International Journal of

Agricultural Research

ISSN 1816-4897

Academic
Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 2 (8): 704-711, 2007
ISSN 1816-4897

Dry Matter Production, Nutrient Uptake and Yield of Rice Crop Influenced by Previous Season Sesame Crop

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Abstract: A field experiment was conducted in loamy sand soils to study the impact of sesame crop on the dry matter production, nutrient uptake and yield of succeeding rice crop during the year 2004-05 in two consecutive seasons in a Factorial Randomized Block Design (FRBD). The field was divided into 60 plots and in the Summer season, sesame crop was raised in 30 plots and the other 30 plots were kept fallow. In the next season (Kharif), the rice crop was raised in all the 60 plots of two different situations viz., with sesame as previous crop (Situation I) and without sesame as pervious crop (Situation II) with two rice cultivars viz., ADT 38 and KR 99001 and five levels of nitrogen (N) viz., 0, 50, 100, 150 and 200 kg N ha^{-1}. The Dry Matter Production (DMP) at Active Tillering (AT) stage was high in situation II over situation I and not so at Panicle Initiation (PI) stage, might be due to low nutrient status at AT caused by previous season sesame crop's removal, might be overcomed at PI by the nutrient addition from mineralizing sesame stubbles. The variation in the situations did not bring any significant variation in grain yield, but slightly higher yield was noticed in situation II over situation I. Both ADT 38 and KR 99001 manifested higher yields at 150 kg N ha^{-1} in both the situations revealed the fact that this level of N is sufficient for better growth and development of rice crop. The straw yield was comparable in both the situations. The nitrogen and potassium (K) uptake was equal under both the situations at AT and PI but phosphorous (P) was accumulated more in situation II at AT but comparable at PI. This might be due to initial low requirement of nutrients met by inorganic sources and later the situation I managed the nutrients lost in previous season with mineralization process, whereas the phosphorous, though applied as basal might not fully available in the initial stages itself, might be fixed. The nutrient uptake by straw was higher in situation II owing to higher DMP but grain uptake was comparable because of genetic nature.

Key words: Rice, sesame, situations, DMP, uptake

INTRODUCTION

Sesame is grown as rice-fallow crop during Summer season with the use of residual moisture and nutrients of pervious season (*Rabi*) rice crop. Hence, no fertilizers are applied to the sesame crop, which is also a nitrogen responsive crop. The response of sesame to N fertilizer varies from 20-150 kg ha^{-1} as per the report of Hemalatha *et al*. (1999). This sesame crop may utilize the native soil N also for its growth and development. This may affect the nutrient uptake by the next season

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crops. If rice crop is grown in the following season, it may suffer to extract nutrients from the soil because of nutrient removal by sesame and also leads to fixation of applied inorganic nutrients. Rice is also a nutrient responsive crop, which is the maximum consumer of N fertilizer constituting one third of the total N consumption of the world (Saravana Pandian and Rani Perumal, 2002). Thus, N is the most critical input that limits rice productivity and increasing rice productivity would mean more supply of N to the crop. Increasing the rice productivity per unit area by the use of appropriate agronomic management practices has become an essential component of rice production technology (Sridevi *et al*., 2006). Lowland rice depends more on soil fertility than on fertilizers. The dependence of lowland rice on soil fertility is best illustrated by a Japanese saying "Grow paddy with soil fertility, Grow barley with fertilizers" (Yoshida, 1981). Since both are nutrient responsive crops, the sesame crop grown in the previous season may affect the growth and development of rice crop. This impact of growing sesame in previous season on dry matter production, nutrient uptake and yield of rice crop was studied in this experiment.

MATERIALS AND METHODS

Experimental Design and Treatment Details

The experiment was conducted in a loamy sand soil of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Union Territory of Pondicherry, India during the year 2004-05. The experimental site is situated 12 km from Bay of Bengal, lies between 10° 49' and 11° 01' North latitude and 78° 43' and 79° 52' East longitude with an altitude of 4 m above Mean Sea Level (MSL). The initial soil analyses showed that the soil was loamy sand in texture falls in ***Fluventic haplustept*** taxonomic class. The soil is optimum in bulk density (1.33 mg m^{-3}) and particle density (2.66 mg m^{-3}) with the porosity of 50%. The soil reaction was neutral (pH: 7.61) and the electrical conductivity is low (0.21 dS m^{-1}). The soil was low in organic carbon content (0.32%) and available nitrogen ($KMnO_4$-N: 213 kg ha^{-1}), medium in available potassium (NH_4OAc-K: 262 kg ha^{-1}) and high in available phosphorous (Olsen-P: 31.4 kg ha^{-1}). The experiment was conducted in FRBD design with three replications. The treatmental details are given in Table 1.

The field was divided in 60 equal plots of 20 m^2. The experiment was carried out in two consecutive seasons. In the Summer season (Chithirai pattam), the 30 plots of the field was raised with sesame and the other plots were kept fallow. The sesame crop was cultivated with residual nutrients of previous season (*Rabi*) rice crop without any artificial means of supply and harvested. In the *Kharif* season, the left out sesame stubbles of about 15-20 cm height were incorporated 15 days before transplanting. Rice crop was raised in all the 60 plots of two different situations viz., with sesame as previous crop (situation I) and without sesame as pervious crop (situation II) with two cultivars viz., a medium duration variety of ADT 38 and a long duration pre-release culture of KR 99001 with five levels of nitrogen viz., 0, 50, 100, 150 and 200 kg N ha^{-1}. The treatment details are given in Table 1. The nitrogen (N) was supplied through urea in four equal splits as basal, at active tillering, panicle initiation and grain filling stages as per the treatment levels. Phosphorous (P) (@ 50 kg ha^{-1}) was supplied through single super phosphate in two equal splits as basal and at active tillering stage; potassium (K) (@ 50 kg ha^{-1}) through muriate of potash in four equal splits as that of N and zinc through zinc sulphate (@ 12.5 kg ha^{-1}) as basal. A hand weeding was done at 25 days after transplanting to remove the competitive weeds in the field. A pesticide spray of monocrotophos @ 250 mL ha^{-1} was given at 30 days after transplanting to control leaf folders. The DMP was recorded at Active Tillering (AT) stage and Panicle Initiation (PI) stage. The plant samples were analyzed for nutrient content and multiplying with DMP the nutrient uptake was calculated. The crop was harvested separately from the plots, harvested and winnowed and grain and straw yields were recorded. The observations collected from the field experiment and the data of analyses of soil and plant samples were subjected to statistical scrutiny as per the procedure of Gomez and Gomez (1984).

Table 1: Treatment details of rice varieties (V) under varying field conditions (S) with nitrogen levels (N)

	Treatment details		
Notation	Previous season crop (S)	Variety (V)	N dose (kg ha^{-1}) (N)
$S_1V_1N_0$	Sesame	ADT 38	0
$S_1V_1N_{50}$	Sesame	ADT 38	50
$S_1V_1N_{100}$	Sesame	ADT 38	100
$S_1V_1N_{150}$	Sesame	ADT 38	150
$S_1V_1N_{200}$	Sesame	ADT 38	200
$S_1V_2N_0$	Fallow	KR99001	0
$S_1V_2N_{50}$	Fallow	KR99001	50
$S_1V_2N_{100}$	Fallow	KR99001	100
$S_1V_2N_{150}$	Fallow	KR99001	150
$S_1V_2N_{200}$	Fallow	KR99001	200
$S_2V_1N_0$	Sesame	ADT 38	0
$S_2V_1N_{50}$	Sesame	ADT 38	50
$S_2V_1N_{100}$	Sesame	ADT 38	100
$S_2V_1N_{150}$	Sesame	ADT 38	150
$S_2V_1N_{200}$	Sesame	ADT 38	200
$S_2V_2N_0$	Fallow	KR99001	0
$S_2V_2N_{50}$	Fallow	KR99001	50
$S_2V_2N_{100}$	Fallow	KR99001	100
$S_2V_2N_{150}$	Fallow	KR99001	150
$S_2V_2N_{200}$	Fallow	KR99001	200

Optimization of N Requirement

The data on the grain yield of rice under various treatments were fitted into the appropriate response function following statistical procedures. In case where the response function was quadratic type, the physical optimum dose of N was calculated by equating the first order derivative of the [dy/dx = 0] response function to zero,

The economic optimum dose was calculated by equating the first order derivative of the response function to the rice ratio (px/py) i.e.,

$$[dy/dx = px/py]$$

taking into account the unit cost of N kg^{-1} as 10.4 and price of rice grain as Rs. 5 kg^{-1}.

RESULTS AND DISCUSSION

Dry Matter Production

At AT, the DMP was found to be higher in situation II over situation I in both the varieties (Table 2). This might be due to the removal of nutrients by sesame crop, which is also N responsive crop as reported by Praveen Rao *et al.* (1994), might cause initial set back in supply of nutrients to the crop. Higher levels of N produced higher DMP at this stage. At PI, unlike at AT, the performance rice varieties were not influenced between the situations. This shows that the crop would have received nutrients from decomposed stubbles of sesame at later stage in situation I. The combination of organic and inorganic N in situation I and the normal supply of nutrients in situation II resulted in better performance of rice crop in both the situations. This kind of results was obtained by Omar Hattab *et al.* (1998) and Priyadarsini and Prasad (2003). In both the situations increasing N levels increased the DMP. This is obvious and in line with the findings of Srinivasalu Reddy (1998) and Somasundaram *et al.* (2002).

Grain Yield

The variation in the field conditions due to the situations did not bring significant variation in grain yield, but slightly higher yield was noticed in situation II over situation I (Table 2). This might be due

Table 2: DMP, grain and straw yield and N uptake by rice varieties under different soil conditions

	DMP at AT (t ha^{-1})			DMP at PI (t ha^{-1})			Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		
Treatments	V_1	V_2	Mean	V_1	V_1	Mean	V_1	V_2	Mean	V_1	V_2	Mean
S_1N_0	0.65	0.65	0.65	2.70	2.95	2.83	2.63	3.48	3.05	5.17	5.95	5.56
S_1N_{50}	0.85	0.89	0.87	2.85	3.01	2.93	2.82	3.95	3.39	5.23	7.12	6.17
S_1N_{100}	1.11	1.09	1.10	3.62	3.68	3.65	3.24	4.31	3.78	6.51	8.75	7.63
S_1N_{150}	1.36	1.23	1.29	3.52	3.75	3.63	3.93	4.70	4.32	7.73	9.86	8.79
S_1N_{200}	1.41	1.47	1.44	3.71	3.99	3.85	3.22	4.06	3.64	7.17	8.87	8.02
Mean	1.08	1.07	1.07	3.28	3.48	3.38	3.17	4.10	3.64	6.36	8.11	7.24
S_2N_0	0.74	0.69	0.72	2.91	2.10	2.51	2.84	3.68	3.26	5.03	6.97	6.00
S_2N_{50}	0.90	0.91	0.91	2.87	2.54	2.71	3.15	4.02	3.58	6.18	8.63	7.41
S_2N_{100}	1.20	1.19	1.20	2.99	3.36	3.17	3.83	4.68	4.25	6.28	9.68	7.98
S_2N_{150}	1.45	1.40	1.42	3.99	3.21	3.60	3.91	4.74	4.32	6.95	9.45	8.20
S_2N_{200}	1.56	1.84	1.70	3.90	4.08	3.99	3.48	4.10	3.79	7.21	9.20	8.21
Mean	1.17	1.21	1.19	3.33	3.06	3.19	3.44	4.24	3.84	6.33	8.79	7.56
	S	SxN	SxVxN	S	SxN	SxVxN	S	SxN	SxVxN	S	SxN	SxVxN
SED	0.42	0.10	0.14	0.15	0.34	0.48	0.12	0.28	0.39	0.33	0.74	1.04
CD	0.09	0.19	0.27	NS	NS	0.97	NS	NS	0.79	NS	1.49	2.11
	N uptake at AT (kg ha^{-1})			N uptake at PI (kg ha^{-1})			N uptake by Grain (kg ha^{-1})			N uptake by Straw (kg ha^{-1})		
S_1N_0	7.33	7.20	7.27	29.21	26.94	28.08	29.87	30.68	30.27	20.86	27.63	24.24
S_1N_{50}	8.48	9.98	9.23	46.37	32.04	39.20	33.15	50.65	41.90	37.33	29.89	33.61
S_1N_{100}	14.05	13.21	13.63	57.30	46.85	52.08	46.24	60.13	53.19	39.54	32.40	35.97
S_1N_{150}	16.49	18.09	17.29	58.00	51.23	54.62	55.83	66.97	61.40	46.34	45.22	45.78
S_1N_{200}	18.21	19.64	18.92	60.75	54.45	57.60	53.25	65.77	59.51	49.17	46.13	47.65
Mean	12.91	13.62	13.27	50.33	42.30	46.31	43.67	54.84	49.25	38.65	36.25	37.45
S_2N_0	5.05	6.32	5.69	29.32	28.66	28.99	28.28	31.97	30.12	32.62	33.55	33.09
S_2N_{50}	7.85	11.89	9.87	40.22	33.98	37.10	40.03	55.95	47.99	34.47	40.19	37.33
S_2N_{100}	14.27	14.49	14.38	48.07	29.88	38.98	50.26	67.99	59.12	42.79	44.98	43.89
S_2N_{150}	16.05	17.61	16.83	58.25	53.77	56.01	55.53	67.64	61.58	44.94	53.86	49.40
S_2N_{200}	18.85	21.61	20.23	68.77	56.62	62.70	58.98	70.07	64.53	54.60	54.11	54.36
Mean	12.41	14.38	13.40	48.93	40.58	44.75	46.61	58.72	52.67	41.89	45.34	43.61
SED	0.48	1.09	1.54	2.25	5.03	7.12	2.85	6.39	9.03	2.15	4.81	6.80
CD	NS	NS	3.11	NS	NS	14.39	NS	NS	18.28	4.35	NS	13.76

S_1: Situation 1; S_2: Situation 2; NS: Non Significant

to the reason that the incorporated stubbles of sesame in field might have released the immobilized N in the later stages and supported the crop growth and yield. The slight variation might be due to the differential supply of nutrients in the initial stages of crop growth, wherein the nutrient supply was low in situation I, caused by uptake of nutrients by sesame crop.

Optimization of Nitrogen Requirement

In the case of medium duration variety ADT 38, the physical optimum was with 157 kg N ha^{-1} and economic optimum was with 133 kg N ha^{-1}. The pre-release culture KR 99001 showed its physical optimum with 131 kg N ha^{-1} and economic optimum with 114 kg N ha^{-1}. Both medium duration variety ADT 38 and long duration pre-release culture KR 99001 manifested higher yields at 150 kg N ha^{-1} in both the situations. This revealed the fact that this level of N, which is a recommended dose of N for medium and long duration rice crop, is capable of supplying nutrients to the demand of the crop at appropriate stages both by direct supply of nutrients and by indirect supply through mineralization of sesame stubbles. This kind of result that is the combination of organic and inorganic sources of N in enhancing the yield finds support from Wopereis *et al.* (1994), Saravana Pandian and Rani Perumal (1994) and Omar Hattab *et al.* (2000).

Straw Yield

The straw yield was not significantly influenced by the situations studied (Table 2). This might be due to late recovery of rice from the impact of nutrient loss caused by the sesame crop in the previous season in situation I. The immobilized N by the sesame stubbles would have been released in the later stages. The beneficial effect of mineralization of nutrients from the crop residues was well established by Omar Hattab *et al.* (1998), Singh *et al.* (1997), Grace *et al.* (1999), Deka Medhi and Medhi (2000) and Rajni Rani and Srivastava (2001).

Nitrogen Uptake at Active Tillering Stage

There was no significant difference in N uptake under the situations studied (Table 2). Each N level performed similarly under both the situations. The reason might be that the accumulation of N in crop at initial stages would be low and be satisfied by the situations and N levels. This is in agreement with the findings of Palaniappan and Siddeswaran (1994), who had witnessed no variations in the N uptake by rice crop at initial stages of crop growth due to different N levels.

Nitrogen Uptake at Panicle Initiation Stage

The same trend as that of AT was noticed here also, but the uptake values were found to be high as compared to active tillering stage. In general, increasing N levels increased the crop N uptake. This was also experienced by Palaniappan and Siddeswaran (1994) and Hussain (1999).

Nitrogen Uptake by Straw

The N uptake by straw was found to be significantly higher in situation II than in situation I. This was well established in long duration KR 99001, but not in medium duration ADT 38. The variation might be due to higher need of N from panicle initiation stage for long duration variety as reported by Sivasamy *et al.* (1994), who observed the maximum rate of N uptake from urea during panicle initiation stage to first flowering phase in long duration CR 1009.

Nitrogen Uptake by Grain

The N uptake by seeds was not significantly influenced by the situations. Each N level performed similarly under both the situations. The N levels increased the N uptake but not significantly. The N uptake by grains was found to be low in control, which is quite expected.

Phosphorus Uptake at Active Tillering Stage

The P uptake was found to be significantly higher in situation II, where the dry matter production was higher over situation I and accordingly manifested higher P uptake (Table 3). The higher uptake of P by medium duration variety ADT 38 in situation II was with 200, 150 and 100 kg N ha^{-1}, but in situation I, it was only with 200 kg N ha^{-1}, revealing the need of N in situation I for P uptake. This might be due to the reason that in situation I the biomass production was high only with 200 kg N ha^{-1}. This possible correlation of N supply with P uptake was pronounced from the findings of Omar Hattab *et al.* (2000).

Phosphorus Uptake at Panicle Initiation Stage

The P uptake was not influenced by the situations studied and N levels compared. This might be due to the reason that at this stage of crop, equal amount of dry matter was produced by both the situations. Increasing N levels increased the P uptake, which was also observed by Omar Hattab *et al.* (2000).

Phosphorus Uptake by Straw

The P uptake of straw was found to be higher in situation II than in situation I. The higher straw yield under situation II resulted in higher P accumulation in straw. Increasing N levels increased the P uptake due to higher DMP. With 150 kg N ha^{-1}, the situation II recorded higher P uptake by producing more biomass than in situation I.

Table 3: P and K uptake by rice varieties under different soil conditions

	P uptake at AT ($kg\ ha^{-1}$)			P uptake at PI ($kg\ ha^{-1}$)			P uptake by Grain ($kg\ ha^{-1}$)			P uptake by Straw ($kg\ ha^{-1}$)		
Height	V_1	V_2	Mean	V_1	V_1	Mean	V_1	V_2	Mean	V_1	V_2	Mean
S_1N_0	1.36	1.18	1.27	4.83	4.31	4.57	6.45	9.06	7.76	8.19	5.54	6.86
S_1N_{50}	1.62	1.32	1.47	5.95	5.63	5.79	8.14	9.10	8.62	9.19	6.99	8.09
S_1N_{100}	2.45	2.44	2.45	6.12	6.56	6.34	10.34	9.60	9.97	9.74	8.66	9.20
S_1N_{150}	3.07	2.58	2.82	7.82	7.87	7.84	13.52	9.81	11.67	9.35	9.67	9.51
S_1N_{200}	3.82	3.57	3.69	9.54	8.44	8.99	14.29	10.15	12.22	14.78	10.99	12.89
Mean	2.46	2.22	2.34	6.85	6.56	6.71	10.55	9.55	10.05	10.25	8.37	9.31
S_2N_0	1.73	1.43	1.58	5.26	3.93	4.59	8.44	7.99	8.22	7.81	5.61	6.71
S_2N_{50}	1.85	2.05	1.95	6.16	5.27	5.72	8.81	8.92	8.87	9.11	6.63	7.87
S_2N_{100}	2.72	2.76	2.74	7.56	6.98	7.27	10.56	9.98	10.27	12.61	8.67	10.64
S_2N_{150}	3.01	3.05	3.03	8.44	8.19	8.32	13.59	11.67	12.63	13.75	10.42	12.08
S_2N_{200}	3.10	3.82	3.46	9.44	9.11	9.28	14.09	13.41	13.75	14.84	13.62	14.23
Mean	2.48	2.62	2.55	7.37	6.70	7.03	11.10	10.40	10.75	11.62	8.99	10.31
	S	SxN	SxVxN	S	SxN	SxVxN	S	SxN	SxVxN	S	SxN	SxVxN
SED	0.08	0.17	0.24	0.28	0.62	0.88	0.48	1.07	1.52	0.35	0.78	1.11
CD	0.16	0.34	0.49	NS	NS	1.77	NS	NS	3.07	0.71	1.59	2.24
	N uptake at AT ($kg\ ha^{-1}$)			N uptake at PI ($kg\ ha^{-1}$)			N uptake by Grain ($kg\ ha^{-1}$)			N uptake by Straw ($kg\ ha^{-1}$)		
S_1N_0	16.2	10.4	13.2	35.1	41.2	38.1	12.3	13.4	12.8	63.4	60.5	62.0
S_1N_{50}	18.7	19.1	18.9	46.0	52.4	49.2	13.7	14.2	14.0	76.9	71.6	74.3
S_1N_{100}	22.7	20.2	21.5	50.8	74.0	62.4	14.1	15.8	15.0	96.9	79.9	88.4
S_1N_{150}	28.0	31.0	29.5	59.7	67.4	63.6	18.9	17.0	17.9	109.7	103.6	106.7
S_1N_{200}	30.1	41.0	35.6	62.2	62.4	62.3	18.2	14.1	16.2	125.2	103.3	114.3
Mean	23.1	24.3	23.7	50.7	59.5	55.1	15.4	14.9	15.2	94.4	83.8	89.1
S_2N_0	16.4	10.3	13.3	49.7	35.2	42.41	12.6	12.1	12.3	84.7	63.0	73.8
S_2N_{50}	20.6	20.0	20.3	51.6	55.7	53.6	13.1	12.7	12.9	90.8	85.4	88.1
S_2N_{100}	25.2	25.2	25.2	54.3	54.7	54.5	17.6	15.8	16.7	103.6	87.1	95.4
S_2N_{150}	28.7	32.2	30.5	59.7	58.0	58.8	20.5	16.3	18.4	113.6	93.3	103.4
S_2N_{200}	32.4	43.3	37.9	64.7	85.3	75.0	20.5	14.0	17.3	124.5	112.4	118.5
Mean	24.7	26.2	25.4	56.0	57.7	56.9	16.9	14.2	15.5	103.4	88.2	95.8
SED	0.92	2.1	2.9	2.0	4.5	6.4	0.6	1.3	1.8	3.1	7.0	9.9
CD	NS	NS	6.0	9.1	13.0	NS	NS	3.6	6.3	NS	20.0	

NS: Non Significant; S_1: Situation 1; S_2: Situation 2

Phosphorus Uptake by Grain

There was no significant variation in P uptake by grain under different situations. The uptake was found to be increased with increased N levels for both the varieties under both the situations, but the increase was not to a greater extent. This slight variation might be due to the variations in grain yield owing to N levels.

Potassium Uptake at Active Tillering Stage

The uptake of K was not significantly influenced by the situations studied (Table 3). Each N level also performed equally between the situations. This might be due to the reason that the ability of the soils of both the situations to supply enough K by direct inorganic source in situation II and by combination of organic and inorganic source in situation I (Priyadarshini and Prasad, 2003).

Potassium Uptake at Panicle Initiation Stage

The situations did not create any variation in the K uptake. But, the highest dose of N i.e., 200 kg N ha^{-1} recorded significantly higher uptake of K in situation II over situation I. Again this result could be the reflection of DMP.

Potassium Uptake by Straw

The K uptake was found to be significantly higher in situation II than in situation I, might be due to the higher straw yield and the K is consumed luxurily by the crop, the straw in situation II showed higher values for K uptake.

Potassium Uptake by Grain

The accumulation of potassium in grain was not significantly varied with the situations. The performances of both each variety and N level were comparable under both the situations.

CONCLUSIONS

The sesame crop grown in previous season with residual moisture and nutrients of *Rabi* rice crop has no profound effect on next season rice crop. The DMP was initially low in situation I but managed in later stages. The N and K uptake at AT was equal under both the conditions but P uptake was high in situation II, because initial fixation of P in the soil. The nutrient uptake at PI stage was comparable in both the situations by the recovery of nutrient from inorganic and organic supply. Thu nutrient uptake by grain was comparable in both the situations owing to genetic nature. The uptake by straw was high in situation II, due to high biomass and luxurious consumption of potassium. The optimization procedure reveals that the recommended dose of N i.e., 150 kg N ha^{-1} will be sufficient for better growth and development. The nutrient uptake and yield of rice crop were not significantly influenced by the previous season sesame crop. The sesame crop grown in previous season did not affect the nutrient uptake and yield of succeeding rice crop.

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