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Biophysical observation and XRD soil analysis for Rice Variety

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ABSTRACT:

The supplementary function of organic manure in conjunction with chemical fertilizers plays a vital role in maintaining soil health, thereby potentially enhancing rice yield.A field trial was conducted in 2020 during the rice cultivation season in the kharif period at a farmer's field in Alwanneri village, Nanguneri Taluk, Tirunelveli district, Tamil Nadu. The study was designed following a Randomized Block Design (RBD) with seven treatments, three replications to assess various organic manures such as Farm Yard Manure (FYM), Vermicompost (VC), and Vegetable waste compost (VWC) at different combination and dosage levels of application (4.5 t ha^{-1},11.5 t ha^{-1}, 17.5 t ha^{-1}) in comparison to a control plot without any manure amendment.The study focused on the impact of plant spacing on rice variety TKM 9, analysing plant growth and yield. Seedlings age under 25 days were transplanted with 30x 20cm spacing for six treatment and control plot. Data on plant height, Number of tillersand leaf width were collected from 7 sampling plants in each plot. Results indicated significant effects of planting density and seedling age on plant height, number of tillers and grain yield. Soil samples were collected from random areas covering the entire area within each plot at (0-30cm) depth at before harvest and after harvest it is used for XRD soil morphology analysis.

Keywords: Farm Yard Manure (FYM), Vermicompost (VC), Vegetable Waste Compost (VWC), Plant spacing, X-ray diffraction (XRD)

INTRODUCTION:

Climate variability and the expanding global population pose significant challenges for the cultivation of rice (Oryza sativa L) as highlighted in previous studies [1]. The shifting climate patterns represent a prominent concern, posing a considerable risk to agricultural output and food security. Within the Indian context, rice is cultivated over an extensive area of 46.38 million hectares, resulting in a total yield of 130.29 million tons and a productivity rate of 2809 kg ha^{-1}. Specifically, in Tamil Nadu, rice cultivation covers 2.21 million hectares, leading to an output of 8.07 million tons and a productivity level of 3658 kg ha^{-1} [2]. Looking at the statistics for the year 2020-21, the overall food grain production reached 305.44 million tonnes, with rice contributing significantly with 121.46 million tonnes from 44 million hectares across India [3]. This demographic surge underscores the necessity for a proportional increase in agricultural output.

Rice plant growth and development are influenced significantly by light [4]. Each plant species needs a specific light intensity for a certain duration to ensure proper growth, sustained development, and maximized productivity [5]. When the amount of light intensity reaching the plants is below the optimum level, it can cause low light stress, which may stress the plant. The consistent stand of rice and its development and productivity can be controlled by considering the age of the seedlings [6].

Planting geometry determines the planting density or plant population in unit area thereby influencing the input use efficiency and yield of the crop.Both variety and spacing are important factors indetermining yield traits and eventually rice yield. Over the control, greater row spacing increased the number of tillers per plant, the number of spikes per hill, the number of spikelet's per spike, the number of seeds per spike, the weight of seed per hill the 1000 grain weight, and the yield t ha^{-1}. It was found that wider spacing of20 cm × 20 cm, 20cm × 25 cm, 20cm × 30 cm, 25cm × 25 cm, and30 cm × 30 cm resulted in considerably more panicles per unit area, longer panicles, higher panicle weight, and higher grain production than the closer spacing of15cm × 10 cm, 15 cm × 15 cm, 20cm × 15 cm [7]. Optimal domain-specific spacing is required along with the introduction of superior varieties and the promotion of row transplanting for higher grain yields.

In this field investigation was done to study the effect biophysically parameters and soil mineralogical studies of organically amended red rice variety. Good soil is central to food production, and therefore to human life. Improving the soil will not only improve the crops we grow, it crucially contributes in healing the planet. Soil has the basic characteristics which adds rich biological life, good structure and readily available nutrients.
X-ray diffraction is a technique that provides information about the atomic structure of crystalline substances. It is a powerful tool in the identification of minerals in rocks and soils. The bulk of the clay fractions of many soils is crystalline, but clay particles are too small for optical crystallographic methods to be applied. Therefore, XRD has long been a mainstay in the identification of clay sized minerals in soils [8].Soil commonly contains primary and secondary minerals and may have crystallographic characteristics that strongly influence the physical and chemical properties of soil. X-ray diffraction is the technique most heavily relied upon soil mineralogical analysis [9-10].

MATERIAL AND METHODS:

Alwanneri village, Nanguneri Taluk, Tamilnadu, State of India which is geographically located in the extreme south of the sub content of Kanyakumari. The field coordinates at Latitude 8.608°, Longitude 77.755° which is 141 meter above the sea level. The soil texture of the experimental site is sandy clay loam .The experiment was laid out in Randomized Block Design (RBD) with six treatments and it is replicated thrice. It is ensured that all the plots treatments received an equal amount of recommended dose of fertilizer except the control plot. The test crop 'TKM 9' rice variety with Seedlings age <26 days of were directly transplanted to the field, keeping 2 seedling/hill at 20 x 20 cm spacing and plot size was 40 sq.m in Kharif season 2020 under puddle conditions. The crop duration is 110 days. Organic manure viz., Farm Yard Manure, Vermicompost (VC), Vegetable Waste Compost (VWC) at different combination and at different dosage level (4.5 t ha^{-1}, 11.5 tha^{-1}, 17.5 t ha^{-1}) were supplied to each plot separately and compared with the control plot under no manure condition.The biophysical parameters of the crop observations viz., the Plant height, No of tillers and leaf width was recorded for randomly selected 7 sampling plants from each plot. Then soil samples are collected before and after harvest at different spots within each plot covering the entire area at soil depth (0-30 cm) and are dried at room temperature, properly sieved used for morphological X –ray diffraction analysis and statistically analysed using SPSS software.

GROWTH PARAMETERS:

Plant height:
Plant height was measured by selecting the main shoot and it was recorded from ground level to the base to fully opened leaf. This measurement was carried out for (45, 65, 85 and 110 days after transplant (DAT)) seven sampling plants were randomly selected in each plot. After the emergence of the panicle, the height was taken up to the base of the panicle. The average plant height was worked out and expressed in centimetres (cm).

Number of tillers per plant:
The number of tillers emerging directly from the main stem was counted and the average of the seven plants was expressed as the number of tillers per plant.

Leaf width:
The uppermost fully expanded leaf of the mother tiller was selected for the estimation Leaf area. Leaf width from each plot of rice variety under all three replication of each treatment was measured.

Grain yield:

Crops were harvested manually leaving few centimetres above the ground and separated the grains and straw by threshing the separated grains were recorded as grain yield.

X-RAY DIFFRACTION:

X-ray diffraction techniques help identify crystalline phases and analyse phase quantities. These techniques excel in revealing the atomic structure of crystalline solids. When a monochromatic X-ray beam of suitable wavelength strikes crystal plane, the X-rays are reflected by the atoms of the crystals. The signal is reinforced in a particular direction if the rays reflected by the different planes are in phase, this phenomenon corresponds to the Bragg equation, $n\lambda = 2d\sin\theta$, is crucial in understanding X-ray diffraction. It involves integers, wavelength, interplanar spacing, and angle of X-ray beam. When the equation is satisfied, diffraction occurs in the direction defined by the angle θ. X-ray diffraction experiments involve diffracted intensities and angles, acting as a chemical fingerprint for identification. Comparison with a known database can aid in chemical identification.From equation of XRD analysis involves fixing lambda and theta angle to determine peak intensity and mineralogical details through d spacing. This method is applicable to single crystals and mineral mixtures in powder form. Diffraction angles and relative peak intensity provide information for establishing structural details and identifying minerals present in mixtures like soil clay fractions.

Table 1-2: Shows the Plant height in cm during growth periods

Control plot test value =47.100							Control plot test value =65.257					
45 DAT							65 DAT					
Plots	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference
T4 A	51.943	2.607	0.985	4.915	0.003	4.843	68.657	3.119	1.178	2.884	0.028	3.400
T4 B	54.857	2.017	0.762	10.174	0.000	7.757	71.971	2.426	0.916	7.322	0.000	6.714
T4 C	56.43	3.18	1.202	7.762	0.000	9.330	72.214	2.286	0.863	8.053	0.000	6.957
T5 A	53.043	3.449	1.303	4.559	0.004	5.943	68.786	3.020	1.141	3.091	0.021	3.528
T5 B	56.714	2.828	1.069	8.993	0.000	9.614	69.514	1.763	0.666	6.385	0.001	4.257
T5 C	57.357	1.791	0.677	15.148	0.000	10.257	71.571	2.036	0.769	8.205	0.000	5.314

Control plot test value =80.208							Control plot test value =93.529					
85 DAT							110 DAT					
Plots	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference
T4 A	91.071	0.897	0.339	32.019	0.000	10.862	92.357	6.081	2.298	-0.510	0.628	-1.171
T4 B	96.900	0.976	0.369	45.229	0.000	16.691	97.700	3.169	1.198	3.482	0.013	4.171
T4 C	80.471	1.311	0.496	0.530	0.615	0.263	93.543	5.873	2.219	0.006	0.995	0.0142
T5 A	86.729	3.952	1.494	4.365	0.005	6.519	94.700	4.391	1.659	0.706	0.507	1.171
T5 B	89.014	2.958	1.118	7.877	0.000	8.805	100.714	.904	.341	29.752	.000	10.171
T5C	88.643	2.683	1.014	8.318	0.000	8.434	101.757	.994	.375	29.826	.000	11.214

Table 3-4: Shows the No of Tillers/m^2 during growth period

Control plot test value =20.286							Control plot test value =58.000					
45 DAT							65 DAT					
Plots	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference

T4 A	27.000	7.000	2.646	2.538	0.044	6.714	46.000	5.537	2.093	-5.733	0.001	-12.000
T4 B	21.429	4.467	1.688	0.677	0.524	1.143	45.000	4.041	1.528	-8.510	0.000	-13.000
T4 C	21.000	6.855	2.591	0.276	0.792	0.714	58.000	2.645	1.000	0.000	1.000	0.000
T5 A	22.286	7.455	2.818	0.710	0.505	1.999	55.000	2.708	1.024	-2.931	0.026	-3.000
T5 B	24.000	4.321	1.633	2.274	0.063	3.714	57.000	2.828	1.069	-0.935	0.386	-1.000
T5 C	23.143	3.671	1.388	2.059	0.085	2.857	54.000	3.000	1.134	-3.528	0.012	-4.000

Control plot test value =62.000							Control plot test value =80.9					
85 DAT							110 DAT					
Plots	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference
T4 A	70.000	3.916	1.480	5.405	0.002	8.000	81.29	4.855	1.835	.210	.840	386
T4 B	68.286	6.237	2.358	2.666	0.037	6.286	80.86	5.429	2.052	-.021	.984	-.043
T4 C	69.286	7.017	2.652	2.747	0.033	7.286	80.14	5.367	2.029	-.373	.722	-.757
T5 A	73.143	3.848	1.455	7.661	0.000	11.143	83.14	4.776	1.805	1.242	.260	2.243
T5 B	76.143	9.957	3.763	3.758	0.009	14.143	91.00	2.000	..756	13.361	.000	10.100
T5 C	68.286	4.680	1.769	3.553	0.012	6.286	91.29	2.928	1.107	9.386	.000	10.386

Table 5-6: **Shows the Leaf width during growth periods**

Control plot test value =0.084							Control plot test value =1.004					
45 DAT							65 DAT					
Plots	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference
T4 A	0.080	0.008	0.003	-247.240	0.000	-0.763	1.000	.000	0.000	….	….	….
T4 B	0.088	0.003	0.001	-528.100	0.000	-0.754	1.000	.000	0.000	….	….	….
T4 C	0.090	0.000	0.000	…..	0.000	-0.753	1.000	.000	0.000	….	….	….
T5 A	0.090	0.000	0.000	…..	0.000	-0.753	1.000	.000	0.000	….	….	….
T5 B	0.090	0.000	0.000	…..	0.000	-0.753	1.000	.000	0.000	….	….	….
T5 C	0.088	0.003	0.001	-528.100	0.000	-0.754	1.000	.000	0.000	….	….	….

Control plot test value =1.0129							Control plot test value =1.0329					
85 DAT							110 DAT					
Plots	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference	Mean	SD	SE	t	Sig. (2-tailed)	Mean Difference
T4 A	1.000	0.009	0.003	-1.948	0.099	-0.007	1.016	0.009	0.003	-4.659	0.003	-0.017
T4 B	1.013	0.009	0.003	-0.012	0.991	-0.000	1.027	0.008	0.002	-2.015	0.091	-0.005
T4 C	1.019	0.006	0.002	2.174	0.073	0.006	1.024	0.005	0.002	-4.264	0.005	-0.008
T5 A	1.014	0.005	0.002	0.686	0.518	0.001	1.034	0.016	0.006	0.227	0.828	0.001
T5 B	1.016	0.007	0.003	0.946	0.381	0.002	1.034	0.012	0.004	0.288	0.783	0.001
T5 C	1.016	0.007	0.003	0.946	0.381	0.003	1.034	0.015	0.005	0.243	0.816	0.001

RESULT AND DISCUSSION:

This study examines the impact of various organic manure combinations on the growth parameters of a specific crop. The plots designated as T4A, T4B, T4C, T5A, T5B, and T5C were treated with different dosage levels @4.5 t ha^{-1},11.5 t ha^{-1},17.5 t ha^{-1} and types of organic manures, including Farmyard manure (FYM), Vermicompost (VC) and Vegetable Waste Compost (VWC), while the control plot (T8) did not receive any organic manure. The main parameters evaluated were average plant height in centimetres, average number of tillers per square meter, and leaf width which is show in table [1-6], Descriptive statistics including the mean, standard deviation (SD), and standard error (SE) were used to analyse the data collected from these plots. This report aims to interpret these findings to understand how different organic manure treatments influenced the growth of the crop compared to the control plot.

Plant height:

At 45 DAT, all plot combinations (T4 A, T4 B, T4 C, T5 A, T5 B and T5 C) exhibit p-values below 0.05 signifying a statistically significant discrepancy between the average plant height and the control plot value. The positive mean disparities imply that the plot combinations display elevated plant heights compared to the control plot. Similarly, at 65 DAT all combinations demonstrate p-values below 0.05, indicating a statistically significant variation in plant height means compared to the control plot.

Furthermore, at 85 DAT, with a mean control plot value of 80.208 for plot combinations T4 A, T4 B, T5 A, T5 B and T5 C, the p-values are less than 0.05, signifying a statistically significant difference in mean plant height relative to the control plot. For the plot combination T4 C the p-value surpasses 0.05, suggesting no statistically significant difference in mean plant height compared to the control plot. At 110 DAT, involving combinations T4 B, T5 B and T5 C the p-values are below 0.05, indicating a statistically significant divergence in mean plant height compared to the control plot. Conversely, for plot combinations T4 A, T4 C and T5A the p-values exceed 0.05, illustrating no statistically significant difference in mean plant height relative to the control plot. Consequently, the analysis leads to the conclusion that most plot combinations exhibit significantly elevated plant heights in comparison to the control plot at 45, 65 and 85 DAT. At 110 DAT T4 B, T5 B, and T5 C demonstrate a noteworthy distinction from the control plot, while the remaining combinations do not. Notably, T5 B and T5 C consistently perform admirably across all time points, suggesting they represent the optimal plot combinations for achieving heightened plant heights

Number of Tillers: T4 A showed a statistically significant difference with more tillers compared to the control plot. Other plot combinations did not show a significant difference from the control plot at 45 DAT were T4 A, T4 B, T5 A, and T5 C at 65 DAT showed statistically significant differences with fewer tillers compared to the control plot. T4 C and T5 B did not show a significant difference from the control plot. Whereas all plot combinations T4 A, T4 B, T4 C, T5 A, T5 B and T5 C at 85 DAT showed statistically significant differences with more tillers compared to the control plot. During 110 DAT the T5 B and T5 C showed statistically significant differences with more tillers compared to the control plot. Other plot combinations did not show a significant difference from the control plot. Thus based on the analysis it is concluded that at 45 DAT, only T4 A showed a significant increase in tillers compared to the control plot. At 65 DAT, several plots had fewer tillers, while T4 C and T5 B showed no significant difference. At 85 DAT, all plot combinations showed more tillers than the control plot. At 110 DAT, T5 B and T5 C showed significantly more tillers, indicating their superior performance well across the growth times.

Leaf Width:

For all plot combinations at 45 DAT (T4 A, T4 B, T4 C, T5 A, T5 B and T5C), the p-values are less than 0.05, indicating a statistically significant difference between the mean leaf width and the control plot value.The mean differences are negative, suggesting that the plot combinations have lower leaf widths compared to the control plot. At 65 DATwith mean control plot test value 1.004 for which all plot combinations (T4 A, T4 B, T4 C, T5 A, T5 B and T5C), the standard deviation and standard error are zero, and the mean leaf width is exactly equal to the control plot value.This indicates that there are no differences between the plot combinations and the control plot at 65 DAT and at 85 DAT for all plots the p-values are greater than 0.05, indicating no statistically significant difference between the mean leaf width and the control plot value. At 110 DATFor plot combinations T4 A and T4 C, the p-values are less than 0.05, indicating a statistically significant difference between the mean leaf width and the control plot value. For plot combinations T4 B, T5 A, T5 B, and T5C, the p-values are greater than 0.05, indicating no statistically significant difference between the mean leaf width and the control plot value.

Grain yield: The total weight of clean and dried grains from each plot was weighed with the help of electronic balanceand converted into t/ha is shown in table-3 and this values are agreeable with [12-13]

Table -7: Shows the grain yield for the plots combination during growth period

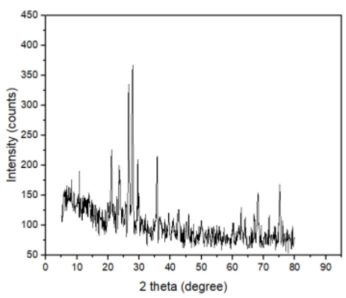
Plots	**Manure**	**Grain yield t ha^{-1}**
T4 A	FYM+VC	3829
T4 B	FYM+VC	3786
T4 C	FYM+VC	3484
T5 A	FYM+VWC	3924
T5 B	FYM+VWC	4000
T5 C	FYM+VWC	4411
T8(Control)	No manure	1917

A- 4.5 t ha^{-1} B – 11.5 t ha^{-1}C- 17.5 t ha^{-1}

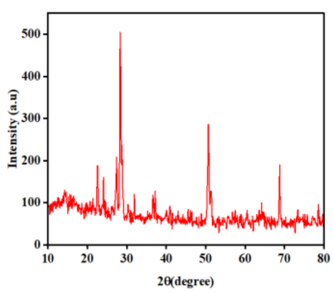
XRD Analysis:
Now the soil samples from before and after harvest are analysed for mineralogical identification using an x-ray Diffractometer. A diffractometer is a measuring instrument for analysing the structure of a material from theScattering pattern produced when a beam of X-ray radiation interacts with it. A typical diffractometer consists of a source of radiation, a monochromator to choose the wavelength, slits to adjust the shape of the beam, a sample and a detector. The setting of the generator is 30 mA/40 kV with CuKα radiation of λ = 1.54060 A^0. A continuous scanning process was carried out with the start position (2q) from 5 to end position (2q) 80 with the preset time of 0.60 sec. The samples are analysed for the xrd patterns and from the values of 2ϴ and d spacing the prominent diffraction pattern at before harvest and after harvest showed the presence of Kaolinite quartz, haematite. The XRD graph shows FYM+VWC at 11.5 t ha^{-}1organic manure amended plot compared with control plot at before and after harvest. The diffraction peak appears at 27.8297,26.6012 and 21.0582 is compared with after harvest peaks 28.3410, 50.664, 68.740.In similar way the diffraction peaks in FYM+VWC at 17.5 t ha^{-1}the diffraction peaks are at 26.469, 27.590, 49.90 and after harvest 27.04, 28.28, 55.408. Further the diffraction peaks of the control plot at before harvest are at 21.940, 26.533.28.140 and after harvest was at 21.061, 26.931, 50.412.Thus the changes in the diffraction peaks of the soil samples before harvest and after harvest, control plot without manure indicate that the soil exhibits crystalline in nature shows variation in soil composition that also confirms the presence of kaolinite, illtite, quartz and hematite in the soil by the supplement of organic manure.This result is agreeable with the [14, 15]

Figure 1-3: Shows the XRD analysis for the best yield combination with control plot (no manure)

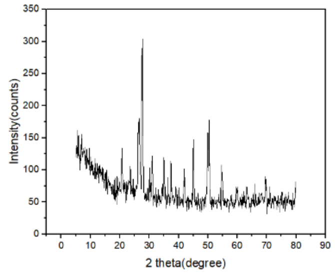
FYM +VWC (before harvest)



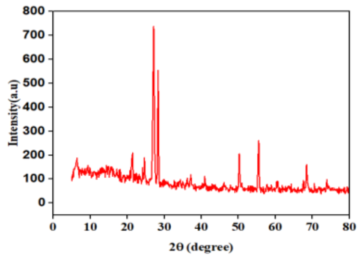
FYM+VWC (after harvest)



FYM+VWC (Before harvest)

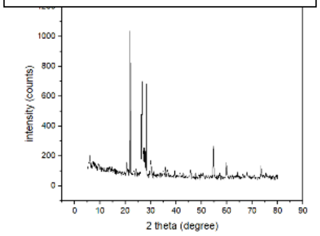


FYM+VWC (after harvest)

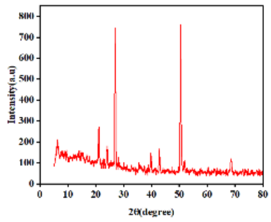


CONTROL PLOT:

Before harvest



After harvest



By using Scherer formula particle size of the soil before and after harvest is calculated
The formula is,
$D = K\lambda/\beta \cos\theta$
Microsoft excel is used to run the equation by substituting the value of K and wavelength of X-ray(λ) which is used to calculate the particle size of the different samples.

Table-8: Particle size analysis for best yield plot is compared with control plot

Plots	Manure	Before harvest	After harvest
T5 B @11.5 t ha^{-1}	FYM+VWC	12.26206	14.27616
T5 C @17.5 t ha^{-1}	FYM+VWC	11.96154	12.22679
T8(CONTROL)	No manure	10.69881	11.58084

The result shows the particle size has been improved from before harvest in after harvest than the control plot

CONCLUSION:

The results highlight the potential benefits of organic manures in enhancing certain growth parameters, though the specific effects may depend on the type and ratio of manure applied. This study underscores the importance of tailored organic manure treatments to optimize growth outcomes in agriculture.

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