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Effect of different nitrogen levels and bio-fertilizers along with banana pseudostem sap on summer hybrid rice (*Oryza sativa* L.) under south Gujarat condition

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Abstract
The experiment was executed during summer 2019 at Main Rice Research Station, Navsari to assess the effect of different nitrogen levels in conjunction with biofertilizers along with banana pseudostem sap on hybrid rice (*Oryza sativa* L.) under south Gujarat. It was carried out in split plot design with three replications and sixteen treatment combinations comprises of four N levels (N_1:80, N_2:100, N_3:120 and N_4:140 kg N/ha) as main plots and four bio-fertilizer treatments (B_1:Control, B_2:*Azospirillum*, B_3:*Azospirillum* + PSB and B_4:Banana pseudostem enrich sap) as sub plots. Significantly maximum plant height, effective tillers hill^{-1}, LAI, CGR obtained with application of 140 kg N/ha. The same N rate also produced highest panicle length, panicles m^{-2}, panicle weight, grains panicle^{-1}, grain yield (4.60 t/ha), straw yield (5.57 t/ha) and harvest index of hybrid rice. Grain and straw yields were increased to the tune of 39.72 and 28%, respectively with 140 kg N/ha over lower N level: however, it remained at par with N_3. The *Azospirillum* + PSB inoculation registered significantly higher growth parameters, yield components and yields of hybrid rice over other tested biofertilizers. *Azospirillum* + PSB application increased the grain (4.52 t/ha) and straw (5.47 t/ha) yields to the tune of 31.39 and 22%, respectively over control (B_1). The N and bio-fertilizer interaction exerted significant effect on growth attributes, yield components and yields except plant height at 20 DAT, LAI, CGR and test weight. The maximum economic benefit was obtained with application of 140 kg N/ha along with *Azospirillum* + PSB.

Keywords: Bio-fertilizers, hybrid rice, nitrogen levels, yield

Introduction
Rice (*Oryza sativa* L.) occupies about 43.79 million hectare area which accounting for 29% of the global rice extent with the production of 118.40 million tonnes in India. In Gujarat, rice is grown in an area of 10.61% of gross cropped area of state and accounts for 25.5% of the total food grain production. It is grown on an average about 8.5 lakh hectares of area comprising nearly 70-80% of the low land *i.e*. transplanted (Anonymous, 2019) [2].

Out of 43 million hectares of rice cultivated area, only 6% of the land is under hybrid rice. Hybrid rice cultivation provides an additional yield advantage of 0.5 to 1 t/ha. Rice crop removes 16-17 kg nitrogen for the production of each ton of rough rice including straw. Instead of using chemical fertilizers alone as a source of nitrogen, it has been found that a combination of bio-fertilizers with chemical fertilizers is better option to decrease the quantity and cost of chemical fertilizers (Singh *et al*., 2006) [17]. Bio-fertilizers will encounter the effect of indiscriminate use of chemical fertilizers, stimulate the plant growth and also enhances the soil health, fertility and productivity status (Islam *et al*., 2012) [8]. Among all bio-fertilizers, *Azospirillum* is found to be associated with grass plants and cereal crops. Banana pseudostem enrich sap is a liquid fertilizer which is rich in nutrients and growth promoting substances. It enhances the crop yield with very less input costs (Salunkhe *et al*., 2013) [15]. So, present study was planned to find out the performance of hybrid rice to different nitrogen levels and bio-fertilizers under south Gujarat condition to enhance the yield, soil health and fertility status on sustainable basis.

Materials and Methods
This field study was carried out during summer season in 2019 at main rice research station farm, Soil and Water Management Research Unit, N.A.U., Navsari. Geographically, farm located at 20^{0}10' N latitude, 73^{0}20' E longitude and has an altitude of 10 m above the mean sea level. The soil was clayey in texture with pH 7.87, 0.4% O. C. (low O.C.), 0.45 dS/m EC, 199 kg available N/ha and 30.4 kg/ha of available P_2O_5.

The hybrid rice (GRH 2) of 30 days old seedlings (single seedling per hill) were transplanted with geometry of 20 x 15 cm on 29th January, 2019 and harvested on 10th June, 2019. The experiment was laid out in split plot technique with three replications. The treatments comprised of combination of four nitrogen levels (80, 100, 120 and 140 kg N/ha) and three bio-fertilizers (*Azospirillum*, *Azospirillum* + PSB and 1% Banana pseudostem enrich sap) along with control.

Nitrogen was applied as per the treatments in the form of urea in three split doses (40% at basal, 40% at tillering and 20% at P.I. stages). Bio-fertilizers *viz*., *Azospirillum* and PSB each of 2 kg/ha were mixed with FYM and applied as per the treatments at transplanting and Banana pseudostem enrich sap (1%) was sprayed at tillering + grain filling stages. Basal application of 30 kg P_2O_5/ha was applied in the form of SSP as common. Growth attributes like plant height at 20, 40 DAT and at harvest, no. of tillers hill^{-1} and effective tillers hill^{-1} at 75 DAT, LAI during 30, 60 and at 90 DAT and CGR at 30-60 and 60-90 DAT were recorded from five selected and tagged hills in each plot and their average was worked out.

LAI was calculated by using following formula

$$\text{LAI} = \frac{\text{Leaf area}}{\text{Ground area}}$$

CGR was calculated by using following formula

$$\text{CGR (g/ m}^2\text{/day)} = \frac{W2-W1}{P\ X\ (t2-t1)}$$

Where, W_1 and W_2 are dry weight of plants m^{-2} at times t_1 and t_2, respectively; P is land area.

Yield parameters *viz*., panicle length, panicles m^{-2}, weight of panicle, grains panicle^{-1}, test weight (1000 grain weight) were recorded at maturity. After harvest, grain yield, straw yield and harvest index also registered. Harvest Index was computed by using following formula

$$\text{H.I. (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \text{ x } 100$$

The economics of hybrid rice was worked out by considering the prevailing market price of the inputs and outputs. BCR was calculated as follows:

$$\text{BCR} = \frac{Gross\ income\ (Rs./ha)}{Total\ cost\ of\ cultivation\ (Rs./ha)}$$

Data was analyzed statistically by the method of analysis of variance (ANOVA) and tested by P- value at 0.05 level of probability and CD was worked out wherever the effects found significant.

Result and Discussion

Growth parameters

Application of 140 kg N/ha produced tallest plants with values of 44.1 cm and 98.9 cm at 40 DAT and at harvest, respectively accounting 13% and 9% more than 80 kg N/ha. However, it remained at par with N_3 at 40 DAT, but, treatments were failed to show the significant effect with respect to plant height at 20 DAT. Significantly highest no. of tillers hill^{-1}, effective tillers hill^{-1}, LAI (30, 60 and 90 DAT), CGR (30-60 and 60-90 DAT) of hybrid rice were recorded under 140 kg N/ha, accounting 24%, 23%, 12%, 9%, 6%, 43% and 25% greater than lower tested nitrogen level, respectively (Table 1).

Plant height was increased linearly with the increase of nitrogen rates and other growth parameters also followed the similar trend. N plays a key role in enhancing the plant height due to its effect on crop vegetative growth development. Maximum no. of tillers and effective tillers hill^{-1} observed with N_4 due to availability of required quantity of N for long period of time (Wijebandara *et al*., 2008) [22]. Maximum no. of leaves and its size increment achieved with N_4. Hence, it helps in enhancing the LAI at all stages. It decreased gradually towards lower N rate. According to Watson (1947) [21], leaf area typically increases after crop emergence to a maximum and then decline. LAI is an essential parameter to describe photosynthesis and plant productivity. Higher LAI augments the dry matter production by accumulating photosynthates. CGR was highest at heading stage of crop. These findings are in agreement with Shivay *et al.* (2003) [16], Singh *et al.* (2006) [17], Lar *et al*. (2007) [9], Awan *et al.* (2011) [4], Gill and Walia (2014) [7], Yadav *et al*. (2016) [24] and Meena *et al*. (2019) [13].

Highest growth parameters *viz*., plant height, no. of tillers hill^{-1}, effective tillers hill^{-1}, LAI and CGR were registered by *Azospirillum* + PSB compared to control (without bio-fertilizer), while, bio-fertilizers responded non-significantly with regard to plant height at 20 DAT (Table 1). However, B_3 was statistically at par with B_2 and B_4 only at 60-90 DAT in case of CGR. Similar observations were within the close vicinity of Yadav *et al*., (2013) [23] and Anand and Kamaraj, (2017) [3]. Higher growth attributes considerably due to *Azospirillum* and PSB inoculation through nitrogen fixation, growth hormone secretion and mineral phosphorus solubility, its uptake by plants, respectively. PSB has ability to produce phyto-hormones, capability of nutrient extraction and converts the insoluble form of phosphorus into soluble forms and made them available to plants which resulted in increased growth and yield. Phosphorus played vital role in translocation of assimilates to the panicles and also as a constituent of protoplasm. Garai *et al.*, (2013) [5] reported that phosphorus played major role in conversion of tiller to effective tiller. Combined application of 140 kg N/ha and *Azospirillum* + PSB proved its superiority over other treatment combinations with respect to all measured growth attributes (Table 3), however, it has shown a non-significant effect on LAI and CGR at all stages of hybrid rice.

Yield components

Fertilization with 140 kg N/ha produced crop with highest panicles m^{-2}, panicle weight, grains panicle^{-1}, accounting 36%, 36% and 31% higher than that of lower N level, however, length of panicle and test weight were failed to show the significant effect (Table 2). All above measured yield components were recorded significantly higher under *Azospirillum* + PSB over other bio-fertilizer and control treatments with the values of 22.8, 279.1, 3.3 and 193.2, respectively, which were 5%, 18%, 26% and 14% more than control (Table 2). While, bio-fertilizer treatments were not showed a significant variation with respect to test weight of rice. *Azospirillum* and PSB helps in enhancing the soil fertility, thereby increase in the availability of nitrogen and phosphorus, respectively. *Azospirillum* improves the nitrogen uptake by the plant through associative symbiosis with rice plants. Application of 140 kg N/ha along with *Azospirillum* +

PSB increased the length of panicle, no. of panicles m^{-2}, panicle weight, grains $panicle^{-1}$ over rest of the combinations (Table 3).

Yield and harvest index

As depicted in Fig. 1, the treatment with 140 kg N ha^{-1} recorded significantly highest grain yield (4.6 t/ha) and straw yield (5.57 t/ha) with an increase to the tune of 5.57 and 4.51 per cent, respectively compared to N_3, but it was remain at par with 120 kg N/ha. Highest harvest index also noted with 140 kg N/ha with the value of 45.21%. The treatment fertilized with 80 kg N/ha registered 28% and 22% lesser grain and straw yields of rice compared to 140 kg N/ha (Table 2). Yields were reduced drastically where 80 kg N/ha was applied. These yield differences were due to differences in number of total and effective tillers per hill as similar result also has been reported by Garai *et al.*, (2013) [5]. Generally, hybrid variety consumes more and more amount of nutrients. In the present experiment, crop yields were increased linearly with increase in nitrogen level due to maximum number of total and effective- tillers, more number of panicles m^{-2} and grains $panicle^{-1}$. The above results are in line with the findings of Shivay *et al*. (2003) [16], Maiti *et al*. (2006) [10], Singh *et al*. (2006) [17], Awan *et al.* (2011) [4], Gill and walia (2014) [7], Yadav *et al*. (2016) [24] and Meena *et al*. (2019) [13].

Inoculation of *Azospirillum* + PSB recorded highest grain yield, straw yield and harvest index with the values of 4.52 t/ha, 5.47 t/ha and 45.22%, respectively, accounting 31%, 22% and 4% higher than control (Table 2). In grain yield, the decreasing order of treatments is of $B_3>B_2>B_4>B_1$. These results are in conformity with those reported by Singh *et al*. (2006) [18], Meena *et al*. (2013) [12], Yadav *et al*. (2013) [23], Ghosh *et al*. (2016) [6], Anand and Kamaraj (2017) [3] and Rozalin *et al.* (2017) [14]. Biofertilizers application increases plant growth and yields without impairing soil fertility and productivity. Highest grain yield, straw yield and harvest index was achieved with the treatment combination of 140 kg N/ha along with *Azospirillum* + PSB over other combinations (Table 3). Wijebandara *et al*. (2008) [22] states that, In addition to its high N fixation, *Azospirillum* is known to synthesize growth substances like IAA, auxins and vitamin B which might have also helped in increasing the plant height, number of tillers, dry matter production and ultimately increase the yield. PSB helps to solubilise the P in soil. The yield attributes like panicles m^{-2}, panicle weight and grains $panicle^{-1}$ were increased in the same treatment combination and ultimately it showed positive effect on rice yields. Similar results were also reported by Mathews *et al*. (2006) [11], Islam *et al*. (2012) [8], Garai *et al*. (2013) [5], Tandel *et al*. (2013) [19], Tejaswini *et al*. (2017) [20] and Aatheeswari *et al*. (2019) [1].

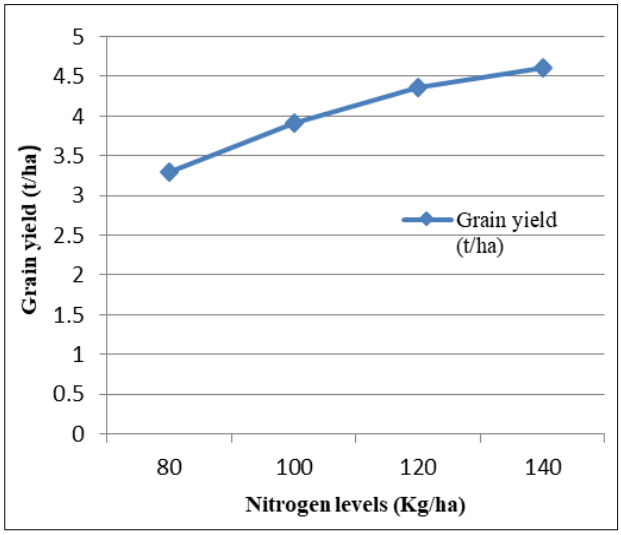

Fig 1: Effect of various N levels on grain yield (t/ha) of hybrid rice

Table 1: Effect of various levels of nitrogen and bio-fertilizers on growth parameters of hybrid rice

Treatment	Plant height (cm)			Total tillers $hill^{-1}$	Effective tillers $hill^{-1}$	LAI			CGR (g/m^2/day)	
	20 DATP	40 DATP	At Harvest			At 30 DATP	At 60 DATP	At 90 DATP	At 30-60 DATP	At 60-90 DATP
Main Plot [Nitrogen levels (N)]										
N_1	24.4	38.8	90.3	17.5	17.4	2.23	4.84	4.19	9.47	28.05
N_2	25.1	42.4	96.1	19.5	19.4	2.33	5.08	4.34	10.40	30.80
N_3	25.6	43.0	96.9	20.8	20.8	2.43	5.21	4.47	13.51	35.01
N_4	25.4	44.1	98.9	21.7	21.5	2.50	5.28	4.48	13.57	35.20
S.Em±	0.2	0.4	0.2	0.3	0.3	0.008	0.008	0.004	0.1	1.1
CD (P=0.05)	NS	1.48	0.88	1.21	1.05	0.03	0.03	0.02	0.60	4.10
Sub Plot [Bio-fertilizers (B)]										
B_1	24.8	40.8	93.6	16.7	16.6	2.33	5.07	4.35	10.60	27.60
B_2	25.1	42.0	95.7	20.8	20.7	2.37	5.10	4.37	11.99	33.66
B_3	25.4	43.3	97.1	21.6	21.6	2.40	5.14	4.39	13.03	34.92
B_4	25.2	42.3	95.9	20.4	20.3	2.38	5.10	4.36	11.33	32.87
S.Em±	0.1	0.3	0.2	0.1	0.1	0.006	0.008	0.003	0.1	0.9
CD (P=0.05)	NS	1.06	0.64	0.42	0.4	0.02	0.03	0.01	0.50	2.89
Interaction	NS*	Sig.*	Sig.	Sig.	Sig.	NS	NS	NS	NS	NS

N_1:80 kg N/ha, N_2: 100 kg N/ha, N_3: 120 kg N/ha, N_4: 140 kg N/ha, B_1: control, B_2: *Azospirillum*, B_3: *Azospirillum* + PSB, B_4: 1% Banana pseudostem enrich sap; *NS: Non Significant, *Sig.: Significant

Table 2: Effect of various nitrogen levels and bio-fertilizers on yield attributes and yields of hybrid rice

Treatment	Panicle length (cm)	Panicles m^{-2}	Weight of panicle (g)	Grains $panicle^{-1}$	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	H.I. (%)
Main Plot [Nitrogen levels (N)]								
N_1	22.1	213.2	2.5	154.1	19.05	3.29	4.34	42.85
N_2	22.3	261.6	3.0	175.9	19.08	3.91	4.76	45.14
N_3	22.3	273.2	3.2	200.1	19.09	4.36	5.33	44.89
N_4	22.6	291.9	3.4	203.0	19.15	4.60	5.57	45.21
S.Em±	0.1	2.2	0.02	2.5	0.02	74	94	0.2
CD (P=0.05)	NS*	7.93	0.1	8.78	NS	258	326	0.85
Sub Plot [Bio-fertilizers (B)]								
B_1	21.7	235.1	2.6	169.3	19.06	3.44	4.47	43.17
B_2	22.4	264.4	3.1	184.8	19.07	4.13	5.09	44.83
B_3	22.8	279.1	3.3	193.2	19.14	4.52	5.47	45.22
B_4	22.3	261.3	3.0	185.8	19.11	4.06	4.97	44.87
S.Em±	0.06	1.9	0.01	1.1	0.02	48	85	0.1
CD (P=0.05)	0.18	5.72	0.04	3.2	NS	141	250	0.58
Interaction (N x B)	Sig.*	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.

N1:80 kg N/ha, N2: 100 kg N/ha, N3: 120 kg N/ha, N4: 140 kg N/ha, B1: control, B2: Azospirillum, B3: Azospirillum + PSB, B4:1%Banana pseudostem enrich sap

Table 3: Interaction effect of different nitrogen levels and bio-fertilizers on growth parameters, yield attributes and yields of rice

Treatment combination	Plant height (cm)		Total tillers $hill^{-1}$	Effective tillers $hill^{-1}$	Panicle length (cm)	Panicles m^{-2}	Weight of panicle (g)	Grains $panicle^{-1}$	Grain yield (t/ha)	Straw yield (t/ha)	H.I. (%)
	At 40 DAT	At harvest									
N_1B_1	36.9	88.1	11.8	11.6	21.4	206.0	2.1	142.3	2.07	3.26	39.16
N_1B_2	39.6	88.9	19.2	19.1	22.4	210.6	2.4	153.6	3.48	4.33	44.54
N_1B_3	39.5	90.9	19.7	19.7	22.7	217.6	2.7	161.0	4.09	5.23	43.92
N_1B_4	39.3	93.2	19.2	19.2	21.8	218.6	2.6	159.6	3.54	4.55	43.81
N_2B_1	43.8	94.5	16.6	16.6	21.8	214.3	2.4	169.0	3.41	4.17	45.01
N_2B_2	42.5	96.4	20.4	20.4	22.4	271.6	3.1	178.3	4.03	4.92	45.06
N_2B_3	42.9	97.9	21.5	21.4	*22.6*	288.3	3.3	180.0	4.30	5.18	45.38
N_2B_4	42.8	95.7	19.3	19.3	22.4	272.3	3.1	176.3	3.91	4.77	45.13
N_3B_1	40.6	94.6	18.8	18.8	21.9	259.3	3.06	181.3	3.93	5.03	43.90
N_3B_2	42.1	97.5	21.3	21.2	22.3	271.3	3.2	202.3	4.40	5.47	44.60
N_3B_3	45.2	99.3	22.2	22.2	22.6	295.0	3.4	214.3	4.80	5.72	45.67
N_3B_4	41.9	96.3	20.9	20.9	22.4	267.3	3.2	202.6	4.29	5.11	45.39
N_4B_1	41.8	97.1	19.5	19.4	22.0	261.0	3.09	184.6	4.36	5.42	44.62
N_4B_2	44.0	100.1	22.2	21.9	22.5	304.0	3.5	205.0	4.62	5.63	45.12
N_4B_3	45.5	100.1	23.0	23.0	23.2	315.6	3.8	217.6	4.91	5.77	45.94
N_4B_4	45.1	98.3	22.0	21.9	22.8	287.0	3.3	204.6	4.51	5.47	45.18
N_1B_1	2.22	1.34	1.24	1.12	0.51	11.9	0.11	9.27	328	513	1.23
CD (P=0.05)	36.9	88.1	11.8	11.6	21.4	206.0	2.1	142.3	2.07	3.26	39.16

N1: 80 kg N/ha, N2: 100 kg N/ha, N3: 120 kg N/ha, N4: 140 kg N/ha, B1: control, B2: Azospirillum, B3: Azospirillum + PSB, B4:1%Banana pseudostem enrich sap

Table 4: Economics of different treatments

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Gross realization (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	BCR
Main plot [Nitrogen levels (N)]						
N_1: 80 kg N/ha	3.29	4.34	54230	31367	22863	1.73
N_2: 100 kg N/ha	3.91	4.76	63277	31611	31666	2.00
N_3: 120 kg N/ha	4.36	5.33	70520	31855	38665	2.21
N_4: 140 kg N/ha	4.60	5.57	74281	32098	42183	2.31
Sub plot [Bio-fertilizers (B)]						
B_1: Control	3.44	4.47	56500	30035	26465	1.88
B_2: *Azospirillum*	4.13	5.09	67005	30963	36042	2.17
B_3: *Azospirillum* + PSB	4.52	5.47	73035	32591	40444	2.24
B_4: Banana pseudostem enrich sap	4.06	4.97	65747	31041	34706	2.12

Selling price of rice grain= 12.5 ₹ kg^{-1}, Straw= 3 ₹ kg^{-1}

Table 5: Economics of different treatment combinations

Treatment combination	Grain yield (t/ha)	Straw yield (t/ha)	Gross realization (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	BCR
N_1B_1	2.069	3.26	35667	31367	4300	1.13
N_1B_2	3.48	4.33	56539	32295	24244	1.75
N_1B_3	4.09	5.23	66828	33923	32905	1.97
N_1B_4	3.54	4.55	57903	32373	25530	1.78
N_2B_1	3.41	4.17	55228	31611	23617	1.74
N_2B_2	4.03	4.92	65253	32539	32714	2.00
N_2B_3	4.30	5.18	69321	34167	35154	2.02
N_2B_4	3.91	4.77	63298	32617	30681	1.94
N_3B_1	3.93	5.03	64343	31855	32488	2.01
N_3B_2	4.40	5.47	71482	32783	38699	2.18
N_3B_3	4.80	5.72	77279	34411	42868	2.24
N_3B_4	4.29	5.11	68970	32861	36109	2.09
N_4B_1	4.36	5.42	70798	32098	38700	2.20
N_4B_2	4.62	5.63	74759	33026	41733	2.26
N_4B_3	4.91	5.77	78725	34654	44071	2.27
N_4B_4	4.51	5.47	72834	33104	39730	2.20

Selling price of rice grain= 12.5 ₹ kg^{-1}, Straw= 3 ₹ kg^{-1}

Economic benefit

Treatment N_4 obtained the maximum gross realization, net returns and B: C ratio followed by level N_3, however lesser economic benefit was recorded in lower level of nitrogen. With respect to bio-fertilizers, treatment B_3 (*Azospirillum* + PSB) secured the highest gross realization, net returns and B: C ratio followed by treatment B_2 (Table 4). These results were identical with the findings of Singh *et al*. (2006) [18], Yadav *et al*. (2013) [23] and Ghosh *et al*. (2016) [6]. Highest economic benefit was found in treatment combination of 140 kg N/ha in conjunction with *Azospirillum* + PSB over other combinations (Table 5).

Conclusion

In the light of results obtained from this investigation, it can be concluded that application of 120 kg N ha^{-1} (40% at basal, 40% at tillering and 20% at panicle initiation stage) along with bio-fertilizers *viz*., *Azospirillum* + PSB at transplanting and common dose of 30 kg P_2O_5 ha^{-1} at basal during summer season gave higher economic yield of hybrid rice cv. GRH 2 under South Gujarat condition.

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