would pave the way for the higher yield and benefit cost ratio. Thus, the study has brought out that in the mixed black soils of Western zone of Tamil Nadu, recommending 50 per cent of NPK doses prescribed as per targetted yield concept under irrigated conditions for rainfed sorghum is the best practice for efficient fertiliser use, higher yield and net profit.

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PHYSIOLOGICAL APPROACHES FOR IMPROVING YIELD OF RICE UNDER LOW IRRADIANCE

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ABSTRACT

A field experiment was ocnducted to investigate the efficacy of a few growth regulators / botanicals / chemicals on alleviating low irradiance stress in rice (*Oryza sativa* L.) High LAI, increased accumulation of chlorophylls, higher soluble protein content and higher NRase activity were evident in the treated plants resulting in increased biomass accumulation. Increased number of spikelets and reduciton in spikelet sterility contributed to higher yield. Brassinosteroid treatment recorded highest yield (4.76 t ha^{-1}) followed by salicylic acid (4.62 t ha^{-1}), coconut water (4.40 t ha^{-1}) and diammonium phosphate (4.32 t ha^{-1}) as against the lowest of 3.46 t ha^{-1} in control.

KEY WORDS : Rice, Low irradiance, Growth regulators, Botanicals, Brassinosteriod, Stress alleviation, Photosynthesis, Yield.

South-East Asian countries including India grow more than 80 per cent of rice crop during monsoon season. In cauvery Delta Zone, the 'Rice Bowl' of Tamil Nadu, about 70-80 per cent of rice is grown during monsoon season (Samba/Thaladi). During this period, cloudy weather prevails and the irradiance is 40 to 60 per cent less than dry season which reduce rice yield upto 50% (Venkateswarlu, 1977) by reducing tillering, panicle weight and dry matter production (Thangaraj and Sivasubramanian, 1990). Growth regulators were reported to vary in amount under low irradiance with drastic reduction in auxins cytokinis (Murthy and Murthy, 1982). Salicylic acid (Jain and Srivastava, 1981) and brassinosteriods (Sairam, 1994) were known to impart tolerance in plants to environmental stress through modification of metabolic processes. Other growth hormones/ botanicals were also reported to improve grain filling in rice under low irradiance (Singh *et al.*, 1984 ; Thangaraj and Sivasubramanian, 1992). In the present investigation an attempt has been made to evaluate the efficacy of a few botanicals/ chemicals/hormones to overcome low irradiance stress in rice and thereby improve rice yield and growth under subdued light.

MATERIALS AND METHODS

A field experiment was conducted during 1996-97 at the Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore in a randomised block design with three replications. Rice variety CO 45 was grown during middle of August to middle of December 1996 so as to coincide the reproductive phases with overcast sky. Cultural operations and fertilizers as per recommendations were given uniformly to all the plots. The treatments viz., Cycocel 500 ppm (T_1), cytozyme 0.1% (T_2), Mepiquat chloride 125 ppm (T_3), Coconut water 1% (T_4), *Albizia amara* leaf extract 5% (T_5), *Sesbania rostrata* leaf extract 5% (T_6), Salicylic acid (SA) 100 ppm (T_7), Paclobutrazol 50 ppm (T_8), Diammonium phosphate (DAP) 2% (T_9), Ascorbic acid 100 ppm (T_{10}) and Brassinosteriod (BR) 0.5 ppm (T_{11}) were foliar sprayed twice at panicle initiation and at flowering stages. cytozyme was applied only at panicle initiation stage. Water spray (T_0) served as control. Leaf samples were collected for analysis fifteen days after treatment. Yield parameters were recorded as per the procedures outlined by Yoshida *et al.* (1976). The photosynthetic pigments viz., Chl 'a', Chl 'b', total chlorophylls were estimated as per the method of Yoshida *et al.*, (1971). Soluble protein content was estimated by the method described by Lowry *et al* (1951) and the activity of enzyme Nitrate reductase was estimated according to the method proposed by Nicholas *et al.* (1976).

RESULTS AND DISCUSSION

Highest accumulation of total chlorophyll (2.40 mg g^{-1}), chlorophyll 'a' (1.48 mg g^{-1}) and chlorophyll 'b' (0.92 mg g^{-1}) was recorded with BR while the lowest (1.82, 1.06 and 0.76 mg g^{-1}) was recorded in control (Table 1). Soluble protein content was recorded highest with BR (5.87 mg g^{-1}) whereas lowest value of 3.05 mg g^{-1} was recorded in control. SA, coconut water and DAP also recorded significantly higher chlorophylls and soluble protein content. Similar observations were reported by Singh *et al.*, (1984), Thangaraj and Sivasubramanian (1992) and Sairam (1994).

Photosynthesis is the basic metabolic process in green plants for biomass production. Plant's inherent capacity and the light energy play an

Table 1. Influence of botanicals / growth regulators spray on LAI, chlorophyll, soluble protein and NRase activity of rice at flowering stage (Var. CO 45)

Treatments	LAI	Chlorophyll a (mg g^{-1})	Chlorophyll b (mg g^{-1})	Total Chlorophyll (mg g^{-1})	Soluble Protein (mg g^{-1})	NRase activity (mg $No2^{-1}s^{-1}kg^{-1}$)
T_0	3.40	1.06	0.76	1.82	3.05	2.99
T_1	3.38	1.46	0.84	2.30	4.60	3.50
T_2	3.86	1.41	0.85	2.26	3.90	3.09
T_4	3.52	1.41	0.83	2.24	4.52	3.42
T_4	4.02	1.46	0.89	2.35	5.29	4.15
T_5	3.40	1.23	0.86	2.09	4.17	3.17
T_6	3.47	1.16	0.81	1.97	3.57	3.96
T_7	4.42	1.46	0.91	2.37	5.65	4.47
T_8	3.39	1.43	0.83	2.26	4.62	3.56
T_9	4.08	1.44	0.89	2.33	4.77	4.45
T_{10}	3.55	1.13	0.84	1.97	4.34	3.29
T_{11}	4.43	1.48	0.92	2.40	5.87	4.67
C.D. (P=0.05)	0.48	0.27	0.09	0.45	0.71	0.47

important role in the photosynthetic production of assimilates in a given environment. Rubisco which plays an important role in photysynthetic carbon fixation was reported to be reduced under low irradiance (Nayak and Murthy, 1980). Increased accumulation of photosynthetic pigments particularly chlorophyll 'b' and soluble protein content might have contributed to the increased biomass production (Table 1). This is corroborated by the findings of Chowdhury *et al* (1994), Viji *et al* (1997) and Thangaraj *et al.*, (1998).

The assimilatory reduction of nitrate by plants is a fundamental biological process. NRase activity (Table 1) was significantly higher in BR (5.07 mg $NO_2^{-}S^{-1}$ kg^{-1}) and SA (4.87 mg $NO_2^{-}S^{-1}$ kg^{-1}) than that of control (2.49 mg NO_2S^{-1} kg^{-1}). Highest LAI at reproductive stage was again recorded in BR (4.43) and SA (4.42). The results indicated that NRase activity and LAI might have contributed to more efficient assimilatory process in the treated plants as reported by Leslie and Romani (1988) and Chatterjee *et al* (1976).

Highest percentage of spikelet fertility (92.9 per cent) and number of spikelets $panicle^{-1}$ (190) was obtained in BR spray followed by SA (90.3 per cent, 185), coconut water (89.5 per cent, 184) and DAP (89.1 per cent, 181) against the lowest (81.0 per cent, 135) in control (Table 2). This resulted in a significanlty higher grain yield of the treated plants. Highest grain yield of 4.76 t ha^{-1} was recorded with BR followed by SA (4.62 t ha^{-1}), coconut water (4.40 t ha^{-1}) and DAP (4.32 t ha^{-1}) against the lowest yield of 3.46 t ha^{-1} in control. The yield increase accounted for 33.7%, 29.8%, 23.6% and 21.3% respectively. These observations corroborated the reports of Jain and Srivastava (1981), Singh *et al* (1984), Thangaraj and Sivasubramanian (1992) and Sairam (1994).

BRs were known to enhance both cell elongation and cell proliferation of meristematic tissues interacting synergistically with auxin. BR application was also reported to increase translocation resulting in increased ear number, grain number per ear, 1000 grain weight and harvest index contributing to higher grain yield in wheat (Sairam, 1994). SA increased NRase activity and delay senescence (Leslie and Romani, 1988). Coconut water contain cytokinin like substances (Letham, 1974) which improve spikelet filling and grain yield in rice by increasing leaf longivity and partitioning (Thangaraj and Sivasubramanian,

Table 2. Yield parameters of rice (Var. CO 45) as influenced by botanicals / growth regulators / chemicals treatments

Treatments	Number of panicles m^{-2}	Number of spikelet / panicles m^{-2}	Filled spikelet (%)	1000 grain weight (g)	Yield (t ha^{-1})	TDM (t ha^{-1})	HI
T_0	580	135	81.0	22.5	3.46	8.65	0.40
T_1	581	161	83.6	23.6	4.03	8.57	0.47
T_2	587	158	84.1	23.3	3.83	9.57	0.40
T_3	586	157	87.9	22.9	4.06	8.83	0.46
T_4	597	184	89.5	23.8	4.40	10.00	0.44
T_5	583	140	84.7	23.5	3.66	9.38	0.39
T_6	587	168	85.4	22.9	3.80	9.50	0.40
T_7	598	185	90.3	23.7	4.62	10.27	0.45
T_8	583	150	82.1	22.8	4.06	8.64	0.47
T_9	597	181	89.1	23.4	4.32	10.05	0.43
T_{10}	588	155	86.0	23.6	3.90	9.28	0.42
T_{11}	609	190	92.9	23.9	4.76	10.35	0.46
C.D. (P=0.05)	NS	15	7.9	NS	0.58	1.28	0.05

1992). These reports corroborated the results of the present study. Under stress condition, nutrient absorption specially nitrogen and phosphorus is reduced. Foliar application of DAP might have increased the nutrient availability for assimilatory processes.

The present study revealed that increased accumulation of chlorophyll 'b' and soluble protein content enhanced photochemical efficiency leading to higher assimilation and grain yield. Sasse (1985) reported that BR induced growth and development was mediated through nucleic acid metabolism suggesting involvement of BRs in transcription and replication leading to increase in enzyme activities. Thus, it can be safely concluded that BR induced increase in enzyme proteins in addition to more accumulation of photosynthetic pigments. These in turn increased metabolism leading to higher leaf area and biomass production. BR also increased translocation, (Fujii *et al.*, 1991) resulting in increased grain number per panicle and harvest index which contributed to higher grain yield.

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