Effectof climatesmart crop establishmentmethodsandnitrogenmanagement practiceson tillers and drymatter productionofrice.
(revised title)

ABSTRACT

Rice (*Oryza sativa* L.) is the second most important staple food crop of world and prime staple food crop of India.Rice (*Oryza sativa* L.) and rice-based cropping systems are integral part of agriculture whose spread and extent is predominant across the countries.The productivity and sustainability of rice-based systems are threatened by the inefficient use of inputs (fertilizer), increasing scarcity of especially water, climate variability and availability of labour. Method of establishment and N management practices influences the performance of rice through its effect on growth and development.A field experiment was conducted during *kharif* 2021-22 and 2022-23 at ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad to study the "Effect of climate smart crop establishment methods and nitrogen management practices on tiller and dry matter production of rice".The experiment was laid out in split plot design with threecrop establishment methods [Manual transplanting (M_1) mechanical transplanting (M2) and wet direct seeded rice (M_3)] in main plots and five nitrogen management practices [S_1- Recommended nitrogen dose (RND), S_2-Leafcolorchart (LCC),S_3-Nutrient Expert (NE), S_4-Greenseeker (GS) ,S_5-Soil test crop Response STCR] in sub-plots with three replications.The results revealed that under crop establishment methods, mechanical transplanting recorded higher tiller bearing capacity per m^{-2}(384,446 and 415 m^{-2}) as well dry matter production(kg ha^{-1})(13927,14395 and 14161) while in nitrogen management practices soil test crop response STCR recorded higher tiller production ability per m^{-2}(414,468and441m^{-2})and drymatterproductio(kg ha^{-1})(13949,14772 and 14360 kg ha^{-1}).Application of nitrogen as per recommendation of Nutrient Expert with NCU (75%) and VC (25%) (N2) recorded significantly higher mean GreenSeeker® NDVI values (0.673 and 0.686 at 60 and 90 DAS, respectively) as compared to nitrogen omission (N5) (0.543 and 0.572 at 60 and 90 DAS, respectively) and absolute control (N6) (0.509 and 0.543 at 60 and 90 DAS, respectively). The results suggest that timely transplanting of younger seedlings, appropriate N management practice based on STCR achieved better crop stand with higher tillering ability and dry matter production efficiency.

Keywords: Crop establishment,Soil test crop response STCR, Dry matter production (DMP)

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the second most important staple food crop of world and prime staple food crop of India. In India, it occupied an area of 47.16 million hectares with an annual production of 131.32 million tones and with a productivity of 2.64 t ha^{-1} whereas, in Andhra Pradesh it is grown over an area of 2.32 million hectares with a production of 8.32 million tones and with a productivity of 3.73 t ha^{-1}[1].Rice (*Oryza sativa* L.) and rice-based cropping systems are integral part of agriculture whose spread and extent is predominant across the countries. In the Indian subcontinent, rice–wheat and rice–rice are the major rice-based cropping systems. Among these cropping systems, rice–maize is the predominant cropping system occupying in an area of 3.5 m ha in Asia after the Rice-rice and rice-wheat cropping system[2].

The food security is challenged by increasing food demand and is threatened by declining availability of water with growing population, increased urbanisation and environmental degradation.Continuous rice monocropping and excessive dependence on chemical fertilizers degrade the soil quality, which can be partly solved by changing into rice based cropping system. It is pertinent to suggest suitable rice based cropping system and nutrient management practices to get higher yield and income with maintaining the soil fertility. Use of high-analysis fertilizers debars the crop of availing the micronutrients and balanced fertilization. The rice–maize cropping sequence extracts large amounts of mineral nutrients from the soil may accelerate the problem of secondary and micronutrient deficiencies not only because larger amounts are removed, but also because the application of high rates of N,P and K to achieve yield targets .

To get a good yield, most rice soils require nitrogen (N) fertilizer. Among N,P and K , Nitrogen is the key nutrient element required in large quantities by rice. In modern agro ecosystems, it was estimated that the removal of as much as 300 kg N ha^{-1} $year^{-1}$ in the above ground portions of the harvested produce requires substantial inputs of N either through fertilizers, manure or N-fixation to maintain the productivity [3]. Higher loss of N from urea necessitates an innovative application technique for increasing the nitrogen use efficiency (NUE). Proper management of N is essential for achieving higher productivity and improving environmental safety by ensuring minimal losses of applied N.

The effective nutrient management involves site specific nutrient recommendations like Soil test crop response, Leaf colour chart, Greenseeker and Nutrient Expert that includes timely and balanced fertilizer nutrient application, using appropriate methods and practicing integrated plant nutrient supply system using chemical fertilizers, organic manures, crop residues and biofertilizers. For improving rice productivity, nitrogen need to be applied in desired quantities and according to the crop needs. Therefore, application of nitrogen to be made by right source, right time and in right amount. Keeping these points in consideration, the experiment entitled “Effect of climate smart crop establishment methods and nitrogen management practices on tiller and dry matter production in rice.”

2. MATERIAL AND METHODS

The study was conducted during *kharif* seasons of 2021-22 and 2022-23, at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research, Agronomy unit, Rajendranagar, Hyderabad which is geographically situated at an altitude of 542.3 m above mean sea level located at 17.19^{o}N latitude and 78.23^{o}E longitude in Southern Telangana Agro-climatic Zone of Telangana.The soil at the experimental site was clay soils in texture[4]with 23.5 g,26.0 g sand, 29.0 g,28.0 g silt and 42.0 g, 44.5 clay per 100 g soil in the surface horizon during both the years of experiment.

2.1 Treatmental Details (Table 1).

The experiment was laid out in a split plot design with three main plots(rice crop establishment methods)includeM_1-Manualtransplanting,M_2-Mechanical transplanting,M_3-Wet-directseededrice (W-DSR) and five subplots (Nitrogen management practices)include S_1 – Recommended nitrogen dose (RND) S_2 -Leafcolor chart(LCC) S_3 -Nutrient Expert(NE) S_4 -Greenseeker S_5 -Soil test based crop response(STCR) which was replicated thrice for rice crop during *kharif* seasons of 2021-22 and 2022-23.

Table 1. Treatment details

Main plots : (Rice crop establishment methods)	
M_1	Manual Transplanting
M_2	Mechanical Transplanting
M_3	Wet direct seeded rice
Sub plots : (Nitrogen Management methods)	
S_1	Recommended Nitrogen dose (RDN)
S_2	LCC based nitrogen management
S_3	Nutrient Expert (NE) based nitrogen management
S_4	Greenseeker based nitrogen management
S_5	Soil test crop response (STCR) based nitrogen management

In main plottreatments, manual transplanting of 21 days oldseedlings, mechanizedtransplanting of 14 days old seedlings, and wet direct seeded rice through sowing of sprouted seeds.In theexperiment, mechanical transplanting of rice wasdone using a self-propelled rice transplanter. Thetransplanter, which has a diesel motor, movesseedlings from mat-style nurseries.Every treatmentreceived the appropriate dose of N as per the recommendations of RDN, Leaf color chart, Nutrient Expert ,Greenseeker and STCR based. Every treatmentreceived the appropriate dose of P and K as per the recommendations of appropriate dose of phosphorus at 60 kg ha^{-1}, potassium at 80 kg ha^{-1} .

Data collection involved selecting and tagging five random hills from each plot to take measurements. Number of tillers per m^{-2} was recorded from the five randomly selected plants, at Active tillering stage, Panicle Initiation Stage, Flowering stage and at harvest stage of selected five hills, and the mean number of tillers per square meter for each plot was calculated. They were pooled and average number of tillers m^{-2} was presented. Dry matter accumulation per square meter was assessed at Active tillering stage, Panicle Intiation Stage, Flowering stage and at harvest stage. Three hills from each plot were cut down, sun-dried, and then oven-dried at 70°C for 48 hours. The average dry matter obtained from these three hills was used to calculate the mean dry matter accumulation per square meter for each plot

Finally, the data analysed by using Analysis of Variance (ANOVA) was performed using standard procedure for split plot design [5].

3. RESULTS AND DISCUSSION

3.1 Number of Tillers m^{-2}

In rice, tillering dynamics greatly depends on the age of seedling at transplanting. Total number of tillers m^{-2} increased from active tillering (a.i stage) stage to flowering stage and showed a slight decreasing trend thereafter towards harvest, due to death of later formed tillers which might be due to competition.

Experimental results (Table 2)At active tillering, recorded maximum number of tillers m^{-2} (358,384 and 446 m^{-2} during 2021-22, 2022-23 and pooled data, respectively) with M_2 and it was on par with M_1. The least number of tillers m^{-2} (302,310 and 306 m^{-2}) was obtained with M_3during both the years of the study and pooled data.

At all other stages (Panicle initiation, flowering and at harvest),among the crop establishment techniques, maximum number of tillers m^{-2} was recorded with M_2 which was significantly superior over other treatments. The number of tillers m^{-2} was significantly lowest in M_3which was at parity with the M_1 during both the years of the study and pooled data.The reason for higher tillering ability with the young seedlings might be due to the completion of more number of *phyllochrons*during the vegetative phase compared to older seedlings and when a seedling is transplanted carefully at the initial growth stage, the trauma of root damage caused during uprooting is minimized. Similar observations were also reported by [6] and [7].

Experimental results (Table 2) expressed were all significantly influenced by nitrogen management practices.during both the years of experimentation as well as in the pooled mean.Nitrogen based management practices, significantly effected the number of tillers m^{-2}at all the crop growth stages of rice. At active tillering stage (a.i stage), the higher number of tillers m^{-2}(378,396 and 387m^{-2})recorded with the application of S_5 was significantly superior to other all treatments and it was followed by S_3(353,370 and 361m^{-2})and

Recommended nitrogen dose S_1(327,343 and 335m^{-2}).The lowestnumber of tillers m^{-2} was noted in S_4(292,308 and 300m^{-2}) based nitrogen application. It was comparable with $S_4$and S_2treatments during 2021-22,2022-2023 and pooled mean.

At all other stages of Panicle initiation, flowering and at harvest, it was observed that highest number of tillers m^{-2} was recorded with S_5 over other treatments during both the years of experimentation as well as in the pooled mean. It was followed by S_3 and S_4. Significantly lower number number of tillers m^{-2} were registered in S_1 based nitrogen application and was comparable or on par with the S_2based nitrogen application during the both years of study and pooled data. This might be due to the fact that greater nutrient availability in the soil induces less tiller mortality, more number of tillersm^{-2},enhanced photosynthetic area and proper nourishment with the abundant supply of nutrients recorded higher number of tillers m^{-2}.The decrease in number of tillers m^{-2} after panicle initiation stage could be due to senescence of late formed tillers. Similar results were alsoreported by [8].

Table2. Number of tillers m^{-2} at different growth stages of rice as influenced by different crop establishment methods and different nitrogen management practices during *kharif,* 2021-22, 2022-23 and pooled data

Treat-ments	2021-22				2022-23				Pooled data			
	Active tillering	Panicle intiation	Flowerig	Harvest	Active tillering	Panicle intiation	Flowering	Harvest	Active tillering	Panicle intiation	Flowering	Harvest
Crop establishment method practices (M)												
M_1	332	389	358	349	352	440	413	393	342	414	386	371
M_2	358	445	403	384	378	493	461	446	368	469	432	415
M_3	302	345	331	311	310	410	371	351	306	377	351	331
S.Em±	7	12	9	8	8	13	11	11	7	12	9	8
CD (p = 0.05)	28	47	36	33	34	51	45	43	29	49	38	35
CV (%)	7.8	9.3	9.9	9.3	9.0	10.3	10.6	10.8	7.4	8.1	8.1	9.7
Nitrogen management practices (S)												
S_1	327	336	317	303	343	384	357	340	335	360	337	322
S_2	302	344	322	318	316	398	368	353	309	371	345	336
S_3	353	428	393	382	370	486	450	429	361	457	422	406
S_4	292	387	357	349	308	441	410	392	300	414	384	371
S_5	378	470	430	414	396	529	490	468	387	499	460	441
S.Em±	8	9	8	10	6	10	10	12	6	9	8	7
CD (p = 0.05)	23	38	34	30	25	40	38	35	24	39	36	24
CV (%)	7.0	8.4	9.8	8.9	8.1	8.4	8.1	9.1	7.6	8.4	8.9	9.0

3.2Dry matter production(kg ha^{-1})

Higher dry matter production per unit area is the critical prerequisite for higher yield. The amount of dry matter production partitioning depends on effective photosynthesis and respiration of crop. The total yield of dry matter is the total amount of dry matter produced and less the photosynthates used for respiration. Finally, the manner in which the net dry matter produced is distributed among different parts of the plant, which determine magnitude of the economic yield.

Experimental results(Table 3) revealed that the trend in drymatter production was lesser at earlier stages and after that improved rapidly gaining a peak at physiological maturity stage in all the treatments. The two factors involved (crop establishment methods and nitrogen management practices) produced significant results in drymatter production during all the growth stages *viz.,* active tillering, panicle Intiation, flowering and at harvest stage.The maximum drymatter accumulation was observed at the time of harvest.

With respect to crop establishment methods, At Active tillering(A.I) stage, maximum drymatter accumulation was recorded with M_2 (1865, 1976 and 1920 kg ha^{-1}).It was comparable with M_1.The lowest drymatter accumulation was registered with M_3(1470,1613 and 1541 kg ha^{-1})during 2021-22, 2022-23 and pooled data, respectively) found significantly inferior to all other crop establishment methods.At panicle Intiation stage and flowering stage the trend in the dry matter production was found to be increasing. At both the stages, M_2recorded significantly more values of drymatter accumulation over other treatments. The least drymatter production was associated withM_1 which was comparable with the M_2 during two consecutive years and pooled data.

Similarly, At harvest stage, significantly higher drymatter accumulation (kg ha^{-1})was recorded with M_2 (13927, 14395 and 14161 kg ha^{-1} during 2021-22, 2022-23 and pooled data, respectively.The treatment M_3 recorded the lower values of drymatter production (11560, 12218 and 11889 kg ha^{-1} during 2021-22, 2022-23 and pooled data, respectively) and was found. It was comparable with M_3.The higher dry matter production (DMP) (kg ha^{-1}) was noticed in Mechanical transplanting (M_2) which might be attributed to better establishment of seedling,gradual increased in plant height, better development of leaves, increased LAI, root activity, profuse and strong tillers with higher crop growth rate and higher nutrient uptake which resulted in higher plant dry matter accumulation.. The results obtained in this investigation are in conformity to the findings of [9] and [10].

Among the nitrogen management practices, there was a progressive increase in drymatter production(kg ha^{-1}) at all stages of observation of rice with thenitrogen management practices. At active tillering stage, the maximum drymatter productionof rice was recorded with the application of S_5(1954,2019 and 1986 kg ha^{-1})which was significantly superior to other all treatments and it was followed byS_3(1791,1908 and 1849 kg ha^{-1}) andS_1(1687,1799 and 1743 kg ha^{-1}).The lower values of drymatter production was recorded with S_4(1437,1619 and 1528kg ha^{-1})based nitrogen application.It was comparable with $S_4$and S_2treatments during both years of the study and pooled data.

At all other stages (Panicle initiation, flowering and at harvest), higher dry matter partitioning was recorded with S_5 over other treatments during both the years of experimentation as well as in the pooled mean. It was followed byS_3 and S_4. The lowest dry matter accumulation was recorded with theS_1 based nitrogen application and was comparable with S_2 based nitrogen application during the both years of study and pooleddata.The higher drymatter partitioning from panicle Initiation stage to harvest was recorded with S_5 which might be due to favourable vegetative growth and development as they received adequate and sufficient nitrogen at proper amount in critical stages. As the results of which the plant height, number of tillers and crop growth rate contributed to higher dry matter production through increased photosynthetic activity of leaves. The current findings are supported by [11].

Table 3. Dry matter production (kg ha^{-1}) at different growth stages of rice as influenced by crop establishment methods and different nitrogen management practices during *kharif,* 2021-22, 2022-23 and pooled data

Treat-ments	2021-22				2022-23				Pooled data			
	Active tillering	Panicle intiation	Flowerig	Harvest	Active tillering	Panicle intiation	Flowering	Harvest	Active tillering	Panicle intiation	Flowering	Harvest
Crop establishment method practices (M)												
M_1	1692	6019	10674	12441	1832	6559	11436	12883	1762	6289	11055	12662
M_2	1865	6983	11840	13927	1976	7518	12383	14395	1920	7251	12112	14161
M_3	1470	5579	9972	11560	1613	6055	10870	12218	1541	5817	10421	11889
S.Em±	28	135	183	248	30	138	192	275	29	134	187	261
CD (p = 0.05)	112	530	721	973	121	542	755	1082	117	528	738	1027
CV (%)	10.3	8.4	8.6	7.6	12.4	10.4	9.1	8.1	11.4	9.4	8.9	7.8
Nitrogen management practices (S)												
S_1	1687	5727	9845	11579	1799	6261	10319	11876	1743	5994	10082	11727
S_2	1509	5416	10018	11863	1690	5987	10756	12211	1599	5701	10387	12037
S_3	1791	6613	11344	13259	1908	7105	12265	13982	1849	6859	11804	13620
S_4	1437	6119	10673	12561	1619	6724	11506	12987	1528	6421	11089	12774
S_5	1954	7094	12262	13949	2019	7476	12971	14772	1986	7285	12616	14360
S.Em±	23	119	136	172	25	124	143	191	24	111	139	181
CD (p = 0.05)	93	347	547	688	100	363	570	765	96	326	558	726
CV (%)	8.4	8.1	7.9	7.1	10.1	9.8	8.9	7.3	9.2	8.9	8.4	7.2

4. CONCLUSION

The study revealed that timely transplanting of younger seedlings, appropriate N management practice based on STCR achieved better crop stand with higher tillering ability and dry matter production efficiency.Therefore, farmers are recommended to applyN,P and Kbased on right source, right time and in right amount by following STCR approaches.

(Revise conclusion)

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