* The rate of removal of volatile matter was faster in the untreated paddy straw than that in the acid treated sample due to the presence of more volatile matter in sample the untreated one.
* The rate of removal of fixed carbon was faster in the acid treated paddy straw than that in untreated one.
* The rate of removal of fixed carbon was faster in the first stage and very slow in the second substage.
* The colour of the ash obtained after thermogravimetric analysis was blackish white in the case of untreated straw and milky white in the case of acid treated straw. This may be due to the removal of the most of the metallic impurities in acid treated straw.
* The temperatures of above 340 and 375oC are required to remove fixed carbon from raw and IN HCI treated paddy straw to got amorphous silica.

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Combining ability analysis for biological nitrogen fixation traits under controlled conditions in greengram *Vigna radiata* (l.) Wilczek.

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Abstract : Combining ability analysis for different biological nitrogen fixation traits in greengram (*Vigna radiata* (L.) Wilczek) was carried out under controlled conditions. Seven parental varieties and their F_1 hybrids were analysed for the estimation of combining ability and gene action under rhizobium inoculated, non-inoculated and absolute control situations. Analysis of variance revealed significant mean square due to general combining ability (gca) and specific combining ability (sca). The parents showed significant variation with respect to gca effect. The parent NDM-88-14 is identified as the best parent having significant gca effect for all the biological nitrogen fixation traits. The hybrids showed sca effects at varying levels. *(Key words: Greengram, Biological nitrogen fixation, Combining ability).*

Pulses are the major source of dietary protein. Legume - Rhizobium symbiosis play a predominant role in agriculture because they can fix atmospheric nitrogen. Sarawgi *et al.* (1999) reported enhanced grain yield in chickpea following rhizobial inoculation. Chaudhary *et al.* (2000) observed enhanced dry matter production in greengram at different growth stages as a result of rhizobial inoculation. Xu Qiaozhen *et al.* (2000) revealed that combatibility of soybean cultivars with rhizobial strain is controlled by a pair of dominant genes. Greengram (*Vigna radiata* (L.) Wilczek) is one of the important grain legume crops of India and is cultivated in upland and in summer rice fallows. There is possibility of breeding legumes for increased nitrogen fixation by improving the biological nitrogen fixation traits (Singh and Murthy, 1988). For developing varieties having good nitrogen fixing capacity and reasonable yield the information on combining ability of parents and the nature of gene action involved in the inheritance of biological nitrogen fixation traits is very essential.

Table 1. Analysis of variance for combining ability for nitrogen fixation traits in pot culture experiment

Characters	Mean squares		
	gca	sca	Error
Inoculated			
Number of nodules at 50% flowering	2918.73*	1256.35*	0.23
Weight of nodules at 50% flowering	12803.48*	4405.18*	0.034
Nitrogen content at 50% flowering	0.057	0.788*	0.001
Dry weight of plants at 50% flowering	13.235*	5.643*	0.004
Non-inoculated			
Number of nodules at 50% flowering	11.601*	5.976*	0.011
Weight of nodules at 50% flowering	3.640*	0.765*	0.009
Nitrogen content at 50% flowering	0.433*	0.314*	0.001
Dry weight of plants at 50% flowering	9.673*	4.937*	0.001
Absolute control			
Number of nodules at 50% flowering	23.116*	4.055*	0.005
Weight of nodules at 50% flowering	3.294*	0.659*	0.001
Nitrogen content at 50% flowering	0.358*	0.286*	0.001
Dry weight of plants at 50% flowering	9.182*	5.673*	0.001

* Significant at 5% level

In this study attempts were made to estimate the combining ability and the nature of gene action with respect to nodulation and other biological nitrogen fixation traits. Combining ability was estimated under different situations *viz.* with Rhizobium inoculation and without inoculation.

Materials and Methods

The experimental material consisted of seven greengram varieties selected based on yield and biological nitrogen fixation traits. The seven varieties were crossed in a diallel fashion without reciprocals. All the F_1 hybrids alongwith the seven parents were raised in pots using sand as the medium. The experiment was laid out in completely randomised block design with seven replications at the College of Agriculture, Vellayani during 1997-98. The seeds were inoculated with a known Rhizobium culture (PA-GG-I) for effective nodulation. The inoculated plants were supplied with nitrogen free nutrient solution. The non-inoculated seeds were used as control and supplied with required nutrients in liquid form. A set of absolute control in which non-inoculated seeds, supplied with nitrogen free nutrient solution was also maintained.

Combining ability for the biological nitrogen fixation traits were estimated under the different situations according to Grifing (1956) (Model I Method 2).

Results and Discussion

Analysis of variance for combining ability for biological nitrogen fixation showed that mean squares due to gca and sca were significant for all the characters studied (Table 1). The estimation of gca effect is presented in Table 2, and the sca effect in Table 3 and genetic components of variation in Table 4.

Number of nodules at 50 per cent flowering

Significant mean square due to gca and sca under inoculated, non-inoculated and absolute control indicated the predominance of additive gene action whereas the ratio of σ^2A to σ^2D was less than unity in the inoculated and non-inoculated population which suggested the predominance of non-additive gene action. In the absolute control the ratio of σ^2A to σ^2D was greater than unity suggesting the predominant role of additive gene action.

The estimate of combining ability revealed that NDM-88-14, P.9333, COGG-902 and LGG-444 had significant positive gca effects while KM-1285, MG-368 and IIPRM-3 showed negative gca effects. Significant positive sca effects were shown by P.9333 x COGG-902 and significant negative sca effects were shown by P.9333 x KM 1285. Both the parents involved in the cross P.9333 x COGG-902 were good general combiners.

Among the non-inoculated population NDM-88-14 had significant positive gca effects and

Table 2. GCA effects of seven parents for various biological nitrogen fixation traits in pot culture experiment

Treatments	No. of nodules at 50% flowering			Wt. of nodules at 50% flowering			Nitrogen content in plants at 50% flowering			Dry weight of plants at 50% flowering		
	Inoculated	Non inoculated	Absolute control	Inoculated	Non inoculated	Absolute control	Inoculated	Non inoculated	Absolute control	Inoculated	Non inoculated	Absolute control
P1 (P.9333)	15.110	0.957	0.976	7.895	0.357	0.426	-0.030*	-0.120	-0.001	1.504	1.235	1.102
P2 (KM-1285)	-15.05	-1.301*	-1.428	-34.106	-0.570	-0.461	-0.395*	-0.373*	-0.322*	-0.949	-1.250*	1.281*
P3 (NDM-88-14)	25.464*	1.737*	2.814*	57.752*	1.055*	1.010*	0.501*	0.328*	0.340*	1.490*	1.271*	1.341*
P4 (MG-368)	-24.113*	-1.231*	-1.661*	-46.017*	-0.731*	-0.689*	-0.120	-0.064	0.022	-0.66	0.767	-0.894
P5 (IIPRM-3)	-13.260	-0.646	-1.252	-29.693	-0.475	-0.523	-0.205	0.012	-0.112	0.778	0.671	0.532
P6 (COGG-902)	3.169	0.467	0.168	22.131	0.051	0.064	0.196	0.092	-0.008	-1.260*	-0.712	-0.578
P7 (LGG-444)	8.683	-0.001	0.384	22.038	0.0131	0.173	0.051	0.124	0.081	-0.890	-0.449	0.222
SE (Gi-Gj)	0.238	0.049	0.032	0.086	0.45	0.006	0.015	0.009	0.008	0.031	0.016	0.011
CD	0.443	0.097	0.063	0.172	0.090	0.011	0.031	0.012	0.016	0.062	0.021	0.020

* Significant at 5% level

KM-1285 and MG-368 had significant negative gca effects. The hybrids NDM-88-14 x LGG-444 recorded significant positive sca effects while KM-1285 x COGG-902 had significant negative sca effects.

Weight of nodules at 50 per cent flowering

Significant mean squares due to gca and sca were recorded for weight of nodules at 50 per cent flowering under inoculated, non-inoculated and absolute control, suggesting the predominance of both additive and non-additive gene action. In the case of inoculated population the ratio of σ^2A to σ^2D found to be less than unity indicating the predominance of non-additive gene action. Sreekumar (1995) in cowpea and Thomas (1996) in blackgram also reported the same result. But in the other two situations the ratio of σ^2A to σ^2D was greater than unity suggesting the importance of additive gene action. This is in agreement with the findings of Miller *et al.* (1986) in cowpea.

Under all the three combinations significant positive gca effects were shown by NDM-88-14 and significant negative sca effects were exhibited by MG-368. In the inoculated condition significant positive sca effects were recorded by P.9333 x COGG-902. Both the parents involved in the cross had good gca. But in the non-inoculated and absolute control P.9333 x NDM-88-14 showed significant positive sca effects. In this case also both the parents involved in the cross were good general combiners.

In the inoculated condition significant negative sca effects were shown by IIPRM-3 x LGG-444. In the other two cases significant negative sca effects were exhibited by KM 285 x LGG-444.

Nitrogen content at 50 per cent flowering

Nitrogen content at 50 per cent flowering had significant mean squares due to gca and sca indicating the predominance of additive and non-additive gene action under all the three situations. The ratio of σ^2A to σ^2D was less than unity indicating the predominance of non-additive gene action. This is in confirmity with the findings of Sreekumar (1995) on cowpea and Thomas (1996) in blackgram.

Under all the three conditions NDM-88-4 had significant positive gca effects and KM-285 had significant negative gca effects and the hybrid P.9333 x NDM-88-14 recorded significant positive sca effects. KM 285 x LGG-444 exhibited significant negative sca effects under inoculated and non-inoculated conditions.

Table 3. SCA effects of hybrids of various nitrogen fixation trials in pot culture experiment

Treatments	No. of nodules at 50% flowering			Wt. of nodules at 50% flowering			Nitrogen content in plants at 50% flowering			Dry weight of plants at 50% flowering		
	Inoculated	Non inoculated	Absolute control	Inoculated	Non inoculated	Absolute control	Inoculated	Non inoculated	Absolute control	Inoculated	Non inoculated	Absolute control
P1 x P2	-20.200*	-0.847	-0.937	7.810	-0.400	-0.131	-0.173	-0.120	-0.181	2.536*	2.697*	2.812
P1 x P3	70.670	3.941	4.354*	95.607	2.064	2.203*	1.808*	0.993*	0.854*	2.197	2.291*	2.307
P1 x P4	-15.140	1.254	0.805	13.563	-0.209	0.263	-0.491	0.092	0.184	-0.049	0.299	0.628
P1 x P5	-0.263	2.110	0.871	31.839	-0.294	-0.240	-0.028	-0.442	-0.267	0.866	1.086	0.990
P1 x P6	72.120	2.826	1.473*	118.029*	0.649	0.670	0.611	0.118	0.205	1.092	0.526	0.622
P1 x P7	18.008	-0.073	2.884	8.394	1.256	1.134	0.501	-0.078	-0.197	1.794	0.046	0.168
P2 x P3	-3.345	-1.361	-0.785	-15.348	-0.169	-0.081	-0.309	-0.755	-0.817*	0.750	0.826	0.785
P2 x P4	21.089	2.546	1.763*	60.322	0.708	0.630	1.060	0.344	0.369	-0.138	0.106	0.189
P2 x P5	22.122*	1.686	2.559	62.855	0.741	0.664	1.110	0.581	0.729	2.576*	2.574	2.873*
P2 x P6	4.435	-1.783*	0.660	9.374	0.095	-0.121	0.086	0.465	0.512	0.212	-0.011	-0.699
P2 x P7	-11.779	1.985	-1.587*	-6.320	-0.827*	-0.933	-1.061*	-0.84*	-0.688	-0.856	-1.252*	-1.359*
P3 x P4	1.761	1.049	-0.753	-6.337	-0.308	-0.447	0.525	-0.038	-0.180	0.372	0.313	-0.118
P3 x P5	0.449	0.691	-0.148	34.453*	0.105	0.187	-0.626	-0.443	-0.126	-0.692	-0.093	0.247
P3 x P6	-14.950	2.331	-1.394	-15.785	-0.330	-0.303	-0.251	-0.662	-0.540	1.022	0.489	-0.119
P3 x P7	64.820	4.769*	1.432	72.965	0.967	0.583*	0.225	0.403	-0.011	1.751	1.246*	2.203
P4 x P5	2.280	-1.141	-0.446	37.252*	0.012	0.044	0.308	0.138	0.273	1.778	2.193	2.393
P4 x P6	-11.960	0.686	-1.680*	-13.243	-0.364	-0.214	0.478	0.127	0.195	1.145	0.536	0.507
P4 x P7	4.456	0.087	0.884	63.063	0.184	0.196	0.878	0.718	0.882*	1.609*	1.275	0.749
P5 x P6	-4.140	-1.257	-0.182	-10.150	0.050	-0.059	0.555	0.625	-0.677	2.275	1.180	1.395*
P5 x P7	-13.480	2.670	-0.849	-29.418*	0.513	-0.583*	0.508	0.674	0.420	2.376	1.789	1.350
P6 x P7	5.088	0.371	1.079	20.986*	0.692	0.347	0.489	-0.059	0.118	-1.568*	2.240	3.114
SE (Sij-Sik)	0.630	0.140	0.090	0.250	0.130	0.190	0.080	0.280	0.020	0.630	0.060	0.040
CD	1.250	0.280	0.180	0.490	0.250	0.370	0.170	0.050	0.050	1.250	0.090	0.070
SE (Sij-Skl)	0.590	0.130	0.090	0.230	0.120	0.170	0.080	0.030	0.020	0.590	0.040	0.030
CD	1.550	5.260	0.170	0.460	0.240	0.340	0.160	0.050	0.040	1.170	0.850	0.060

* Significant at 5% level

But in the case of absolute control KM-1285 x NDM-88-14 recorded significant positive sca effects. KM-1285 x LGG-444 exhibited significant negative sca effects under inoculated and non-inoculated conditions. But in the case of absolute control KM-1285 x NDM-88-14 recorded significant negative sca effects.

Dry weight of plants at 50 per cent flowering

Mean squares due to gca and sca were significant for dry weight of plants at 50 per cent flowering under inoculated, non-inoculated and absolute control. The ratio of s^2A to s^2D was less than unity suggesting the predominance of non-additive gene action.

In the case of inoculated population significant positive gca effects were shown by P.9333 and NDM-88-14 and significant negative gca effects were shown by COGG-902. Significant positive sca effects were shown by hybrids KM 1285 x IIPRM-3 and P.9333 x KM-1285 and significant negative sca effects were recorded by COGG-902 x LGG-444.

In the other two conditions NDM-88-14 exhibited significant positive gca effects and KM-1285 exhibited significant negative gca effects. Among the non-inoculated population significant positive sca effects were observed in P.9333 x KM-1285 and significant negative sca effects were recorded by KM-1285 x LGG-444. Both the hybrids had parents with positive and negative gca effects. Under absolute control significant positive sca effects were shown by hybrids P.9333 x KM-1285 and KM-1285 x IIPRM-3 and significant negative sca effects were recorded by KM-1285 x LGG-444.

For important nitrogen fixation traits NDM-88-14 was the best general combiner among the seven parents used for hybridization and P.9333 x NDM-88-14 was the best specific combiner.

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Table 4. Estimate of genetic components of variance for various nitrogen fixation traits in pot culture experiments

Sl. No.	Characters	Additive variance σ^2A	Dominance variance σ^2D	σ^2A/σ^2D
	Inoculated			
1.	Number of nodules at 50% flowering	738.83	1256.12	0.588
2.	Weight of nodules at 50% flowering	3732.56	4405.1551	0.847
3.	Nitrogen content at 50% flowering	-0.027	0.787	-0.017
4.	Dry weight of plants at 50% flowering	3.374	5.639	0.598
	Non inoculated			
1.	Number of nodules at 50% flowering	2.5	5.96	0.419
2.	Weight of nodules at 50% flowering	1.27	0.756	1.69
3.	Nitrogen content at 50% flowering	0.052	0.314	0.168
4.	Dry weight of plants at 50% flowering	2.10	4.93	0.425
	Non inoculated			
1.	Number of nodules at 50% flowering	8.47	4.05	2.09
2.	Weight of nodules at 50% flowering	1.17	0.659	1.775
3.	Nitrogen content at 50% flowering	0.032	0.286	0.112
4.	Dry weight of plants at 50% flowering	1.55	5.67	0.27

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Effect of tillage practices and pre-emergence herbicides application for weed control in wet-seeded rice

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Abstract : Investigations were carried out for two seasons (July 1998 - November 1998 and June 1999 October 1999) at FIPPAT Agricultural experimental farm, Padappai, to study the efficiency of three pre-emergence herbicides applied under different tillage systems *viz.* conventional tillage, conservation tillage and tillage - fallow (no-till), for controlling the mixed population of weeds in wet-seeded rice. The herbicides *viz.* Pretilachlor 750 g ha^{-1}, Butachlor 1250 g ha^{-1} and Oxadiargyl 100 g ha^{-1} were applied at 4 DAS, compared with hand weeding (twice) and unweeded control. Results revealed that, Oxadiargyl and Pretilachlor application effectively controlled the weeds in both the season. Among different tillage systems, conservation tillage was found effective. Hence, Oxadiargyl 100 g ha^{-1} and Pretilachlor 750 g ha^{-1} applied at 4 DAS under conservation tillage system compared with other tillage systems may therefore be recommended for effective weed control in wet-seeded rice.

Rice is the most important food cereal, grown under direct and transplanting methods. Among this, direct seeded rice under wet condition is less costly than transplanting due to lower requirement of labour and water. In view of this, wet-seeded rice is gaining popularity in most of the rice growing countries including in India. The main disadvantage of wet-seeded rice is high weed infestation, so effective and timely weed control is necessary. Yield loss in wet-seeded rice due to weed competition was estimated to be 30 - 35 per cent (Pillai, 1977). When weeds are controlled properly, grain yield from wet-seeded rice can be increased considerably (Biswas *et al.* 1991). Under ideal conditions and proper weed management, wet-seeded rice can yield on par or even higher than transplanted rice (Venkateshwarlu, 1980). Most of the occasions, adoption of tillage practices drastically reduced weed infestation (Balasubramanian, 1997). Tewari and Singh (1991) reported that the tillage destroyed the top and underground growth of perennials and exposed the tubers of sedges. Apart from this, pre-emergence herbicides application in rice resulted effective control of annual and perennial weeds (Smith and Moody, 1979). Now-a-days, labour for hand weeding is becoming too expensive. It is therefore the greatest interest and necessity to develop new integrated strategies for weed management in wet-seeded rice to ensure sustainable rice production to meet the requirements of the growing population.

Adoption of integrated weed control systems will be a holistic approach to the control of weeds using a range of techniques including choice of cultural methods and chemical inputs. Hence, the present study was designed to investigate the impact of cultural methods in conjunction with the application of pre-emergence herbicides for the control of mixed population of weeds in wet-seeded rice.

Materials and Methods

Field studies were conducted at FIPPAT Agricultural experimental farm, Padappai, during July 1998-November 1998 (Season 1) and June 1999 - October 1999 (Season 11), keeping three replications in a Split-plot design. The soil of the field was sandy loam. Both the field study, tillage practices *viz.* conventional tillage (T_1),