Soil Science

Progress Report of Soil Science Coordinated Program
(*Rabi* and *Kharif* - 2022)

SOIL SCIENCE

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5. SOIL SCIENCE

Summary

The coordinated multi-location evaluation program in Soil Science addresses the issues related to sustaining productivity of soil and crop systems on long term basis; soil quality and productivity assessment for bridging the gap in farmers' fields; management of sodic soils using nano Zn formulation; management of acid soils; residue management in rice based cropping systems; nano-fertilizers for increasing nutrient use efficiency, yield and economic returns in transplanted rice; yield maximization in different rice growing zones and evaluation of organic fertilizers and Natural farming practices for enhancing the crop productivity and soil health. A total of eight trials were conducted during *Rabi*-2021-22 and *Kharif*-2022 in 16 locations (funded as well as voluntary centers) representing typical soil and crop systems and important rice growing regions.

5.1. Long-term soil fertility management in rice-based cropping system

In the 34th year of study on long term soil fertility management in RBCS, the treatment RDF + FYM resulted in maximum grain yield at all 3 locations and the treatment with FYM alone was on par to RDF during *Kharif* at MTU and in both seasons at TTB. Nutrient omission and reduction of NPK to 50% resulted in yield reduction at all three centers in both seasons. Fifty per cent (50%) reduction in NPK resulted in more loss at TTB compared to other two centers in both seasons. Over a period of 34 years, supplementary dose of FYM along with RDF recorded positive growth rate in productivity with 63, 75 and 58 kg/ha/year at MTU, TTB and MND, respectively, compared to RDF where growth rate varied from less than 1 kg/ha/year at MND to 42 kg/ha/year at TTB.

Supplementary dose of FYM along with RDF resulted in maximum grain yield at all locations and nutrient omission and reduction of NPK to 50% resulted in significant yield reduction at all centers. FYM along with RDF recorded a higher positive growth rate in productivity compared to RDF.

5.2. Soil quality and productivity assessment for bridging the yield gaps in farmers' fields

This trial was conducted in farmers' fields in few selected centres, viz., – Chinsurah, Titabar, Pantnagar, Kanpur, Kaul and Karaikal to assess the variability in soil nutrient supply, its relationship with rice yields at current recommended and farmers' fertilizer practices in some new farm sites and fine-tune the fertilizer nutrient requirement for specific target yields in a given environment and validation of fertilizer recommendations for targeted yields. Sharp

variations in mean grain yields recorded varied from 2.38 t /ha among low yielders to 4.73 t /ha among high yielders at Chinsurah, from 2.48 t /ha among low yielders to 3.43 t /ha among high yielders at Titabar , varied from 4.76 t /ha among low yielders to 6.59t /ha among high yielders at Kanpur, varied from 4.83 t /ha among low yielders to 5.84 t /ha among high yielders at Pantnagar, from 3.83 t /ha among low yielders to 4.36 t/ha among high yielders at Karaikal and from 1.44 t /ha among low yielders to 8.8 t /ha among high yielders at Kaul. Fertilizer prescriptions were worked out for all the farm sites. The soil quality index was much superior at Pantnagar and was at par for all other centers.

- **Out of many factors that contribute to the yield gap, soil quality vis a vis rice yield was studied across several dominant rice ecologies of India and sharp variations in yield and soil quality indices were noted across rice ecologies and farming communities.**
- **Closing the yield gap requires a multi-faceted approach that addresses the underlying causes of low yields and hence, fertilizer prescriptions were worked out for all the farm sites to bridge the yield gap.**

5.3. Management of sodic soils using nano Zn formulation

In a study on "Management of Sodic soils using nano zinc formulation", two genotypes were evaluated with six different set of nutrient management practices at four different locations. Significant genotypic and location-specific differences in yield parameters and yield were observed at all four locations. At Kanpur and Pusa, soil application of $ZnSO_4$ @ 50 kg/ha registered higher grain (4.36 t/ha, 3.41 t/ha) and straw (6.25 t/ha, 5.15 t/ha) yields where as at Mandya and Faizabad foliar application of nano Zn @ 50 ppm recorded significantly higher grain (6.24 t/ha, 3.99 t/ha) and straw yields (6.86 t/ha, 5.37 t/ha). In case of Varieties, DRR Dhan 48 found superior at Mandya and Faizabad and CSR23 performed better at Kanpur. Nutrient uptake also followed similar trend as that of grain and straw yields. The variety DRR Dhan 48 has accumulated higher amount of NPK and Zn at Mandya, Pusa and Faizabad and CSR 23 recorded significantly higher nutrient uptake at Kanpur.

- **Foliar application of nano Zn@ 50 ppm has performed better across the locations except Kanpur.**
- **The variety DRR Dhan 48 exhibited superior performance in all the locations except Kanpur.**
- **Significantly superior performance of Zn application (Soil/foliar/nano formulations) was observed in sodic soils across the locations.**

5.4. Management of acid soils

The second year study of the trial on "Management of acid soils" indicate that application of RDF + dolomite + Silixol recorded the highest yields at all locations (except Ranchi) where RDF + Dolomite + RHA application recorded the highest grain yield. Between two varieties, Uma yielded the highest at majority locations while Vasundhara performed better at Moncompu. Ameliorative effect of application of RDF + dolomite + RHA was observed as the pH increased to 4.39 and 6.25 was observed in acid soils of Moncompu and Titabar respectively when compared to RDF alone (4.21 and 5.22, respectively) at these locations.

Application of RDF + dolomite (250 kg/ha) + Silixol spray (at vegetative, booting and grain filling stage) improved yields over sole RDF by 12-35% in irrigated rice and by 14% under upland rice.

5.5. Residue management in rice based cropping systems

The disposal of huge quantity of paddy residues is a big problem, particularly in North-West Indian states, resulting in farmers preferring to burn the residues *in-situ* leading to air pollution, smog and loss of the appreciable amount of plant essential nutrients besides being deleterious to soil microbes. The trial was conducted this year at nine centres. The results showed that the crop residues can be deployed to substitute half of the recommended nitrogen without yield penalty. The crop residue treatments were at par with each other and lower than RDF in terms of nutrient uptake and also maintained higher nutrient use efficiencies over RDF. Post-harvest soil nutrient status was not influenced much by various residue treatments which were at par with each other.

Supplementation of nitrogen (50%) through crop residues either alone or in combination with GM (50%) and 50% RDF with or without Pusa Decomposer, gave on par yields with 100% RDF at majority of the centres.

5.6. Nano-fertilizers for increasing nutrient use efficiency, yield and economic returns in transplanted rice *(collaborative trial with Agronomy)*

The trial on "Nano-fertilizers for increasing nutrient use efficiency, yield and economic returns in transplanted rice" was continued in the second year at 23 locations with six treatments (in collaboration with Agronomy). The results indicated that additional application of nano urea

with 100% RDN improved the yield, yield parameters and N uptake at Jagdalpur, Faizabad, Chata, ARI, Mandya, Pantnagar, Moncompu, Sabour, Kanpur and Warangal. Whereas, 75% RDN + two sprays of nano urea registered the highest growth parameters, yield and N uptake at Karaikal, Kanpur, Coimbatore, Mandya, Bankura, Khudwani, Pattambu, and Puducherry. At Bankura, Khudwani and Karaikal, the higher NUE was observed with 75% RDN + two sprays of nano urea treatment, but 100% RDN + two sprays of nano urea treatment registered a higher NUE at rest of the locations.

Additional input of nano urea (two sprays) along with either 75% RDN or 100% RDN was found better for yield, N uptake and nutrient use efficiency at majority of the locations but did not fetch much benefit in economic returns over RDN.

5.7 Yield maximization of rice in different zones *(collaborative trial with Agronomy)*

Included in the Agronomy progress report

5.8 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health (*collaborative trial with Agronomy*)

The third year of study on "Enhancing productivity of Organic Rice cultivation", revealed that organic treatment with 100% FYM improved the majority of the soil characteristics compared to other treatments at KRK and CHN, and the organic treatments, 50% N (FYM)+ 50% N (Vermicompost) manure recorded higher yield and yield parameters at CHN.

In the modified trial on "Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health", the first year results indicated better performance of integrated Crop Management (with need based pesticides for pest management) than other treatments at MND, KHD, PNT, PUSA, PUD, and TTB in terms of grain yield and yield parameters and majority of the soil parameters at CHN, MND, PNT, and PUSA were improved with integrated crop management treatment (with organic methods of pest management).

Integrated Crop Management, ICM (with need based pest management) performed significantly better in terms of grain yield and yield parameters and majority of the soil parameters improved with NPOF package/ ICM (with organic methods of pest management).

DETAILED REPORT

5.1 Long-term soil fertility management in rice-based cropping systems (RBCS)

Long-term studies with well-defined nutrient management treatments and cropping systems were initiated in 1989-90 at four selected locations representing major rice growing regions and cropping systems *viz*., Mandya (MND) in Karnataka (rice-cowpea, Deccan Plateau), Maruteru (MTU) in Andhra Pradesh (rice-rice, Delta system), Titabar (TTB) in Assam (rice-rice, Alluvial soils) and Faizabad (FZB) in Uttar Pradesh (rice-wheat, Indo Gangetic plains) to study the dynamics of soil and crop productivity in relation to management for identifying the constraints that affect the sustainability of a given production system. The trial at Faizabad was discontinued during 2007-08 for lack of manpower support and being continued at 3 centres only. Hence, the results of 34th year of cropping *i.e., Rabi* 2021-22 and *Kharif*-2022 are presented in Tables 5.1.1 to 5.1.11.

Crop productivity and soil fertility during *Rabi* 2021-22

Grain and straw yields of rice at MTU and TTB are presented in Table 5.1.2. At MTU, grain yield ranged from 2.83 (control) to 6.97 t/ha (RDF+FYM) with a mean of 5.02 t/ha. RDF, RDF + FYM and 50% NPK substituted with FYM treatments were at par. The omission of N, P, K, Zn and S resulted in yield reduction by 0.82 t/ha in -S to 2.25 t/ha in -P plots over RDF. FYM alone treatment was on par to 50% NPK+ 50% FYM-N and 50% NPK + 25% GM-N+ 25% FYM-N and this treatment was superior to all nutrient (NPK) omission plots. At Titabar, grain yield ranged from 1.33 t/ha in control to 4.63 t/ha in RDF+FYM which was on par to RDF (4.43 t/ha). Here also, the omission of nutrients resulted in grain yield reduction by 0.45 t/ha in -Zn to 0.85 t/ha in - N plots over RDF. Here, at TTB also, FYM alone treatment was on par to RDF and significantly superior to all nutrient (NPK) omission plots. Fifty per cent (50%) reduction in RDF resulted in 68% yield reduction in silty clay soil of TTB compared to 35% reduction in clay loam soil of MTU over RDF. Fifty per cent (50%) reduction in NPK resulted in more loss at TTB compared to other two centers since 100% RDF itself was much lower than other centres Compared to previous year, the yield difference between RDF and RDF+FYM is more by 10% at MTU and by 5% at TTB showing the beneficial effect of organics over a period of time. Straw yields followed the similar trend as that of grain yield at both locations. At MND, cowpea yield ranged from 219 kg/ha to 409 kg/ha with a mean of 353 kg/ha.

Total nutrient (NPK) uptake followed similar trend as that of grain yield with minor variations among the treatments and control recorded minimum uptake at both TTB and MTU (Table 5.1.3). With regard to soil fertility status after harvest at MTU, soil organic carbon content was significantly higher when 50% RDF was substituted with FYM/GM+FYM compared to RDF and FYM alone treatment recorded maximum values (1.57%) which was 45% higher than RDF alone. No definite trend was recorded in case of other soil parameters though there was an improvement with addition of organics (Table 5.1.4). In nutrient omission plots of P and K, there was a significant reduction in available P and K compared to plots with RDF and RDF+FYM.

FYM along with RDF resulted in maximum grain yield while nutrient omission/50% reduction of NPK resulted in reduction of yield as well as soil available NPK at all centers.

Crop productivity and soil fertility status during *Kharif*-2022

At MTU, the treatments receiving organics and biofertiliser recorded grain yield (5.03-5.90 t/ha) that was on par to RDF (5.47 t/ha) [Table 5.1.5]. Omission of major nutrients N and P resulted in significant yield loss (1.04 and 1.30 t/ha, respectively) compared to RDF. At TTB also, RDF+FYM (5.55 t/ha) recorded maximum yield which was on par to RDF (5.38 t/ha) and treatments that received organics. Here also, yield loss due to omission of major and micro nutrients was observed. At MND, RDF+FYM recorded maximum yield (5.77 t/ha) which was significantly superior to RDF (4.89 t/ha) and on par when 50% NPK was replaced by 25% GM-N+ 25% FYM-N (5.54 t/ha). Here also, all nutrient omission plots recorded significantly lower yields than RDF. With regard to FYM alone treatment, it recorded slightly higher yield that RDF at MTU; on par to RDF at TTB and lower than RDF at MND. But, this treatment was significantly superior to all the nutrient omission plots at all 3 locations. With regard to straw yield, the trend was almost similar to grain yield trend at all locations with higher yields recorded where organics were added. The total nutrients (NPK) uptake by the above ground biomass was almost similar to that of grain yield trend at all locations with minimum uptake in control and maximum in RDF+FYM closely followed by RDF and the treatments where organics were added (Table 5.1.6). Soil fertility status at the end of *Kharif*-2022 (Tables 5.1.7 and 5.1.8) indicated an improvement in most of the soil properties with addition of organics and higher

values were recorded in RDF+FYM and FYM alone treatments for most of the properties at all 3 locations. Omission plots recorded significant reduction in NPK values compared to RDF at MND and TTB and only in K values at MTU. Organic carbon values were significantly higher in FYM alone and RDF+FYM than all other treatments followed by the treatments where organics were added and control recorded the lowest values.

Nutrient omission plots recorded significantly lower yields than RDF and the treatment with FYM alone was significantly superior to all the nutrient omission plots at all 3 locations. Improvement in most of the soil properties with addition of organics was observed with significantly higher organic carbon values in FYM alone and RDF+FYM treatments.

Long term changes in crop productivity and soil fertility over a period of 34 years

The trends in mean grain yields over 34 years (1989-2022) of *Kharif* and *Rabi* rice at MND, MTU and TTB by fitting to linear function using actual yields and the per cent change in important soil properties in some important treatments were analyzed and presented below.

Linear trends in crop productivity (Tables 5.1.9 and 5.1.10)

During *Kharif* 2022, the treatment, RDF+5t FYM/ha recorded maximum mean yield at all 3 locations (MND- 5.29; MTU-5.24 and TTB- 5.04 t/ha) with an average increase of 12, 3.4 and 13.3%, respectively, at MND, MTU and TTB by this treatment over RDF. Linear trends of productivity over the years with current RDF indicated slightly positive growth in the sandy loam of MND and delta soils of MTU (0.5 and 11 kg grain/ha/year, respectively) and more positive growth in the acid alluvial soils of TTB (42 kg/ha/year). An additional dose of FYM @ 5t/ha along with RDF improved the growth rate substantially with 63, 75 and 58 kg/ha/year at MTU, TTB and MND, respectively. FYM alone treatment recorded a more positive growth rate compared to RDF at all 3 locations.

During *Rabi* also, RDF+5t FYM recorded maximum mean grain yield both at MTU (6.31 t/ha) and TTB (4.38 t/ha) and this treatment recorded growth rate of 14 and 45 kg/ha/year at MTU and TTB, respectively (Table 5.1.10).

Changes in soil fertility compared to initial values (Table 5.1.11)

The organic carbon (OC) content increased in the treatments with organics at MTU compared to initial values. At MND, maximum positive change was observed in INM treatment with a decrease in control. At TTB also, OC decreased in control but increased in treatments with addition of organics. Maximum increase in OC was in FYM alone treatment at MTU; RDF+FYM at TTB and in 50% NPK+25% GM+ 25% FYM treatment at MND. Available N decreased in all treatments at MTU but at MND, it decreased in control with a marginal increase in INM and FYM alone treatments compared to RDF. With regard to available P, there was a buildup in all treatments compared to initial value at all three locations except in control at TTB where the % change was –ve. In case of available K, at MTU, there was a decrease and –ve change in all treatments compared to initial value. At MND and TTB, there was a –ve change in control and +ve change in other treatments where the increase was to a greater extent at MND and to a lesser extent at TTB.

Summary

From the results of 34th year of study on long term soil fertility management in RBCS, superior performance of RDF+FYM was noticed over other treatments but this treatment was on par to RDF (except at MND). FYM alone treatment was on par to RDF but significantly superior to all nutrient omission plots at all 3 locations. Omission of major and micro nutrients resulted in yield reduction at all three locations. In general, INM and organics alone treatments resulted in improvement of soil fertility parameters and OC was significantly higher in FYM and RDF+FYM treatments. Additional dose of FYM @ 5 t/ha along with RDF resulted in positive growth rate at all three locations. Compared to initial values, changes in soil fertility showed +ve values in INM and organics alone treatments.

- **Superior performance of RDF+FYM was noticed but this treatment was on par to RDF at most of the locations.**
- **Omission of major and micro nutrients resulted in yield reduction at all locations.**
- **INM and organics alone treatments improved soil fertility parameters and OC was significantly higher when FYM was added either alone or as supplementary dose.**
- **Over a period of 34 years, FYM along with RDF recorded a higher positive growth rate in productivity compared to RDF.**

Table 5.1.1: Long-term soil fertility management in RBCS, 2022
Soil and crop characteristics

Cropping system	**Maruteru**		**Titabar**	**Mandya**
	Rice-Rice		**Rice-Rice**	**Rice-Rice**
Variety				
Kharif	MTU 1064		Gitesh	KMP 175
Rabi	MTU 1121		Disang	Cowpea
Recommended Fertilizer Dose (kg NPK /ha)				
Kharif	90:60:60:50		40:20:20:20	100:50:50:20
Rabi	180:90:60:50		40:20:20	-
STCR based dose				
Kharif	83.6:63.9:53.6		9.8:7.68:98.56	70.9:36.1:20.5
Rabi	124.5:87.4: 59.9		12.56:0: 103	-
Crop growth: *Kharif*	-		Good	-
Rabi	-		Good	-
% Clay	38		42	11.1
% Silt	28		28.5	18.1
% Sand	34		29.5	62.8
Texture	Clay Loam		Silty Clay	Sandy loam
pH (1:2)	5.45 (Rabi)	6.63 (Kharif)	5.4	5.87
Organic carbon (%)	1.05	1.07	1.1	0.30
CEC (cmol (p^+)/kg)	48.6	48.9	12.5	-
EC (dS/m)	0.64	0.69	0.03	0.28
Avail. N (kg/ha)	218	184	495	208
Avail. P_2O_5 (kg/ha)	-	33.9	22.4	19.7
Avail. K_2O (kg/ha)	368	397	112	117.6

Table 5.1.2: Long-term soil fertility management in RBCS, *Rabi*-2022
Grain and straw yields of rice and cowpea

Treatments	Grain yield (t/ha)			Straw yield (t/ha)	
	Maruteru	Titabar	Mandya (Cowpea-kg/ha)	Maruteru	Titabar
Control	2.83	1.31	219.5	4.79	1.59
100% PK	4.37	3.58	249.5	6.98	4.32
100% NK	3.97	3.68	242.9	8.14	4.45
STCR recommendation	5.05	4.10	268.8	8.49	4.98
100% NP	4.08	3.87	258.1	8.30	4.64
100% NPKZnS	6.22	4.43	286.0	9.40	5.36
100% NPKZnS + FYM/PM @ 5t/ha	6.97	4.63	382.5	9.82	5.61
100% NPK –Zn	5.09	3.98	277.4	9.08	4.82
100% NPK – S	5.40	3.60	281.0	9.07	4.33
100%NPK-S+1t lime/ha	-	4.19	-	-	5.08
100% N+50% PK	4.86	3.42	245.0	7.36	4.14
50 % NPK	4.60	2.63	260.6	8.09	3.19
50 % NPK + Biofertiliser	5.61	3.22	258.8	8.40	3.88
50%NPK+ 50% GM-N	4.99	3.78	345.5	7.78	4.59
50% NPK + 50% FYM-N	5.52	4.15	380.3	8.48	5.04
50% NPK + 25% GM-N+25% FYM-N	5.13	4.18	408.8	8.96	5.06
FYM @ 10 t/ha	4.96	4.43	367.7	6.53	5.38
FYM @ 10 t/ha + Split application	5.74	-	390.6	8.23	-
Expt. Mean	**5.02**	**3.72**	**301.4**	**8.11**	**4.49**
CD (0.05)	**1.61**	**0.32**	**42.4**	**1.26**	**0.46**
CV (%)	**19.4**	**5.17**	**6.64**	**9.46**	**6.24**

Table 5.1.3: Long-term soil fertility management in RBCS, *Rabi* 2022- Total Nutrient uptake (kg/ha)

Treatments	Maruteru			Titabar		
	N	P	K	N	P	K
Control	26.8	11.8	59.8	19.7	4.01	27.9
100% PK	45.1	18.5	124.0	54.3	11.9	83.5
100% NK	40.4	11.5	104.3	57.4	10.9	86.1
STCR recommendation	55.3	25.5	149.3	64.9	13.9	97.4
100% NP	48.1	23.9	96.7	60.5	12.9	82.5
100% NPKZnS	56.3	26.6	123.3	72.3	16.6	112.3
100% NPKZnS + FYM/PM @ 5t/ha	60.2	28.4	161.0	76.5	18.3	125.4
100% NPK – Zn	52.0	21.6	127.4	63.9	14.5	101.6
100% NPK – S	45.7	21.5	130.1	59.9	11.9	90.5
100%NPK-S+1t lime/ha	-	-	-	77.3	13.6	107.6
100% N+50% PK	50.4	20.9	121.8	54.1	10.6	88.1
50 % NPK	53.4	25.3	119.2	40.2	8.09	56.3
50% NPK + Biofertiliser	53.9	23.5	142.9	53.3	12.3	83.7
50% NPK+ 50% GM-N	51.0	23.9	144.0	60.6	13.2	97.3
50% NPK + 50% FYM-N	57.2	24.8	133.6	67.3	15.8	106.8
50% NPK + 25% GM-N+ 25% FYM-N	50.2	26.3	158.5	68.5	15.4	105.8
FYM @ 10 t/ha	54.1	29.8	124.5	42.0	7.09	-
FYM @ 10 t/ha + Split Vermi	57.1	19.7	169.5	-	-	-
Expt. Mean	**50.4**	**22.6**	**128.8**	**58.4**	**12.4**	**90.8**
CD (0.05)	**15.1**	**7.3**	**37.6**	**6.81**	**2.28**	**11.3**
CV (%)	**18.2**	**19.8**	**17.7**	**7.07**	**11.1**	**7.5**

Table 5.1.4: Long-term soil fertility management in RBCS, *Rabi*-2022
Soil fertility status at harvest

Treatments	Maruteru					
	pH	EC (dS/m)	Org C (%)	Avail. N (kg/ha)	Avail. P_2O_5 (kg/ha)	Avail. K_2O (kg/ha)
Control	6.63	0.70	1.07	184.0	33.9	397.3
100% PK	6.17	0.32	1.06	268.3	42.8	361.3
100% NK	6.28	0.65	1.46	236.3	27.8	462.0
STCR recommendation	6.19	0.33	1.14	207.0	45.1	407.0
100% NP	6.44	0.43	1.34	245.3	48.6	341.3
100% NPKZnS	6.53	0.28	1.08	233.3	52.9	463.3
100% NPKZnS + FYM/PM @ 5t/ha	6.18	0.30	1.26	262.7	51.8	369.7
100% NPK – Zn	6.60	0.53	1.01	210.0	36.7	424.7
100% NPK – S	6.39	0.83	1.38	233.3	45.1	468.7
100%NPK-S+1t lime/ha	-	-	-	-	-	-
100% N+50% PK	6.52	0.51	1.23	221.6	42.1	364.3
50 % NPK	6.48	0.60	1.06	225.0	37.5	340.0
50% NPK + Biofertilizer	6.09	0.43	1.29	201.3	38.9	385.7
50% NPK+ 50% GM-N	6.12	0.81	1.43	277.0	45.1	466.7
50% NPK + 50% FYM-N	6.24	0.47	1.58	216.0	72.4	389.7
50% NPK + 25% GM-N+ 25% FYM-N	6.18	0.54	1.36	233.3	52.5	521.3
FYM @ 10 t/ha	5.84	0.87	1.57	329.6	54.0	462.7
FYM@10 t/ha + 3.0 t/ha Vermicompost +200 kg/ha oil cakes	6.27	0.60	1.33	213.0	72.3	588.7
Expt. Mean	6.30	0.54	1.27	235.1	47.0	424.4
CD (0.05)	**0.6**	**0.46**	**0.45**	**66.8**	**23.9**	**162.6**
CV (%)	**5.7**	**51.7**	**21.5**	**17.2**	**30.8**	**23.23**

Table 5.1.5: Long-term soil fertility management in RBCS, *Kharif* -2022
Yield and yield parameters of rice

Treatments	Grain yield (t/ha)			Straw yield (t/ha)		
	MTU	**TTB**	**MND**	**MTU**	**TTB**	**MND**
Control	3.02	1.57	2.07	4.57	2.32	2.72
100% PK	4.17	4.08	2.32	7.05	5.94	2.97
100% NK	4.43	4.22	2.61	6.80	6.26	3.32
STCR recommendation	4.62	4.77	3.79	8.24	7.08	4.42
100% NP	5.25	4.18	2.70	6.04	6.19	3.52
100% NPKZnS	5.47	5.38	4.89	8.02	7.98	5.38
100% NPKZnS + FYM/PM @ 5 t/ha	5.67	5.55	5.77	9.15	8.25	6.49
100% NPK –Zn	5.10	4.52	3.94	8.43	6.69	4.62
100% NPK – S	5.00	4.41	3.92	7.75	6.54	4.68
100%NPK-S+ 1t limelime/ha	-	3.05	-	-	6.69	-
100% N+50% PK	5.27	3.96	4.42	8.04	5.47	5.26
50 % NPK	4.82	2.64	3.37	9.05	3.92	4.28
50 % NPK + Bio fertilizer	5.46	4.18	3.68	8.57	6.20	4.30
50% NPK+ 50% GM-N	5.90	4.81	4.68	8.99	7.14	5.48
50% NPK + 50% FYM-N	5.03	4.86	4.75	8.86	7.20	5.61
50% NPK + 25% GM-N+25% FYM-N	5.52	5.02	5.54	9.12	7.43	6.58
FYM @ 10 t/ha	5.49	4.90	4.50	8.63	7.27	5.25
FYM@10 t/ha + 3.0 t/ha Vermicompost +200 kg/ha oil cakes	5.18	-	4.50	9.08	-	5.35
Expt. Mean	5.14	**4.22**	3.96	8.02	**6.38**	4.72
CD (0.05)	**0.82**	**1.07**	**0.26**	**1.04**	**0.29**	**0.33**
CV (%)	**9.6**	**15.4**	**3.2**	**7.88**	**2.81**	**3.36**

MTU-Maruteru TTB-Titabar MND- Mandya

Table 5.1.6: Long-term soil fertility management in RBCS, *Kharif-2022*
Total Nutrient uptake (kg/ha) in total dry matter

Treatments	Maruteru			Titabar			Mandya		
	N (kg /ha)	P (kg /ha)	K (kg /ha)	N (kg /ha)	P (kg /ha)	K (kg /ha)	N (kg /ha)	P (kg /ha)	K (kg /ha)
Control	53.7	23.6	119.6	19.7	4.22	31.4	24.7	5.64	34.3
100% PK	90.3	37.0	248.2	56.1	12.5	88.5	32.9	6.62	39.4
100% NK	80.8	23.0	208.6	55.3	11.6	92.9	36.4	7.43	45.6
STCR recommendation	110.7	51.0	298.6	68.1	14.0	106.6	56.4	12.5	62.5
100% NP	96.3	47.9	193.5	60.1	10.9	83.7	44.5	10.4	52.3
100% NPK + Zn + S	112.5	53.1	246.5	81.6	17.5	128.3	81.7	17.5	83.5
100% NPK + Zn + S + FYM/PM @ 5 t/ha	120.4	56.9	322.0	84.7	17.4	141.1	107.8	22.9	105.5
100% NPK –Zn	104.0	43.2	254.7	67.7	14.8	108.3	63.1	13.9	71.9
100% NPK – S	91.5	42.7	260.3	71.0	12.0	104.5	66.1	18.2	71.9
100%NPK-S+ 1t limelime/ha	-	-	-	64.6	10.1	98.6	-	-	-
100% N+50% PK	100.7	41.7	243.6	54.1	9.9	89.4	75.3	15.5	76.9
50 % NPK	106.8	50.5	238.3	38.3	7.4	53.2	58.6	11.4	58.5
50 % NPK + Biofertilizer	107.7	47.1	285.8	64.7	13.2	102.5	61.7	13.1	63.7
50% NPK+ 50% GM-N	101.7	47.9	288.0	69.9	14.0	117.0	80.7	18.8	79.9
50% NPK+ 50% FYM-N	114.4	49.5	267.1	75.6	15.2	116.8	86.2	19.5	86.9
50% NPK +25% GM-N +25% FYM-N	100.5	52.9	317.1	75.8	15.4	119.5	104.5	23.8	102.3
FYM @ 10 t/ha	108.2	59.6	250.9	73.3	16.3	120.1	78.7	16.6	76.6
FYM@10t/ha +3.0 t/ha Vermi+200 kg/ha oil cakes	114.1	39.4	339.1	-	-	-	78.9	15.3	75.5
Expt. Mean	**100.8**	**45.1**	**257.7**	**63.6**	**12.7**	**100.2**	**66.9**	**14.7**	**69.8**
CD (0.05)	**15.2**	**7.4**	**37.6**	**9.06**	**2.4**	**10.6**	**19.3**	**4.5**	**16.4**
CV (%)	**18.4**	**19.8**	**17.8**	**11.5**	**15.6**	**8.6**	**40.7**	**43.9**	**33.2**

Table 5.1.7: Long-term soil fertility management in RBCS, *Kharif*-2022

Soil fertility status at harvest

Treatments	Maruteru				Titabar			
	Org. C (%)	**Avail. N (kg/ha)**	**Avail. P_2O_5 (kg/ha)**	**Avail. K_2O (kg/ha)**	**Org. C (%)**	**Avail N**	**Avail. P_2O_5 (kg/ha)**	**Avail. K_2O (kg/ha)**
Control	1.17	219.7	62.3	368.0	0.54	141.6	10.9	66.5
100% PK	1.33	196.3	74.3	393.3	0.93	257.7	18.5	76.7
100% NK	1.32	241.0	62.5	351.0	1.14	178.3	21.2	91.7
STCR recommendation	1.33	279.3	69.5	341.6	1.17	288.3	27.8	98.3
100%NP	1.16	260.3	70.2	295.0	0.98	179.0	29.0	89.3
100% NPKZnS	1.14	202.7	69.0	376.3	1.51	351.7	36.8	153.3
100% NPKZnS + FYM/PM @ 5t/ha	1.36	237.0	81.1	353.7	1.70	391.0	37.8	181.3
100% NPK –Zn	1.25	273.0	65.2	347.0	1.01	288.3	26.8	156.0
100% NPK – S	1.34	202.7	73.8	351.3	1.09	358.3	32.3	147.0
100%NPK-S+ 1t limelime/ha	-	-	-	-	1.13	366.6	30.8	150.7
100% N+50% PK	1.23	220.0	68.3	364.7	0.98	281.0	26.2	84.8
50 % NPK	1.28	173.0	64.9	341.7	0.77	221.0	26.3	85.0
50 % NPK + Biofertiliser	1.26	254.0	71.9	348.0	1.22	353.3	33.8	156.0
373.750% NPK+ 50% GM-N	1.24	230.3	65.8	348.0	1.57	389.3	31.7	140.7
50% NPK + 50% FYM-N	1.29	256.0	78.2	339.0	1.53	351.3	32.3	157.7
50% NPK + 25%GM-N+25%FYM-N	1.39	234.3	69.5	401.0	1.54	373.7	32.7	158.3
FYM @ 10 t/ha	1.43	215.7	78.2	383.7	1.72	396.0	38.2	173.3
FYM@10 t/ha +3.0 t/ha Vermicompost +200 kg/ha oil cakes	1.41	211.3	82.4	369.3	-	-	-	-
Expt. Mean	**1.29**	**229.8**	**71.0**	**357.2**	**1.20**	**303.9**	**29.1**	**127.4**
CD (0.05)	**0.22**	**95.8**	**12.0**	**36.4**	**0.14**	**52.5**	**6.2**	**15.6**
CV (%)	**10.5**	**25.3**	**10.3**	**6.2**	**7.21**	**10.5**	**12.9**	**7.4**

Table 5.1.8: Long-term soil fertility management in RBCS, *Kharif* 2022
Soil fertility status at harvest (Mandya)

Treatments	Mandya			
	Org. C (%)	Avail. N (kg/ha)	Avail. P_2O_5 (kg/ha)	Avail. K_2O (kg/ha)
Control	0.25	222.8	38.8	97.0
100% PK	0.33	228.5	46.0	129.0
100% NK	0.35	242.8	41.6	138.9
STCR recommendation	0.39	257.3	47.3	143.7
100%NP	0.44	255.3	47.1	125.9
100% NPKZnS	0.58	280.8	51.0	214.5
100% NPKZnS + FYM/PM @ 5t/ha	0.69	281.4	62.0	253.9
100% NPK –Zn	0.35	277.3	53.6	222.7
100% NPK – S	0.35	282.0	53.7	235.6
100%NPK-S+ 1t limelime/ha	-	-	-	-
100% N+50% PK	0.43	274.5	49.5	237.7
50 % NPK	0.52	243.4	47.8	243.4
50 % NPK + Biofertilizer	0.54	288.3	53.1	228.4
373.750% NPK+ 50% GM-N	0.61	300.3	54.4	233.0
50% NPK + 50% FYM-N	0.70	299.9	64.5	245.1
50% NPK + 25%GM-N+25%FYM-N	0.74	316.2	61.3	253.9
FYM @ 10 t/ha	0.63	310.5	51.9	243.2
FYM@10 t/ha +3.0 t/ha Vermicompost +200 kg/ha oil cakes	0.61	315.5	54.7	233.2
Expt. Mean	**0.50**	**275.1**	**51.1**	**204.7**
CD (0.05)	**0.04**	**8.3**	**2.7**	**9.6**
CV (%)	**3.55**	**1.4**	**2.5**	**2.2**

Table 5.1.9: Long-term soil fertility management in RBCS
Linear trends of changes in *Kharif rice* yields (t/ha) from 1989 to 2022

Treatments	MTU			TTB			MND		
	Mean yield (t/ha)	Slope (kg/ha/yr)	Intercept (t/ha)	Mean yield (t/ha)	Slope (kg/ha /yr)	Intercept (t/ha)	Mean yield (t/ha)	Slope (kg/ha/yr)	Intercept (t/ha)
Control	2.85	9	2.63	1.97	-52	2.90	2.20	-55	3.13
100% PK	3.52	37	2.86	3.26	43	2.51	2.72	-37	3.35
100% NK	4.08	-3	4.13	3.58	26	3.13	3.38	-76	4.66
100% NP	4.48	-12	4.68	3.78	22	3.39	3.79	-83	5.19
100% NPK + Zn + S	5.07	11	4.87	4.45	42	3.72	4.72	0.27	5.18
100% NPKZnS + FYM	5.24	63	3.78	5.04	75	3.32	5.29	58	3.96
100% NPK – Zn	4.81	-7	4.81	4.18	22	3.79	4.49	-52	5.36
100% NPK – S	4.70	3	4.70	4.15	7	4.03	4.39	-49	5.22
100% N + 50% PK	4.46	2	4.42	3.68	-0	3.61	4.03	-63	5.10
50% NPK	4.32	3	4.26	3.18	-31	3.73	3.73	-43	4.47
50% NPK + 50% GM-N	4.53	15	4.26	3.87	30	3.34	4.75	7	4.87
50% NPK + 50% FYM-N	4.78	15	4.51	4.01	36	3.37	4.83	4	4.76
50% NPK + 25% GM-N + 25%FYM-N	4.58	16	4.30	4.07	36	3.45	5.39	9	5.23
FYM @ 10 t/ha	4.47	13	4.24	4.13	54	3.18	4.16	19	3.83

Table 5.1.10: Long-term soil fertility management in RBCS
Linear trends of changes in *Rabi* rice yields (t/ha) from 1989 to 2022

Treatments	MTU			TTB		
	Mean yield (t/ha)	Slope (kg/ha/yr)	Intercept (t/ha)	Mean yield (t/ha)	Slope (kg/ha/yr)	Intercept (t/ha)
Control	2.30	41	1.42	1.68	-33	2.20
100% PK	3.04	71	1.77	3.00	55	2.15
100% NK	4.10	27	3.61	3.29	29	2.82
100% NP	4.95	4	4.87	3.42	15	3.19
100% NPK + Zn + S	5.73	39	5.02	3.92	34	3.37
100% NPKZnS + FYM/PM	6.31	14	6.40	4.38	45	3.46
100% NPK – Zn	5.21	23	4.80	3.69	21	3.36
100% NPK – S	5.32	27	4.85	3.58	19	3.28
100% N + 50% PK	5.15	15	4.88	3.39	12	3.19
50% NPK	4.28	18	3.95	2.81	-4	2.88
50% NPK + 50% GM-N	4.93	7	4.80	3.39	25	2.99
50% NPK + 50% FYM-N	5.19	34	4.58	3.49	35	2.93
50% NPK + 25% GM-N + 25% FYM-N	5.00	10	4.82	3.50	33	2.97
FYM @ 10 t/ha	4.18	44	3.40	3.53	40	2.89

Table: 5.1.11: Long-term soil fertility management in RBCS
Changes (%) in soil fertility parameters over 1989 to 2022

Treatments	Maruteru				Titabar			Mandya			
	OC	N	P	K	OC	P	K	O.C.	N	P	K
Control	31.5	-26.3	205	-9.4	-43.2	-17.4	-54.5	-28.6	-53.4	97.0	-17.1
100% NPK + Zn + S	28.1	-32.0	238	-7.4	58.9	178.8	5.0	65.7	2.9	158.9	82.9
100% NPK + Zn + S + 5 t/ha FYM	52.8	-20.5	298	-13.1	78.9	186.4	24.2	97.1	22.1	214.7	117.0
50% NPK + 25% GM-N + 25% FYM-N	56.2	-21.5	241	-1.2	61.1	144.7	8.0	111.4	22.1	211.2	117.0
FYM @ 10 t/ha	60.7	-27.6	283	-5.4	62.1	147.7	18.7	80.0	16.9	177.7	107.9

5.2. Soil quality and productivity assessment for bridging the yield gaps in farmers' Fields (*Kharif*)

Sustainable Rice production is essential to meet future food requirements amid strong competition for limited resources and steep and sometimes skewed variations in yield are a major impending problem in India. Ecology wise and region-wide yield gap analysis is a useful method to examine how large the ranges are between potential, desirable rice yields and those actually realized in farmers' fields. Proper and balanced nutrient application is must to meet the growth requirements of a genotype for realizing the yield potential of several contemporary genotypes. Current fertilizer management practices are age old, in general, and are not tailored to site specific soil nutrient supply capacities and crop demand. Blanket fertilizer recommendations are still being followed in large domains with less importance being given to management induced site variations of soil nutrient supply capacities, and crop demand more so when new high yielding cultures with increasing yield potential are being regularly introduced. This has been the major reason for reported nutrient imbalances and un-sustainability in realizing yields. This trial was, therefore, conducted in farmers' fields around a few selected centres – Chinsurah (pool of 46 farmers), Titabar (pool of 30 farmers), Pantnagar (pool of 50 farmers), Kanpur (pool of 20 farmers), Kaul (pool of 24 farmers) and Karaikal (pool of 22 farmers). The specific aim was to assess the variability in soil nutrient supply, its relationship with rice yields at current recommended and farmers' fertilizer practices in some new farm sites and fine-tune the fertilizer nutrient requirement for specific target yields in a given environment and validation of fertilizer recommendations for targeted yields. The *kharif* 2022 and in *Rabi* 2022 (Karaikal alone) data were received representing the irrigated and shallow lowland rice ecosystems are presented in Tables 5.2.1 to 5.2.4. The test varieties were Swarna, Khitish, Shatabdi at Chinsurah, Ranjeet, Ranjeet Sub 1, Bahadur, Swarna at Titabar, Pioneer 3727, Pioneer 2761, Arize 6444, Sudha, Kaveri 9090 at Kanpur, PR114, CSR-30, PR-1509,27P-31, PR-114, PR-114, PR-1121 at Kaul, Sarbati, Pusa 150, PR121, Indrasan, PR1509, PR126, Hybrid, PD10, PD 12, HR 47, Pusa 154, 2967, PD 18, Sarju 52, HR 47, Saket 4, Basmati, Pusa Basmati, HR 147, local at Pantnagar and CR 1009, BPT 5204, ADT 46 at Karaikal. The methodology involved as conduction of a survey in nearby villages during *Kharif*-2022 and *Rabi*-2022 involving data collection from various farmers' fields at different locations across different rice ecologies. The farmers' fields were grouped into two categories of 'low' and 'high' yield. Soil and plant samples were collected from the field after harvest and analyzed for their nutrient contents, and soil quality indexes were calculated. For next season crop, site specific recommendations to the farmers have been generated and is being given for higher productivity and soil health improvement. The details of

crop, soil and weather parameters of the experimental sites, presented in the Table 5.2.1, show variation in soil characteristics with reference to pH, organic carbon content, soil texture and available nutrient status.

Table 5.2.2 gives information collected in the new farm sites on yields obtained, nutrient uptake and Soil quality index calculated from all the soil samples collected from the farmers' fields. Sharp variations in mean grain yields recorded varied from 2.38 t/ha among low yielders to 4.73 t/ha among high yielders at Chinsurah, from 3.1 t/ha among low yielders to 4.75 t/ha among high yielders at Titabar , varied from 4.76 t/ha among low yielders to 6.59 t/ha among high yielders at Kanpur, varied from 4.83 t/ha among low yielders to 5.84 t/ha among high yielders at Pantnagar, from 3.83 t/ha among low yielders to 4.36 t/ha among high yielders at Karaikal and from 1.44 t/ha among low yielders to 8.8 t/ha among high yielders at Kaul. Soil parameters data were pooled in different categories and the resulting soil quality index generated showed variations in the quality and health of the soil across different farmer's categories. The poorest soil quality index was calculated for farmers from Titabar due to considerable variation among the farm sites and soil test values. The soil quality index was much superior at Kaul, Pantnagar and others were at par for all other centers. Large variations were seen for nutrient uptake between low yielders and high yields across the centers. Soil nutrient uptake for major nutrients varied widely among the sites. At all these locations wide variations in grain yields and nutrient uptake were recorded (Table 5.2.3), while soil test values did not match the yields recorded with rice yield and nutrient uptake at both the locations, suggesting perhaps less suitability of current soil testing methods for flooded soils. However, some centers reported soil quality index at par with their resulting grain yield and nutrient uptake patterns. Table 5.2.3 recorded the nutrient requirement per ton grain yield variations obtained at all the centers. Nutrient requirement calculations were useful to know how the responses were for fertilizers applied per ton of the grain yield.

Fertilizer prescriptions were worked out for all the farm sites (being the highest yield recorded at the test sites rounded to the next big numeral) and specific fertilizer recommendations were suggested for target yield: **Chinsurah - 5** t/ha **Titabar - 5** t/ha**, Pantnagar - 6.5** t/ha**, Kaul - 10** t/ha**, Kanpur - 6.5** t/h and **5t/ha** Karaikal at these locations with reference to grain yields and average uptake of nutrients and nutrient requirement per ton grain yield recorded at the test sites. The target yields were the maximum recorded at the test sites under recommended fertilizer practice (RDF). The fertilizer recommendations presented show a range of fertilizer doses of major nutrients to achieve the targeted productivity which has already been harvested. High estimates of P and K fertilizer requirements are due to lower recovery efficiency of applied P and

higher accumulation of potassium per ton of grain. The study, thus indicated ample scope for improvement in nutrient use efficiency, and an attempt has been made to refine the current blanket recommended dose of fertilizer based on site specific nutrient supply, nutrient use efficiency and crop demand. While the yields were having considerable variation with the farmers' fertilizer practices, respectively with corresponding variation in soil test values and uptake pattern followed. Wide variations in yields were recorded under recommended fertilizer practices and with all the nutrients under farmers practice indicating mismatch of the fertilizer doses.

Yield Gap analysis

Yield gap analysis was done for all farm fields. The need was assessed to ascertain the gaps of technology and compared the yield variations among low yielders and high yielders vis a *vis* uptake, soil quality index gaps. Yield Gap was estimated based on the existing gaps in yields which were recorded between the low yielders and the high yielders and what was the prevalent grain yield in those farmers' sites prevalent across the region. The results have been enlisted in the table no.5.2.4. The highest level of yield gap (83.6 %) was recorded at Kaul, followed by 49.6 % at Chinsurah, 27.7 % at Titabar, 17.3% at Pantnagar, 17.3% at Karaikal and 27.8% at Kanpur. This shows a wide gap of grain harvest existed. However, ample scope existed at these centre to increase yields.

Summary

This trial was conducted in farmers' fields around a few selected centres – Chinsurah (pool of 46 farmers), Titabar (pool of 30 farmers), Pantnagar (pool of 50 farmers), Kanpur (pool of 20 farmers), Kaul (pool of 24 farmers) and Karaikal pool of 22 farmers) to assess the variability in soil nutrient supply, its relationship with rice yields at current recommended and farmers' fertilizer practices in some new farm sites and fine-tune the fertilizer nutrient requirement for specific target yields in a given environment and validation of fertilizer recommendations for targeted yields. Sharp variations in mean grain yields recorded varied from 2.38 t/ha among low yielders to 4.73 t/ha among high yielders at Chinsurah, from 2.48 t/ha among low yielders to 3.43 t/ha among high yielders at Titabar , varied from 4.76 t/ha among low yielders to 6.59t /ha among high yielders at Kanpur, varied from 4.83 t/ha among low yielders to 5.84 t /ha among high yielders at Pantnagar, from 3.83 t /ha among low yielders to 4.36 t/ha among high yielders at Karaikal and from 1.44 t/ha among low yielders to 9.9 t /ha among high yielders at Kaul. Soil Parameters data were pooled in different categories and the resulting soil quality index generated showed variations in the quality and health of the soil across different farmer's categories.

Fertilizer prescriptions were worked out for all the farm sites and specific fertilizer recommendations were suggested for target yield Chinsurah- 5 t/ha Titabar-5 t/ha, Pantnagar -6.5 t/ha, Kaul-10 t/ha, Kanpur-6.5 t/ha at these locations (target yield is decided being the highest yield recorded at the test sites) with reference to grain yields and average uptake of nutrients and nutrient requirement per ton grain yield recorded at the test sites. The soil quality index was much superior at Pantnagar and were at par for all other centers. The highest level of yield gap (83.6 %) was recorded at Kaul, followed 49.67 at Chinsurah, 27.7% at titabar, 17.3% at Pantnagar, 17.3% at Karaikal and 27.8% at Kanpur. This shows a wide gap of grain harvest existed. However, ample scope existed at these centers to increase yields.

- **Sharp variations in mean grain yields with wide yield gaps recorded among farmers and rice ecologies indicate mismatch of the fertilizer doses and establishing the probable cause of such gaps**
- **Soil quality index generated showed variations in the quality and health of the soil across different farmer's categories with the poorest soil quality index from Titabar and superior from Karaikal and Pantnagar.**

Table 5.2.1. Rice productivity in relation to internal supply capacity of nutrients in farmers' fields, *kharif* 2022 (Soil, crop and weather data)

Parameter	Chinsurah	Titabar	Kanpur	Kaul	Karaikal	Pantnagar
Variety	Swarna , Khitish, Shatabdi	Ranjeet, Ranjeet Sub 1, Bahadur, Swarna	Pioneer 3727, Pioneer 2761,Arize 6444,Sudha, Kaveri 9090	PR114,CSR-30,PR-1509,27P-31,PR-114,PR-114,PR-1121	CR 1009, BPT 5204, ADT 46	Sarbati, Pusa 150, PR121, Indrasan, PR1509, PR126, Hybrid, PD10, PD 12, HR 47, Pusa 154, 2967, PD 18, Sarju 52 HR 47, Saket 4, Basmati, Pusa Basmati, HR 147, local
Crop growth	Good	Good	Good	Good	Good	Good
RFD (kg NPK/ha)	Varying-48-24-24, 50-25-25, 60-30-30, 70-35-35, 80-40-40	Varying – 20-15-20,20-15-10,30-15-25,40-20-25,25-25-30,20-15-30,40-20-30,30-20-15,35-20-15,30-15-30	Varying 120-40-0,100-40-0,150-60-40,120-60-0,120-60-20,120-60-30,120-60-40	-	168:58:45, 100: 58: 60, 114:58:45, 80:58:37, 162:58:60, 80:58:37, 80: 58: 60,120:58:45, 120:58:60, 80: 58: 60	180,60,40, 150,60,50, 120,60,40, 120,60,50, 200,60,40, 150,60,40, 150,50,50, 150,50,40, 120,50,40, 120,60,40, 160,60,50, 160,60,50,
% Clay	-	32-44	-	-		
% Silt	-	25.5-30.8	-	-		
% Sand	-	22-28	-	-		
Soil Texture	-	Sandy loam to silty clay	-	-		
pH	6.49-7.20	5.2-5.6	7.78-8.54	7.5-9.2	7.5-8.36	7.0-7.9
EC (mmhos/cm)	0.18-0.44	0.01-0.11	0.15-0.68	0.15-0.74	0.15-0.95	0.26-0.56
Org. carbon (%)	0.85-1.28	0.5-0.8	0.43-0.78	0.39-0.68	0.03-0.87	0.25-0.74
Avail. N (kg/ha)	378-507	220-310	147-204	135-198	113-204	125-215
Avail. P_2O_5 (kg/ha)	85-103	8.5-14.5	32-57	29.31	15-66	5.5-16.3
Avail. K_2O (kg/ha)	265-303	105-140	150-375	223-392	138-502	110-220

Table 5.2.2. Rice productivity in relation to internal supply capacity of nutrients in farmers' fields*, kharif 2022*

- Soil nutrient supply potential vis a vis nutrient uptake assessed among different farmers' categories

Categories/ Nutrient	**Chinsurah** (Total of 46 sites, 12 low yielders and 21 high yielder sites)			**Titabar** (Total of 30 sites, 21 low yielders and 9 high yielder sites)		
	Minimum	**Maximum**	**Mean***	**Minimum**	**Maximum**	**Mean****
Grain yield (t/ha)						
Low Yielders	1.76	3.06	2.38	2.00	2.85	2.48
High Yielders	4.27	4.99	4.73	3.10	4.75	3.43
Nutrient uptake (kg/ha)						
	Low Yielders					
N	-	-	-	-	-	-
P	-	-	-	-	-	-
K	-	-	-	-	-	-
	High Yielders					
N	-	-	-	-	-	-
P	-	-	-	-	-	-
K	-	-	-	-	-	-
Soil Quality Index						
Low yielders(0.7) High Yielders 0.9 (Very High)				**Low Yielders 0.3 (very poor), High Yielders (0.4) Average**		

Categories/ Nutrient	**Kanpur** (Out of 20,5 low yielders, 15 high yielders)			**Pantnagar** (Out of 50,9 low yielders,51 high yielders)		
	Minimum	**Maximum**	**Mean***	**Minimum**	**Maximum**	**Mean****
Grain yield (t/ha)						
Low Yielders	4.59	4.98	4.76	4.0	4.5	4.83
High Yielders	5.31	7.18	6.59	5.1	7.4	5.84
Nutrient uptake (kg/ha)						
	Low Yielders					
N	74.88	80.38	77.57	31.2	48.02	40.17
P	26.82	29.42	28.13	2.7	7.0	4.73
K	8.92	9.72	9.30	21.6	40.0	29.81
	High Yielders					
N	83.11	131.45	113.93	28.08	72.52	47.8
P	32.21	54.43	44.59	4.56	13.32	8.58
K	11.24	19.02	14.93	18.2	44.4	28.69
Soil Quality Index						
Low yielders(0.7) High Yielders 0.67(good)				**Low yielders(0.6-good) High Yielders** (0.8) very good		

Categories/ Nutrient	**Kaul** (Out of 24, 14 low yielders, 10 high yielders)			**Karaikal** (Out of 22,16 low yielders, 6 high yielders)		
	Minimum	**Maximum**	**Mean***	**Minimum**	**Maximum**	**Mean****
Grain yield (t/ha)						
Low Yielders	1.3	1.7	1.44	3.56	3.92	3.83

High Yielders	7.5	9.9	8.8	4.03	4.65	4.36
Nutrient uptake (kg/ha)						
	Low Yielders					
N	24.3	38.4	30.4	23.96	30.77	26.83
P	8.3	16.1	11.3	9.16	21.49	15.12
K	27.8	44.8	35.4	17.20	49.23	30.12
	High Yielders					
N	96	128	114.5	22.57	54.68	33.83
P	37.87	53.1	42.09	3.84	26.65	16.68
K	40.5	54.9	45.63	19.44	53.84	31.37
Soil Quality Index						
0.67(good)				NA		

Table 5.2.3. Rice productivity in relation to internal supply capacity of nutrients in farmers' fields, *kharif* 2022 - - Nutrient Requirement per ton grain yield

Farmers categories	**Chinsurah**			**Titabar**		
	Mean yield (t/ha)	**Mean uptake (kg/ha)**	**Nutrient Requirement (kg/t grain)**	**Mean yield (t/ha)**	**Mean uptake (kg/ha)**	**Nutrient Requirement (kg/t grain)**
Low Yielders (12 sites)	2.38	-	-	2.48	-	-
N		-	-		-	-
P		-	-		-	-
K		-	-		-	-
High Yielders (34 sites)	4.73	-	-	3.43	-	-
N		-	-		-	-
P		-	-		-	-
K		-	-		-	-
Farmers categories	**Kanpur**			**Pantnagar**		
	Mean yield (t/ha)	**Mean uptake (kg/ha)**	**Nutrient Requirement (kg/t grain)**	**Mean yield (t/ha)**	**Mean uptake (kg/ha)**	**Nutrient Requirement (kg/t grain)**
Low yielders	4.76			4.83		
N		77.57	16.29		40.17	8.31
P		28.13	5.90		4.93	1.02
K		9.30	1.95		29.81	5.96
High yielders	6.59			5.84		
N		113.93	17.28		**47.8**	8.18
P		44.59	6.76		**8.58**	1.46
K		14.93	2.26		**28.69**	4.92

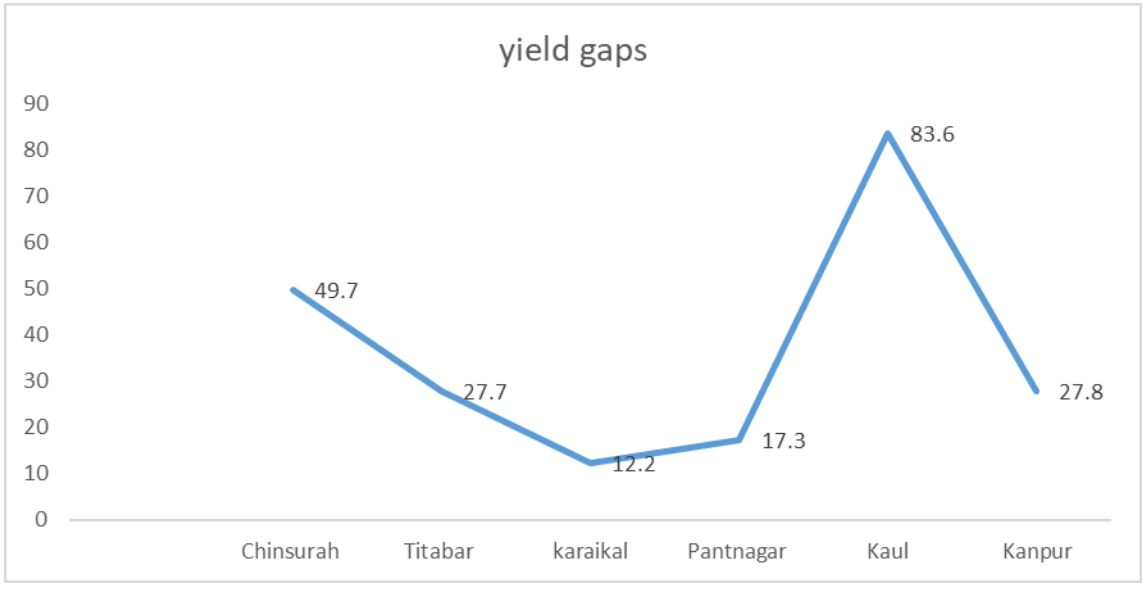
Farmers categories	**Kaul**			**Karaikal**			
	Mean yield (t/ha)	**Mean uptake (kg/ha)**	**Nutrient Requirement (kg/t grain)**	**Farmers categories**	**Mean yield (t/ha)**	**Mean uptake (kg/ha)**	**Nutrient Requirement (kg/t grain)**

Low yielders							
N	1.44	30.4	21.11		3.83	26.83	7.01
P		11.3	7.84			15.12	3.94
K		35.4	24.5			30.12	7.84
High yielders							
N	8.8	114.5	13.01		4.36	33.83	7.75
P		42.09	4.78			16.68	3.82
K		45.63	5.18			31.37	7.19

Table 5.2.4 Rice productivity in relation to internal supply capacity of nutrients in farmers' fields, *kharif* 2022 (Site-specific fertilizer recommendation (kg/ha) for a target yield)

Site /centers.	Current mean yield from low yielders group (t/ha)	Current mean yield from high Yielders group (t/ha)	Percent increase in yield over low yielders groups	Fertilizer recommendation for the target yield (t/ha) Chinsurah- 5 Titabar-5 Karaikal -4.5 Kaul-10, Kanpur-7, Pantnagar – 6/ha		
				N (Urea)	P_2O_5 (SSP)	K_2O (Potash)
Chinsurah	2.38	4.73	49.7	90	25	50
Titabar	2.48	3.43	27.7	85	23	47
Karaikal	3.83	4.36	12.2	32	18	36
Pantnagar	4.83	5.84	17.3	62	8	44
Kaul	1.44	8.8	83.6	114	42	45
Kanpur	4.76	6.59	27.8	119	42	16

Figure 1. Yield Gaps among all centers



5.3. Management of Sodic Soils Using Nano Zinc Formulation

Sodic soils have high soil pH (8.5 - 11.0) and exchangeable sodium percentage (ESP) of greater or equal to 15, electrical conductivity of less than 4 dS/m, low organic matter and nutrient content and a preponderance of carbonates and bicarbonates of sodium or excess salt content. These soil characteristics strongly modify the availability of micronutrients and thereby crop productivity. These soils can be managed by either growing a crop variety suitable for a particular soil or by applying suitable chemical material to withstand the crop in adverse conditions. Sodic soil is deficient in micronutrients like Zn, Fe, Mn and Cu, among these Zn present in the level less than 0.5 ppm. Keeping these points in view, this trial was conducted with nano Zn material to enhance the Zn availability to the plants with various concentration on sodic soils. This trial has started in *Kharif-2021* with the nano Zn chemicals in a different concentration (20 and 50 ppm). In the current year, this trial was conducted at four different locations viz., Kanpur, Mandya, Pusa and Faizabad. The selected genotypes (CSR 23 and DRR Dhan 48) were evaluated under different set of nutrient management practices (Control; $ZnSO_4$ @ 0.5 % foliar spray; Nano Zn @ 20 ppm foliar spray; Nano Zn @ 50 ppm foliar spray; Soil application of $ZnSO_4$ @ 50 kg/ha; Silicic acid @ 40 ppm). The experimental results are presented in tables 5.3.1- 5.3.14 and briefly discussed.

Yield Parameters

Yield parameters like tiller number and panicle number per meter square were represented in the table 5.3.2 and 5.3.3. Significant differences were observed in the tiller number due to varieties and treatments at all the centers except Pusa. Among the treatments, soil application of $ZnSO_4$ @ 50 kg/ha produced highest tiller number at Kanpur (337) and Pusa (240) whereas foliar application of nano Zn @ 50 ppm has produced highest tiller number at Mandya (425) and Faizabad (308). In case of Varieties, DRR Dhan 48 registered higher tiller number at all the locations except Kanpur where CSR 23 registered higher tiller number per square meter. Panicles/m^2 differed significantly among the varieties and treatments at all locations except Pusa. Among the treatments, foliar application of nano Zn @ 50 ppm has registered higher panicle number at Mandya (286) and Faizabad (303) whereas soil application of $ZnSO_4$ @ 50 kg/ha has recorded higher panicle number at Kanpur (249) and Pusa (217). With respect to varieties, CSR 23 produced higher panicles at Kanpur (233) and Mandya (253) where as DRR Dhan 48 produced higher panicle number at Pusa (208) and Faizabad (287).

Grain and Straw yields

Grain and straw yields showed significant differences between the genotypes and treatments and depicted in table 5.3.4 and 5.3.5. At Kanpur, soil application of $ZnSO_4$ @ 50 kg/ha registered higher grain (4.36 t/ha) and straw (6.25 t/ha) yields whereas foliar application of nano Zn @ 50 ppm recorded on par grain (4.08 t/ha) and straw yields (5.70 t/ha). Between the varieties, CSR23 has recorded significantly higher grain (4.43 t/ha) and straw (5.78 t/ha) yields compared to DRR Dhan 48.

In case of Mandya, foliar application of nano Zn @ 50 ppm recorded significantly higher grain (6.24 t/ha) and straw yields (6.86 t/ha) compared to all other treatments. With respect to varieties, DRR Dhan 48 produced significantly higher grain (5.43 t/ha) and straw yields (6.01 t/ha) than CSR23.

At Pusa, Soil application of $ZnSO_4$ @ 50 kg/ha registered higher grain yield (3.41 t/ha) followed by application of silicic acid @ 40 ppm (3.20 t/ha). In case of straw yield, soil application of $ZnSO_4$ @ 50 kg/ha registered higher straw yield (5.15 t/ha) followed by silicic acid @ 40 ppm (4.84 t/ha) and Nano Zn @ 50 ppm (4.69 t/ha). However, there is no significant difference among the varieties.

In Faizabad, foliar application of nano Zn @ 50 ppm recorded significantly higher grain (3.99 t/ha) and straw yields (5.37 t/ha) compared to all other treatments. Between the varieties, DRR Dhan 48 was superior to CSR 23. Interaction between treatments and genotypes was found to be non-significant in most of the cases.

Soil application of $ZnSO_4$ @ 50 kg/ha registered higher thousand grain weight at Kanpur (21.0 g) and Pusa (22.0 g) while foliar application of nano Zn @ 50 ppm recorded higher thousand grain weight at Mandya (23.2 g). In case of varieties, CSR 23 recorded higher thousand grain weight at Kanpur (26.7 g) and Pusa (25.2 g) whereas DRR Dhan 48 recorded significantly higher thousand grain weight at Mandya (22.3 g) (Table 5.3.6).

Nutrient uptake

Significant differences in nutrient uptake of NPK and Zn were observed at all the locations (Table 5.3.7 and 5.3.10). At Kanpur and Pusa, soil application of $ZnSO_4$ @ 50 kg/ha has recorded higher NPKZn uptake whereas at Mandya and Faizabad, Nano Zn @ 50 ppm foliar spray recorded higher NPKZn uptake. In case of varieties, DRR Dhan 48 has accumulated higher amount of NPKZn at Mandya, Pusa and Faizabad and CSR 23 recorded significantly higher nutrient uptake at Kanpur.

Partioning of Zn in Grain and straw: Zinc accumulation in grain and straw significantly differed among the treatments at all the locations but varietal difference was observed only at Kanpur (Table 5.3.11- 5.3.13). Uptake of Zinc was more in straw compared to grain at all the locations due to higher concentration of Zn and higher straw yields. Application of $ZnSO_4$ @ 50 kg/ha has registered higher grain and straw Zn uptake at Kanpur and Pusa while at Mandya Nano Zn @ 50 ppm foliar spray accumulated more amount of Zn in grain and straw.

Post-harvest soil Zn status: The available Zn status in soil after harvest was significantly differed among the treatments but not between the varieties (Table 5.3.14). Application of $ZnSO_4$ @ 50 kg/ha has recorded significantly higher Zn status in Mandya (2.38 mg/kg) compared to rest of the treatments. In Kanpur, except control and silicic acid applied plots, all other treatments were on par with each other with respect to post harvest soil Zn status.

Summary:

Significant genotypic and location-specific differences in yield parameters and yield were observed at all four locations. At Kanpur and Pusa, soil application of $ZnSO_4$ @ 50 kg/ha registered higher grain (4.36 t/ha, 3.41 t/ha) and straw (6.25 t/ha, 5.15 t/ha) yields whereas at Mandya and Faizabad foliar application of nano Zn @ 50 ppm recorded significantly higher grain (6.24 t/ha, 3.99 t/ha) and straw yields (6.86 t/ha, 5.37 t/ha). In case of Varieties, DRR Dhan 48 found superior at Mandya and Faizabad and CSR23 performed better at Kanpur. Nutrient uptake also followed similar trend as that of grain and straw yields. The variety DRR Dhan 48 has accumulated higher amount of NPK and Zn at Mandya, Pusa and Faizabad and CSR 23 recorded significantly higher nutrient uptake at Kanpur.

- **Foliar application of nano Zn@ 50 ppm has performed better across the locations except Kanpur.**
- **The variety DRR Dhan 48 exhibited superior performance in all the locations except Kanpur.**
- **Significantly superior performance of Zn application (Soil/foliar/nano formulations) was observed in sodic soils across the locations.**

Table 5.3.1: Management of Sodic soil using nano zinc formulations

(Crop and soil characteristics)

Parameters	Kanpur	Mandya	Pusa	Faizabad
Season	***Kharif* -2022**	***Kharif* -2022**	***Kharif* -2022**	***Kharif* -2022**
Varieties	CSR 23, DRR Dhan 48	CSR 23, DRR Dhan 48	CSR 23 DRR Dhan 48	CSR 23 DRR Dhan 48
Fertilizer dose	150:60:60	125:62.5:62.5	120:60:40:50	120:60:60:25
Soil pH	9.90	9.02	9.61	9.6
Soil EC (dS/m)	0.23	0.34	0.61	2.85
Available N (kg/ha)	147	281	172	210
Available P (kg/ha)	12.4	30.2	19	25
Available K (kg/ha)	208	350	102	235
Texture	Sandy Clay Loam	Sandy loam	Sandy loam	Sandy loam
OC (%)	0.21	0.65	0.42	0.39
DTPA-Zn (mg/kg)	0.48	0.86	0.42	-

Table 5.3.2: Management of Sodic soils using nano Zn formulation, Tillers /m^2 of rice at different locations

Treatments/ Varieties	**Kanpur**			**Mandya**			**Pusa**			**Faizabad**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	284	276	280	317	328	322	216	221	218	251	264	258
$ZnSO_4$ @ 0.5 % foliar spray	318	289	304	359	356	358	219	223	221	269	272	270
Nano Zn @ 20 ppm foliar spray	326	294	310	392	401	396	226	228	227	284	290	287
Nano Zn @ 50 ppm foliar spray	343	304	323	420	429	425	231	224	228	298	318	308
Soil application of $ZnSO_4$ @ 50 kg/ha	353	320	337	404	409	406	234	246	240	294	308	301
Silicic acid @ 40 ppm	292	286	289	391	394	393	221	234	227	292	302	297
Mean	319	295	307	380	386	383	225	229	226	281	292	287
CD (0.05) M	14.4			20.9			NS			4.37		
CD (0.05) S	6.41			5.28			NS			2.55		
M X S	15.7			NS			NS			6.23		
S XM	15.1			NS			NS			5.40		
CV (%) M	3.65			4.24			4.89			1.43		
CV (%) S	2.87			1.90			6.04			1.46		

Table 5.3.3: Management of Sodic soils using nano Zn formulation, panicles /m^2 of rice at different locations

Treatments/ Varieties	**Kanpur**			**Mandya**			**Pusa**			**Faizabad**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	203	197	200	217	218	218	194	198	196	246	259	252
ZnSO4 @ 0.5 % foliar spray	222	213	217	244	241	242	197	202	200	263	268	265
Nano Zn @ 20 ppm foliar spray	237	215	226	260	256	258	204	206	205	280	285	283
Nano Zn @ 50 ppm foliar spray	251	217	234	283	288	286	210	202	206	294	313	303
Soil application of $ZnSO_4$ @ 50 kg/ha	262	236	249	274	267	271	210	223	217	288	302	295
Silicic acid @ 40 ppm	222	204	213	239	239	239	201	214	207	287	297	292
Mean	233	214	223	253	252	252	203	208	205	276	287	282
CD (0.05) M	13.9			15.3			NS			4.71		
CD (0.05) S	6.37			NS			NS			2.44		
M X S	NS			NS			NS			5.97		
S XM	NS			NS			NS			5.39		
CV (%) M	4.84			4.72			5.04			1.57		
CV (%) S	3.93			2.81			6.29			1.43		

Table 5.3.4: Management of Sodic soils using nano Zn formulation, Grain yields (t/ha) of rice at different locations

Treatments/ Varieties	**Kanpur**			**Mandya**			**Pusa**			**Faizabad**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	3.44	1.83	2.64	4.24	4.31	4.27	2.54	2.78	2.66	2.53	3.16	2.84
$ZnSO_4$ @ 0.5 % foliar spray	4.17	2.45	3.31	5.34	5.47	5.40	2.68	2.74	2.71	2.90	3.82	3.36
Nano Zn @ 20 ppm foliar spray	4.67	2.86	3.77	5.53	5.57	5.55	2.87	2.93	2.90	3.13	4.11	3.62
Nano Zn @ 50 ppm foliar spray	5.02	3.13	4.08	6.20	6.27	6.24	3.04	3.11	3.07	3.52	4.46	3.99
Soil application of $ZnSO_4$ @ 50 kg/ha	5.27	3.44	4.36	5.34	5.50	5.42	3.29	3.53	3.41	3.32	4.30	3.81
Silicic acid @ 40 ppm	4.02	2.24	3.13	5.39	5.48	5.44	3.13	3.26	3.20	3.22	4.25	3.73
Mean	4.43	2.65	3.54	5.34	5.43	5.39	2.93	3.06	2.99	3.10	4.02	3.56
CD (0.05) M	0.38			0.18			0.30			0.09		
CD (0.05) S	0.23			0.03			NS			0.05		
M X S	NS			NS			NS			0.13		
S XM	NS			NS			NS			0.11		
CV (%) M	8.37			2.62			7.75			2.38		
CV (%) S	9.03			0.70			8.82			4.48		

Table 5.3.5: Management of Sodic soils using nano Zn formulation, Straw yields (t/ha) of rice at different locations

Treatments/ Varieties	**Kanpur**			**Mandya**			**Pusa**			**Faizabad**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	4.40	2.65	3.53	4.69	4.91	4.80	3.86	3.89	3.88	3.55	3.16	3.83
ZnSO4 @ 0.5 % foliar spray	5.38	3.68	4.53	5.77	5.95	5.86	4.11	4.14	4.13	4.05	3.82	4.51
Nano Zn @ 20 ppm foliar spray	6.05	4.38	5.21	6.14	6.29	6.22	4.39	4.42	4.40	4.32	4.11	4.82
Nano Zn @ 50 ppm foliar spray	6.55	4.85	5.70	6.80	6.91	6.86	4.63	4.74	4.69	4.91	4.46	5.37
Soil application of $ZnSO_4$ @ 50 kg/ha	7.10	5.40	6.25	5.82	5.95	5.88	4.96	5.33	5.15	4.63	4.30	5.11
Silicic acid @ 40 ppm	5.17	3.40	4.29	5.98	6.06	6.02	4.79	4.89	4.84	4.44	4.25	4.96
Mean	5.78	4.06	4.92	5.87	6.01	5.94	4.46	4.57	4.51	4.32	5.22	4.77
CD (0.05) M	0.60			0.23			0.56			0.13		
CD (0.05) S	0.28			0.02			NS			0.07		
M X S	NS			0.05			NS			0.16		
S XM	NS			0.17			NS			0.15		
CV (%) M	9.47			3.06			9.63			2.61		
CV (%) S	7.77			0.51			10.7			2.29		

Table 5.3.6: Management of Sodic soils using nano Zn formulation, Thousand grain weight (g) of rice at different locations

Treatments/ Varieties	**Kanpur**			**Mandya**			**Pusa**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	26.2	13.9	20.1	20.2	20.7	20.4	24.7	17.9	21.3
$ZnSO_4$ @ 0.5 % foliar spray	26.7	14.2	20.4	21.6	21.7	21.6	24.9	17.8	21.3
Nano Zn @ 20 ppm foliar spray	26.8	14.4	20.6	22.1	22.5	22.3	25.2	18.0	21.6
Nano Zn @ 50 ppm foliar spray	26.9	14.8	20.9	23.0	23.4	23.2	25.2	18.3	21.8
Soil application of $ZnSO_4$ @ 50 kg/ha	27.0	14.9	21.0	22.6	22.9	22.7	25.8	18.2	22.0
Silicic acid @ 40 ppm	26.6	14.4	20.5	22.8	22.9	22.9	25.7	18.2	22.0
Mean	26.7	14.4	20.6	22.0	22.3	22.1	25.2	18.0	21.6
CD (0.05) M	0.21			0.89			NS		
CD (0.05) S	0.11			0.19			0.37		
M X S	NS			NS			NS		
S XM	NS			NS			NS		
CV (%) M	0.79			3.12			2.19		
CV (%) S	0.71			1.16			2.33		

Table 5.3.7: Management of Sodic soils using nano Zn formulation, Total nutrient uptake of rice at Kanpur

Treatments/ Varieties	**N uptake (kg/ha)**			**P uptake (kg/ha)**			**K uptake (kg/ha)**			**Zn uptake (g/ha)**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	45.7	25.2	35.4	14.6	9.01	11.8	55.7	33.3	44.5	1337	797	1067
$ZnSO_4$ @ 0.5 % foliar spray	62.4	38.5	50.4	20.3	13.7	17.0	72.1	49.4	60.7	2500	1684	2092
Nano Zn @ 20 ppm foliar spray	73.8	46.9	60.3	22.8	16.69	19.7	82.6	59.5	71.0	2955	2074	2515
Nano Zn @ 50 ppm foliar spray	81.9	54.4	68.1	27.0	19.36	23.2	90.7	67.1	78.9	3365	2389	2877
Soil application of $ZnSO_4$ @ 50 kg/ha	89.8	61.5	75.6	29.9	22.26	26.1	101.2	76.7	88.9	3721	2752	3237
Silicic acid @ 40 ppm	59.1	34.7	46.9	20.0	12.72	16.4	69.5	46.4	58.0	2346	1522	1934
Mean	68.7	43.5	56.1	22.4	15.6	19.0	78.6	55.4	67.0	2704	1870	0.19
CD (0.05) M	7.04			2.60			6.92			325		
CD (0.05) S	3.04			1.30			4.06			189		
M X S	NS			NS			NS			NS		
S XM	NS			NS			NS			NS		
CV (%) M	9.74			10.7			8.03			11.0		
CV (%) S	7.47			9.40			8.35			11.3		

Table 5.3.8: Management of Sodic soils using nano Zn formulation, Total nutrient uptake of rice at Mandya

Treatments/ Varieties	**N uptake (kg/ha)**			**P uptake (kg/ha)**			**K uptake (kg/ha)**			**Zn uptake (g/ha)**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	68.3	69.0	68.7	11.2	11.9	11.6	53.9	56.8	55.3	993	1108	1050
$ZnSO_4$ @ 0.5 % foliar spray	92.3	95.0	93.7	15.9	16.9	16.4	72.1	74.8	73.4	1741	1746	1744
Nano Zn @ 20 ppm foliar spray	99.8	103.7	101.8	18.4	19.0	18.7	82.8	84.1	83.4	1962	1989	1976
Nano Zn @ 50 ppm foliar spray	124.7	124.5	124.6	23.3	20.7	22.0	101.4	103.6	102.5	2428	2500	2464
Soil application of $ZnSO_4$ @ 50 kg/ha	95.6	98.7	97.1	17.4	18.1	17.7	75.5	78.3	76.9	1832	1918	1875
Silicic acid @ 40 ppm	94.2	94.2	94.2	15.8	17.5	16.6	77.9	78.0	77.9	1714	1724	1719
Mean	95.8	97.5	96.6	17.0	17.3	17.2	77.3	79.3	78.3	1778	1830	1804
CD (0.05) M	6.31			1.93			5.94			52.1		
CD (0.05) S	1.51			NS			1.30			44.82		
M X S	NS			NS			NS			NS		
S XM	NS			NS			NS			NS		
CV (%) M	5.07			8.75			5.90			2.25		
CV (%) S	2.16			7.45			2.20			3.42		

Table 5.3.9: Management of Sodic soils using nano Zn formulations, Total nutrient uptake of rice at Pusa

Treatments/ Varieties	**N uptake (kg/ha)**			**P uptake (kg/ha)**			**K uptake (kg/ha)**			**Zn uptake (g/ha)**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	47.1	49.0	48.1	11.1	11.6	11.3	63.5	65.0	64.3	1520	1605	1562
$ZnSO_4$ @ 0.5 % foliar spray	49.7	50.4	50.1	11.3	11.4	11.4	67.9	69.5	68.7	1723	1770	1747
Nano Zn @ 20 ppm foliar spray	53.0	53.8	53.4	12.0	12.2	12.1	73.2	74.3	73.7	1898	1969	1934
Nano Zn @ 50 ppm foliar spray	55.5	57.7	56.6	12.8	13.1	13.0	77.7	80.3	79.0	2069	2134	2101
Soil application of $ZnSO_4$ @ 50 kg/ha	60.6	65.0	62.8	13.8	14.9	14.3	89.5	94.2	91.9	2293	2449	2371
Silicic acid @ 40 ppm	57.1	59.6	58.3	13.4	13.7	13.6	81.5	84.4	83.0	2000	2068	2034
Mean	53.8	55.9	54.8	12.4	12.8	12.6	75.5	77.9	76.7	1917	1999	1958
CD (0.05) M	6.35			1.22			9.92			205		
CD (0.05) S	NS			NS			NS			NS		
M X S	NS			NS			NS			NS		
S XM	NS			NS			NS			NS		
CV (%) M	8.39			7.51			10.0			8.13		
CV (%) S	10.2			11.1			12.0			10.9		

Table 5.3.10: Management of Sodic soils using nano Zn formulation, Total nutrient uptake of rice at Faizabad

Treatments/ Varieties	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	52.5	70.4	61.5	28.7	39.0	33.8	40.1	50.9	45.5
$ZnSO_4$ @ 0.5 % foliar spray	64.9	94.6	79.8	36.4	52.5	44.5	50.2	67.0	58.6
Nano Zn @ 20 ppm foliar spray	74.5	102.7	88.6	42.7	62.1	52.4	56.6	78.3	67.5
Nano Zn @ 50 ppm foliar spray	87.9	120.7	104.3	53.1	70.3	61.7	69.1	87.7	78.4
Soil application of $ZnSO_4$ @ 50 kg/ha	79.7	105.5	92.6	45.1	61.8	53.5	60.2	78.0	69.1
Silicic acid @ 40 ppm	78.0	107.8	92.9	46.2	67.0	56.6	60.5	82.0	71.3
Mean	72.9	100	86.6	42.0	58.7	50.4	56.1	73.9	65.0
CD (0.05) M	4.42			2.93			3.19		
CD (0.05) S	2.24			1.43			1.53		
M X S	5.49			3.50			3.75		
S XM	5.00			3.23			3.49		
CV (%) M	4.79			5.45			4.61		
CV (%) S	4.27			4.67			3.88		

Table 5.3.11: Management of Sodic soils using nano Zn formulation, Zn uptake in grain and straw of rice at Kanpur

Treatments/ Varieties	**Grain uptake (g/ha)**			**Straw uptake (g/ha)**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	313	171	242	1024	627	825
$ZnSO_4$ @ 0.5 % foliar spray	863	527	695	1637	1158	1397
Nano Zn @ 20 ppm foliar spray	1040	645	842	1915	1429	1672
Nano Zn @ 50 ppm foliar spray	1224	773	998	2142	1617	1879
Soil application of $ZnSO_4$ @ 50 kg/ha	1353	903	1128	2368	1849	2109
Silicic acid @ 40 ppm	810	463	637	1536	1059	1297
Mean	934	580	757	1770	1289	1530
CD M	126			225		
CD S	69.5			123		
M X S	NS			3.50		
S XM	NS			3.23		
CV (%) M	13.0			11.4		
CV (%) S	12.6			11.0		

Table 5.3.12: Management of Sodic soils using nano Zn formulation, Zn uptake in grain and straw of rice at Mandya

Treatments/ Varieties	**Grain uptake (g/ha)**			**Straw uptake (g/ha)**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	370	372	371	623	735	679
$ZnSO_4$ @ 0.5 % foliar spray	627	612	619	1114	1134	1124
Nano Zn @ 20 ppm foliar spray	676	719	697	1287	1269	1278
Nano Zn @ 50 ppm foliar spray	908	927	918	1520	1573	1547
Soil application of $ZnSO_4$ @ 50 kg/ha	657	695	676	1175	1223	1199
Silicic acid @ 40 ppm	570	539	554	1143	1185	1164
Mean	634	644	639	1143	1186	1165
CD M	34.9			36		
CD S	NS			38.5		
M X S	NS			NS		
S XM	NS			NS		
CV (%) M	4.25			2.40		
CV (%) S	4.11			4.55		

Table 5.3.13: Management of Sodic soils using nano Zn formulations, Zn uptake in grain and straw of rice at Pusa

Treatments/ Varieties	**Grain uptake (g/ha)**			**Straw uptake (g/ha)**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	639	717	678	880	888	884
$ZnSO_4$ @ 0.5 % foliar spray	716	746	731	1006	1024	1015
Nano Zn @ 20 ppm foliar spray	769	815	792	1130	1154	1142
Nano Zn @ 50 ppm foliar spray	828	879	854	1241	1255	1248
Soil application of $ZnSO_4$ @ 50 kg/ha	926	996	961	1367	1453	1410
Silicic acid @ 40 ppm	798	845	821	1202	1224	1213
Mean	779	832	806	1138	1166	1151
CD M	88.4			138		
CD S	NS			NS		
M X S	NS			NS		
S XM	NS			NS		
CV (%) M	8.53			9.36		
CV (%) S	11.0			11.8		

Table 5.3.14: Management of Sodic soils using nano Zn formulations, Post-harvest soil zinc (mg/kg) status

Treatments/ Varieties	**Kanpur**			**Mandya**		
	CSR 23	DRR Dhan 48	Mean	CSR 23	DRR Dhan 48	Mean
Control	0.38	0.37	0.38	0.84	0.87	0.86
ZnSO4 @ 0.5 % foliar spray	0.52	0.51	0.52	0.97	1.01	0.99
Nano Zn @ 20 ppm foliar spray	0.53	0.54	0.54	1.06	1.07	1.06
Nano Zn @ 50 ppm foliar spray	0.56	0.57	0.56	1.12	1.15	1.14
Soil application of $ZnSO_4$ @ 50 kg/ha	0.59	0.59	0.59	2.31	2.45	2.38
Silicic acid @ 40 ppm	0.44	0.45	0.44	0.99	0.99	0.99
Mean	0.50	0.50	0.50	1.22	1.26	1.24
CD M	0.07			0.14		
CD S	NS			NS		
M X S	NS			NS		
S XM	NS			NS		
CV (%) M	10.2			8.85		
CV (%) S	10.7			6.30		

5. 4 Management of Acid soils

Acid soils are wide spread in Eastern, North Eastern and coastal regions of the Indian Peninsula and are poor in soil fertility and are associated with toxicity of iron in lowlands, aluminium in the uplands, with depletion of Ca, Mg and K, deficiency of B, Mo and Si. The soils also fix large quantities of soluble P, which lead to sub optimal productivity of crops. Management options include liming to correct soil acidity, balanced application of P, K, and silicates and organic manuring besides growing tolerant cultures. In addition, the identification of suitable genotypes with high yield potential helps stabilize rice productivity. The trial was, therefore, conducted at four centers viz., Moncompu-MCP (Kuttanad, Kerala, soil pH 4.66), Ranchi-RCI (Jharkhand, soil pH 5.22) and Titabar-TTB (Assam, soil pH 5.2) under irrigated conditions and at Mizoram (ICAR RC NEH Region, Mizoram Centre, Kolasib, soil pH 5.12-5.42) under rainfed upland conditions during *kharif* 2022. The genotypes Uma and Vasundhara (Moncompu, Ranchi, Titabar) and Uma and RC Maniphou-6 (Mizoram) were evaluated under seven sets of nutrient management treatments *viz*., i) NPK (RD), ii) NPK (RD)+ Silixol spray (at vegetative, booting and grain filling stage), iii) NPK (RD) + Rice husk ash, 250 kg/ha during land preparation, iv) NPK (RD) + Dolomite 250 kg/ha 30 days after transplanting, v) NPK (RD) + Silixol spray (at vegetative, booting and grain filling stage) + Dolomite 250 kg/ha, 30 days after transplanting, vi) NPK (RD)+ Rice husk ash, 250 kg/ha during land preparation + Dolomite 250 kg/ha, 30 days after transplanting and viii) Potassium Silicate Solution- Four sprays at 15 days interval starting from 15 DAT (days after transplanting). The details of crop, soil, and weather parameters of the experimental sites (Table 5.4.1) show variations in soil characteristics with reference to pH, organic carbon content, soil texture and available nutrient status. The experimental results are presented in Tables 5.4.2 – 5.4.8 and briefly discussed.

Yield and yield parameters

At Moncompu (MCP), application of dolomite + Silixol spray in combination with RDF (4.12 t/ha) yielded significantly higher than other treatments (Table 5.4.3). The yields obtained with RDF + Dolomite + RHA (3.83 t/ha), RDF+ K-Silicate (3.68 t/ha), RDF + Silixol spray (3.55 t/ha) application were on par, while the treatment with that received only recommended dose of fertilizer (RDF) recorded the lowest yield of 3.05 t/ha. Among varieties, the yield of Vasundhara (3.64 t/ha) was significantly higher than Uma (3.42 t/ha) at MCP. Straw yields recorded with RDF + dolomite + Silixol spray (5.81 t/ha) and RDF +

dolomite + RHA (5.62 t/ha) were on par and significantly higher than other treatments. Similar to grain yield, the application of RDF + dolomite + Silixol spray (Table 5.4.2), resulted in the highest number of tillers/m^2(191), panicles/m^2 (160) and filled grain/ panicle (119). Application of RDF+ K-Silicate and RDF + dolomite + Silixol spray recorded significantly higher 1000 grain weight of 26.30 g and 25.86 g, respectively.

At Titabar (TTB), significant differences were observed in nutrient management treatments (Table 5.4.3), with the highest yield recorded with RDF + dolomite + Silixol spray (4.70 t/ha). The other treatments recorded comparable on-par yields ranging from 4.36 t/ha to 4.05 t/ha, while the lowest yield was observed in the treatment with sole RDF application (3.78 t/ha). Between the varieties, the genotype Uma, recorded significantly superior yields (4.36 t/ha) compared to Vasundhara (4.07 t/ha). Straw yields followed similar trends as grain yields at Titabar for both nutrient management and varieties. The highest number of tillers/m^2(387), panicles/m^2(341) and filled grain/ panicle (119) were observed following the application of RDF + dolomite + Silixol spray (Table 5.4.2).

In acid soils of Ranchi, application of RDF + Dolomite + RHA (5.76 t/ha) recorded the highest grain yield, while among the varieties, Uma recorded a significantly higher yield (5.49 t/ha) than Vasundhara (5.26 t/ha).

Grain yield, straw yield, plant height, and yield parameters like tillers/hill and filled grains/panicle of the variety Vasundhara was not significantly influenced by nutrient management practices at Mizoram (Table 5.4.4). Treatment differences in the grain yield of variety Mahipou 6 were observed, with the RDF + dolomite + Silixol spray (4.01 t/ha) recording significantly higher yields than other treatments. No significant effect of the treatments was observed for straw yield and other parameters like plant height, and yield parameters like tillers/hill and filled grains/panicle.

Total nutrient uptake

Different treatments and varieties significantly influenced total nutrient uptake at Moncompu (Table 5.4.5). Among the treatments, RDF + dolomite + Silixol spray recorded significantly higher nitrogen uptake (91.14 kg/ha), phosphorus uptake (44.54 kg/ha), and potassium uptake (92.42 kg/ha) compared to the rest of the treatments. Between the two varieties, Vasundhara recorded the highest nitrogen uptake (77.65 kg/ha) and phosphorus uptake (34.98 kg/ha) and potassium uptake (82.87 kg/ha).

RDF + dolomite + Silixol spray recorded significantly higher nitrogen, phosphorus and potassium uptake (79.86 kg/ha, 15.46 kg/ha and 106.56 kg/ha, respectively) at Titabar (Table 5.4.5) compared to other treatments, while the variety Uma recorded high NPK uptake (79.86 kg/ha, 15.46 kg/ha and 106.56 kg/ha respectively) than Vasundhra.

No significant differences in N and P uptake were observed at Mizoram for the variety Vasundhara (Table 5.4.6). Treatment differences were observed for K uptake as significantly higher and comparable potassium uptake was observed with RDF + dolomite + RHA (269.99 kg/ha), RDF + potassium silicate (257.05 kg/ha), RDF + dolomite + Silixol spray (245.99 kg/ha) and RDF + RHA application (235.75 kg/ha) compared to other treatments. A significant effect of treatments was observed for nitrogen and phosphorus uptake by Mahipou 6 variety (Table 5.4.6), while no effect was observed for potassium uptake. Application of RDF + dolomite + Silixol spray resulted in the highest N (40.05 kg/ha) and P (23.21 kg/ha) uptake by Mahipou 6.

Post-harvest soil properties

A significant effect of treatments was observed for post-harvest soil characteristics in Moncompu and Titabar soils (Table 5.4.7). At Moncompu, RDF + dolomite + RHA caused an increase in pH (4.39) compared to the control (4.21). The highest improvement in OC% was observed in the RDF + RHA (3.06%), RDF + dolomite + RHA (3.02%) and RDF + dolomite + Silixol spray (3.00 %) treatments. The available N in soil was highest under treatments with RDF + dolomite + Silixol spray (358.84 kg/ha) and RDF + dolomite + RHA (352.50 kg/ha). While no treatment differences were observed for soil phosphorus, significantly higher potassium and zinc availability were observed due to the application of RDF + RHA (240.56 kg/ha and 1.98 ppm, respectively) and RDF + dolomite + RHA (238.18 kg/ha and 1.96 ppm respectively). No significant differences between varieties were observed for soil properties except for available K.

At Titabar, application of RDF + dolomite + RHA (6.25), RDF + dolomite + Silixol spray (6.22) and RDF + dolomite (6.15) significantly increased the soil pH. Significantly higher accumulation of organic carbon was observed in the treatments with RDF + RHA () and RDF + dolomite + RHA (). The available nitrogen status in soil showed a significant increase due to RDF + dolomite + Silixol spray (323.00 kg/ha) and RDF + dolomite + RHA (319.80 kg/ha) compared to other treatments. All treatments except RDF and RDF + Silixol spray significantly increased soil available phosphorus (22.00-23.66 kg/ha). No significant differences were observed for soil available K.

The post-harvest soil characteristics of Mizoram after harvest of Mahipou 6 variety is presented in Table 5.4.8. No significant effect of treatments was observed for soil pH, soil SOC and available NPK.

Summary

The results indicate that application of RDF + dolomite (250 kg/ha) + Silixol spray (at vegetative, booting and grain filling stage) recorded the highest yields at three locations, viz., Moncompu (4.12 t/ha), Titabar (4.70 t/ha) and Mizoram (Mahipou 6 - 4.01 t/ha) while in acid soils of Dhumka, RDF + Dolomite + RHA (5.76 t/ha) application recorded the highest grain yield. Between two varieties, while Vasundhara (3.64 t/ha) performed better at Moncompu, the genotype Uma yielded the highest at Titabar (4.36 t/ha) and Dhumka (5.49 t/ha). Ameliorative effect of application of RDF + dolomite (250 kg/ha) + RHA (250 kg/ha) was observed as the pH increased to 4.39 and 6.25 was observed in acid soils of Moncompu and Titabar respectively when compared to RDF alone (4.21 and 5.22 respectively) at these locations.

- **Application of RDF + dolomite + Silixol spray improved yields over sole RDF by 12-35% in irrigated rice and by 14% under upland rice.**
- **Application of RDF + dolomite + rice husk ash resulted in an increase in soil pH over RDF and RDF + dolomite, indicating the improved ameliorative potential of combined application of dolomite + RHA.**

Table 5.4.1: Management of acid soils (*Kharif*-2022)

Soil and crop characteristics

Parameter	Ranchi	Mizoram		Moncompu	Titabar
Cropping system		Mono-cropping upland rice		Rice - Rice	Rice -Fallow
Rice Variety	Vasundhara and Uma	RC Maniphou-6	Vasundhara	Vasundhara and Uma	Vasundhara and Uma
RDF (kg NPK/ha)	-	80:60:40		90:45:45	60:20:40
Crop growth	-	Good		Good	Good
Soil characteristics					
% Clay	-	30	30	-	34
% Silt	-	15	15	-	33
% Sand	-	55	55	-	28
Soil Texture	-	Sandy clay loam	Sandy clay loam	-	Silty Clay
pH (1:2.5)	5.22	5.42	5.12	4.21	5.3 (1:1)
Org. carbon (%)	-	1.97	1.2	2.98	0.86
CEC [c mol (p+)/kg]	-	-	-	-	11.1
EC (ds/m)	-	-	-	0.13	0.15
Avail.N (kg/ha)	-	232.96	112.45	347.8	312
Avail. P_2O_5 (kg/ha)	-	38.08	53.76	71.4	20.7
Avail. K_2O (kg/ha)	-	414.4	470.4	214.3	162
Avail S (mg/kg)	-	-	-	14.8	-
DTPA –Zn (mg/kg)	-	-	-	1.88	-
DTPA –Fe (mg/kg)	-	-	-	276	-
DTPA –Mn (mg/kg)	-	-	-	2.08	-
DTPA –Cu (mg/kg)	-	-	-	1.72	-

Table 5.4.2: Management of acid soils (*Kharif*-2022)

Yield parameters at Moncompu and Titabar

Treatments	Tillers m^{-2}		Panicles m^{-2}		Filled grains/panicle		1000 grain wt. (g)
	Moncompu	Titabar	Moncompu	Titabar	Moncompu	Titabar	Moncompu
Nutrient management							
RDF	166	270	139	219	90	92	24.78
RDF + Silixol	183	360	153	299	96	105	25.62
RDF + RHA*	175	302	152	261	96	100	25.19
RDF + Dolomite	171	310	145	264	91	99	25.06
RDF + Dolomite+ Silixol	191	387	160	341	119	119	25.86
RDF + Dolomite + RHA	182	329	156	284	114	113	26.09
RDF + K-Silicate	188	329	153	287	109	104	26.30
CD (0.05)	7.0	32	6.0	35	9.0	15.0	0.44
CV(%)	3.75	7.66	3.97	9.94	7.91	11.09	1.65
Varieties							
Vasundhara	184	320	154	271	103	101	25.63
Uma	175	333	148	288	101	108	25.49
Experimental Mean	179	327	151	279	102	104	25.56
CD (0.05)- varieties	4.0	NS	3.0	10	NS	6.0	NS
Interaction -M X S	NS	NS	NS	NS	NS	NS	0.65
Interaction -S X M	NS	NS	NS	NS	NS	NS	0.56
CV(%)	3.68	7.34	3.8	5.38	6.16	9.25	1.73

*Rice husk ash, M – Main plot (Nutrient management), S – Subplot (Varieties)

Table 5.4.3: Management of acid soils (*Kharif*-2022)

Grain and straw yields at Moncompu, Titabar and Ranchi

Treatments	Grain yield (t/ha)			Straw yield (t/ha)	
	Moncompu	Titabar	Ranchi	Moncompu	Titabar
Nutrient management					
RDF	3.05	3.78	4.97	4.61	4.12
RDF + Silixol	3.55	4.36	5.25	5.37	4.77
RDF + RHA*	3.36	4.05	5.32	5.16	4.42
RDF + Dolomite	3.13	4.14	5.48	4.92	4.53
RDF + Dolomite + Silixol	4.12	4.70	5.54	5.81	5.05
RDF + Dolomite + RHA	3.83	4.26	5.76	5.62	4.66
RDF + K-Silicate	3.68	4.22	5.33	5.40	4.60
CD (0.05)	0.36	0.31	NS	0.35	0.34
CV(%)	9.76	5.80	7.84	6.36	5.81
Varieties					
Vasundhara	3.64	4.07	5.26	5.56	4.44
Uma	3.42	4.36	5.49	4.98	4.74
Experimental Mean	3.53	4.21	5.38	5.27	4.59
CD (0.05)- varieties	0.19	0.17	1.62	0.16	0.19
Interaction -M X S	NS	NS	NS	NS	NS
Interaction -S X M	NS	NS	NS	NS	NS
CV%	9.57	6.03	4.56	5.5	6.32

*Rice husk ash, M – Main plot (Nutrient management), S – Subplot (Varieties)

Table 5.4.4: Management of acid soils (*Kharif*-2022)

Yield parameters and yield at Mizoram

Treatments	Plant height (cm)		Tillers/hill		Filled grains/panicle		1000 grain wt (g)	Grain yield (t/ha)		Straw yield (t/ha)	
	V1	V2	V1	V2	V1	V2	V1	V1	V2	V1	V2
RDF	89.72	110.78	9	7	106	89	2.38	3.33	3.53	9.43	9.62
RDF + Silixol	90.89	112.56	10	9	110	93	2.49	3.65	3.53	9.12	9.49
RDF + RHA*	88.72	114.00	9	10	108	92	2.46	3.59	3.70	9.59	8.80
RDF + Dolomite	88.33	113.45	9	8	107	95	2.56	3.42	3.77	9.49	9.39
RDF + Dolomite + Silixol	92.66	116.22	10	12	112	101	2.54	3.73	4.01	9.72	10.12
RDF + Dolomite + RHA	88.78	118.45	9	8	107	104	2.61	3.44	3.65	9.77	10.12
RDF + K-Silicate	89.44	113.11	9	8	114	99	2.45	3.50	3.72	9.52	9.82
Experimental mean	89.79	114.08	9	9	109	96	2.50	3.52	3.70	9.52	9.62
CD (0.05)	NS	NS	NS	NS	NS	NS	0.18	NS	0.23	NS	NS
CV(%)	2.74	2.47	7.73	22	6.42	7.12	3.98	6.49	3.48	9.4	8.47

*Rice husk ash, V1= Vasundhara, V2= Mahipou 6

Table 5.4.5: Management of acid soils (*Kharif*-2022)
Nutrient (NPK) uptake at Moncompu and Titabar

Treatments	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	Moncompu	Titabar	Moncompu	Titabar	Moncompu	Titabar
Nutrient management						
RDF	60.05	49.54	24.61	8.33	63.12	62.81
RDF + Silixol	75.09	70.04	32.58	12.62	79.16	89.48
RDF + RHA*	69.03	55.2	30.45	10.07	73.59	79.86
RDF + Dolomite	61.75	58.5	28.38	10.4	68.61	79.24
RDF + Dolomite + Silixol	91.14	79.86	44.54	15.46	92.42	106.56
RDF + Dolomite + RHA	86.34	63.52	39.34	10.70	85.82	85.51
RDF + K-Silicate	82.67	65.94	36.17	12.14	87.36	91.96
CD (0.05)	4.01	5.93	2.83	1.90	3.65	7.52
CV(%)	5.08	7.46	7.99	13.26	4.42	7.03
Varieties						
Vasundhara	77.65	59.98	34.98	10.58	82.87	79.68
Uma	72.65	66.48	32.47	12.2	74.29	90.44
Experimental Mean	75.15	63.23	33.73	11.39	78.58	85.06
CD (0.05)- varieties	3.12	2.47	2.23	1.30	2.66	5.01
Interaction -M X S	NS	NS	NS	NS	NS	NS
Interaction -S X M	NS	NS	NS	NS	NS	NS
CV(%)	7.47	5.9	11.88	17.19	6.08	8.9

*Rice husk ash, M – Main plot (Nutrient management), S – Subplot (Varieties)

Table 5.4.6: Management of acid soils (*Kharif*-2022)
Nutrient uptake (NPK) at Mizoram

Treatments	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	V1	V2	V1	V2	V1	V2
RDF	39.27	26.32	13.41	16.19	186.15	209.55
RDF + Silixol	42.21	28.19	13.97	15.57	209.16	234.53
RDF + RHA*	46.42	28.67	14.39	17.1	235.75	204.92
RDF + Dolomite	42.66	29.04	14.97	17.11	206.83	221.99
RDF + Dolomite + Silixol	43.34	40.05	15.13	23.21	245.99	239.73
RDF + Dolomite + RHA	41.11	34.42	14.55	17.65	269.99	192.52
RDF + K-Silicate	43.82	37.52	14.28	19.41	257.05	216.76
Experimental mean	42.69	32.03	14.39	18.03	230.13	217.14
CD (0.05)	NS	8.33	NS	3.74	52.99	NS
CV(%)	13.08	14.62	13.61	11.67	12.94	22.35

*Rice husk ash, V1= Vasundhara, V2= Mahipou 6

Table 5.4.7: Management of acid soils (*Kharif*-2022)

Post-harvest soil characteristics at Moncompu and Titabar

Treatments	Soil pH		Soil OC (%)		Soil EC (dS/m)	Available N (kg/ha)		Available P (kg/ha)		Available K (kg/ha)		Available Zn (ppm)
	MCP	TTB	MCP	TTB	MCP	MCP	TTB	MCP	TTB	MCP	TTB	MCP
Nutrient management												
RDF	4.21	5.22	2.92	0.84	0.14	344.02	314.34	71.75	20.84	218.64	160.66	1.82
RDF + Silixol	4.18	5.26	2.88	0.86	0.16	347.98	313.34	75.30	21.16	226.78	161.66	1.85
RDF + RHA*	4.26	5.20	3.06	0.90	0.12	345.00	315.66	75.00	22.66	240.56	163.84	1.98
RDF + Dolomite	4.32	6.15	2.79	0.86	0.12	344.82	318.17	71.26	22.50	223.54	161.66	1.83
RDF + Dolomite + Silixol	4.24	6.22	3.00	0.86	0.14	358.84	319.83	78.02	23.00	236.83	162.50	1.89
RDF + Dolomite + RHA	4.39	6.25	3.02	0.90	0.14	352.50	323.00	76.32	23.66	238.18	166.17	1.96
RDF + K-Silicate	4.16	5.35	2.90	0.86	0.14	349.66	314.84	73.16	22.00	232.39	163.00	1.84
CD (0.05)	0.05	0.18	0.1	0.02	NS	7.19	3.81	NS	1.75	3.44	NS	0.08
CV(%)	1.17	2.52	3.26	2.12	33.23	1.96	0.96	5.13	6.26	1.42	1.59	3.92
Varieties												
Vasundhara	4.25	5.65	2.94	0.87	0.14	349.32	317.19	74.07	22.76	232.29	163.10	1.88
Uma	4.25	5.68	2.94	0.86	0.14	348.63	316.86	74.73	21.76	229.69	162.48	1.88
Experimental Mean	4.25	5.66	2.94	0.87	0.14	348.97	317.02	74.4	0.88	230.99	162.79	1.88
CD (0.05)- varieties	NS	NS	NS	NS	NS	NS	NS	NS	22.26	1.23	NS	NS
Interaction -M X S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction -S X M	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)	1.5	2.97	2.58	2.63	36.13	2.07	1.53	4.7	5.96	0.96	0.77	4.51

*Rice husk ash, M – Main plot (Nutrient management), S – Subplot (Varieties), MCP- Moncompu, TTB- Titabar

Table 5.4.8: Management of acid soils (*Kharif*-2022)

Post-harvest soil characteristics at Mizoram

Treatments	Soil pH	Soil SOC (mg/g)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
	V2	V2	V2	V2	V2
RDF	5.45	1.99	104.72	17.22	184.25
RDF + Silixol	5.52	1.99	102.85	18.84	188.50
RDF + RHA*	5.46	2.1	111.07	19.22	174.50
RDF + Dolomite	5.56	1.96	112.37	15.98	174.50
RDF + Dolomite + Silixol	5.53	2.09	119.84	17.53	188.25
RDF + Dolomite + RHA	5.47	1.98	111.07	22.10	179.75
RDF + K-Silicate	5.47	2.06	114.05	16.84	181.75
Experimental mean	5.49	2.02	110.85	18.25	181.57
CD (0.05)	NS	NS	NS	NS	NS
CV(%)	1.47	9.87	5.63	16.53	6.16

*Rice husk ash, V2= Mahipou 6

5.5: Residue management in rice based cropping systems

In India, huge quantities of crop residues (about 371 million tons) are produced annually of which paddy residues constitute 51–57%. The disposal of paddy residues has become a big problem, particularly in North-West Indian states, mainly due to the use of combine harvester and narrow time gap (one to three weeks) between paddy harvesting and planting of wheat in NW India, resulting in farmers preferring to burn the residues in-situ. Burning biomass not only pollutes environment by depleting air quality, emitting greenhouse gases (GHGs), but also causes smog in the environment, results in loss of appreciable amount of plant essential nutrients besides being deleterious to soil microbes. The incineration of crop residues contributes to emissions of harmful air pollutants, which can cause severe impacts on human health too. Thus, proper residue management is of utmost important as it contains plant nutrients and improves the soil-plant-atmospheric continuum. As an alternative strategy, these crop residues can be used for mulching, compost making and in-situ incorporation for improving soil fertility.

Keeping this in view, the present trial was initiated, in *Kharif*-2018, to study the influence of crop residues on rice productivity in rice based cropping systems (RBCS). In the current year, the trial was conducted at nine centers *viz*., Faizabad (FZB), Kanpur (KPR), Karaikal (KRK), Kaul (KUL), Khudwani (KHD), Maruteru (MTU), Moncompu (MCU), Pantnagar (PNT) and Pusa (PSA).

The treatments in the current year were simplified to five combinations consisting of application of recommended dose of fertilizers (RDF), crop residues in combination with chemical fertilizers, green manure (GM)/green leaf manure (GLM) to supply the N requirement on equal basis (50%: 50%) with and without the addition of Pusa Decomposer, developed by ICAR-IARI, New Delhi along with an absolute control (Table 5.5.1.). Pusa Decomposer is a microbial consortium, capable of producing hydrolytic enzymes responsible for the degradation of the polysaccharides in plant cell wall resulting in faster decomposition.

The test varieties were Samba Mahsuri Sub-1 at FZD, Sarjoo-52 at KPR, ADT 37 at KRK, Basmati CSR 30 at KUL, Shalimar Rice-4 at KHD, MTU-1064 at MTU, Uma at MCU, Pant Dhan-18 at PNT and Rajendra Nilam at PSA. The details of crop, soil and weather parameters of the experimental sites (Table 5.5.2) show variation in soil characteristics with reference to pH, organic carbon content, soil texture and available nutrient status. The data from nine locations are presented in Tables 5.5.3 to 5.5.6.

Rice productivity

Data presented in Tables 5.5.3 shows that the rice productivity significantly varied with the source of nitrogen. Application of 100% RDF resulted in significantly highest grain yield at two centers *viz*., FZD (4484 kg/ha) and KHD (7550 kg/ha). Supplementation of 50% recommended N through residues along with microbial culture (Pusa Decomposer) gave yields on par with 100% RDF at more than half of the centers studied *viz*., KNP, KUL, MCU, PNT and PSA. At MTU and KRK the treatment differences were not significant. The results prove that the crop residues in combination with Pusa decomposer can be deployed to substitute half of the recommended nitrogen without yield penalty. Similar trend was also observed for straw yield as well.

Nutrient uptake and use efficiency

Data presented in Table 5.5.4 show significant effect of source of N application on nutrient uptake. Application of RDF alone or 50% RDF combined with crop residues/MC/GM resulted in nutrient uptake values (33-187 kg N/ha, 7-54 kg P/ha and 23-467 kg K/ha) which were at par with each other and significantly higher than absolute control, across the centers.

Data presented in Table 5.5.5 show lower nutrient use efficiencies in RDF as compared to crop residue treatments which were mostly at par with each other.

Post-harvest soil nutrient status:

The available nutrient status (N, P and K) of soils at are presented in Table 5.5.6. The data reveals that the soil nitrogen, phosphorus and potassium contents after harvest of the crop were not influenced much by various residue treatments and were at par with each other.

Summary

The disposal of huge quantity of paddy residues is a big problem, particularly in North-West Indian states, resulting in farmers preferring to burn the residues *in-situ* leading to air pollution, smog and loss of appreciable amount of plant essential nutrients besides being deleterious to soil microbes. The trial was conducted this year at nine centres. The results show that supplementation of nitrogen (50%) through crop residues either alone or in combination with GM (50%) and 50% RDF with or without Pusa Decomposer, gave on par yields with 100% RDF at majority of the centres. The different crop residue treatments resulted in nutrient uptake values of 33-187 kg N/ha, 7-54 kg P/ha and 2-467 kg K/ha which were at par with each other and significantly higher than absolute control, across the centres.

Post-harvest soil nutrient status was not influenced much by various residue treatments which were at par with each other.

- **Crop residues along with Pusa decomposer can be deployed to substitute half of the recommended nitrogen without yield penalty.**
- **Nutrient use efficiencies were lower in RDF as compared to crop residue treatments which were mostly at par with each other.**

Table: 5.5.1 Residue management in RBCS

Treatments Details

Sl. No	Treatment
1	Absolute control
2	100% RDF (Recommended Dose of Fertilizer)
3	50% Residue + 50% RDF
4	50% Residue + 50% RDF + Pusa decomposer
5	50% Residue + 50% GM/GLM

Table: 5.5.2 Residue management in RBCS

Crop and soil characteristics

Parameter	**FZD [1]**	**KNP [2]**	**KRK [3]**	**KUL [4]**	**KHD [5]**	**MTU [6]**	**MCU [7]**	**PNT [8]**	**PSA [9]**
Cropping system	Rice-Wheat	Rice-Wheat	Rice-Wheat	Rice-Wheat	Rice-Wheat	Rice-Rice	Rice - Rice	Rice-Wheat	Rice-wheat
Variety									
Kharif	Samba Mahsuri Sub-1	Sarjoo-52	ADT 37	Basmati CSR 30	Shalimar Rice-4	MTU-1064	Uma	Pant Dhan-18	Rajendra Nilam
Rabi	-	-	-	-	-	-	-	-	-
RFD (Kg NPK/ha)									
Kharif	120:60:60:25	120:60:60	150: 60: 60	-	120:60:30	90: 60: 60	90: 45: 45	120:60:30	120:60:40:25
Rabi	-	-	-	-	-	-	-	-	
Crop growth									
Kharif	Good	Good	Good	Good	Good	Good	Good	Good	Good
Rabi	-	-	-	-	-	-	-	-	-
Soil data									
% clay	23	17.83	17.4	-	37	38	-	25.9	15
% silt	21	22.77	2.0	-	45	28	-	61.4	29
% sand	56	59.40	82.76	-	18	34	-	12.9	56
Soil Texture	Sandy Loam	Sandy Loam	Sandy loam	Clay loam	Silty clay loam	Clay loam	Sandy loam	Silty clay loam	Sandy loam
pH (1:1)	7.6	7.8	5.91	8.1	6.4	6.12	5.09	7.4	8.3
Org. carbon (%)	0.4	0.49	0.21	0.5	0.67	1.36	3.18	0.58	0.52
CEC [c mol (p+)/kg]	13.5	-	10.2	-	-	48.6	-	23.5	-
EC (ds/m)	1.04	0.56	0.071	0.15	0.21	0.69	0.07	0.35	0.29
Avail.N (kg/ha)	215	219	325	171	302	132	369.8	164	254
Avail. P_2O_5 (kg/ha)	25	23.2	20.5	26.8	32.6	50.07	51.1	10.8	31.5
Avail. K_2O (kg/ha)	237	209	207.7	399	253	440	189.3	210	143.4

Table: 5.5.3 Residue management in RBCS
Grain and straw yields (*Kharif* 2022)

Treatment	Grain yield (kg/ha)									Straw yield (kg/ha)								
	FZD [1]	KNP [2]	KRK [3]	KUL [4]	KHD [5]	MTU [6]	MCU [7]	PNT [8]	PSA [9]	FZD [1]	KNP [2]	KRK [3]	KUL [4]	KHD [5]	MTU [6]	MCU [7]	PNT [8]	PSA [9]
Absolute control	2376	1883	3333	2058	5613	-	3550	2338	3525	3355	2560	12750	4598	6325	-	5863	2655	5325
100% RDF (Recommended Dose Fertilizer)	4484	4550	4375	3106	7550	5228	5213	4580	5413	6152	6288	12250	7162	8413	9054	8538	5325	8078
50% Residue + 50% RDF	3250	4025	4333	3098	6525	5258	4800	4093	4803	4429	5546	13584	7053	7350	8588	7700	4958	6908
50% Residue + 50% RDF + Pusa decomposer	3679	4283	4209	2959	6700	5250	4975	4653	5180	5006	5740	14042	7118	7663	8492	8050	5325	7343
50% Residue + 50% GM/GLM	2930	3706	4250	3051	6050	5370	5063	4050	4408	3973	5109	13250	7007	6575	8934	8163	4548	6288
Expt. Mean	3344	3690	4100	2854	6488	5276	4720	3943	4666	4583	5048	13175	6587	7265	8767	7663	4562	6788
CD (0.05)	152	399	NS	470	719	NS	722	118	696	224	618	NS	480	1433	NS	478	284	1046
CV (%)	3.0	7.0	13.1	10.7	7.2	9.3	9.9	1.9	9.7	3.2	8.0	17.4	4.7	12.8	6.6	4.1	4.0	10.0

Table: 5.5.4 Residue management in RBCS
Nutrient uptake (Kg/ha) in total dry matter (*Kharif* 2022)

Treatment	FZD [1]			KPR [2]			KRK [3]			KUL [4]			KHD [5]			MTU [6]			MCU [7]			PNT [8]			PSA [9]		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Absolute control	40	14	23	33	8	35	143	7	343	48	18	66	91	16	84	-	-	-	64	27	79	41	7	32	57	14	82
100% RDF (Recommended Dose Fertilizer)	106	45	56	93	25	94	165	18	401	82	34	111	136	25	114	65	38	169	116	54	139	103	23	97	97	24	137
50% Residue + 50% RDF	62	25	39	85	22	85	170	9	467	79	32	108	114	21	102	71	31	146	89	44	110	89	17	83	82	20	113
50% Residue + 50% RDF + Pusa decomposer	77	32	47	94	24	89	187	13	464	78	33	108	116	21	101	60	22	203	100	45	122	99	22	95	89	21	122
50% Residue + 50% GM/GLM	52	18	27	80	20	79	160	10	464	77	30	105	102	19	86	53	27	147	106	50	129	83	16	77	74	17	100
Expt. Mean	67	27	38	77	20	76	165	11	428	73	29	100	112	20	97	62	30	166	95	44	116	83	17	77	80	19	111
CD (0.05)	5.4	3.0	12.5	8.2	2.8	9.9	NS	4.9	NS	8.5	3.7	8.5	12.4	2.5	16.7	10.8	3.3	26.3	13.4	5.8	7.6	3.3	2.4	4.9	NS	NS	NS
CV (%)	5.2	7.4	5.3	6.9	9.1	8.4	19.7	28.4	17.3	7.6	8.4	5.5	7.2	7.8	11.1	10.9	6.9	9.9	9.1	8.6	4.2	2.6	9.1	4.1	8.6	10.0	10.6

Table: 5.5.5 Residue management in RBCS
Nutrient use efficiency (kg grain/kg uptake) (*Kharif* 2022)

Treatment	FZD [1]			KPR [2]			KRK [3]			UL [4]			KHD [5]			MTU [6]			MCU [7]			PNT [8]			PSA [9]		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Absolute control	59.8	175.5	102.9	57.0	234.2	54.3	23.4	512.7	10.1	66.5	43.2	113.8	61.0	347.2	67.3	-	-	-	55.6	133.5	44.9	57.2	345.3	74.6	62	257	43
100% RDF (Recommended Dose Fertilizer)	42.2	100.1	69.7	48.9	181.8	48.4	26.7	254.8	11.4	111.3	38.0	91.2	55.6	305.0	66.3	81.4	137.3	31.0	44.7	98.0	37.9	44.5	200.9	47.6	55	230	40
50% Residue + 50% RDF	52.8	133.0	84.0	47.3	179.0	47.3	26.1	481.5	9.3	107.6	39.1	95.9	57.1	306.6	65.8	73.9	172.1	36.7	54.4	110.4	43.8	45.9	247.5	49.1	58	244	42
50% Residue + 50% RDF + Pusa decomposer	47.5	116.6	77.8	45.5	175.7	48.1	24.4	356.7	9.5	108.6	37.7	91.1	57.8	316.2	66.3	89.1	237.6	26.5	49.8	111.5	40.9	46.8	209.7	49.2	58	245	42
50% Residue + 50% GM/GLM	56.8	159.7	96.1	46.3	184.3	47.2	26.9	464.7	9.9	105.4	39.7	101.6	59.8	323.0	71.7	102.4	196.8	37.0	47.8	103.0	39.4	48.8	253.1	52.4	60	253	44
Expt. Mean	51.8	137.0	86.1	49.0	191.0	49.1	25.5	414.1	10.0	99.9	39.5	98.7	58.3	319.6	67.5	86.7	185.9	32.8	50.5	111.3	41.4	48.6	251.3	54.5	58.9	246	42.3
CD (0.05)	2.1	8.9	4.4	1.9	15.4	2.1	NS	184.1	NS	2.4	7.1	NS	NS	NS	NS	15.1	30.7	NS	5.2	NS	NS	1.5	25.4	5.2	NS	NS	NS
CV (%)	2.7	4.2	3.3	2.5	5.3	2.8	17.8	28.9	22.3	5.5	4.0	4.6	5.7	6.2	14.2	10.9	10.3	13.8	6.7	16.3	9.1	2.0	6.6	6.2	4.4	5.0	8.6

Table: 5.5.6 Residue management in RBCS
Post-harvest nutrient status of soil (kg/ha) (*Kharif* 2022)

Treatment	KAN			KRK			KAUL			KHD			MTU			MCU			PNT			PSA		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Absolute control	192.0	20.2	207.0	65.9	22.5	89.5	167.6	22.7	387.9	278.0	13.0	189.1	-	36.1	-	330.9	36.1	178.4	214.1	13.5	150.3	240.8	19.5	208.4
100% RDF (Recommended Dose Fertilizer)	212.0	22.8	210.0	94.9	16.7	65.1	182.3	33.7	416.9	283.3	15.8	222.7	204.3	43.1	212.0	345.9	43.1	198.7	247.4	20.2	184.4	268.8	27.4	233.9
50% Residue + 50% RDF	197.0	22.2	199.0	100.4	15.1	249.7	178.9	29.3	404.8	297.1	14.1	210.7	204.3	44.9	272.3	342.9	44.9	206.0	247.4	19.0	165.5	261.8	25.2	225.5
50% Residue + 50% RDF + Pusa decomposer	206.0	21.9	201.0	104.3	12.8	141.1	181.2	31.6	412.7	299.6	13.9	209.7	198.3	42.4	342.8	349.1	42.4	207.4	251.2	18.6	173.3	264.6	26.0	228.1
50% Residue + 50% GM/GLM	199.0	21.2	208.0	101.1	23.3	230.7	175.8	28.9	403.8	302.1	13.3	204.8	203.5	45.0	282.0	352.3	45.0	200.1	241.7	16.6	174.8	254.8	22.9	221.1
Expt. Mean	203.5	22.0	204.5	100.2	17.0	171.7	179.5	30.8	409.6	295.5	14.3	212.0	202.6	43.9	277.3	347.5	43.9	203.0	246.9	18.6	174.5	262.5	25.4	227.1
CD (0.05)	NS	NS	NS	17.55	7.57	99.17	9.31	3.35	13.83	NS	1.34	13.96	NS	5.19	37.24	12.40	5.19	7.97	4.20	1.65	7.53	13.80	2.59	13.16
CV (%)	6.05	7.17	7.35	12.21	27.19	41.47	3.41	7.45	2.21	5.33	6.21	4.37	13.37	7.97	8.4	2.34	7.97	2.61	1.14	6.11	2.88	3.47	6.93	3.82

5.6. Nano-fertilizers for increasing nutrient use efficiency, yield and economic returns in transplanted rice

The Nitrogen Use Efficiency (NUE) in agricultural systems has remained low; meaning that on a global scale, more than 50% of the N applied to agricultural soils is potentially lost into the environment. The current NUE needs to be improved substantially by increasing the efficiency of agricultural systems, adopting environmentally sound agronomic practices, and exploring disrupting technologies. Nano-fertilizers possess unique features that enhance plants' performance in ultra-high absorption, increase in production, rise in photosynthesis, and significant expansion in the leaves' surface area. It would be very helpful if we use nano-fertilizer for specific crops such as rice to minimize the potential negative effects brought about by the extensive use of chemical inputs without compromising production and nutritional benefits. In this background and based on a one-year field study with objectives 1. To study the efficiency of nano-fertilizer in increasing the growth and yield of rice crops and 2. To find out the nutrient use efficiency of nano-fertilizers in rice crops. A total of Six treatments namely, **T1**: Recommended dose of nitrogen (RDN) through urea (recommended P and K) **T2**: T1+ Two foliar sprays Nano-Urea @ 2% at active tillering and panicle initiation stages, **T3**: 50 % of RDN + Two foliar sprays Nano-urea @ 2% (AT and PI) **T4**: 75 % RDN **T5**: 75% of RDN + Two foliar sprays Nano-urea @ 2% (AT and PI) **T6**: Control (no application of fertilizer) were taken in this trial. The trial was conducted in RBD and replicated thrice. The trial was conducted in collaboration with Agronomy in a total of 23 locations (Jagdalpur-JDP, Jagtial-JGL, Khudwani-KHD, Mandya-MND, Maruteru-MTU, Moncompu-MNC, Pantnagar-PNT, Pattambi-PTB, Puducherry-PDU, Pusa-PSA, Rajendranagar-RNR, Warangal-WGL, Nellore-NLR, Navsari-NVS, Bankura-BNK, Coimbatore-CBE, Kanpur-KNP, Karaikal-KRL, Ranchi-RCI, Sabour-SBR, Chatha-CHT and Faizabad-FZB). The results of the second-year study were summarized and presented in **Tables 5.6.2 to 5.6.7** and the salient findings are as followed.

Yield parameters like tiller number and panicle number per meter square were documented and represented in table 5.6.2. Significant differences were observed in the yield parameters due to variations in treatments at all the locations (Table 5.6.2). Application of 100 % RDN along with two sprays of nano urea at active tillering and panicle initiation stage registered the highest tiller and panicle numbers (per m^2) at Kanpur (330, 229), Jagdalpur (240, 240),

Faizabad (281,278), Chata (248, 225), ARI (301, 273), Mandya (361, 329), Pantnagar (248, 241), Moncompu (309, 236), Warangal (350, 326), which was on par with the recommended dose of N treated plots. At a few centers, application of 75% RDN and two sprays of nano urea recorded higher tiller and panicle numbers (per m^2) *i.e*., Karaikal (498, 441), Khudwani (313, 299), Pattambi (238, 238), Coimbatore (386, 364), respectively. Whereas, the application of 50% RDN combined with two sprays (T3) and 75% RDN alone also improved the tiller numbers in all centers over absolute control but not to the level of T1 treatment. In general, the order of improvement was observed as T6<T4=T3<T5<T1=T2 across the locations. A similar trend was observed in panicle number also (Table 5.6.3).

Grain and straw yields at all the locations showed significant differences with the addition of nano urea treatments (Table 5.6.3). Application of RDN and two sprays of nano urea at two critical stages of rice crop recorded the highest grain and straw yields at a majority of the locations i.e., Kanpur (5.32 and 6.93 t/ha), Jagdalpur (5.50 and 7.50 t/ha), Faizabad (6.00 and 8.22 t/ha), Chatha (3.12 and 7.02 t/ha), Kaul (6.48 and 6.67 t/ha), Mandya (6.07 and 8.79 t/ha), Pantnagar (5.29 and 5.98 t/ha), Sabour (5.26 and 6.43 t/ha), Warangal (6.43 and 7.20 t/ha), Moncompu (5.11 and 6.01 t/ha), Jagtial (7.21 and 5.78 t/ha), respectively. At Bankura (5.87 and 7.55 t/ha), Karaikal (5.44 and 8.82 t/ha) Khudwani (7.70 and 7.75 t/ha), Coimbatore (6.72 and 8.87 t/ha), Pattambi (5.04 and 8.00 t/ha) and Puducherry (6.77 and 9.99 t/ha) exhibited highest grain and straw yields to the application of 75% RDN along with two sprays of nano urea followed by 100% RDN + two sprays of nano urea. While at Navsari and Pusa centers, RDN outperformed and registered higher grain yields i.e., 5.51 and 4.50 t/ha, respectively.

The N uptake of rice plants was documented and represented in table 5.6.4. Additional application of nano urea (two sprays) with RDN registered the highest N uptake in rice plants grown at Chatha (46.4 kg/ha), Jagadalpur (134.8 kg/ha), Jagtial (136.1 kg/ha), Kanpur (103.3 kg/ha), Pantnagar (88.9 kg/ha), Ranchi (91.6 kg/ha), Sabour (99.6 kg/ha) and Kaul (119.9 kg/ha), respectively followed by two sprays of nano urea in addition to 75 % RDN, which was on par with T1 (100% RDN). Whereas in Puducherry, the order of N uptake varies with the season *i.e*. during Kharif 100% RDN + two sprays (141.0 kg/ha) registered the highest N uptake, while during Rabi T3 registered the highest N uptake (152.3 kg/ha). A combination of 75% RDN + two sprays of nano urea effectively improved the N uptake at Coimbatore (120.4 kg/ha) and

Khudwani (159.8 kg/ha). Whereas, RDN application recorded a high value of uptake at Pusa (80.8 kg/ha) and Navasari (100.8 kg/ha).

The effect of nitrogen application through conventional fertilizer and nano urea significantly improved the soil available N in rice (Table 5.6.5). Either application of 100 % RDN or 100% RDN + foliar sprays of urea positively improved the soil available N over absolute N control across the locations. Treatments namely, T4 (75% RDN) and T5 (75% RDN + 2 sprays of nano urea) recorded on par value across the locations, which can be considered that additional spray of nano urea in the plant did not have a beneficial role in the improvement of soil N.

The use of nano urea in rice crop significantly improved the BC ratio (Economic returns) across the locations (Table 5.6.6). The highest benefit and returns were observed with T2 at Sabour (2.14), Pantnagar (1.43), Jagdalpur (1.89), Kanpur (1.99), Chatha (3.17) and Moncompu (2.22). Whereas, 75% RDN + two sprays of nano urea registered higher benefits at Pattambi (2.11) and Coimbatore (2.58), respectively. At Pusa and Khudwani centers, RDN recorded the highest returns (2.47 and 2.20, respectively) than nano urea-involved treatments. In general, an additional application of nano urea along with 100% RDN was on par with the 100% RDN treatments and did not fetch much monetary benefit in irrigated rice crops.

Application of nano urea has increased the NUE (Agronomic efficiency) across the locations as given in table 5.6.7. The highest use efficiency was observed with T2 (100% RDN + two sprays of nano urea) at Kaul (16.8), Warangal (9.2), Sabour (19.9), Ranchi (16.2), ARI (13.9), Pantnagar (25.9), Mandya (24.7), Kanpur (17.7) and Jagtial (22.7). Application of 75% RDN plus two sprays recorded higher AE at Bankur (12.1), Khudwani (17.8) and Karaikal (11.0), respectively. While at Pusa and Navasari, 100% RDN exhibited higher NUE than other treatments.

Summary:

Application of nano urea improved the tiller, panicle numbers, and grain yield of rice crops over the absolute N control. Out of all treatments, two sprays of nano urea along with RDN application performed well with respect to the tiller, panicle numbers, yield and N uptake at Jagdalpur Faizabad, Chata, ARI, Mandya, Pantnagar, Moncompu, Sabour, Kanpur and Warangal. But, application of 75% + two sprays of nano urea was found better at Karaikal, Kanpur, Coimbatore, Mandya, Bankura, Khudwani, Pattambu, and Puducherry for the tiller,

panicle numbers and grain yield parameter. At Bankura, Khudwani and Karaikal, the higher NUE was observed with with 75% RDN + two sprays of nano urea treatment while 100% RDN + two sprays of nano urea treatment registered a higher NUE at rest of the locations.

- **At the end of second year study, additional input of nano urea (two sprays) along with either 75% RDN or 100% RDN was found better for yield, B:C ratio, N uptake and nutrient use efficiency at 61% locations.**

Table 5.6.1: List of centers with trial details

S. No	Centre name	Variety	Soil Type	Soil values (Initial)	Fertilizer Dose
1.	Jagdalpur	-	-	-	100:60:30
2.	Jagtial	JGL 24423		195.3:54.7:442	120:50:40
3.	Khudwani		Silty clay	317:1736:232	120:60:30
4.	Mandya	93-R	Red Sandy Loam	270:61.4:226.8	100:50:50
5.	Maruteru	-	-	-	-
6.	Moncompu		Clay Loam	372:69.4:182.3	-
7.	Pantnagar	PD-24	Silty Loam	231:22.3:221	67.5:21:23
8.	Pattambi	-	-	-	94:45:45
9.	Puducherry	ADT 54	Clay Loam	123:11.4:105	120:40:40
10.	Pusa	Rajendra Sweta	Sandy Loam	224:12.5:135	120:60:40
11.	ARI, Rajendranagar	JGL 24423	Clay Loam		120:60:40
12.	Warangal		Clay Loam		120:60:40
13.	Nellore	NLR 3354		213:60:288	120:60:40
14.	Navsari		Clay	271:28:736	100:30:0:0
15.	Bankura	Ajit			
16.	Coimbatore		Clay Loam	227:18.2:411	150:50:50
17.	Kanpur		Sandy Loam	219:23.2:209	120:60:60
18.	Karaikal				150:50:50
19.	Ranchi	MTU 1010			120:60:40
20.	Sabour		Silty Loam		100:40:20
21.	Chatha	Basmati-370	Sandy clay loam	245:14.3:146.3	30:20:10
22.	Faizabad	NDR 2065	Sandy Loam	215:25:235	120:60:60
23.	Kaul	HKR 127	Clay loam		120:60:60:25

Table 5.6.2: Effect of nano urea application growth parameters of Rice (Tiller (T) and Panicle (P) Numbers per m^2)

	BNK		KRK		KNP		JDP		KHD		FZB		CHT	
	T	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**
T1	155	148	471	400	290	271	208	206	314	296	256	251	224	201
T2	146	138	463	435	330	299	240	240	305	281	281	278	248	225
T3	186	179	432	394	265	261	175	174	303	287	247	243	196	174
T4	191	183	445	357	275	265	179	178	307	281	217	202	199	175
T5	158	151	498	441	310	285	200	197	313	299	265	259	215	193
T6	188	177	356	332	318	260	139	138	287	257	181	172	152	139
Mean	**170**	**162**	**444**	**393**	**297**	**273**	**190**	**188**	**304**	**283**	**241**	**234**	**205**	**184**
CD (0.05)	**10.2**	**10.4**	**60.9**	**63.4**	**30.9**	**27.5**	**30.7**	**31.2**	**30.2**	**26.9**	**15.6**	**12.6**	**6.3**	**4.7**
CV (%)	**3.3**	**3.5**	**7.5**	**8.9**	**5.7**	**5.5**	**8.8**	**9.0**	**5.4**	**5.2**	**3.5**	**2.9**	**1.8**	**1.4**

T= Tiller numbers per m^2, P = Panicle number per m^2

	PTB		NLR		CBT		ARI, Rajendranagar		MND		NVS		PNR	
	T	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**
T1	201	201	372	339	363	342	253	242	336	306	187	170	248	233
T2	207	207	326	290	376	354	301	273	361	329	181	162	248	241
T3	223	223	348	327	346	324	239	215	291	265	165	153	209	204
T4	207	207	429	416	358	336	226	222	304	258	169	151	217	213
T5	238	238	425	332	386	364	241	225	324	282	173	156	235	232
T6	195	195	262	248	222	210	202	199	276	213	161	136	158	146
Mean	**211**	**211**	**360**	**325**	**341**	**321**	**243**	**229**	**315**	**275**	**172**	**154**	**219**	**211**
CD (0.05)	**15.2**	**15.2**	**71**	**64.7**	**10.2**	**13.2**	**20.6**	**20.3**	**52.8**	**37.5**	**16.5**	**19.9**	**7.0**	**16.5**
CV (%)	**3.9**	**3.9**	**10.8**	**10.9**	**1.6**	**2.3**	**5.6**	**5.8**	**9.2**	**7.5**	**5.3**	**7.1**	**1.8**	**4.3**

T= Tiller numbers per m^2, P = Panicle number per m^2

Continued….

	PDU (K)		PDU (R)		MNC		SBR		PSA		WGL		RCI	KUL	JGL	MTU
	T	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**P**	**P**	**P**	**P**
T1	320	300	342	316	266	226	288	212	336	231	349	323	246	366	427	272
T2	340	235	336	308	309	236	292	215	291	217	350	326	272	381	403	289
T3	311	291	374	351	260	205	223	164	317	192	342	304	211	336	324	246
T4	311	321	357	335	264	205	234	175	317	226	346	315	232	358	370	252
T5	362	350	368	344	277	194	244	180	328	230	348	320	246	364	395	250
T6	299	259	307	277	242	154	193	142	248	211	341	300	181	372	317	285
Mean	**327**	**292**	**347**	**321**	**269**	**203**	**246**	**181.8**	**306**	**217**	**346**	**315**	**231**	**363**	**372**	**266**
CD (0.05)	**7.6**	**8.2**	**7.8**	**4.0**	**38.3**	**12.0**	**31**	**30.2**	**18.3**	**23.8**	**6.3**	**11.6**	**38.0**	**11.1**	**75.0**	**20.1**
CV (%)	**1.3**	**1.5**	**1.3**	**0.7**	**7.8**	**3.3**	**6.9**	**9.14**	**3.3**	**5.9**	**1.0**	**2.0**	**11.1**	**2.0**	**11.0**	**4.2**

T= Tiller numbers per m^2, P = Panicle number per m^2

Table 5.6.3: Effect of nano urea application growth parameters of Rice (Grain (t/ha) and straw yield (t/ha))

Treatments	BNK		KRK		KNP		JDP		KHD	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T1	5.19	6.57	4.97	9.15	5.02	6.50	4.72	6.63	7.63	7.69
T2	5.49	6.52	4.51	7.99	5.32	6.93	5.50	7.50	7.40	7.50
T3	5.36	6.56	5.02	8.08	4.59	5.68	4.00	5.82	7.50	7.58
T4	5.67	7.09	4.84	8.99	4.86	5.87	4.05	5.67	7.40	7.49
T5	5.87	7.55	5.44	8.82	5.24	6.83	4.63	6.52	7.70	7.75
T6	4.90	5.54	3.79	5.72	3.20	3.41	3.12	4.50	5.57	5.61
Mean	**5.41**	**6.64**	**4.76**	**8.2**	**4.70**	**5.87**	**4.33**	**6.10**	**7.20**	**7.27**
CD (0.05)	**0.10**	**0.67**	**0.9**	**1.9**	**0.49**	**0.61**	**0.7**	**1.1**	**0.70**	**0.56**
CV (%)	**1.1**	**5.5**	**10.6**	**12.9**	**5.7**	**5.7**	**9.78**	**9.9**	**5.30**	**4.2**

Treatments	FZB		CHT		CBT		KUL		MND	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T1	5.14	6.95	2.89	6.51	6.06	8.62	6.22	6.47	5.39	7.94
T2	6.00	8.22	3.12	7.02	6.21	8.76	6.48	6.67	6.07	8.79
T3	4.44	6.24	2.73	6.06	5.92	7.98	5.69	6.38	4.83	6.47
T4	3.80	5.22	2.78	6.26	5.98	8.12	5.99	6.24	4.97	6.86
T5	5.55	4.56	2.81	6.33	6.72	8.87	6.23	6.36	5.57	7.89
T6	2.12	3.08	2.19	4.39	2.05	3.77	4.00	4.27	3.61	5.10
Mean	**4.50**	**6.21**	**2.75**	**6.09**	**5.49**	**7.68**	**5.77**	**6.06**	**5.07**	**7.2**
CD (0.05)	**0.18**	**0.18**	**0.05**	**0.10**	**0.08**	**0.12**	**0.51**	**0.41**	**0.62**	**0.69**
CV (%)	**2.20**	**1.62**	**0.91**	**0.94**	**1.0**	**1.0**	**5.9**	**4.6**	**6.8**	**5.3**

Continued…..

Treatments	PTB		NLR		NVS		PNR		PSA	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T1	4.07	5.78	5.34	7.20	5.51	7.22	4.86	5.55	4.50	8.06
T2	4.44	8.17	4.97	6.11	5.48	6.93	5.29	5.98	4.34	6.76
T3	4.42	6.91	5.30	6.56	4.66	6.37	3.57	4.13	3.63	7.46
T4	3.77	5.45	5.62	7.44	4.89	6.52	4.04	4.44	4.13	8.13
T5	5.04	8.0	4.81	7.83	4.42	6.66	4.82	5.08	4.40	6.76
T6	3.28	5.61	3.98	5.47	3.99	5.49	2.18	2.50	3.10	6.60
Mean	**4.17**	**6.82**	**5.00**	**6.76**	**4.83**	**6.53**	**4.13**	**4.62**	**4.01**	**7.29**
CD (0.05)	**0.60**	**2.12**	**0.39**	**0.41**	**0.70**	**1.02**	**0.36**	**0.63**	**0.48**	**NS**
CV (%)	**7.95**	**17.1**	**4.34**	**3.35**	**8.0**	**8.61**	**4.9**	**7.5**	**6.6**	**15.8**

Treatments	PDU (K)		PDU (R)		SBR		WGL		MNC	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T1	6.24	9.24	6.45	9.51	4.88	5.98	6.27	7.13	4.76	5.75
T2	6.57	9.63	6.06	8.96	5.26	6.43	6.43	7.20	5.11	6.01
T3	6.17	9.07	7.01	10.4	4.04	4.95	5.93	6.70	3.59	4.63
T4	6.38	9.42	6.69	9.86	4.48	5.47	5.80	6.80	4.11	5.11
T5	6.77	9.99	6.81	10.6	4.83	5.91	6.13	7.00	4.18	5.28
T6	4.70	6.77	4.71	7.24	3.26	3.99	5.33	6.27	2.97	4.06
Mean	**6.14**	**9.02**	**6.28**	**9.42**	**4.45**	**5.45**	**5.98**	**6.85**	**4.13**	**5.14**
CD (0.05)	**0.26**	**0.31**	**0.22**	**0.10**	**0.37**	**0.43**	**0.97**	**0.86**	**0.63**	**1.04**
CV (%)	**2.3**	**1.8**	**1.91**	**0.64**	**4.5**	**4.35**	**8.9**	**6.91**	**8.5**	**11.2**

Continued…..

Treatments	JGL		ARI, Rajendranagar	RCI	MTU	
	Grain	Straw	Grain	Grain	Grain	Straw
T1	6.52	5.16	6.60	4.55	5.32	6.21
T2	7.21	5.78	6.79	4.86	5.68	6.62
T3	5.55	4.28	6.01	3.86	4.54	5.38
T4	6.14	4.38	6.22	4.22	4.96	5.78
T5	6.46	4.67	6.58	4.44	4.99	5.88
T6	4.50	3.85	5.07	3.16	5.58	6.48
Mean	**6.12**	**4.68**	**6.21**	**4.18**	**5.18**	**6.06**
CD (0.05)	**0.59**	**0.65**	**0.56**	**0.61**	**NS**	**NS**
CV (%)	**5.3**	**7.6**	**6.01**	**9.72**	**8.5**	**8.2**

Table 5.6.4: Effect of nano urea application on total N uptake (kg/ha) in rice

Treatments	CHT	CBE	JDP	JGL	KNP	KHD	NVS	PNR	PDU (K)	PDU (R)	PSA	RCI	SBR	KUL
T1	45.7	112.3	114.6	116.5	87.9	157.5	100.8	80.1	135.7	138.0	80.8	84.3	94.7	112.0
T2	46.4	116.4	134.8	136.1	103.3	152.0	95.3	88.9	141.0	124.6	73.9	91.6	99.6	119.9
T3	39.6	104.7	98.5	84.7	66.9	154.6	84.1	62.0	125.0	152.3	67.5	72.6	81.9	105.3
T4	40.1	108.4	100.5	96.7	76.9	143.1	86.1	70.6	134.3	144.3	75.7	80.1	88.1	105.6
T5	42.2	120.4	115.8	105.7	98.6	159.8	81.5	86.6	142.7	145.3	74.3	84.7	93.8	114.4
T6	35.6	80.5	73.3	49.6	40.0	99.7	63.9	37.8	87.7	91.6	60.3	60.3	58.2	68.7
Mean	**41.6**	**107.1**	**106.2**	**98.2**	**78.9**	**144.4**	**85.3**	**71.0**	**127.7**	**132.7**	**72.0**	**78.9**	**86.1**	**104.3**
CD (0.05)	**0.30**	**1.8**	**19.2**	**7.1**	**11.6**	**13.2**	**12.7**	**7.4**	**8.0**	**7.6**	**9.4**	**8.2**	**5.5**	**8.7**
CV (%)	**0.40**	**0.9**	**9.9**	**3.9**	**7.8**	**5.0**	**8.2**	**5.7**	**3.4**	**3.2**	**7.2**	**6.9**	**3.5**	**5.6**

Table 5.6.5: Effect of nano urea application on available N (kg/ha) in soil

Treatments	SBR	KUL	PSA	PNT	NVS	KHD	JGL	CBE	CHT
T1	155.7	186.3	235	219	234.7	333	135.4	213	235
T2	156.2	189.5	235	216	235.7	332	122.8	217	239
T3	150.7	177.4	230	219	239.3	338	97.6	207	231
T4	156.8	181.5	235	220	243.0	329	110.2	210	226
T5	155.9	183.7	233	223	224.3	326	116.5	218	230
T6	144.8	172.6	216	212	236.7	307	94.5	197	223
Mean	**153.4**	**181.8**	**231**	**218**	**235.6**	**327**	**112.8**	**210**	**236**
CD (0.05)	**1.6**	**6.9**	**5.8**	**2.8**	**45.8**	**17.5**	**23.6**	**3.7**	**1.9**
CV (%)	**0.6**	**2.5**	**1.4**	**0.7**	**10.7**	**2.9**	**11.5**	**1.0**	**0.5**

Table 5.6.6: Effect of nano urea application on Benefit: Cost Ratio in rice

Treatments	SBR	PSA	PTB	PNT	NVS	CBE	JDP	KNP	KHD	CHT	MND	MNC
T1	1.97	2.47	1.72	1.25	1.81	2.46	1.61	1.91	2.20	2.87	1.88	2.19
T2	2.14	2.29	1.86	1.43	1.73	2.36	1.89	1.99	2.00	3.17	2.01	2.22
T3	1.66	1.93	1.86	0.80	1.54	2.29	1.42	1.71	2.07	2.35	1.65	1.68
T4	1.84	2.25	1.60	1.05	1.63	2.45	1.52	1.82	2.06	2.77	1.75	1.94
T5	2.02	2.33	2.11	1.41	1.48	2.58	1.55	1.97	2.10	2.81	1.86	1.89
T6	1.32	1.85	1.42	0.32	1.40	1.13	1.08	1.26	1.47	1.99	1.34	1.46
Mean	**1.82**	**2.19**	**1.72**	**1.04**	**1.59**	**2.22**	**1.52**	**1.77**	**2.20**	**2.66**	**1.75**	**1.90**
CD (0.05)	**0.22**	**0.27**	**0.25**	**0.19**	**0.20**	**0.05**	**0.25**	**0.07**	**0.23**	**0.06**	**0.19**	**0.30**
CV (%)	**6.7**	**6.9**	**7.86**	**10.0**	**6.8**	**1.12**	**8.95**	**8.20**	**6.4**	**1.33**	**5.89**	**8.7**

Table 5.6.7: Effect of nano urea application on Nutrient Use Efficiency (NUE) in rice

Treatments	BNK	KUL	WGL	SBR	RCI	ARI, RJNR	PSA	PDU (K)	PDU (R)	PNT	NLR	NVS	MND	KHD	KRK	KNP	JGL
T1	3.6	14.0	7.8	16.2	13.4	12.3	12.2	14.5	12.8	22.3	11.3	15.2	17.9	17.2	7.9	15.2	19.7
T2	7.4	16.8	9.2	19.9	16.2	13.9	10.7	11.3	15.6	25.9	8.2	14.9	24.7	15.3	4.8	17.7	22.7
T3	5.8	10.4	5.0	7.8	5.6	7.8	4.2	19.2	12.2	11.5	11.1	6.7	12.2	16.1	8.2	11.5	8.8
T4	9.6	12.8	3.9	12.1	9.7	8.7	8.5	16.5	14.0	15.5	13.7	9.0	13.6	15.3	7.0	13.9	13.7
T5	12.1	14.9	6.7	15.6	11.9	12.5	10.9	17.5	17.2	21.9	6.9	4.4	19.6	17.8	11.0	17.0	16.4

Trial 5.8. Evaluation of Organic fertilizers and Natural farming practices for enhancing the Productivity and soil health

The trial was conducted during *rabi* 2021-22 and *kharif*-2022 in collaboration with Agronomy to "Evaluate the Organic fertilizers and Natural farming practices for enhancing the productivity and soil heath" and its influence on productivity, grain quality, soil health and environmental sustainability. Currently, organic produce including organic rice is in huge demand owing to its potential to fetch premium prices in the global market.

There were mainly nine treatments during *rabi* 2021-22-viz.,1) Absolute control (No: NPK), 2) 100% RDN, 3) 100% N (FYM), 4) 150% N (FYM), 5) 50% N (FYM)+ 50% N (Green manure/Green Leaf Manure, 6) 50% N (FYM)+ 50% N (Vermicompost), 7) 50% N (FYM)+ 50 % N (Neem / Castor/ any cake), 8) Optional 1: 75% RDN: 50% each through FYM + Vermicompost, 9) Optional 2: Best sate organic practice and during *kharif* 2022 the trial was modified with five treatments *viz 1)* Control, 2) Complete NF, 3) AI-NPOF package (All India Network programme on Organic Farming), 4) Integrated Crop Management (with organic pest management practices) and 5) Integrated Crop Management (need based pesticides). All farming practices starting from seed treatment to harvest were practiced as per the technical programme; observations were recorded on grain and straw yields and other yield parameters. Soil samples were collected before conducting experiment and after harvest and were analyzed for important soil properties. The trial was conducted at eight locations *viz*., [Chinsurah-CHN, Moncompu-MNC, Mandya-MND, Khudwani-KHD, Pantnagar-PNT, Pusa-PSA, Pudhuchery-PUD and Titabar-TTB] during *kharif*- 2022 and at CHN and Karaikal-KRK during *rabi* 2021-22. The results are presented in Tables 5.8.1 to 5.8.19.

Grain, straw yield and yield parameters

Among the eight locations, grain yield during *kharif*-2022 (Table 5.8.2) was significantly superior in (T5) Integrated Crop Management (need based pesticides) [3.01, 6.73, 2.09, 3.52, 5.82, 4.85 t/ha] treatment as compared to other treatments recording 93%, 15%, 42% ,11%, 16%, 50% higher yield over complete natural farming, at MND, KHD, PNT, PSA, PUD and TTB, respectively. Whereas at CHN (5.13 t/ha) and MNC (4.83 t/ha) complete natural farming recorded higher grain yield which was 2.4% and 26 % higher as compared integrated crop management (need based pesticides), respectively. Straw yield followed a similar trend as that of grain yield at most of the locations (Table 5.8.3) recording 76%, 14%, 27% 18%, 15% and 23% higher yield in integrated crop management (need based pesticides) over complete natural farming at MND, KHD, PNT, PSA, PUD and TTB, respectively. With regard to yield parameters (tillers/m^2, panicles/m^2, 1000 grain weight), and nutrient uptake the treatment integrated crop management (need based pesticides) recorded

significantly higher values as compared to other treatments MND, KHD, PNT, PSA, PUD and TTB, but at MNC complete natural farming treatment recorded significantly higher as compared to other treatments (Table 5.8.4 to 5.8.11).

At CHN location, during *rabi* 2021-22 (Table 5.8.12) grain and straw yields were significantly superior in inorganic RDF as compared to other treatments and with 48% and 42% higher grain and straw yields over Organic POP recommendation. With regard to tillers/m^2, panicles/m^2, 1000-grain wt. (g), in inorganic RDF recorded significantly higher values. Among the organic treatments, 50% N (FYM) + 50% N (Vermicompost) manure recorded higher yield and highest number of tillers/m^2 (292) and panicles/m^2 (272) and 1000-grain weight (20.20 g) as compare other organic treatments. At KRK location, during *rabi* 2021-22 (Table 5.8.13) performed significantly superior in 100% N (FYM) as compared to other treatments.

Soil properties after harvest

At CHN, MND, PNT and PSA most of the soil properties improved with Integrated Crop Management (with organic pest management practices) and at MNC, KHD, PUD improved with AI-NPOF package, as organic treatments compared to other treatments. The important soil properties from eight locations (CHN, MNC, MND, KHD, PNT, PSA, PUD and TTB) are presented in Table (5.8.4, 5.8.14 to 5.8.19). At CHN, MND, PNT and PSA most of the soil properties improved with Integrated Crop Management (with organic pest management practices) and are on par in all treatments (Table 5.8.4, 5.8.16, 5.8.17 and 5.8.18) respectively. At and MNC, KHD, PUD improved with AI-NPOF package, as treatments compared to other treatments (Table 5.8.16, 5.8.18 and 5.8.12) respectively. At KRK and CHN most of the soil properties improved with 100% N (FYM), organic treatments compared to other treatments (Table 5.8.12 and 5.8.13) respectively.

Summary

The third year of study on "Enhancing productivity of Organic Rice cultivation", revealed that among the organic treatments, 50% N (FYM)+ 50% N (Vermicompost) manure recorded higher yield and yield parameters at CHN. At KRK and CHN most of the soil properties improved with 100% N (FYM) and organic treatments compared to other treatments.

In the first year of study on "Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil heath", out of five treatments, Integrated Crop Management (with need based pesticides) was significantly superior as compared to other treatments at MND, KHD, PNT, PSA, PUD and TTB in terms of grain yield and yield parameters. At CHN, MND, PNT and PUSA most of the soil properties improved with Integrated Crop Management (with organic pest

management practices) while at MNC, KHD and PUD, soil properties improved with AI-NPOF package compared to other treatments.

- **In the first year of study on evaluation of Organic fertilizers and Natural farming practices, Integrated Crop Management (with need based pesticides) was significantly superior in terms of grain yield and yield parameters.**
- **Most of the soil properties improved with Integrated Crop Management (with organic pest management practices of NF) and AI-NPOF practices.**

Table 5.8.1 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health
Soil and crop characteristics

Parameters	CHN	MNC	MND	KHD	PNT	PSA	PUD	TTB
Cropping system	**Rice**	**Rice - Rice**	**Rice**	**Rice-Wheat**	**Rice-Wheat**	**Rice-wheat**	**Rice – Rice**	**Rice -Fallow**
Variety – *Kharif*	Sukumar	Pournami	KMP-175	Shalimar Rice-4	Pant Dhan-18	Rajendra Nilam	ADT 54	Bokul Joha
RDF (kg NPK/ha)		90:45:45	100:50:50	120:60:30	120:60:30	120:60:40	150:50:50	-
Crop growth:	-	-	-	-		-	-	-
Soil characteristic								
% Clay	-	-	-	37	25.9	15	-	35
% Silt	-	-	-	45	61.4	29	-	34
% Sand	-	-	-	18	12.9	56	-	27
Texture	Clay loam	-	-	Silty clay loam	Silty clay loam	Sandy loam	Clay loam	Silty Clay
pH (1:2)	7.51	4.87	7.4	6.3	7.4	8.3	6.71	5.3
Organic carbon (%)	1.2	3.19	0.54	0.67	0.58	0.52	0.29	0.58
CEC (cmol (p^+)/kg)	-	-	-		23.5	-	-	10.1
EC (dS/m)	0.4	0.14	0.12	0.25	0.35	0.29	0.24	0.13
Avail. N (kg/ha)	521	374.6	235.6	321	164	254	156	284
Avail. P_2O_5 (kg/ha)	110	71.2	21.3	31.7	10.8	31.5	36	22.5
Avail. K_2O (kg/ha)	386.5	208.5	161.2	192	210	143.4	158	127

Table 5.8.2 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Grain yield of *kharif* (Locations: CHN, MNC, MND, KHD, PNT, PSA, PUD and TTB)

Treatment	Grain yield (t/ha)							
	CHN	**MNC**	**MND**	**KHD**	**PNT**	**PSA**	**PUD**	**TTB**
Control	3.22	3.39	1.27	5.13	1.00	2.8	3.6	2.58
Complete NF	5.13	4.83	1.56	5.84	1.47	3.14	5.01	3.23
AI-NPOF package	5.11	3.71	2.23	6.34	1.79	3.05	5.21	3.45
Integrated Crop Management	4.97	4.03	2.96	6.75	2.04	3.45	5.73	3.58
Integrated Crop Management (Pest management)	5.01	3.83	3.01	6.73	2.09	3.52	5.82	4.85
Exp. mean	4.69	3.96	2.21	6.12	1.68	3.19	5.07	3.54
CD (0.05)	0.04	0.57	0.31	0.63	0.11	0.38	0.7	0.72
CV (%)	0.57	9.41	9.26	6.69	4.18	7.77	7.37	13.29

Table 5.8.3 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health-

Straw yield of *kharif* ((Locations: CHN, MNC, MND, KHD, PNT, PSA, PUD and TTB)

Treatment	Straw yield (t/ha)							
	CHN	MNC	MND	KHD	PNT	PSA	PUD	TTB
Control	4.29	4.46	1.54	6.25	1.28	4.12	5.11	6.35
Complete NF	6.82	8.62	2.02	6.95	1.79	4.5	7.12	7.75
AI-NPOF package	6.35	6.38	2.63	7.43	2.02	4.45	7.7	7.48
Integrated Crop Management	5.55	6.68	3.55	7.94	2.24	5.07	8.35	7.70
Integrated Crop Management (Pest management)	5.21	5.24	3.55	7.89	2.28	5.33	8.17	9.55
Exp.mean	5.64	6.27	2.66	7.29	1.92	4.69	7.29	7.77
CD (0.05)	0.25	1.07	0.38	0.9	0.04	0.57	0.93	1.43
CV (%)	2.9	11.06	9.25	8.01	1.31	7.84	6.81	11.96

Table 5.8.4 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Yield parameters and Soil properties after harvest of *kharif* (Locations: CHN)

Treatment Name	Tiller Number/m^2	Panicle number/m^2	1000 grain wt (g)	Soil pH	Soil EC (dS m^{-1})	Soil OC (%)	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)	Soil Zn (mg/kg)
Control	258	219	20.18	7.02	0.22	1.17	429.50	88.50	282.65	17.60
Complete NF	249	216	19.63	7.02	0.22	1.22	459.50	91.00	290.10	17.28
AI-NPOF package	259	225	19.65	7.06	0.21	1.10	470.00	93.50	291.15	17.23
Integrated Crop Management	264	227	19.80	7.05	0.21	1.12	486.25	99.25	296.10	17.15
Integrated Crop Management (Pest management)	247	214	20.95	7.06	0.21	1.19	490.25	95.25	290.20	17.20
Exp. mean	255	220	20.04	7.04	0.21	1.16	467.10	NS	290.04	NS
CD (0.05)	NS	NS	NS	NS	NS	NS	24.14	8.93	7.54	0.48
CV (%)	9.60	7.55	3.23	0.36	8.76	6.01	3.35	6.20	1.69	1.81

Table 5.8.5 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Yield parameters and nutrient concentration *kharif* (Location: MNC)

Treatment Name	Tiller Number/m^2	Panicle number/m^2	1000 grain wt (g)	Grain N (%)	Grain P (%)	Grain K (%)	Grain Zn (mg/kg)	Straw N (%)	Straw P (%)	Straw K (%)	Straw Zn (mg/kg)
Control	165	145	26.50	0.95	0.25	0.29	21.03	0.50	0.24	1.13	23.43
Complete NF	199	170	29.68	1.19	0.33	0.38	24.48	0.67	0.34	1.31	28.10
AI-NPOF package	171	152	29.50	1.01	0.27	0.32	25.55	0.54	0.27	1.18	28.40
Integrated Crop Management	190	160	28.23	1.10	0.36	0.34	24.33	0.65	0.37	1.28	26.98
Integrated Crop Management (Pest management)	178	156	27.93	1.05	0.32	0.31	24.15	0.61	0.30	1.22	25.83
Exp. mean	180.60	157	28.37	1.06	0.31	0.33	23.91	0.59	0.30	1.22	26.55
CD (0.05)	6.03	2.73	0.64	0.12	NS	NS	NS	0.11	0.07	0.09	NS
CV (%)	2.17	1.13	1.46	7.12	16.80	18.39	12.49	12.30	15.13	5.02	11.19

Table 5.8.6 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Yield parameters and nutrient concentration, *kharif* (Location: MND)

Treatment Name	Tiller Number/m^2	Panicle number/m^2	1000 grain wt (g)	Grain N (%)	Grain P (%)	Grain K (%)	Grain Zn (mg/kg)	Straw N (%)	Straw P (%)	Straw K (%)	Straw Zn (mg/kg)
Control	161.00	140.50	18.81	0.81	0.06	0.28	5.93	0.53	0.04	0.32	8.17
Complete NF	162.25	147.50	19.72	0.87	0.08	7.98	5.81	0.54	0.03	0.42	8.70
AI-NPOF package	162.00	150.00	19.90	0.90	0.08	0.33	6.02	0.56	0.05	0.43	9.00
Integrated Crop Management	185.00	158.50	19.99	0.98	0.11	0.37	6.53	0.61	0.09	0.52	11.78
Integrated Crop Management (Pest management)	190.75	168.00	20.79	1.01	0.12	0.40	6.89	0.62	0.09	0.54	13.07
Exp.mean	172.20	152.90	19.84	0.91	0.09	1.87	6.24	0.57	0.06	0.45	10.14
CD (0.05)	15.22	6.59	0.98	0.04	0.02	NS	0.54	0.04	0.02	0.03	0.81
CV (%)	5.74	2.80	3.20	2.71	10.97	366.86	5.64	4.82	16.32	5.06	5.17

Table 5. 8.7 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Yield parameters and nutrient concentration , *kharif* (Location: KWD)

Treatment Name	Tiller Number/m^2	Panicle number/m^2	1000 grain wt (g)	Grain N Uptake (kg/ha)	Grain P Uptake (kg/ha)	Grain K Uptake (kg/ha)	Straw N Uptake (kg/ha)	Straw P Uptake (kg/ha)	Straw K Uptake (kg/ha)
Control	322.75	284.50	25.58	53.72	10.17	11.97	27.30	6.94	66.71
Complete NF	331.25	295.75	25.93	63.07	12.03	13.72	31.86	8.16	74.77
AI-NPOF package	350.50	304.50	26.05	68.88	13.66	15.50	35.04	9.31	81.87
Integrated Crop Management	364.50	309.75	26.03	76.52	13.95	17.97	39.07	10.15	89.87
Integrated Crop Management (Pest management)	366.75	310.75	26.43	74.93	14.48	18.64	39.53	10.47	88.83
Exp.mean	347.15	301.05	26.00	67.42	12.86	15.56	34.56	9.01	80.41
CD (0.05)	21.40	NS	NS	5.90	2.68	3.24	6.04	1.87	10.35
CV (%)	4.00	4.35	3.54	5.68	13.54	13.53	11.33	13.45	8.36

Table 5.8.8 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Yield parameters and nutrient concentration, *kharif* (Location: PNT).

Treatment Name	Tiller Number/m^2	Panicle number/m^2	1000 grain wt (g)	Grain N (%)	Grain P (%)	Grain K (%)	Grain Zn (mg/kg)	Straw N (%)	Straw P (%)
Control	98	87	17.48	0.90	0.07	0.80	9.53	0.40	0.11
Complete NF	112	99	19.13	0.96	0.09	0.76	9.83	0.47	0.14
AI-NPOF package	118	112	19.85	1.03	0.14	0.87	10.55	0.58	0.25
Integrated Crop Management	127	116	20.05	1.04	0.15	0.95	11.03	0.65	0.22
Integrated Crop Management (Pest management)	128	117	20.43	1.04	0.15	0.97	10.90	0.78	0.24
Exp. mean	117	106	19.39	1.00	0.12	0.87	10.37	0.58	0.19
CD (0.05)	6.02	3.76	0.72	NS	0.03	0.08	0.84	0.15	0.03
CV (%)	3.34	2.30	2.39	2.47	13.71	5.88	5.27	16.79	8.86

Table 5.8.9 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Yield parameters and nutrient concentration, *kharif* (Location: PSA)

Treatment Name	Tiller Number/m^2	Panicle number/m^2	1000 grain wt (g)	Grain N (%)	Grain P (%)	Grain K (%)	Straw N (%)	Straw P (%)	Straw K (%)
Control	216.50	198.00	26.40	1.37	0.28	0.16	0.66	0.07	1.23
Complete NF	233.25	213.50	26.80	1.38	0.29	0.17	0.67	0.07	1.25
AI-NPOF package	230.00	209.00	26.73	1.38	0.30	0.17	0.68	0.08	1.26
Integrated Crop Management	246.50	223.75	27.20	1.40	0.33	0.19	0.75	0.08	1.30
Integrated Crop Management (Pest management)	253.25	238.50	27.03	1.42	0.33	0.19	0.75	0.08	1.31
Exp. mean	235.90	216.55	26.83	1.39	0.31	0.18	0.70	0.08	1.27
CD (0.05)	NS	23.26	NS	NS	NS	0.01	0.06	0.00	NS
CV (%)	7.00	6.97	2.10	5.50	9.17	5.51	5.35	4.16	3.01

Table 5.8.10 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Yield parameters and nutrient concentration, of *kharif* (Locations: PUD)

Treatment Name	Tiller Number/m^2	Panicle number/m^2	Grain N (%)	Grain P (%)	Grain K (%)	Straw N (%)	Straw P (%)	Straw K (%)	Soil pH
Control	228.33	144.67	0.93	0.19	0.29	0.30	0.17	0.84	6.65
Complete NF	394.67	343.67	1.21	0.27	0.42	0.41	0.20	1.05	6.37
AI-NPOF package	429.67	365.00	1.23	0.27	0.43	0.44	0.22	1.16	6.40
Integrated Crop Management	457.33	410.67	1.27	0.29	0.44	0.44	0.24	1.11	6.42
Integrated Crop Management (Pest management)	457.33	419.33	1.29	0.28	0.43	0.45	0.23	1.15	6.57
Exp. mean	393.46	336.67	1.19	0.26	0.40	0.41	0.21	1.06	6.48
CD (0.05)	44.26	45.02	0.22	NS	NS	0.10	0.03	0.20	NS
CV (%)	5.97	7.1	9.91	18.09	14.81	12.48	7.8	9.97	3.36

Table 5.8.11 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Yield parameters and nutrients uptake of *kharif* (Locations: TTB)

Treatment Name	Tiller Number/m^2	Panicle number/m^2	1000 grain wt (g)	Soil pH	Soil OC (%)	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)	Soil Zn (mg/kg)
Control	238	213	11.60	5.25	0.59	232.43	16.95	104.50	0.62
Complete NF	255	246	11.48	5.73	0.60	247.36	18.88	109.91	0.74
AI-NPOF package	303	296	12.53	5.58	0.58	245.28	18.18	109.30	0.73
Integrated Crop Management	258	251	11.38	5.23	0.53	256.42	18.96	112.05	0.69
Integrated Crop Management (Pest management)	300	298	12.30	5.18	0.55	254.25	18.30	112.64	0.70
Exp.mean	271	261	11.86	5.39	0.57	247.15	18.25	109.68	0.70
CD (0.05)	24.54	45.48	0.77	0.20	0.03	5.17	NS	NS	NS
CV (%)	5.88	11.32	4.19	2.38	3.16	1.36	5.22	4.78	12.53

Table 5.8.12 Enhancing productivity of organic rice cultivation
Yield parameters and post harvest soil status during *rabi* (Location: CHN)

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Tiller/m^2	Panicle /m^2	1000 grain wt	Soil OC (%)	Avail N (kg/ha)	Avail P_2O_5 (kg/ha)	Avail K_2O (kg/ha)	Avail S (mg/kg)	DTPA-Zn (mg/kg)	DTPA-Fe (mg/kg)	DTPA-Mn (mg/kg)	DTPA-Cu (mg/kg)
1	2.36	2.78	258	220	20.18	1.19	440.60	91.30	284.74	18.48	17.62	14.19	3.04	5.16
2	5.47	6.46	364	318	21.50	1.16	458.60	89.10	288.10	19.52	17.20	14.27	3.06	5.15
3	2.74	3.26	250	217	19.60	1.11	480.00	98.10	295.74	19.52	17.10	14.20	3.09	5.14
4	2.65	3.15	259	225	20.20	1.18	489.20	95.50	291.58	18.44	17.24	14.21	3.06	5.12
5	3.37	4.13	251	209	19.80	1.11	480.00	98.10	295.74	19.52	17.10	14.20	3.09	5.14
6	3.69	4.55	292	272	20.20	1.18	466.20	95.30	294.24	18.12	17.38	14.26	3.06	5.17
7	2.76	3.3	260	226	19.80	1.10	474.19	93.40	282.62	18.90	17.25	14.28	3.07	5.19
8	2.74	3.24	269	232	19.86	-	-	-	-	-	-	-	-	-
9	2.73	3.25	248	215	20.82	-	-	-	-	-	-	-	-	-
Exp. mean	3.17	3.8	272	237	20.22	1.15	469.83	94.40	290.39	18.93	17.27	14.23	3.07	5.15
CD (0.05)	0.2	0.28	28.05	28.7	0.65	NS	NS	5.54	7.72	NS	NS	NS	0.03	NS
CV (%)	5.02	5.75	8.06	9.47	2.51	6.64	5.35	4.5	2.04	4.56	1.55	0.69	0.8	1.31

1-Absolute control, 2-100% RDN, 3-100% N (FYM), 4-150% N (FYM), 5- 50% N (FYM) + 50% N (GM), 6- 50% N (FYM) + 50% N (Vermicompost), 7- 50% N (FYM) + 50% N (Neem/castor/any cake), 8- Optional 1: RDN 50% each through FYM + Vermicompost ; FYM as basal and VC 20., 9-Optional 2: Vermicompost @ 50% as basal, 25% at active tillering and 25% at PI

Table 5.8.13 Enhancing productivity of organic rice cultivation
Yield parameters, nutrient concentration and soil properties of *Rabi* (Location: KRK)

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Grain N (%)	Grain P (%)	Grain K (%)	Straw N (%)	Straw P (%)	Straw K (%)	Soil pH	Soil EC (dSm^{-1})	Soil OC (%)	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)	Soil S (ppm)
1	3.04	5.58	1.37	0.17	1.31	0.51	0.09	1.99	5.25	0.07	1.07	118.13	36.77	212.00	14.79
2	3.88	7.35	1.74	0.16	1.66	0.5	0.07	2.56	5.05	0.06	0.94	133.8	50.33	274.83	22.65
3	4.13	6.15	1.77	0.2	1.31	0.39	0.09	2.09	5.03	0.06	1.35	164.13	75.37	227.73	22.65
4	4.36	6.59	1.59	0.18	1.21	0.37	0.1	2.52	5.78	0.09	0.75	155.77	63.6	455.47	12.45
5	3.89	6.67	1.46	0.21	1.16	0.36	0.09	2.36	4.97	0.07	1.05	159.97	51.1	164.9	19.56
6	4.16	6.69	1.62	0.22	1.46	0.43	0.08	2.12	5.66	0.30	0.71	175.6	56.8	278.73	14.71
7	4.27	6.54	1.59	0.29	1.11	0.48	0.13	2.36	5.36	0.24	0.72	168.3	65.4	196.27	14.46
8	4.06	6.24	1.43	0.27	0.96	0.37	0.17	2.42	5.44	0.65	0.81	152.63	61.07	200.23	11.28
9	4.21	6.91	1.46	0.29	1.01	0.41	0.07	2.13	4.77	0.29	0.49	156.8	37.1	180.6	11.95
Exp.mean	4.00	6.53	1.55	0.21	1.25	0.42	0.10	2.33	5.28	0.19	0.85	152.73	55.35	235.18	15.98
CD (0.05)	0.64	1.09	NS	NS	NS	NS	NS	NS	NS	0.32	NS	NS	NS	NS	7.70
CV (%)	9.27	9.63	12.32	43.65	19.13	18.02	52.52	26.78	8.66	99.26	41.34	23.76	29.14	51.96	28.09

1 Absolute control, 2. 100%RDN, 3. 100%N through FYM, 4. 150%N through FYM, 5. . 50%N through FYM+50%N through GLM, 6. 50%N through FYM+50%N through Vermicompost, 7. 50% N through FYM+50% N through Neemcake, 8. 75%RDN (50%N each through FYM and vermicompost), 9. Best state organic practiice (10 t/ha FYM+2.5 t/ha Vermicompost+3%Fish Amino acid spray)

Table 5.8.14 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health-Nutrients uptake and Soil properties after harvest of *kharif* (Location: MNC)

Treatment Name	Soil OC %	Soil N (kg/ha)	Soil K (kg/ha)	Soil P (kg/ha)	Soil Zn (mg/kg)	Total N uptake (kg/ha)	Total uptake P (kg/ha)	Total uptake K (kg/ha)
Control	3.00	368.38	168.10	38.37	1.18	55.04	19.17	60.14
Complete NF	3.02	376.95	202.38	48.02	1.19	115.41	44.70	131.08
AI-NPOF package	3.05	382.65	203.15	50.77	1.16	71.51	27.15	86.79
Integrated Crop Management	3.01	375.08	193.28	44.81	1.14	87.80	38.98	98.74
Integrated Crop Management (Pest management)	2.98	374.75	188.55	45.72	1.18	71.66	27.86	75.59
Exp.mean	3.01	375.56	191.09	45.54	1.17	80.28	31.57	90.47
CD (0.05)	NS	5.04	6.05	4.31	NS	14.87	5.03	15.13
CV (%)	2.73	0.87	2.05	6.14	4.95	12.02	10.33	10.85

Table 5.8.15 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health-Nutrient uptake and Soil properties after harvest of *kharif* (Location: MND)

Treatment Name	Soil pH	Soil EC (dSm^{-1})	Soil OC %	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)	Soil Zn (mg/kg)	Total N uptake (kg/ha)	Total uptake P (kg/ha)	Total uptake K (kg/ha)
Control	7.56	0.12	0.51	227.38	20.17	162.05	0.63	18.52	1.35	8.56
Complete NF	7.49	0.13	0.55	234.85	21.96	160.33	0.63	24.48	1.83	122.73
AI-NPOF package	7.48	0.13	0.55	240.05	20.63	156.28	0.92	34.65	3.09	18.58
Integrated Crop Management	7.34	0.13	0.54	256.08	24.79	180.40	1.14	50.32	6.12	29.30
Integrated Crop Management (Pest management)	7.42	0.13	0.53	257.40	25.17	180.08	1.17	52.46	6.82	30.92
Exp.mean	7.46	0.13	0.54	243.15	22.54	167.83	0.90	36.09	3.84	42.02
CD (0.05)	0.11	NS	0.03	7.35	2.19	8.16	0.11	5.46	0.64	NS
CV (%)	0.96	6.91	3.06	1.96	6.31	3.16	7.87	9.82	10.80	232.03

Table 5.8.16 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Nutrient uptake and Soil properties after harvest of *kharif* (Location: KWD)

Treatment Name	Soil pH	Soil EC (dSm^{-1})	Soil OC (%)	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)
Control	6.45	0.27	0.67	301.68	13.15	152.33
Complete NF	6.38	0.25	0.74	317.78	14.60	161.68
AI-NPOF package	6.20	0.26	0.81	341.45	14.85	169.18
Integrated Crop Management	6.25	0.25	0.75	324.68	16.40	172.03
Integrated Crop Management (Pest management)	6.20	0.26	0.78	319.40	15.78	176.48
Exp. mean	6.30	0.26	0.75	321.00	14.96	166.34
CD (0.05)	NS	NS	0.07	NS	1.67	14.95
CV (%)	2.92	8.54	6.10	5.56	7.26	5.83

Table 5.8.17 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Nutrient uptake and Soil properties after harvest of *kharif* (Location: PNT)

Treatment Name	Soil pH	Soil EC (dSm^{-1})	Soil OC (%)	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)	Soil Zn (mg/kg)	Total N uptake (kg/ha)	Total uptake P (kg/ha)	Total uptake K (kg/ha)
Control	7.13	0.22	0.30	132.75	9.28	114.00	8.85	9.00	0.73	8.04
Complete NF	7.15	0.26	0.45	148.50	10.40	137.50	10.45	14.0	1.28	11.09
AI-NPOF package	7.38	0.42	0.54	155.50	11.65	160.00	12.03	18.51	2.50	15.59
Integrated Crop Management	7.33	0.45	0.62	161.50	13.23	182.50	12.78	21.30	3.05	19.45
Integrated Crop Management (Pest management)	7.48	0.47	0.62	159.00	13.18	168.75	13.25	21.65	3.10	20.30
Exp. mean	7.29	0.36	0.51	151.45	11.55	152.55	11.47	16.9	2.13	14.89
CD (0.05)	0.22	0.06	0.06	5.59	0.60	4.09	0.65	NS	0.51	1.12
CV (%)	1.96	11.42	7.52	2.40	3.36	1.74	3.68	2.45	15.52	4.86

Table 5.8.18 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health- Nutrient uptake and Soil properties after harvest of *kharif* (Location:PSA)

Treatment Name	Soil pH	Soil EC (dSm^{-1})	Soil OC (%)	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)	Total N uptake (kg/ha)	Total uptake P (kg/ha)	Total uptake K (kg/ha)
Control	8.37	0.32	0.46	219.75	26.60	121.30	65.49	10.79	55.25
Complete NF	8.30	0.28	0.47	224.00	27.45	125.63	73.30	12.39	61.63
AI-NPOF package	8.29	0.25	0.52	232.50	27.93	127.33	72.14	12.42	61.12
Integrated Crop Management	8.34	0.30	0.50	250.50	30.38	141.45	86.26	15.46	72.43
Integrated Crop Management (Pest management)	8.31	0.29	0.52	253.50	31.30	143.48	90.05	16.02	76.43
Exp.mean	8.32	0.29	0.49	236.05	28.73	131.84	77.45	13.42	65.37
CD (0.05)	NS	0.04	NS	NS	NS	15.20	11.80	2.14	8.17
CV (%)	0.81	9.47	11.21	7.58	8.18	7.48	9.89	10.33	8.11

Table 5.8.19 Evaluation of Organic fertilizers and Natural farming practices for enhancing the productivity and soil health Nutrient uptake and Soil properties after harvest of *kharif* (Location: PUD)

Treatment Name	Soil EC (dSm^{-1})	Soil OC (%)	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)	Total N uptake (kg/ha)	Total uptake P (kg/ha)	Total uptake K (kg/ha)
Control	0.22	0.27	112.00	35.67	134.33	36.88	11.69	40.42
Complete NF	0.25	0.31	138.13	48.00	159.33	67.42	20.69	72.03
AI-NPOF package	0.28	0.35	145.33	48.67	166.67	72.94	23.29	83.67
Integrated Crop Management	0.32	0.29	141.87	43.33	157.33	82.23	27.18	88.51
Integrated Crop Management (Pest management)	0.29	0.32	134.40	46.33	153.00	83.98	26.41	89.62
Exp. mean	0.27	0.31	134.35	44.40	154.13	68.69	21.85	74.85
CD (0.05)	0.06	NS	NS	NS	17.59	16.90	4.52	21.28
CV (%)	10.99	9.25	9.13	12.55	6.06	13.06	10.99	15.1