Wakisaka *et al.* (1992) also observed the variation in the reproductive ability, adult longevity, preovipositional period and fecundity of DBM when fed on broccoli, Chinese cabbage which were significantly higher than when fed on a wild crucifer Capsella bursa-pastoris. They also reported on the influence of temperature and nutrition of host plants in the survival of immature stages and reproduction of adults.

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Prediction of potential yield of rice across India through simulation modelling

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Abstract : An analysis of rice growth and its performance (cv IR 72) across India by a simulation study utilizing the historical mean weather data confirms that rice could be cultivated throughout India. The potential grain yields vary from 9.34 to 13,98 t ha^{-1} between 9°08' and 31°25'N latitude. The potential yield is increasing for increasing latitudes (9° to 23°N) and elevation (0 to 900m MSL). The growth duration varies (100 to 146 days) depending upon the geographical location. Suitable times for sowing also varies from all the 12 months in the South to a short period of only 4 months in the North. Optimum time of sowing for most of the locations in India seems around 15-June. It could be concluded that a detailed more realistic prediction is possible by simulation models, provided day wise more precise weather data including solar radiation is available for the testing centers. (*Key Words : Simulation model, Potential grain yield, Optimum sowing period, Growth duration)*

Rice research is predominant among agricultural scientific community. There is constant attempt by the scientists, to evolve newer high yielding genotypes to replace the existing ones; to find out newer cultural management practices to enhance the productivity; and to find out the causes for the yield decline in some parts of the rice growing environments etc. But the time required to arrive any confirmed results take years together. Nowadays simulation models are available as right tool to reduce the time required for the field study.

There are large number of climatic, edaphic, hydrologic, biotic, agronomic and socio-economic factors that influence crop growth and productivity. Analyzing the effects of some specific factors without consideration of interactions and feedback's from other controlling elements can often be misleading. For understanding such complex production systems, de Wit proposed four levels of crop production in order of deciding productivity (Penning De Vries *et. al.*, 1989). In production level one, growth occurs with ample water and nutrient availability throughout the plant life. It is assumed that there are no abiotic factors limiting growth. In such conditions, growth and productivity are primarily determined by solar radiation and temperature. Potential yield is thus the integrated expression of the influence of radiation and temperature on crop growth, development and grain yield and its estimation is important for determining the scope of yield improvement. At level two, growth is limited by water availability. At level three, growth is limited by shortage of nitrogen and water for some part of plant life. In level four, growth is limited by additional shortage of phosphorus and other minerals. At all levels, it is assumed that biotic factors are not constraint to growth. Here an attempt is being made through a simulation model, ORYZA1 (Kropff *et al.* 1993)

i) to estimate the climatically determined potential grain yield for different locations in India,

ii) to determine the effect of climatic variability on optimum time of sowing.

iii) to find out optimum crop duration in different climates and

iv) to find climatically available growing season for rice.

Materials and Methods

The simulation model ORYZA1 (v 2.11) describing the potential production of rice (Kropff *et al.* 1993) was used in this study.

Under favorable growth conditions, light, temperature and the varietal characteristics for phenological, morphological, and physiological processes are the main factors determining the growth rate of the crop on a specific day. The model follows a daily calculation scheme for the rates of dry matter production of the plant organs, the rate of leaf area development, and the rate of phenological development. By integrating these rates over time, dry matter matter production of the crop is simulated throughout the growing season. Input requirements of the model are: geographical latitude, daily weather data (solar radiation, minimum and maximum temperature), plant desity, date of crop emergence and transplanting and parameter values that describe the morpho-physiological characteristics of rice. The time step of integration is one day.

Weather data from 'Normals of Agroclimatic Observations in India' by India Meteorological Department, Pune was developed as weather files. The average standard weekly weather data is interpolated for the whole week. The solar radiation is derived from sunshine hours by computing the Angstrom formula :

$$S_g=S_o\ (a_A+b_A*(n_r/N_r))$$

Where

So - is the theoretical amount of global radiation without an atmosphere.

a_A - an empirical constant (0.25 for dry tropical zones, 0.29 for humid tropical zones & 0.8 for cold an temperate zone).

b_A - an empirical constant (as 0.45, 0.45, 0.55 respectively for the previous zones)

n_r/N_r - the ratio between the amount of bright sunshine hours (ns) and the maximum amount of sunshine hours (day length) (Ns).

The crop data obtained by IRRI / APPA division in 1992 with the *Oryza sativa* cv IR 72, Dry season at 220 kg N was used in this model (Kropff *et al.* 1993). Potential grain yield at 14% moisture for rice cv IR 72 was simulated for 37 locations in India (Table 1) for 24 times of sowing (15 days interval, two sowings per month). The simulated results were analyzed for the effect of latitude, elevation, optimum time of sowings and optimal crop duration.

Results and Discussion

Climatically possible potential grain yield

The simulated rice potential grain yield of the standard cv IR 72-a short - medium duration variety, for the 24 dates of sowings with an interval of 15 days, by well spread samples of 37 meteorological locations, are presented Table 1 to 3. From the results it could be drawn that rice can be cultivated throughout India with high potential yield. It can be confirmed with the simulated climatically possible potential grain yield which ranged between 9.34 to 13.98 t ha^{-1} without much geographical limitations to the entire country. The potential grain yield achievable in each location varied with season owing to their weather parameters. The variation is marginal when compared to wheat cultivation potential as predicted by Aggarwal et. al., (1994), wherein the simulated potential grain yield varied between 2.56 and 8.25 t ha^{-1} depending upon location. This wide variation may be accounted to available wheat growing periods, which varies very widely (from two months in the south to more than six months in the north). Because of this constraint wheat cultivation in India is limited to specific season in an year, whereas rice can be cultivated through out the year (see Table 1).

The concept of delineating 'efficient crop zones' based on the performance of individual crops for different agro-climatic zones by simulation modelling predicts rice in all the regions studied. But in reality the variation reported is very wide because rice cultivation in India undergoes all the four levels of constraints reported de Wit (Penning de Varies *et. al.*,1989) Rice is cultivated from lowland to upland; irrigated to rainfed; intermittent drought to prolonged submergence; efficient management to least aftercare and many more. Because of these problems, the wide variation in grain yield recorded exist in this vast sub-continent. The average national productivity is only 2.0 t ha^{-1}, which is far below the potential yield predicted. The historical weather says that rice could be cultivated throughout India starting from Kayamgulam in the South and Jullunder in the North with very high yield potential. Absolutely there are variations in terms of possible periods of rice sowing, optimum period of rice sowing, growth duration etc., which is discussed below in this paper.

Effect of geo graphical coordinates on potential rice yield

Simulated potential rice grain yield across India revealed little impact for longituditional position, a phenomenon which was well observed with wheat cultivation (Aggarwal *et. al.*,1994). While on the contrary, latitude and elevation have distinct impact on the growth, duration and grain yield of rice.

Potential grain yield increases (9.74 t ha^{-1} to 12.43 t ha^{-1}) as the latitude increases (form 9°08' N to 22°52' N) ($GY=7.7752\ e^{0.0189L}$; $R^2 = 0.94$). The impact is apparent between 9°08 and 15°9' N but not seen with higher latitudes studied (23° N to 31°25' N).

As elevation increases the grain yield potential also increases (between 3 and 899m + MSL studied) which is conspicuous only within the lower latitudes (9°08 to 22°52' N). The impact of elevation on potential grain yield is fabulous up to 13° N ($GY = 9.4935\ e^{0.004m}$; $R^2 = 0.93$) compared to the yield potential between 13° and 22°52' N ($GY = 11.441\ e^{0.00032m}$; $R^2 = 0.33$) and was not pronounced well in the higher latitudes. This is possible because of a decrease in the maximum and minimum temperatures for increases in the elevation, which normally leads to extended growth duration by reduced rate of growth and reduced respiration loss that ultimately leads to higher grain yield.

Growth duration and geographical locations

The rice growth period from seed to maturity for this cv. IR 72, which tested as 114 days at IRRI, Philippines during Summer 1992 season (Kroppf *et.al.*, 1993b), varied in great extent across the country for different weather conditions. The simulated growth duration ranged between 100 and 146 days between latitudes and season. In general, for the period of potential production, the growth period is found increasing from lower latitudes to higher latitudes and from lower elevation to higher elevation and from summer to winter. The cause is mainly due to a decrease in the mean temperatures in all the conditions stated above since, all the rice cultivars available as on date are possessing at least a minimum sensitiveness to temperature. The growth period increases for an increase in the latitude under plains or at relatively lower elevations particularly below 100m + MSL ($D = 108.7 + 0.8791L$; $R^2 = 0.48$) whereas, at higher latitudes or at higher elevations (200 to 800m + MSL) there is tendency towards decrease for an increase in elevation ($D+136.91 - 0.298L$; $R^2 = 0.04$). Shortest growth period is observed near 23°N when the sun is overhead. During the hot weather period (usually in June and July in India), the duration decrease from South to North of India with a clear impact between 9°08' and 23°N ($D=114.03-0514L$;$R^2 = 0.79$).

Besides analysing simulated rice performance in all the 24 sowings for the potential maximum production, its performance was also studied for a) at the shortest growth period and b) at a period when most of the area is reported with rice sowings (viz., 15-June). The results are discussed below.

a. Performance of IR 72 during its shortest growth period across India (Table 2)

The shortest growth period falls as early as March itself in the Southern part of India and extends upto July in the North with few exceptions. Such exceptions are true with reference to its local climatic conditions than the climate of wide range. There is fairly a good relation between the shortest growth periods and position of the sun. When the sun moves from Southern hemisphere, the shortest growth period also moves along its path. As such it is true the summer starts early (March) in the South.

It is interesting to note that the grain yield potential during its shortest growth period for this cv. IR 72 ranged narrowly between 7.01 and 9.56 with exception to Mandya and Hebbal, where the elevation has more role than these factors. An analysis on the shortest growth periods for all the locations show that for increasing in elevations the grain yield increases (GY = 7.6029 $e^{0.0004m}$; R^2 = 0.85). This increase is greater for the increasing altitude if that area falls between 9.08 and 13°N (GY = 7.866 $e^{0.0004m}$; R2 = 0.85) than 13° and 23°N (GY = 7.4101 $e^{0.0004m}$; R^2 = 0.77). The shortest growth period also decreases from lower latitude to higher latitude. This decrease is greater with the centres having low elevations (less than 100m+MSL) (D = 110.23 - 0.03514L R^2 = 0.52)

b) Performance of IR 72 during the major rice growing season - 15- June Table 3

An analysis in the performance of the cv. IR 72 during 15- June, the period where majority of the locations are reported with rice season revealed that many locations had shortest growth duration around this period. The duration ranged between 101 and 110 days. It can also be noted that these locations are lying between 20°15,N and 22°52,N. Here the duration decreases for increase in the elevation as D=144.03 - 0.514m with R2 = 0.79 for centers with low elevation (below 100m + MSL) whereas, the decrease is slow under higher elevations (200 to 800m + MSL).

Simulated potential grain yield across Indian sub-continent is above 7 t ha^{-1}, with a range of 7.01 to 11.9 t ha^{-1}. Grain yield of more 9 t ha^{-1} during this period could be seen with higher elevations (around 500 m + MSL) and higher amount of net PAR availability in that location. During this period, the grain yield decreases with an increase in the latitude particularly when the location is situated in an altitude of less than 100m. (GY= 9.6316e-0.0111L;R2 = 0.56).

No doubt here again the grain yield increases for an increases in the altitude as (GY = 8.5377e0.0003m; R2 = 0.81) more clearly in the lower latitudes (9 - 13°) than 13 to 23°N GY = 7.401e 0.0004m; R2 = 0.72). The HI, estimated for this cultivar during this period ranged between 0.53 and 0.58.

Available periods of sowings in India

Being a vast country which extends from 8°N to 36°N between South and North and possess different agro-climatic regions in it, it is conventional to identify the possible periods for growing rice. An attempt was made through the simulated rice growth at 15 days interval across India, to find out the successful sowings, meaning the crop matures with the climate within the period. Interstingly, the length of successful sowing periods in India varied very widely for the 37 location studied. It is possible to sow the crop throughout the year (All the 24 sowings from Jan to Dec.) And to reap successful crop in some parts, and to a very short period of only 4 months in some other parts. The length of sowing periods, here considered as number of months from the first possible sowing to the last, decreases linearly as the latitude increases (SP = 14.334 - 0.3232L ; R^2 = 0.726, where SP is sowing periods & L - latitude in degrees). It can be generalized that rice could be cultivated successfully throughout the year with high total annual rice yield in the lower latitudes (up to 15° N) whereas, in the North (beyond 23° 25') it is better to restrict the sowing periods for 5 months from April to August. In rest of the period, the crop faces either cold or hot periods and ends with failure of the crop. It should be kept in mind to have higher per day productivity, 15-June as best time of sowing for majority of the locations (15°N to 22°45' N), 1-July for locations above 23°25' N and 1-march for southern latitudes, particularly the west coast areas of Kerala with exceptions to Tamil Nadu, whose climate is predominantly interfered by Western Ghats during the south west monsoon period. In reality, eight states grow rice only in one season; five states cultivate 69% or more area in one season. Only 7% and 3% of Karnataka and Uttar Pradesh, respectively are planted to summer rice. Kerala has about the same acreage under first and second rice, and 11% under summer rice. Rice is evenly distributed between the first two seasons in Kerala, mainly beause rainfall is spread over more than 150 days and transplanting of rice is practised. In Andhra Pradesh, 96% of the rice area is irrigated and three crops are widely grown. The state accounts for 8.7% of the all - India rice area and 12% of India's total rice prodiction (Sreenivasan,1980).

Table 1. Simulated rice (IR 72) growth performance for the period of potential yield across India

Location	Latitude	Longitude	Elevation (m +MSL)	Max growth period -d	Optimum sowing period-d	Potential grain yield (t ha^{-1})	HI	PAR (MJ m^{-2} d^{-1})
Kayamgulam	9.08	76.31	3	113	1-Dec	9.74	0.56	5.98
Ollukara	10.32	76.30	22	114	1-Dec	9.51	0.56	5.78
Vedasandur	10.32	76.16	76	119	15-Nov	10.50	0.54	5.87
Pattambi	10.48	76.12	25	118	1-Jan	9.48	0.53	6.14
Coimbatore	11.00	77.00	431	121	1-Oct	10.74	0.56	5.15
Aduthurai	11.01	79.32	19	117	1-Dec	10.31	0.54	6.00
Kasargod	12.30	74.59	11	112	1-Dec	9.58	0.55	5.95
Mandya	12.30	76.50	695	134	15-Sep	13.01	0.56	5.49
Hebbal	13.00	77.38	899	139	15-Aug	13.70	0.58	5.22
Bellary	15.09	76.51	448	127	1-Oct	11.09	0.55	5.62
Ibrahimpatnam	17.06	78.40	542	139	1-Sep	13.67	0.57	5.48
Rajendranagar	17.19	78.23	542	135	15-Sep	12.89	0.57	5.59
Anakapalli	17.40	83.00	10	126	1-Nov	10.48	0.54	5.45
Parbhani	19.16	76.47	408	133	1-Sep	12.20	0.58	5.57
Bhubaneshwar	20.15	85.52	26	126	15-Sep	11.12	0.59	5.18
Cuttack	20.29	85.52	24	126	15-Sep	11.30	0.59	5.05
Akola	20.42	77.02	282	133	15-Aug	12.61	0.59	5.53
Nagpur	21.09	79.02	311	137	1-Sep	11.91	0.59	4.91
Surat	21.12	72.50	12	135	1-Nov	11.30	0.56	5.50
Samakunta	21.56	86.46	15	125	15-Aug	11.60	0.61	5.18
Barrackpore	22.45	88.26	9	132	1-Sep	12.30	0.64	4.72
Chinsura	22.52	88.24	9	131	1-Sep	12.43	0.64	4.96
Kanke	23.25	85.20	675	135	1-Aug	9.58	0.45	5.04
Kota	25.11	75.30	257	146	15-Aug	13.86	0.62	5.23
Jhansi	25.27	78.35	251	128	1-Aug	11.51	0.61	5.22
Madipura	25.50	86.40	42	126	15-Aug	11.20	0.63	4.76
Pusa	25.59	85.40	52	125	15-Aug	11.10	0.63	4.86
Gwalior	26.15	78.14	208	143	15-Aug	13.44	0.64	5.03
Agra	27.10	78.05	169	126	1-Aug	10.94	0.59	5.22
Aligarh	27.53	78.05	187	113	15-Jul	11.47	0.70	5.19
Pantnagar	29.00	79.30	244	131	1-Aug	11.83	0.62	4.92
Hissar	29.10	75.46	221	142	1-Nov	10.08	0.55	4.93
Muzaffarnagar	29.28	77.44	241	111	15-Jul	9.46	0.58	5.26
Nagina	29.28	78.32	249	128	1-Aug	11.80	0.62	5.02
Dehradun	30.20	77.52	640	140	15-Jul	13.98	0.63	5.01
Chandigarh	30.45	76.52	370	124	1-Aug	10.21	0.58	4.97
Jullunder	31.25	75.35	238	118	15-Jul	9.87	0.58	5.19

Table 2. Performance of rice (IR 72) growth performance during its shortest growth period across India-simulated results

Location	Latitude	Longitude	Elevation (m +MSL)	Duration (d)	Sowing period-d	Potential grain yield (t ha^{-1})	HI	PAR (MJ m^{-2} d^{-1})
Kayamgulam	9.08	76.31	3	104	1-Mar	7.67	0.56	4.180
Kottayam	9.32	76.30	73	106	15-Mar	8.29	0.53	4.943
Ollukara	10.32	76.16	22	107	15-Mar	7.01	0.56	3.561
Vedasandur	10.32	77.57	76	110	1-Jul	8.38	0.54	5.073
Pattambi	10.48	76.12	25	109	1-Mar	7.78	0.57	3.807
Coimbatore	11.00	77.00	431	108	1-Jun	9.17	0.56	4.898
Aduthurai	11.01	79.32	19	105	15-Jul	8.35	0.53	5.295
Kasargod	12.30	74.59	11	105	1-Mar	8.39	0.52	5.514
Mandya	12.30	76.50	695	115	1-Mar	10.27	0.54	5.826
Hebbal	13.00	77.38	899	118	1-Mar	11.18	0.55	5.856
Bellary	15.09	76.51	448	110	15-Jun	9.14	0.56	5.009
Ibrahimpatnam	17.06	78.23	542	112	1-Jun	9.59	0.56	4.768
Rajendranagar	17.19	78.23	542	107	15-Jun	8.78	0.55	4.766
Anakapalli	17.40	83.00	10	107	15-Jun	7.56	0.55	4.336
Parbhani	19.16	76.47	408	109	15-Jun	8.85	0.56	4.706
Bhubaneshwar	20.15	85.52	26	101	15-Jun	7.53	0.55	4.545
Cuttack	20.29	85.52	24	101	15-Jun	7.01	0.55	4.168
Akola	20.42	77.02	282	109	15-Jun	8.54	0.58	4.394
Nagpur	21.09	79.02	311	106	1-Jul	7.9	0.58	4.236
Surat	21.12	72.50	12	102	15-Jun	7.6	0.57	4.392
Samakunta	21.56	86.46	15	106	15-Jun	8.31	0.56	4.623
Barrackpore	22.45	88.26	9	102	15-Jun	7.05	0.55	4.137
Chinsura	22.52	88.24	9	100	1-Jul	7.24	0.54	4.540
Kanke	23.25	85.20	675	109	1-Jun	8.64	0.55	4.367
Kota	25.11	75.30	257	111	1-Jul	9.23	0.58	5.054
Jhansi	25.27	78.35	251	110	15-Jun	8.66	0.57	4.782
Madipura	25.50	86.40	42	102	15-Jun	7.75	0.55	4.716
Pusa	25.59	85.40	52	102	1-Jul	7.47	0.54	4.755
Gwalior	26.15	78.14	208	107	1-Jul	7.95	0.56	4.542
Agra	27.10	78.05	169	110	1-Jul	8.77	0.57	5.091
Aligarh	27.53	78.05	187	110	15-Jun	8.6	0.55	4.955
Pantnagar	29.00	79.30	244	106	15-Jun	8.36	0.56	4.821
Hissar	29.10	75.46	221	109	1-Jul	8.24	0.56	4.651
Muzaffarnagar	29.28	77.44	241	111	15-Jul	9.46	0.58	5.261
Nagina	29.28	78.32	249	104	15-Jun	8.07	0.54	4.904
Dehradun	30.20	77.52	640	112	1-Jun	9.36	0.57	4.545
Chandigarh	30.45	76.52	370	108	1-Jul	8.7	0.55	5.111
Jullunder	31.25	75.35	238	112	1-Jul	9.09	0.56	5.250

Table 3. Simulated rice growth and yield performance on 15-June across Indian subcontinent.

Location	Latitude	Longitude	Elevation (m)	Duration (d)	Potential grain yield (t ha^{-1})	HI	PAR (MJ m^{-2} d^{-1})
Kayamgulam	9.08	76.31	3	106	8.86	0.56	4.87
Kottayam	9.32	76.30	73	110	9.03	0.55	4.72
Ollukara	10.32	76.16	22	108	7.57	0.55	3.90
Vedasandur	10.32	77.57	76	111	8.58	0.55	5.05
Pattambi	10.48	76.12	25	110	8.94	0.57	4.55
Coimbatore	11.00	77.00	431	109	9.41	0.56	4.53
Aduthurai	11.01	79.32	19	107	8.72	0.55	5.26
Kasargod	12.30	74.59	11	110	9.07	0.56	4.53
Mandya	12.30	76.50	695	118	10.78	0.56	5.08
Hebbal	13.00	77.38	899	127	11.87	0.54	5.13
Bellary	15.09	76.51	448	110	9.14	0.56	5.01
Ibrahimpatnam	17.06	78.40	542	113	9.86	0.56	4.89
Rajendranagar	17.19	78.23	542	107	8.78	0.55	4.77
Anakapalli	17.40	83.00	10	107	7.56	0.55	4.34
Parbhani	19.16	76.47	408	109	8.85	0.56	4.71
Bhubaneshwar	20.15	85.52	26	101	7.53	0.55	4.54
Cuttack	20.29	85.52	24	101	7.01	0.55	4.17
Akola	20.42	77.02	282	109	8.54	0.58	4.39
Nagpur	21.09	79.02	311	106	7.57	0.58	3.93
Surat	21.12	72.50	12	102	7.60	0.57	4.39
Samakunta	21.56	86.46	15	106	8.31	0.56	4.62
Barrackpore	22.45	88.26	9	102	7.05	0.55	4.14
Chinsura	22.52	88.24	9	101	7.32	0.54	4.50
Kanke	23.25	85.20	675	111	9.14	0.56	4.59
Kota	25.11	75.30	257	111	8.86	0.58	4.76
Jhansi	25.27	78.35	251	110	8.66	0.57	4.78
Madipura	25.50	86.40	42	102	7.75	0.55	4.72
Pusa	25.59	85.40	52	102	7.46	0.53	4.76
Gwalior	26.15	78.14	208	107	7.95	0.56	4.54
Agra	27.10	78.05	169	110	8.34	0.56	4.85
Aligarh	27.53	78.05	187	110	8.60	0.55	4.95
Pantnagar	29.00	79.30	244	106	8.36	0.56	4.82
Hissar	29.10	75.46	221	109	8.24	0.56	4.65
Muzaffarnagar	29.28	77.44	241	108	8.64	0.55	5.03
Nagina	29.28	78.32	249	104	8.07	0.54	4.90
Dehradun	30.20	77.52	640	113	9.84	0.58	4.73
Chandigarh	30.45	76.52	370	108	8.48	0.56	4.91
Jullunder	31.25	75.35	238	112	8.67	0.54	5.20

An analysis of rice growth and its performance (cv IR 72) across India by a simulation study, utilizing the historical mean weather data agreed with the well known fact that rice could be cultivated throughtout India. The potential grain yield varied from 9.34 to 13.98 t ha-l between 9°08' and 31°25' N latitude. The potential yield is increasibng for increasing latitudes from (9° to 23° N) and elevation (0 to 900m + MSL). The growth duration varied depending upon the geographical coordinates (100 to 146days). Possibly suitable times for sowing also varies from all the 12month in the South to a short period of only 4 months in the North. Optimum time of sowing for most of the locations in India seems around 15-June. It could be concluded that a detailed more realistic prediction is posible by simulation models, provided day wise more reliable weather data including solar radiation is available for the testing centers. It also possible to compare the actual and predicted grain yields if ground truths and crop data are available.

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Effect of integrated nitrogen management on fertility status of rice soil

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Abstract : Field experiment with rice crop using N fertiliser, FYM, *Sesbania aculeata and Azospirillum* at Tamil Nadu Agricultural University farm, Coimbatore revealed that there was a depletion of all the major nutrients with the application of fertiliser N alone. Conjoint addition of green manure with fertiliser N improved the status of available N, organic carbon, NH_4-N, Olsen - P and NH_4OAc-K. A substantial increase in the fertility status was also observed with the incorporation of FYM with higher doses of N fertilisers. However, there was a drastic reduction of NO_3-N in rice soil with all the treatments studied.
(Key Words : Rice, FYM, Green manure, Azospirillum, Buildup, Depletion)

Rice crop utilises nitrogen inefficiently. Under tropical condition, the efficiency of fertiliser N was usually 30-40 per cent. The nitrogen is subjected to different losses which causes depletion of nutrients in the post harvest soil. The supply of fertiliser N along with other organic sources is known to stimulate the mineralisation and then immobilisation of organic N and reduces the losses of N (Meelu *et al.*, 1985). Integrated use of organic sources in combination with the fertiliser N and their management for efficient as well as economic use of fertiliser and maintenance of soil fertility and productivity is very essential for tropical countries. Keeping these facts in perspective, the present investigation was taken up to study the integrated nitrogen use on the fertility status of rice soil in Noyyal series (Typic Haplustalf).