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Full Length Research Paper

The effects of seed number per hill on grain yield and source-sink relations of three rice cultivars

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In order to study the effects of seed number per hill on the yield and physiological source-sink relations of three rice cultivars in Khouzestan climate conditions (South West of Iran), this research was conducted in form of a split plot experiment with Randomized Complete Block Design (RCBD) with three replications in the experimental field of Islamic Azad University - Khouzestan Science and Research Branch in the 2008 cropping season. Three rice cultivars including Danial, Red Anbouri and Champa were used as the main plots, and seed numbers per hill of 2, 4, 6 and 8 as the secondary factors were placed in the subplots. To calculate the source limitation, the upper and the lower halves of rice panicles were cut. The contributions of flag leaf and the sub flag leaf were assessed through cutting them at the pollination stage. Results showed that the highest yield was obtained from 6 seeds per hill. With an average yield of 4011 kg ha^{-1}, Danial outweighed the other two cultivars. The highest 1000-grain weights in the upper and the lower halves of the panicle by cutting the flag leaf and the sub flag leaf were obtained from the Danial breeded cultivar. All the cultivars revealed a significant difference in terms of grain weight between the control and the removal of the flag leaf and the sub flag leaf treatments. Due to the removal of the flag leaf and the sub flag leaf, all the cultivars had a decrease in grain weight compared to the control. Therefore, it seems that all the studied cultivars lacked sink limitation. Grain weight potential in both spikelet cutting treatments (upper and lower halves of the panicle) showed a significant difference. With the decrease in the number of the economical sink, grain weight in all cultivars increased compared to the control, which indicates that there was a source limitation.

Key words: Rice, seed number, hill, cultivar, source-sink relations.

INTRODUCTION

Yield is a function of many factors including plant growth duration, speed, duration and the association of many critical processes during the plant development. Yield components do not function independently and an increase in one component can lead to a decrease in another. Generally, as the number of plants rises, the number of panicles per area unit rises as well, and the increase in the number of seeds per panicle results in a decrease in the weight of each seed. Therefore, a proper yield requires all the components to function harmoniously only with each other (Hashemi Dezfouli et al., 1992). Unlike other cereals, rice yield is less likely to improve through increasing the grain size because of the grain growth is physiologically restricted by the grain crust, and in most areas, the 1000 grain weight of rice is one of the most stable genetic characteristics. The number of plants per area unit is considered as one of the crucial components of grain yield. Plant number should not be very low because the total production potential will not be achieved, and it should not be very high because it triggers sever competition among the plants for moisture, nutrients and the other factors affecting growth, which in turn impedes the total yield of the plant (Kouchaki, 1989). Satoshi et al. (2000) studied the effects of seed number on yield and yield components in rice direct planting and found that when the seed number increases, panicle number per square meter raises significantly and the seed number per panicle falls indicating the reversible nature of these two characteristics. The results of this experiment demonstrated the positive effects of seed number per panicle on rice yield making up for the decreasing panicle number. Grain weight was the second factor determining yield. Nourbakhshian (2004) investigated the changes in yield and yield components of rice (cv. Champa lordegan) at 20 × 20, 25 × 25 and 30 × 30 cm densities and found that yield decreases with the increase in plantation space. Michael and Zeng (2000) attempted to compare the effects of density in direct plantation and transplanting on rice yield. They concluded that the average yields for direct plantation and transplanting were 2102 and 2244 $kgha^{-1}$ respectively. However, with increase in density, direct plantation grain yield increased. Mesbah et al. (2004) examined the relationships between yield and yield components of 17 rice cultivars. They concluded that yield is positively correlated with the number of seeds per panicle, the number of filled grains per panicle and the 1000 grain weight. Moreover, the seed number per panicle and filled grain number per panicle were the main factors influencing the grain yield. Richard (1982) reported that the leaf area index and the number of spikelet are positively correlated at the flowering stage. Abou-Khalifa et al. (2008) found that both the economical and biological yields were closely correlated with optimum leaf area index (LAI) of different rice cultivars. Boshar et al. (1991) stated that rice flag leaf area significantly influences grain yield, seed number per panicle and the panicle length. Singh and Ghosh (1981) claimed that the greatest decrease in grain yield occurs when the flag leaf is cut immediately after the panicle appears. The top three leaves contribute mostly to grain yield. They not only assimilate the majority of carbon for grain filling during the ripening stage, but also provide large proportion of remobilized-nitrogen for the grain development during their senescence (Misra and Misra, 1991).

Grain weight depends on the photosynthetic materials particularly at the earlier stages of gain development and the capability of the growing grain (sink) to use the available assimilate (Hashemi and Marashi, 1998). Modhej et al. (2008) claimed that the physiological source-sink relations can be studied through calculation. The degree of sink limitation can be calculated by cutting a part of plant leaves and the lack or existence of source limitation in plants can be calculated via the removal of a part of spikelets and evaluating the grain weight changes in the remaining spikelets. Youshida (1981) holds that filled grains percentage can be determined through the proportion of the source strength to its size, panicle strength to absorb carbohydrates and the transfer of photosynthetic materials (assimilates) from the leaves to panicles. Ashraf et al. (1993) also revealed that specific reductions of the capacity for photosynthetic materials from source to sink can be another factor to limit grain yield. The results of studies on source-sink relations in plants have illustrated that grain yield is not influenced by the grain capacity to store photosynthetic materials and is mostly limited by supplying these materials after pollination. Therefore, some researchers believe that sink is limiting, while others consider the source limitation as a factor that decreases yield (Hashemi Dezfouli et al., 1992).

The present study aims to investigate the effects of seed number per hill on grain yield and some physiological characteristics such as source-sink relations in rice cultivars.

MATERIALS AND METHODS

This experiment attempted to study the effects of seed number per hill on yield and the physiological source-sink relations of three rice cultivars in Khouzestan province climate conditions in the experimental field of Islamic Azad University-Khouzestan Science and Research Branch in the 2008 cropping season, Ahvaz, south west of Iran (latitude 31° 20N, longitude 48° 41E and altitude 22.5 m) with moderate winter and hot summer. The study was in form of a split-plot- experiment with Randomized Complete Block Design (RCBD) and three replications. Three rice cultivars including Danial(C_1), Red Anbouri(C_2) and Champa(C_3) were considered as the main plots, and the subplots consisted of four seed numbers per hill, 2(D_1), 4(D_2), 6(D_3) and 8(D_4). To calculate source limitation, the upper and the lower halves of rice panicles were cut. The contribution of the flag leaf and the sub flag leaves were assessed through cutting them at the pollination stage.

After preparing the field and plugging the soil, seeds were planted in 20 × 20 cm and under dry conditions at a 3 to 4 cm depth. Based on the planting nature and heavy soil texture, until the three-leaf stage, the plots were irrigated at two-day intervals, and after that, it was done every other day and in a direct manner. The irrigation wasstopped 10 days prior to the harvesting time. When the panicles emerged, considered half – a – meter of margins in each plot, 40 panicles of the main stem were selected by a red ribbon. The treatments were identified 5 to 7 days after pollination as follows:

a) To evaluate the effect of the flag leaf and the sub flag leaf of the main stem on grain weight, these two leaves were cut on 10 plants at the maturity stage, these panicles were separately harvested along with 10 control panicles without cutting the leaves.
b) To examine the source limitation, all the spikelet (1/2 upper half and 1/2 lower half) were cut.

At the maturity stage, the treatment and control panicles were separately harvested and their seeds were separated as well. Seed numbers per panicle were counted, and the average weight of the seeds was calculated. Source-sink limitation was determined by comparing the weight reduction of the remaining seeds in each treatment. Source limitation percentage was calculated according to the following equation (Nicknejad, 2003):

$$SL\,(\%) = \left(a - \frac{b}{b}\right) \times 100 \quad (1)$$

Where SL is the source limitation percentage, a is the grain weight in the panicle with removed spike let, b is the grain weight in the control panicles.

Evaluating the source limitation of the upper and the lower halves of the treatment and control panicles were conducted separately.

At the physiological maturity stage, the equation as follows was used to determine the harvest index (HI) (Hashemi et al., 1992):

Table 1. Summary of analysis of variance for grain yield, source-sink relation and related traits.

Source of variation	df	Mean square									
		Panicle length	No. grain per panicle	No. panicle per m^{-2}	Harvest index	Grain yield	Biological yield	Panicle lower half		Panicle upper half	
								Fertility	1000 grain weight	Fertility	1000 grain weight
Replicate	2	5.88	4.4	642.9	23	1.7	29.17	411.81	0.21	24.05	0.22
Cultivar(C)	2	50.17^{**}	9.5	21827.85^{**}	12.1^{ns}	1^{**}	134.26^{*}	98.78^{ns}	42.23^{**}	13.75^{*}	35.14^{**}
Error a	4	1.43	3.4	628.78	7.7	1	36.9	93.85	2.42	12.42	2.85
Grain number per hill(GN)	3	2.15^{*}	10.1	13273.74^{ns}	5.2^{ns}	0.2^{ns}	2.1^{ns}	115.51^{ns}	0.84^{ns}	14.68^{**}	0.11^{ns}
C*GN	6	1.19^{*}	7.6	60446.58^{ns}	3.3^{ns}	0.4^{ns}	10.15^{ns}	25.94^{ns}	0.37^{ns}	6.96^{*}	0.14^{ns}
Error b	18	0.46	2.4	5137.19	6.1	0.2	27.04	36.72	0.3	2.55	0.23
	Cv(%)	2.8	6.9	6.6	5.9	6.7	7.59	4.3	2.7	1.8	3.9

ns, * and **: Non Significant, significant at the 0.05 and 0.01 probability levels, respectively.

$$HI(\%) = \left(\frac{\text{Grain yield}}{\text{Biological yield}}\right) \times 100 \qquad (2)$$

In order to determine the yield components and the related characteristics, 10 plants were randomly harvested from each plot. Grain fertility percentage was calculated by the portion of filled grains to the total number of grains multiplied by 100. Grain yields were determined in an area of 5 square meters in each plot. The data were analyzed by the SAS software through the analysis of variance and Duncan at the 0.05 probability level.

RESULTS AND DISCUSSION

Grain yield and yield components

Results of the analysis of variance showed that there were significant differences between the cultivars in terms of panicle length, grain yield, panicle number per area unit, the 1000 grain weight of the upper and the lower halves of the panicle, seed number per panicle, harvest index and the fertility percentage in the upper half of the panicle (Table 1).

The effect of the seed number per hill on the panicle number per area unit, biological and grain yields, harvest index, the 1000 grain weight of the upper and the lower halves of the panicle and the fertility percentage of the upper half of the panicle were not significant. However, the effects of seed number per hill treatment on the panicle length, grain number per panicle and the fertility percentage of the upper half of the panicle were significant. Comparison of the means revealed that the highest and the lowest panicle lengths belonged to the local cultivar (24 cm) and the Danial cultivar (21 cm) (Table 2). The local cultivars had greater panicle lengths because of their prolonged development periods and taller plants. Honarnejad (1995) reported that dwarf genotypes of rice, with a higher number of tillers, had a smaller panicle length compared to tall genotypes. Nourbakhshian and Rezaie (2004) have also found that despite their lower grain yield, long-duration cultivars had taller plants and greater panicle lengths rather than short-duration ones. Since long- duration cultivars are usually local ones, they have longer development periods and, as a result, the plants are taller and the panicles are longer in comparison with short-duration cultivars. Pirdashti (2000) and Nicknejad (2003) have attributed panicle length differences between different rice cultivars to genetic differences.

The red Anbouri cultivar with an average of 171 seeds per panicle and Danial with an average of 156 seeds per panicle had the highest and the lowest seed numbers respectively (Table 2). Gilani (1998) reported that tall cultivars had more seeds per panicle rather than dwarf cultivars because they have longer panicles. Thus, they have more spikelets per length unit of panicles. In addition, tall cultivars have a higher leaf area index and a faster crop growth rate, and they are more likely to produce more dry matter and filled grains. These findings were compatible with Yamamoto et al. (1991).

With an average number of 386 panicles per area unit, Danial had the highest panicle number, and the lowest panicle number belonged to Red Anbouri with 292 panicles per square meter which did not differ significantly from Champa (295 panicles per square meter).Danial grain yield increased through the production of abundant

Table 2. Comparison of grain yield means and some traits related to sink-source limitation.

Treatment	Panicle length (cm)	No. grain per Panicle	No. panicle per ear	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)	Panicle lower half		Panicle upper half	
							Fertility (%)	1000 grain weight (g)	Fertility (%)	1000 grain weight (g)
Cultivar										
Red Anbouri	25^{a*}	171^{a}	292^{b}	12361^{b}	3439^{c}	27^{b}	78^{a}	19^{ab}	89^{b}	20^{ab}
Champa	25^{a}	157^{b}	295^{b}	12944^{a}	3773^{b}	29^{b}	78^{a}	18^{b}	88^{b}	19^{b}
Danial	21^{b}	156^{b}	368^{a}	10983^{b}	4011^{a}	36^{a}	50^{b}	22^{a}	91^{a}	23^{a}
Grain numbers per Hill										
2	25^{a}	174^{a}	278^{d}	12444^{ab}	3665^{b}	29^{b}	74^{c}	20^{a}	88^{b}	20^{a}
4	24^{ab}	165^{ab}	304^{c}	11514^{b}	3885^{a}	33^{a}	80^{ab}	20^{a}	91^{a}	20^{a}
6	24^{ab}	155^{b}	369^{a}	13009^{a}	3886^{a}	30^{b}	82^{a}	20^{a}	90^{a}	20^{a}
8	23^{b}	151^{b}	323^{b}	11418^{b}	3556^{c}	31^{ab}	79^{b}	20^{a}	89^{ab}	20^{ab}

Means followed by similar letters have not significantly different (p<o.o5) – Using Duncan test.

fertile tillers per area unit. The significant difference between the local Champa cultivar and the Danial cultivar represents a 15.2% improvement of Danial over Champa. Danial enjoyed the highest harvest index and the 1000 grain weight in both halves of the panicle (Table 2). In this experiment, the local cultivars had a lower harvest index because of their taller heights. This is probably due to the higher respiration of tall cultivars than the dwarf ones; thus, some of the dry matter used to improve the height and development of the plant instead of being stored in the plant tissues. In an experiment on the association of source- sink relation and its characteristics with the harvest index of the Yuexiang Zhan breeded cultivar, Yauping et al. (2001) concluded that this cultivar had a larger sink and a better filling capacity and the main reason behind its higher harvest index and yield could be the source-sink balance and the coordination with the current photosynthetic materials.

Nourbakhshian and Rezaie (2004) claimed that unlike the long-duration tall cultivars, the short-duration cultivars had a higher harvest index and a higher 1000-grain weight which were positively correlated with yield because theybegin the flowering earlier and there is enough time for the grains to fill. Moreover, the plant height of these short-duration cultivars had a positive effect onthe harvest index.

The breeded Danial cultivar had the highest 1000-grain weight in the both halves of the panicle as well as the highest fertility percentage in the both halves. In contrast, the lowest 1000 grain weight belonged to Champa cultivar (Table 2). This may be caused by the genetic differences of the cultivars. Mahdavi et al. (2004), also, reported the same findings demonstrating that grain-filling duration is longer in the breeded cultivars and, they had a greater 1000 grain weight due to accumulation more dry matter compared to the local cultivars. Comparison of the average 1000-grain weight in the upper and the lower halves of the panicle in all cultivars indicate that the highest 1000 grain weight was in the upper half of the panicle. Youshida (1981) found that grain weight was a function of the inner panicle and the grains which formed earlier were heavier.

Physiological source-sink relations

Source limitation

The difference between cultivars with respect to the grain weight potential in both spikelet removal treatments (upper and lower half) was significant at the 0.01 probability level (Table 5). The highest grain weight potential in both treatments belonged to the breeded Danial cultivar and the lowest weight to the local Champa cultivar. Grain weights in all the treatment cultivars were higher than the control cultivars.

The increase in grain weight potential in all the cultivars and the decrease in the number of

Table 3. Summary of variance analysis for 1000-grain weight in upper and lower half panicle under removal of the first (flag leaf) and second (under flag leaf) leaves.

S.O.V	Df	Panicle upper half		Panicle lower half	
		1000-grain weight at removal of flag leaf	1000-grain weight at removal of second leaf	1000-grain weight at removal of flag leaf	1000-grain weight at removal of second leaf
Replicate	2	0.18	0.01	0.28	0.17
Cultivar(C)	2	60.31**	49.47ns	73.66**	57.82**
Error a	4	0.25	2.59ns	0.55	3.85
Grain number per hill(GN)	3	0.49 ns	0.43ns	1.92ns	0.94ns
C*GN	6	0.84ns	0.11ns	1.58ns	0.8ns
Error b	18	0.49	0.42	0.93	2.47
(%)cv	---	2.2	3.46	3.2	2.3

ns, * and ** : Non Significant, significant at the 0.05 and 0.01 probability levels, respectively.

economical sink confirm the source limitation of the cultivars. As a result, more processed materials were devoted to fewer grains and this in turn led to the rise in grain weight in the limited-source cultivars. Hashemi Dezfouli and Marashi (1998) stated that if sink capacity is not limited, cutting 50% of the spikelet triggers an increase in grain weight because these cultivars have source limitation. Comparing the grain weight potential in the two panicle-removal treatments in all cultivars, Frank and Blauer (2004) showed that the upper half panicle-removal treatment had a lower grain weight potential than the lower half one. This was due to the remaining panicles position. In both the upper and the lower halves removal conditions, Danial and Champa cultivars respectively had the highest and the lowest grain weight potentials and the percentage of the grain weight increase was higher in the breeded cultivar than Chmpa. This can be attributed to the thicker grain crust in Champa compared to the other two cultivars (Table 6). Because of more grains per hill, the local cultivars showed a more intense competition between the grains than the more prolific cultivars. Besides, since there was more total dry matter produced in the local cultivars than the more prolific cultivars, the latter produced and transferred more dry matter during the grain-filling stage than the former.

In addition, with the spikelet removal, the local cultivars showed a higher source limitation percentage although the difference in the average source limitation between all the cultivars was not significant. In the present study, the difference in the average source limitation of the seed number treatment was significant, and the density of 6 seeds per hill with a 5.1% average and the density of 2 seeds per hill with a 2.3% average had the highest and lowest source limitation percentages (Table 6).

The weight potential of each grain is determined through the number of cells formed throughout the endosperm meristem period (Nicknejad, 2003). The reduction in assimilate supply, competition during this period and hormonal effects especially on the grain-removed treatment which can alter the normal condition should be taken in to consideration because the grain sytokinin activity reaches its maxim soon after flowering (Sarmadnia and Kouchaki, 1999). Comparisons of the average source limitation between different densities by the removal of the lower half grain of the panicle manifested that the source limitation increases with the rise in density. Meanwhile grain number per panicle is lower in higher densities because with the increase in density, space becomes limited and an intense competition happens during the earlier stages of development and then a great deal of yield potential will be consumed for between-plants competition.

Sink limitation

All the under study cultivars showed a significant difference in terms of grain weight between the control and cutting the flag leaf and the sub flag leaf (Table 3).The greatest average grain weight was obtained in the upper and the lower half of panicle (control) and the cutting of the flag leaf and the sub flag leaf of the Danial cultivar, By cutting the flag leaf and the sub flag leaf, grain weight of all cultivars decreased (Tables 2 and 4). This shows that all the cultivars lacked sink limitation. Therefore, despite the current photosynthesis in the plant tissues and the retransfer of the processed materials, grain weight decreased because of the decrease in the current photosynthesis caused by the cutting of the flag leaf and the sub flag leaf. The results of this study conform to Naderi et al. (2000) findings. By cutting a part of the flag leaf during the flowering stage and 8 days after flowering, Blade and Baker (1999) found a remarkable decrease in the grain weight. The proportion of the grain weight decrease caused by cutting the flag leaf and the sub flag leaf of all the studied cultivars and the interaction effects of the cultivar and density were probably due to

Table 4. Comparison of means for 1000-grain weight in upper and lower half panicle under removal of the first (flag leaf) and second (under flag leaf) leaves.

Treatment	Panicle upper half		Panicle lower half	
	1000-grain weight at removal of flag leaf (g)	1000-grain weight at removal of second leaf (g)	1000-grain weight at removal of flag leaf (g)	1000-grain weight at removal of second leaf (g)
Cultivar				
Red Anbouri	19.03[b]	19.08[a]*	18.38[b]	18.73[b]
Champa	18.51[b]	18.65[b]	17.64[b]	17.83[b]
Danial	22.34[a]	22.32[a]	21.87[a]	22.16[a]
Grain number per Hill				
2	20[a]	20[a]	19[a]	19[a]
4	20[a]	20[a]	18[a]	19[a]
6	19[a]	20[a]	19[a]	19[a]
8	19[a]	19[a]	19[a]	19[a]

* Means followed by similar letters have not significantly different (p<o.o5) – Using Duncan test.

Table 5. Summary of variance analysis for grain weight potential and source limitation percentage.

S.O.V	df	Grain weight potential at removal of upper half panicle	Source limitation	Grain weight potential at removal of lower half panicle	Source limitation
Replicate	2	0.51	5.19	0.8	37.45
Cultivar(C)	2	42.72**	3.56[ns]	44.39**	7.15**
Ea	4	3.22	8.81	3.35	1.46
Grain number per hill(GN)	3	0.14ns	7.48ns	0.28ns	12.42ns
C*GN	6	0.34ns	2.75ns	0.36ns	3.81ns
Eb	18	0.61	4.72	0.22	2.5
(%)cv	----	3.7	4.4	2.2	4.9

ns, * and ** : Non Significant, significant at the 0.05 and 0.01 probability levels, respectively.

Table 6. Comparison of means for grain weight potential and source limitation percentage.

Treatment	Grain weight potential at removal of upper half panicle (g)	Source limitation percentage At removal of upper half panicle (%)	Grain weight potential at removal of lower half panicle (g)	Source limitation percentage at removal of lower half panicle (%)
Cultivar				
Red Anbouri	20.11 [ab]*	2.95 [a]	20.86 [ab]	3.65 [a]
Champa	18.93[b]	3.5 [a]	19.96 [b]	2.85 [a]
Danial	22.95 [a]	2.41 [a]	23.65 [a]	2.5 [a]
Grain number per hill				
2	20.82 [a]	21.28 [a]	21.28[a]	1.96 [a]
4	20.71 [a]	21.41 [a]	21.41 [a]	2.48 [ab]
6	20.99 [a]	21.67 [a]	21.67 [a]	4.5 [a]
8	20.74[a]	21.6 [a]	21.6 [a]	2.42 [ab]

* Means followed by similar letters have not significantly different (p<o.o5) – Using Duncan test.

the variety of the stimulating effects of cutting the flag leaf and the sub flag leaf on the photosynthesis of the other photosynthesizing organs or the redistribution of the materials. Aggarwal et al. (1999) reported that the decrease in the grain numberper area unit through cutting the plant leaves was not effective, while this reduction was about 16%.

Comparison of the means revealed that the greatest grain weight reduction in the flag leaf-cutting treatment was for Red Anbouri in the upper half of the panicle and for Champa in the lower half of the panicle. Moreover, the greatest grain weight reduction in the sub flag leaf cutting treatment belonged to RedAnbouri in both the upper and the lower halves of the panicle (Table 4).

Danial had the highest average 1000 grain weight among all the cultivars and cutting the flag leaf and the sub flag leaf and this breeded cultivar, compared to the control, had the lowest weight reduction rather than the other two cultivars (Tables 2 and 4). Gilani (1998) claimed that leaf surface decrease was higher for the local cultivars than the more prolific ones resulting in a more grain weight reduction due to cutting the flag leaf and the sub flag leaf in the more prolific cultivars. Since grain number per panicle is higher in the local cultivars than the more prolific ones, the decrease in the amount of the processed materials because of source limitation and the higher number of sinks in these cultivars gave rise to a lower allocation of the processed materials and a greater grain weight reduction in the local cultivars than the breeded ones. Mombeni (2003) reported that because of the earlier maturity and faster leaves senescence after flowering in the local cultivars, the rate of the transfer of stored assimilates in the leaves to the grains are lower compared to the breeded cultivars. The percentage of grain weight reduction rose by cutting the sub flag leaf, and it was much higher in the local cultivars than the more prolific one, on the other hand, both the cuttings of the flag leaf and the sub flag leaf were more effective on grain weight reduction for the local cultivars than Danial, hence, it seems that the effects of the flag leaf and the sub flag leaf to provide the grain dry matter were more significant in the local cultivars than the more prolific one (Table 4).

Conclusion

To achieve maximum economical yield in these cultivars, it should be considered that any form of source limitation such as the sheath-burning disease and environmental stresses like drought can lead to the extreme yield reduction of these cultivars. However, protecting the leaves through spraying nutrients or eradicating the pests and diseases can improve the yield.

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