Table 6. Biochemical analysis of Chickpea variety CO4 (COG 30)

S.No.	Culture/Variety	Protein content on dry wt. basis (g/100g)
1.	COG 30	29.60
2.	CO 3 (check)	24.33

Table 7a. Cooking quality test

Variety / Culture	Wt. before soaking (g)	Wt. after soaking (g)	Increase in Wt. (g)	Water uptake (ml.)	Cooking time (min)
COG 30	200	407	207	265	18
CO 3	200	415	215	265	19

Table 7b. Organoleptic evaluation

Variety / Culture	Colour & Appearance	Flavour	Texture	Taste	Overall acceptability	Mean
COG 30	8.0	8.5	8.2	8.5	8.5	8.34
CO 3	8.3	8.2	8.2	8.0	8.0	8.14

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Effect of organic manure, biofertilizers, inorganic nitrogen and zinc on growth and yield of rabi rice *(Oryza sativa L.)*

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Abstract : Field experiments were conducted during rabi 1995-96 and 1996-97 to study the effect of organic and inorganic nitrogen with zinc on growth and yield of rice. The study revealed that application of either green manure *(Sesbania aculeata* at 6.25 t ha^{-1} or FYM 12.5 t ha^{-1} combined with Azospirillum (2 kg ha^{-1}) significantly increased the growth attributes than the combined application of Azolla (1 t ha^{-1}). Among the levels of N (112.5, 150 and 187.5 kg ha^{-1}) with or without 25 kg ZnSO4 ha^{-1}, combined application of 187.5 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} though recorded significantly the higher growth attributes it was comparable with 150 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}. Application of GM with Azospirillum recorded significantly shorter period for 50 per cent flowering, highest number of productive tillers m^{-2}, filled grains per panicle, panicle length and grain yield (5282 and 5218 kg ha^{-1}) in both the years. Eventhough the highest level of N (187.5 kg ha^{-1}) along with Zn application recorded significantly higher yield attributes and yield (5516 and 5376 kg ha^{-1}) it was comparable with 150 kg N ha^{-1} with Zn. *(Key Words : Rice, Organic manures, Biofertiliser, Nitrogen, Zinc, Yield)*

Zinc deficiency appears to be the most important nutritional factor limiting growth and yield of wetland rice *(Oryza sativa* L.) next to nitrogen and phosphorus. Importance of zinc has been recognised because it is a major component and activator of several enzymes and involved in various metabolic activities like protein synthesis, carbohydrate metabolism and utilization of nitrogen and phosphorus. Vyas *et al.* (1990) reported synergistic effect between applied nitrogen and zinc. Besides poor available nitrogen, a heavy loss of applied N occurs under rice soils which causes N and Zn deficiency in soil and result in poor crop production. Hence, the present study was carried out to enhance the production of low land rice by the combined application of organic manures with biofertilisers and inorganic N with Zinc.

Materials and Methods

Field experiments were conducted at Agricultural College and Research Institute, Madurai during rabi 1995-96 and 1996-97 to study the effect of organic and inorganic nitrogen with zinc on growth and yield of rice. The experiment was laid

out in split plot design with three replications. The main plot treatments consisted of application of green manure *(Sesbania aculeata* at 6.25 t ha^{-1}) and farm yield manure (12.5 t ha^{-1}) in combination with biofertilisers (Azospirillum at 2 kg ha^{-1} as basal soil application and Azolla at 1 t ha^{-1} on 3 DAT). The sub plots comprised of three levels of N (112.5, 150 and 187.5 kg ha^{-1}) with and without 25 kg $ZnSO_4$ ha^{-1}. The soil of the experimental field was sandy clay loam with pH 7.6, low in available N (166.5 kg ha^{-1}), medium in available P (15.0 kg ha^{-1}) high in available K (276.1 kg ha^{-1}) and available Zn of 2.92 ppm. The variety ADT 39 was used with a spacing of 20 x 10 cm. Data on growth, yield attributes, grain and straw yield were recorded and statistically analysed.

Results and Discussion

The results revealed that all the growth attributes were significantly influenced by the treatments (Table 1). Among the organics, GM + Azospirillum produced significantly taller plants (87.80 cm), more number of tillers m^{-2} (540), higher LAI (5.67) and dry matter production at harvest (13891 kg ha^{-1}) as compared to other treatments irrespective of the years of study and it was comparable with FYM + Azospirillum. Application of 187.5 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} produced significantly taller plants (90.60 cm), more number of tillers m^{-2} (558), maximum LAI (5.78) and more DMP (14291 kg ha^{-1}) and it was comparable with that of 150 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} in both years. The beneficial effect of organic manures might be due to the advancement of time and proper availability of nutrients by releasing the requirement of crop demand (Buresh *et al.*, 1993). Vigorous plants with more number of tillers and broader leaves could be the possible reasons for increased LAI recorded under GM + Azospirillum combination (Nagaraju *et al.*, 1995). The beneficial effect of N + Zn could be attributed to the synergistic effect between these nutrients and continuous and enhanced N supply (Ram *et al.*, 1995).

Yield attributes

Significant influence on yield parameters were observed due to addition of organic and inorganics along with biofertilizers (Table 2). Application of GM + Azospirillum took significantly shorter period for 50 per cent flowering (82 and 84 days), produced the highest number of productive tillers m^{-2} (436 and 447), filled grains per panicle (81.10 and 76.26) and panicle length (18.74 and 18.36 cm) in both years respectively and was comparable with FYM + Azospirillum. In both years early flowering was observed with 187.5 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} and produced significantly higher number of productive tillers m^{-2}, panicle length and filled grains per panicle. This effect was comparable with 150 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} application. The supremacy of yield components due to the application of organic manures and biofertilizers might be due to the release of major nutrients during decomposition. Favourable effect of combined application of N and Zn might be due to increased vigour, photosynthate accumulation and better translocation of photosynthates to the sink as suggested by Khanda and Dixit (1995).

Grain and Straw yield

The effect of organics combined with biofertilizers with different levels of N with $ZnSO_4$ on grain yield was well pronounced in both years. Application of GM + Azospirillum significantly recorded higher grain yield (5282 and 5218 kg ha^{-1}) which was on par with that of FYM + Azospirillum with an yield increase of 7.8 and 6.2 per cent respectively over FYM + Azolla. Regarding inorganics, application of 187.5 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} produced significantly higher grain yield of 5516 and 5376 kg ha^{-1} and was comparable with 150 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} which registered 5414 and 5210 kg ha^{-1} during 1995-96 and 1996-97 respectively. The effect of treatments on straw yield followed a similar trend. The favourable and significant influence of organic manures with biofertilizers might be due to enhanced growth characters, increasing rate of N for longer period from the GM and synchronised the crop demand. Combined application of N and Zn increased the grain yield owing to better utilisation of N and P for grain production through metabolic activities (Vyas *et al.*, 1990).

Thus it is evident that combined application of organic manures like GM *(Sesbania aculeata* 6.25 t ha^{-1}) or FYM (12.5 t ha^{-1}) with Azospirillum (2 kg ha^{-1}) and application of N 150 kg ha^{-1} with 25 kg $ZnSO_4$ ha^{-1} maximised the growth and yield attributes and finally yield of rabi rice.

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Table 1. Effect of treatments on growth attributes of rice

Treatments	Plant height at harvest (cm)		Number of tillers m^{-2} at flowering		Leaf area index at flowering		Dry matter production at harvest (kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Oragnic manures and biofertilisers								
GM + Azolla	85.34	85.82	520	510	5.42	5.50	13693	13253
GM + Azospirillum	87.80	87.26	540	537	5.60	5.67	13891	13836
FYM + Azolla	81.80	85.35	490	502	5.40	5.48	13336	12930
FYM + Azospirillum	86.20	86.41	536	530	5.42	5.56	13878	13613
CD (P=0.05)	1.10	0.97	16	17	NS	NS	149	358
Inorganics								
112.5 kg N ha^{-1}	74.80	83.11	483	484	5.19	5.40	13100	13054
112.5 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	83.30	83.94	502	497	5.24	5.41	13434	13113
150 kg N ha^{-1}	83.71	85.18	510	503	5.46	5.45	13504	13106
150 kg N ha^{-1} + 25kg $ZnSO_4$ ha^{-1}	88.60	87.21	542	545	5.54	5.57	13998	13718
187.5 kg N ha^{-1}	87.10	88.10	534	534	5.57	5.65	13870	13518
187.5 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	90.60	89.13	558	556	5.78	5.82	14291	13938
CD (P=0.05)	3.28	3.47	24	26	0.18	0.18	234	403

Table 2. Effect of treatments on yield attributes of winter rice

Treatments	Days to 50 per cent flowering		Productive tillers m^{-2}		panicle length (cm)		Filled grains per panicle^{-1}	
	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97
Oragnic manures and biofertilisers								
GM + Azolla	86	87	418	417	17.21	17.21	78.30	73.17
GM + Azospirillum	82	84	436	447	18.74	18.36	81.10	76.26
FYM + Azolla	90	91	389	383	17.95	17.00	73.63	72.71
FYM + Azospirillum	83	85	428	436	18.60	18.12	79.60	74.98
CD (P=0.05)	3	2	9	12	0.78	0.75	2.73	1.59
Inorganics								
112.5 kg N ha^{-1}	88	90	374	384	17.03	16.42	72.12	70.15
112.5 kg N ha^{-1} + 25 kg $ZnSo_4$ ha^{-1}	87	91	404	403	17.08	17.28	76.20	72.36
150 kg N ha^{-1}	85	87	412	413	18.01	17.51	76.40	71.27
150 kg N ha^{-1} + 25kg $ZnSO_4$ ha^{-1}	83	85	437	444	19.12	18.38	81.60	75.58
187.5 kg N ha^{-1}	84	84	427	431	18.26	17.67	79.70	77.11
187.5 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	82	84	452	452	19.22	18.64	82.95	79.21
CD (P=0.05)	3	2	24	18	1.14	0.87	3.20	3.27

Table 3. Effect of treatments on grain yield and straw yield (kg ha^{-1}) of rabi rice

Treatments	Grain yield			Straw yield	
	1995 - 96	1996 - 97	Pooled analysis	1995 - 96	1996 - 97
Oragnic manures and biofertilisers					
GM + Azolla	5072	4800	4952	6798	6528
GM + Azospirillum	5282	5218	5236	6980	7096
FYM + Azolla	4897	4712	4812	6722	6503
FYM + Azospirillum	5207	5102	5149	6903	6990
CD (P=0.05)	135	123	138	172	153
Inorganics					
112.5 kg N ha^{-1}	4683	4503	4601	6444	6193
112.5 kg N ha^{-1} + 25 kg $ZnSo_4$ ha^{-1}	4875	4743	4798	6747	6504
15. kg N ha^{-1}	4887	4774	4835	6752	6628
15. kg N ha^{-1} + 25kg $ZnSO_4$ ha^{-1}	5414	5210	5303	7046	7179
187.5 kg N ha^{-1}	5308	5136	5234	6953	6924
187.5 kg N ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	5516	5376	5447	7162	7247
CD (P=0.05)	185	238	216	207	251

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Studies on inter-cropping green manures with grain legumes in the pre-rice season and its effect on rice

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Abstract : Field investigations were carried out to assess the possibility of including green manure crops with grain legumes in the pre-rice season and to study their effect on the succeeding rice. Two green manures, *Sesbania aculeata* and *Sesbania rostrata* were inter-cropped with greengram and redgram and incorporated to the follow up rice crop treated with three levels of N viz., 0, 50 and 100 kg N ha^{-1}. Results indicated that loss in yield of grain legumes due to intercropping was well compensated by the green manure contribution to the succeeding rice. Rice yield obtained with incorporation of *S. rostrata* and redgram with 50 kg N ha^{-1} was higher than that obtained with 100 kg N ha^{-1} alone thus resulting in a saving of 50 kg of fertiliser N ha^{-1}. *(Key Words : Grain legumes, Green manures, Succeeding rice, N levels)*

To minimise the dependence on non renewable sources of energy and also to sustain soil productivity, attention is now focussed on alternate sources of N. In this context, green manures are gaining popularity. The capital, time and labour involved in raising a green manure can be reduced if it is suitably included in the pre-rice season during which a grain legume is normally grown. By inter-cropping in suitable proportions, the green manures and grain legumes can be utilised as a source of grain, fodder and biological nitrogen. According to Bhagat *et al.*, (1988) application of 50 per cent of the total N as S. *aculeata* and remaining N as urea gave higher rice yields and resulted in lower losses of ammoniacal and nitrate N. Becker *et al.* (1988) reported that ratooned sesbania showed faster growth than seeded plants. By growing green manure in the off-season, leaching loss of N and other nutrients could be reduced and the green manure crop could use forms of phosphorus and zinc less available to rice and increase their availability. Enhanced availability of micronutrients like iron due to green manure incorporation was also reported by Takkar and Nayyar (1986).

Materials and Methods

Experiments were conducted in the Wetland Farm of Tamil Nadu Agricultural University during summer (February-June) and kharif (July-October) seasons. The soil of the experimental field was black clayey in nature, classified taxonomically as Vertic Ustochrefit, low in available N, medium in available P and high in available K. The pre-rice crops including grain legumes viz., greengram *(Vigna radiata)* variety Co 4 and redgram *(Cajamus cajan)* variety ICPH 73, green manures *S. rostrata* and *S. aculeata* were raised in 3:1 proportion. Greengram was sown at a spacing of 30 x 10 cm as sole crop and 25 x 10 cm as inter-crop. Redgram was sown at 60 x 20 cm as sole crop and 45 x 20 cm as inter-crop. The green manure crops were sown at 30 x 15 cm as sole crop and 40 x 15 cm as inter-crops. The grain legume and green manure treatments were laid out in a randomised block design and replicated thrice. The succeeding rice crop (var. CR 1009) was raised in split plot design and replicated thrice with the eight treatment combinations of grain legumes and green manures in main plots and three levels of N (0, 50 and 100 kg ha^{-1}) in the sub plots. The green manures were cut as a height of 30 cm from the ground on 45 DAS for fodder and ratooned. The biomass of the ratoon crop was incorporated. In case of grain legumes, the pods were harvested and the haulms of greengram were removed for fodder