townes and B. P. Stoicheff. This process is analogous to Raman maser action, but with molecular vibration replaced by an acoustic wave of frequency about 3×10^{10} cps, and with both the acoustic and scattered light waves emitted in specific directions.

In this phenomenon either compressional or shear waves can be excited, but for a compressional wave the coupling between acoustic and optical waves is simplest, and describable as electrostriction. Electrostrictive pressure is given by $p = (E^2/8\pi)\ d\epsilon/d\rho = (E^2B/8\pi)\ d\epsilon/dp$, where E is the electric field, ρ the density of material, ϵ the dielectric constant and B the bulk modulus. Thus two optical waves whose frequencies differ by ω_s can drive a pressure wave of this frequency, due to quadratic dependence of pressure on E and the consequent generation of a beat frequency. Similarly a pressure wave of frequency ω_s couples to an electromagnetic wave E through the varying induced dipole moment density $(E/4\pi)\ (d\epsilon/dp)p$. The authors discuss the conditions for the build-up of the acoustic and scattered waves when the radiation is contained in a resonant cavity, and show that under these conditions coherent scattering of radiation of frequency $(\omega_0 - \omega_s)$ occurs in the direction θ given by $\omega_s = 2\omega_0 (\nu n/c) \sin \frac{1}{2}\theta$, where ν is the velocity of the acoustic wave of frequency ω_s, n the refractive index and θ is the angle between the incident and scattered radiation.

In the experimental set-up intense 6940 Å radiation from a giant-pulse ruby laser, with a power output of about 50 megawatts during 30 nsec., was focussed inside the quartz crystal, and the backward (180°) scattered radiation was studied with the aid of two Fabry-Perot interferometers using mirrors of reflectance 1 and 0·1. A comparison of the two interferograms photographed simultaneously with a single maser pulse distinguished clearly between radiation coming from the ruby, and that scattered directly backward from the sample. In the light backscattered from the sample the original ring due to the maser wavelength was accompanied by an inner ring of comparable intensity which was evidently the amplified Brillouin scattering. Measurement of the shift corresponded to an acoustic wave frequency near 3×10^{10} cps.—(*Phys. Rev. Letters*, 25 May 1964, p. 592.)