OptimizingNutrientUptakeinRiceCropsthroughIntegratedOrganicManureApplication:AComprehensiveAnalysisofGrainandStrawComposition

Abstract

Rice(*Oryzasativa*L.)isthestaplefoodofmorethan60percentoftheworld'spopulationandisconsideredthe"globalgrain".ItisthemainstaplefoodintheAsiaandthePacificregion.ThisstudywasconductedtoascertaintheImpactofVariousTreatmentCombinationsontheNutrient Uptakeofricegrainsandstraw.ThefieldexperimentswerecarriedoutattheresearchFarmof AcharyaNarendraDevaUniversityofAgriculture&Technology,Kumarganj,Ayodhya(U.P.)during*Kharif*,2021-22.Theexperimentwaslaidoutinrandomizedblockdesignwith3replicationshaving8treatments.Theeighttreatmentscombinationswere:T$_1$ (AbsoluteControl),T$_2$(Biodecomposedcompost1q/ha+50%RDF),T$_3$(Biodecomposedcompost1.5q/ha+50%RDF),T$_4$(Biodecomposedcompost1q/ha+50%RDF+Rootdippingwithbiodecomposedcompostwash10ml/litofwater),T$_5$(Biodecomposedcompost1.5q/ha+50%RDF+Rootdippingwithbiodecomposedwash10ml/litofwater),T$_6$(Biodecomposedcompost1q/ha+50%RDF+foliarapplicationofbiodecomposedcompostwashof10ml/litofwater),T$_7$(Biodecomposedcompost1.5q/ha+50%RDF+foliarapplicationofbiodecomposedcompostwashof10ml/litofwater),T$_8$(100%RDF).Asperfindings,NutrientuptakeofN,PandKbygrainofRicevariedfrom44.32 kgha^{-1}to77.03kgha^{-1},11.90kgha^{-1}to20.85kgha^{-1},and22.16kgha^{-1}to45.17kgha^{-1}.InRicestraw,N,PandKuptakevariedfrom20.16kgha^{-1}to36kgha^{-1},8.17kgha^{-1}to15.62kgha^{-1},and66.67kgha^{-1}to100.55kgha^{-1}.Theapplicationoforganicmanuressignificantlyinfluencednutrientuptake,attributedtoenhancedphotosynthesis,increasedbiomass,andimprovednutrientavailability.Thefindings alignwithpreviousresearch,emphasizingthepositiveimpactoforganicmanureonnutrientuptakeinricecrops.Thesestudiescontributevaluableinsightsintooptimizingagriculturalpracticesforenhancednutrientmanagementandsustainablecropproduction.

Keywords: Nutrientuptake,Biodynamiccompost,OrganicManures,Biomass

1. **Introduction:**Rice(OryzasativaL.)isthestaplefoodandmainsourceofenergyformorethan threebillionpeoplearoundtheglobe,mostlyconsistingofSouthAsiaandIndiawhereas,itisth

emainsourceofdietarycarbohydratefor65%oftheIndianpopulation**(Patraetal.,2020)**.Moreover,riceaccountsformorethan40%offood-grainproductioninIndia,providingdirectemploymentto70%ofpeopleinruralareas.Ricecultivationaccountsformorethan80%oftheNorth–EasternHimalayanregion’stotalcultivatedarea(7.8%ofIndia’stotalricecultivationarea)andcontributessignificantlytodomesticriceproduction**(Patraetal.,2020)**.Attheglobal level,riceisgrowninanareaofabout165millionhawithproductionof519milliontonnesrespectively**(FAO,2022).**InIndia,riceisthemostimportantandextensivelygrownfoodcropoccupying46.38mhaareawithaproductionof130.29mtandproductivityof28.09q ha^{-1} **(Agril.Statistics,2022).**Agriculturefacesthedualchallengeofmeetingincreasingglobalfooddemandswhileminimizingenvironmentalimpact.Traditionalfarmingpracticesoftenrelyonsyntheticfertilizers,contributingtosoildegradationandenvironmentalpollution.Bio-dynamiccompostisapromisingalternative,leveragingaholisticapproachtosoilfertilityandplantnutrition.TheintegrationofvariousorganicmanuresresultedinhigherNPKuptake,potentiallyduetoincreasedmicrobialactivityandthereleaseoforganicacids.

Bio-decomposedcompostwashisproducedbyrepeatedlysprayingwateroncompost,allowingittoseepthroughandcollectingthewashedwater.Thisprocessisrepeateduntilonlyaminimalamountofwashedwaterremains,whichisthenutilizedascompostwash.Thismethod,knownasbiodynamiccomposting,isanexpeditedapproachtocompostproductionconductedonthesurfaceratherthanintraditionalpits.Thecompostheapisenergizedusingspecificpreparationstoenhancenutrientcontentandacceleratedecomposition.Builtonaflatsite,awayfromtreeshadeandwaterlogging,thecompostheaptakestheformofarectangle,typically2mwideand4mlong,dependingonbiomassavailability.Awindtunneloflogsisplacedlengthwiseinthemiddleoftherectangle.Itisaspeciallypreparedorganicmaterialinfusedwithdiversemicroorganisms.Thesemicroorganismsplayapivotalroleinenhancingsoilstructure,fosteringwaterretention,andincreasingnutrientavailability.Humicacid,akeycomponentofhumiccompounds,playsavitalroleinthisprocess.Humicsubstances,createdthroughthebiologicalactivityofmicroorganismsandthehumificationofplantandanimalmaterials,influenceplantdevelopment.Theeffectsofhumicchemicalsonplantgrowtharedeterminedbyfactorssuchastheirsource,concentration,molecularweight,andmolecularfraction.Byaddinghumicandfulvicacidstothesoil,itispossibletoseethebeginningofrootaugmentationandimprovedrootdevelopment(**Pettit,2004**).Macronutrients,suchasnitrogen(N),phosphorus(P),andpotassium(K)

,arepresentinorganicmanureinvaryingproportions.Thesenutrientsarecrucialforplantgrowth,asnitrogenisessentialforleafandstemdevelopment,phosphoruspromotesrootgrowthandflowering,andpotassiumsupportsoverallplantvigouranddiseaseresistance.Thebalancedsupplyofthesemacronutrientsinorganicmanurehelpsprovideplantswiththenecessaryelementsforoptimalgrowthandproductivity.Thiscanenhancesoilnutrientsduetoenhancedsoilmicrobialactivity,improvingsoilphysicalandchemicalproperties(**Adekiya*etal*.,2019**). TheslowandgradualreleaseofNfromorganicmanureisanadvantageoversolechemicalfertilizationforachievinghigherNUE,grainyield,andqualityofrice.Organicmanuresarefractionatedbasedontheirsolubilitycharacteristicstoextracthumicandfulvicacidsfromhumus(**Shirisha,2002,Kar*etal*.,2012andRamalakshmi*etal*.,2013**).Thisresearchaimstoinvestigatetheimpactofdiversetreatmentcombinationsonnutrientuptakeinricecrops.Thestudyfocusesonnitrogen,phosphorus,potassium,andproteincontentinricegrainsandstraw.Withtherisingglobalpopulation,understandingtherelationshipsbetweendifferenttreatmentsandnutrientcompositioniscrucialforinformedagriculturalpractices,aimedatimprovingnutrientutilizationandensuringsustainablecropproduction.Keepingtheseinview,theresearchwascarriedouttofindouttheuseofurbansolidwastecompostasasourceofnutrientsforricecroppresentresearchwasconducted.

2. MaterialsandMethods:

ThefieldexperimentwasconductedduringtheKharifseason2021AgriculturalResearchFarmofAcharyaNarendraDevaUniversityofAgriculture&Technology,Kumarganj,Ayodhya(U.P.).Theexperimentwaslaidoutinrandomizedblockdesignhaving8treatments(Table1)aspertherecommendeddosefertilizer(RDF)appliedthroughUrea,DAPandMOPaspertreatments.Halfdoseofnitrogenandfulldoseofphosphorusandpotassiumwereappliedbasally.TheremaininghalfNdosewasappliedintwoequalsplitsonceattilleringandrestpanicleinitiationstages.However,biodynamiccompostwasappliedatrootdippingjustbeforetransplantingandfoliarapplicationat30DAT(DaysAfterTransplanting)instandingcrop.

Table1:Detailsoftreatment

TreatmentNo.	Treatmentdetails
T_1	AbsoluteControl
T_2	BioDynamicCompost1q/ha+50%RDF

T_3	BioDynamiccompost1.5q/ha+50%RDF
T_4	T_2+RootdippingwithBioDynamiccompostwash10ml/litofwater
T_5	T_3+RootdippingwithBioDynamiccompostwash10ml/litofwater
T_6	T_2+foliarapplicationofBioDynamiccompostwashof10ml/litofwater
T_7	T_3+foliarapplicationofBioDynamiccompostwashof10ml/litofwater
T_8	100%RDF

2.1.NutrientAnalysis: Availablenitrogeninsoilwasdeterminedusingthealkalinepotassiumpermanganatemethodby**SubbaiahandAsija(1956).**Theprocedureinvolveddistilling20gofsoilwith0.32%$KMnO_4$and2.5%NaOH,absorbingammoniagasin4%boricacid(pH4.5),andbacktitratingwith0.02NH_2SO_4.Resultswereconvertedtokgha^{-1}.Availablephosphoruswasassessedfollowing**Olsenetal.,(1954)**method.Ina150mlflask,2.5gofair-drysoilwasmixedwithP-freeactivatedcharcoal,Olsen'sreagent($NaHCO_3$,pH8.5),andshaken.Colordevelopmentwasmeasuredat660nmusingaspectrophotometer,withvaluesconvertedtokgha^{-1}.Foravailablepotassiumdetermination,soilextractionutilizedneutralammoniumacetate(pH7.0)following**HanwayandHeidal(1952)**.Potassiumlevelsintheextractweremeasuredusingaflamephotometer,andresultswereconvertedtokgha^{-1}

2.2. Proteincontent(%): Proteincontent(%)ingrainwasworkedoutbymultiplyingthenitrogencontentingrainbyfactor6.25**(A.O.A.C.,1970).**

2.3. Nutrientuptake: Fortheanalysisofnutrientuptake,plantshootsamplesendureddiacidextractionfornitrogenestimation,followingHumphries'micro**Kjeldahlmethod(1956)**,expressedasapercentageonadryweightbasis.Forphosphorus,thetripleacidextractionmethodby **Jackson et al.,(1962)**wasemployed,andresultswerepresentedasapercentageonadryweightbasis.Potassiumlevelsweredeterminedusingflamephotometryonatripleacidextract,asper**Jackson et al.,(1962)**,expressedasapercentageondryweightbasis.Nutrientuptake/removalingrainandstrawofthecropswerecalculatedinkgha^{-1}aboutyieldha^{-1}byusingthefollowingformula**(Jacksonet al.,1967)**Nutrientuptake(kg/ha)=Nutrientcontent(%)×yield(q/ha)

2.4. StatisticalAnalysis: Theobservationsrecordedduringtheinvestigationweretabulatedandanalyzedstatisticallytodrawavalidconclusion.Thedatawereanalyzedasperthestandardpr ocedurefor“AnalysisofVariance”(ANOVA)asdescribedby**GomezandGomez(1984)**.Thestandarderrorofmean(SEm±)wascomputedinallcases.Thedifferenceinthetreatmentmeanwastestedbyusingcriticaldifference(CD)orleastsignificantdifference(LSD)at5%levelofprobability.

3. ResultsandDiscussion:

3.1.Nitrogencontentingrainandstraw(%)

TheconcentrationofnitrogeninbothgrainsandstrawofRice,aspresentedinTable2.TheNconcentrationofgrainvariedfrom1.12to1.33%.ThehighestgrainNconcentration1.33%wasobservedintreatmentT_7.Conversely,thelowestnitrogencontent(1.12%)ingrainswasobservedintreatmentT_1(Control).Thesefindingsalignwiththosereportedby**Bisht*etal.*(2013)**.Instraw,theNconcentrationrangedfrom0.37to0.47%.Thehighestnitrogencontentinstraw(0.47%)wasobservedintreatmentT_7.Thesefindingsareconsistentwiththeresearchof**Satish*etal.*(2011)andRamalakshmi*etal.*(2012).**

3.2.Nitrogenuptakebygrainandstraw(Kgha^{-1})

Thenitrogenuptakeinricegrainsexhibitedarangefrom44.32Kgha^{-1}to77.03Kgha^{-1},asindicatedinTable3.ThehighestnitrogenuptakeinricegrainswasobservedintreatmentT_7(77.03Kgha^{-1}),statisticallycomparabletoT_5(74.41Kgha^{-1}).Conversely,thelowestnitrogenuptakeinricegrainswasrecordedinthecontrolplotT_1(44.32kg/ha).Inthecaseofricestraw,nitrogenuptakerangedfrom20.16Kgha^{-1}to37.6Kgha^{-1}.ThehighestnitrogenuptakeinricestrawoccurredinT_5(37.6Kgha^{-1}),statisticallyatparwithT_7(35.36Kgha^{-1}),whilethelowestnitrogenuptakewasobservedinthecontrolplotT_1(20.16Kgha^{-1}).Thevariationinnitrogenuptakeinbothgrainsandstrawacrossdifferenttreatmentswasprimarilyattributedtoyielddifferencesand,tosomeextent,tothenitrogencontentingrainsandstraw.Theapplicationoforganicmanuresprovidedsufficientnutrientsforenhancedphotosynthesis,resultingininincreasednitrogenuptakeinbothgrainsandstraw,contributingtotheoverallnitrogenuptake.ThehigherNPKuptakecanbeattributedtoincreasedyieldsintreatments,asreportedby**Kumari*etal.*(2013),**andsupportedbysimilarfindingsfrom**Satish*etal.*(2011)**and**Ramalakshmi*etal.*(2012).**

3.3.Proteincontentingrain(%)

Theexaminationofdataconcerningproteincontentingrains,aspresentedinTable2,indicatesthatvarioustreatmentcombinationsinfluencedtheoutcomes.TheProteinconcentrationofgrainvariedfrom7.0to8.3%.Thehighestproteincontentingrains(8.31%)wasassociatedwithtreatmentT_7,significantlysurpassingT_1andstatisticallycomparabletoT_5andT_6.Incontrast,thelowestproteincontent(7.00%)wasnotedintreatmentT_1(Control).Additionally,**Balasubramaniam*etal.*(1989)**reportedasignificantincreaseinproteincontentingroundnutswiththeapplicationofhumicacid(HA).

3.4.Phosphoruscontentingrainandstraw(%)

ThedatapresentedinTable2concerningphosphoruscontentingrainsaswellasstrawindicatestheinfluenceofvarioustreatmentcombinations.ThePhosphorouscontentingrainvariedfrom0.30to0.36%.Themaximumphosphoruscontentingrains(0.36%)wasobservedwithtreatmentT_7,significantlyexceedingT_1andstatisticallycomparabletoT_5andT_6.Incontrast,theminimumphosphoruscontent(0.30%)ingrainswasnotedintreatmentT_1(Control).TheseresultsareconsistentwiththefindingsofMondal*etal.***(2016).**Instraw,thePconcentrationvariedfrom0.15to0.19%.ThehighestPcontentinstraw(0.19%)wasobservedintreatmentsT_7andT_5instatisticallycomparabletoT_4andT_6.

3.5.Phosphorousuptakebygrainandstraw(kgha^{-1})

Thephosphorusuptakeinricegrainsdisplayedarangefrom11.90kgha^{-1}to20.85kgha^{-1},aspresentedinTable3.ThehighestphosphorusuptakeinricegrainswasobservedintreatmentT_7(20.85kgha^{-1}),statisticallycomparabletoT_5(20.60kgha^{-1}),whilethelowestphosphorusuptakeoccurredinthecontrolplotT_1(11.90kgha^{-1}).Inthecaseofricestraw,phosphorusuptakevariedfrom8.17kgha^{-1}to15.62kgha^{-1}.ThehighestphosphorusuptakeinricestrawwasrecordedinT_7(15.62kgha^{-1}),statisticallyatparwithT_5(15.53kgha^{-1}),andthelowestphosphorusuptakewasfoundinthecontrolplotT_1(8.17kgha^{-1}).Theincreasednutrientuptakeobservedwithorganicmanureapplicationcanbeattributedtothesolubilizationofnativenutrients,chelationofcomplexintermediateorganicmoleculesproducedduringthedecompositionofaddedorganicmanures,andthemobilizationandaccumulationofdifferentnutrientsinvariousplantparts.Theseresultsalignwiththefindingsof**Mohapatra*etal.*(2008).**Additionally,theapplicationofbiofertilizersfurtherfacilitatestheincreasedavailabilityofnitrogenandphosphorusinthesoil,enhancingtheiruptakebyplants.

3.6.Potassiumcontentingrainandstraw(%)

Theanalysisofdataaboutpotassiumcontentingrainsaswellasstraw,presentedinTable4,highlightstheinfluenceofvarioustreatmentcombinations.ThePotassiumcontentingrainvariedfrom0.61to0.79%.Themaximumpotassiumcontentingrains(0.79%)wasobservedwithtreatmentT_5,significantlysurpassingT_1andstatisticallycomparabletoT_7andT_6.Conversely,theminimumpotassiumcontentingrains(0.61%)wasnotedintreatmentT_1.Instraw,thePotassiumcontentinstrawvariedfrom1.15to1.28%.Themaximumpotassiumcontentinstraw(1.28%)wasobservedwithtreatmentT_7,significantlysurpassingT_1andstatisticallycomparabletoT$_5$,andstatisticallycomparabletoT_6.Incontrast,theminimumpotassiumcontentinstraw(1.15%)wasnotedintreatmentT_1.Thesefindingsareconsistentwiththeresultsreportedby**Kumari*etal*.(2013).**

3.7.Potassiumuptakebygrainandstraw(kgha^{-1})

Thepotassiumuptakeinricegrainsexhibitedarangefrom22.16kgha^{-1}to45.17kgha^{-1},asoutlinedinTable3.ThehighestpotassiumuptakeinricegrainswasobservedintreatmentT_7(45.17kgha^{-1}),statisticallycomparabletoT_5(44.41kgha^{-1}),whilethelowestpotassiumuptakeoccurredinthecontrolplotT_1(22.16kgha^{-1}).Inthecaseofricestraw,potassiumuptakerangedfrom66.67kgha^{-1}to105.28kgha^{-1}.ThehighestpotassiumuptakeinricestrawwasfoundinT_7(105.28kgha^{-1}),statisticallyatparwithT_5(103.81kgha^{-1})andthelowestpotassiumuptakewasrecordedinthecontrolplotT_1(66.67kgha^{-1}),Theincreaseduptakeofpotassiuminbothgrainandstrawmaybeattributedtotheapplicationoforganicnitrogensources,whichreleasedmoreNH_4^+andNO_3^{--}inthesoil.This,inturn,occupiedtheselectiveexchangesitesinthe2:1layerclaymineral,replacingtheK^+ionsfromtheseexchangesites.Consequently,thisledtothehighestavailablepotassiumconcentrationinthesoilsolution,resultingingreaterabsorptionbyrice.Thesimilarityinionicradiiofnitrogenandpotassiumionscouldcontributetothisphenomenon.Thecontroltreatmentexhibitedthelowestnitrogen,phosphorus,andpotassiumuptake.**BindraandThakur(1996)**reportedincreasednitrogen,phosphorus,andpotassiumuptakeingrainandstrawduetomanuring.

Table2:EffectofdifferenttreatmentsonN,PandKconcentrationbygrainandstrawofricecrop.

S.No.	Treatmentcombination	Content/Concentration(%)					
		Grain				Straw	
		N	P	K	Protein	N	P
1	Control	1.12	0.3	0.61	7	0.37	0.15
2	Biodynamiccompost1qha^{-1}+50%RDF	1.19	0.31	0.63	7.4	0.38	0.14
3	Biodynamiccompost1.5qha^{-1}+50%RDF	1.24	0.31	0.64	7.7	0.39	0.16
4	T2+RootdippingwithBiodynamiccompostwash10mllit^{-1}ofwater	1.28	0.33	0.68	8	0.42	0.17
5	T3+RootdippingwithBiodynamicwash10mllit^{-1}ofwater	1.32	0.35	0.79	8.2	0.46	0.19
6	T2+foliarapplicationofBiodynamiccompostwashof10mllit^{-1}ofwater	1.28	0.33	0.71	8	0.43	0.17
7	T3+foliarapplicationofBiodynamiccompostwashof10mllit^{-1}ofwater	1.33	0.36	0.78	8.3	0.47	0.19
8	100%RDF	1.25	0.32	0.66	7.81	0.4	0.16
SEm±		0.017	0.005	0.009	0.109	0.006	0.002
C.Dat5%		0.051	0.016	0.029	0.332	0.017	0.006

Table3:Effectofdifferenttreatmentsontotalnutrientuptakebyricecrop.

S.No.	Treatmentscombination	Nutrientuptake(Kgha^{-1})					
		Grains			Straw		
		N	P	K	N	P	K
T_1	**Control**	44.32	11.9	22.16	20.16	8.17	66.67
T_2	**Biodynamiccompost1qha^{-1}+50% RDF**	56.05	14.6	29.67	25.57	8.86	79.43
T_3	**Biodynamiccompost1.5qha^{-1}+50% RDF**	60.78	15.07	31.12	27.23	11.17	72.57
T_4	**T_2+RootdippingwithBiodynamiccompostwash10mllit^{-1}ofwater**	68.09	17.55	36.17	31.99	12.95	92.17
T_5	**T_3+RootdippingwithBiodynamicwash10mllit^{-1}ofwater**	74.41	20.6	44.41	37.6	15.53	103.81
T_6	**T_2+foliarapplicationofBiodynamiccompostwashof10mllit^{-1}ofwater**	70.2	18.1	38.94	32.74	13.45	100.55
T_7	**T_3+foliarapplicationofBiodynamiccompostwashof10mllit^{-1}ofwater**	77.03	20.85	45.17	35.36	15.62	105.28
T_8	**100%RDF**	67.97	16.35	33.73	28.8	11.55	86.66
SEm±		0.891	0.226	0.47	0.407	0.163	1.178
C.D.		2.728	0.693	1.439	1.246	0.498	3.609

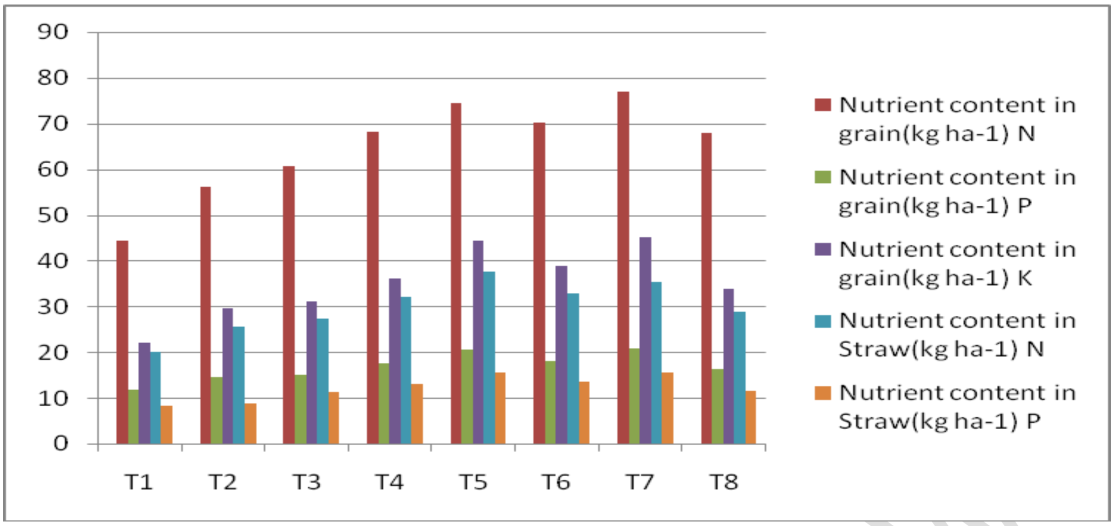

Fig:1Effectofdifferenttreatmentsonuptakeofnitrogen,phosphorus,andpotassium(kgha^{-1})ingrainandstrawofrice.

4. **Conclusion:**Inconclusion,thestudyunderscoresthesignificantpositiveimpactoforganic manureapplication,particularlyintreatmentT_7,onnutrientcompositionanduptakeinricegr ainsandstraw.Theresultsemphasizetheefficacyofintegratedorganicmanurestrategiesine nhancingnitrogen,phosphorus,potassium,andproteincontent.Theobservedvariationsinn utrientuptakearelinkedtoincreasedyieldandimprovednutrientavailabilityfacilitatedbyor ganicmanure.Thecompetitiveuptakeofnitrogenandpotassiumionsfurthercontributestoth eoverallnutrientenhancement.Thesefindingsoffercrucialinsightsforadvancingsustainabl eagriculturalpracticesandoptimizingnutrientmanagementinricecultivation.

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