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QUALITY OF RICE GRAIN IS INFLUENCED BY ORGANIC AND INORGANIC SOURCES OF NUTRIENTS AND ANTIOXIDANT APPLICATION

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ABSTRACT. The present research was conducted to study the influence of organic and inorganic sources of nutrients as well as antioxidant on rice quality. The experiment was designed in split-split plots with four replications, where main plots were assigned to nitrogen (0, 55, 110 and 165 kg N ha^{-1}) and sub plots were allocated to compost (0, 3.5 and 7 tons ha^{-1}), while the sub-sub plots were assigned to ascobien (control, spraying with ascobien in two times at 15 and 30 days after transplanting (DAT), spraying with ascobien three times at 15, 30 and 45 DAT). The result indicated that grain quality traits were significantly influenced by the organic and inorganic fertilizers, and ascobien. The percentage of hulling, milling and amylose were positively and significantly influenced by nitrogen, organic and antioxidants application. Most of studied characters produced the highest values with the organic fertilize were combined with nitrogen and antioxidants. Application of 110 kg N ha^{-1}, 7 t ha^{-1} compost and two or three spraying of ascobien, 110 kg N ha^{-1} or 3.5 t ha^{-1} compost and three times spraying and 55 kg N ha^{-1}, 7 t ha^{-1} compost and two times spraying could be recommended for optimum grain quality of Sakha106 rice variety. It can be concluded that compost along with the foliar application of ascobien can be saved from 50 to110 kg N ha^{-1}, without reducing grain quality. It can be the key to reduce the need for chemical fertilizers and decrease the cost of production with keeping healthy soil.

Key words: ascobien; grain quality; nitrogen; *Oryza sativa*; rice straw compost.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops of the world, grown in different areas over the world. Grain quality of rice is very complicated, but an important

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properties in many areas for rice production in the world, mainly defined by four constituents: namely, milling, cooking, appearance and nutritional quality (Li *et al.,* 2003). Among environmental factors, nutrient sources supplying during the life cycle of the crop also provides to the physico-chemical quality of the produce (Miller *et al.,* 1980).

Composting is a biological process in which organic biodegradable wastes are converted into hygienic, humus rich product (compost) for use as a soil conditioner and an organic fertilizer (Popkin, 1995). The using of organic materials it could help to solve pollution problems caused that by agro-industrial wastes. Adding much nitrogen fertilizer, whether in the form of organic matter or chemical fertilizer, some of the excess nitrogen is converted to nitrates, which are harmful to human health (Preap *et al.* 2002). Rice straw compost is organic manure that can be made on the farm at very low cost. Most of the Egyptian farmers tried to get rid of rice straw by burning, which caused bad effect on the environment. Although there are other economical ways to get a foot from it, such as incorporation into the soil as a source of organic matter and making compost, which can used instead of burning. Srivastava *et al.* (2009) found that application of organic fertilizer to rice plant enhanced grain quality characters as well as grain yield.

Nitrogen (N) is necessary for rice, and it is the most yield-limiting nutrient in irrigated area of rice production around the world (Samonte *et al.,* 2006). Earlier studies reveal that judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Place *et al.,* 1970). Maqsood *et al.* (2013) recorded that nitrogen rate had a significant effects on chlorophyll content, amylose content and protein percentage positively in rice at the higher level of nitrogen. Application nitrogen increase soil acidity and excessive nitrogen fertilizer supplying lead to pest problems by increasing the birth rate, longevity and overall fitness of certain pests (Jhan *et al*., 2005). On the other hand, increasing of nitrogen rate fertilizer could increase the yield but reduce the quality of the grain (Tayefe *et al.,* 2014).

Ascobien contains 13% citric acid, 25% ascorbic acid plus 62% organic materials. Ascorbic acid has effects on many physiological processes including the regulation of growth and metabolism of plants. Gharib *et al.* (2011) studied the effect of some stimulating compounds like ascobien (13% citric acid, 25% ascorbic acid plus 62% organic materials), hammer (86% humate potassium), pepton (85% amino acid + 12% organic nitrogen + 3% K_2O), and nitrogen fertilizer levels on growth and yield of Hybrid 1 (Egyptian hybrid rice). They found that foliar application of ascobien resulted in a significant increase in most of growth and yield characters compared with other stimulative compounds. The results indicated that foliar application of ascobien can be saved 50 kg N ha^{-1} without reducing grain yield. Therefore, with keeping the above points in view, the present study was planned to improve and maximizing the quality of rice by using some antioxidants with combination of compost and nitrogen under the environmental conditions of delta region, Egypt.

MATERIALS AND METHODS

Experimental site and initial soil characteristics and processing

This experiment was conducted with Sakha106 rice cultivar during 2012 and 2013 rice growing seasons at the Experimental Farm, Rice Research and Training Center, Sakha, Kafrelsheikh, Egypt. The previous crop was barley in the two seasons. Some chemical and physical properties of the soil of the experimental site are presented in (*Table 1*).

Table 1 - Physical and chemical properties of the experimental soil before planting in 2012 and 2013

Soil properties	2012	2013
Physical:		
Clay %	55.9	56.0
Silt %	31.5	32.0
Sand %	12.6	12.0
Texture	Clayey	Clayey
Chemical:		
Organic matter (O.M)%	1.45	1.50
pH(1:2.5 soil suspension)	8.35	8.44
Ec ($ds.m^{-1}$)	3.12	3.34
Total N (ppm)	477.00	430.50
Available P (ppm)	14.00	12.00
Available K (ppm)	460	432
Available ammonium (ppm)	18.0	17.2
Nitrate concentration (ppm)	14.0	13.2
Soluble anions, $meq.L^{-1}$:		
CO^{-}_{3}	--	--
HCO^{-}_{3}	5.30	6.20
Cl^{-}	8.50	9.10
SO^{--}_{4}	17.40	18.00
Soluble cations, $meq.L^{-1}$:		
Ca^{++}	11.70	10.70
Mg^{++}	3.50	5.00
Na^{++}	1.60	2.00
K^{+}	14.40	15.60
Availabe micronutrients (ppm):		
Fe^{++}	5.00	5.80
Mn^{++}	3.04	3.20
Zn^{++}	1.00	0.95

Experimental materials, design and agronomic practices

The experiment was laid out in split-split plots design with four replications, where main plots were assigned to nitrogen levels (0, 55, 110 and 165 kg N ha^{-1}) and subplots were allocated to compost rates (0, 3.5 and 7 tons ha^{-1}), while the sub-subplots were assigned to ascobien treatments (ascobien spray at two times- 15 and 30 DAT, and at three times - 15, 30 and 45 DAT). Ascobien (13% citric acid, 25% ascorbic acid plus 62% organic materials) was applied at the concentration of 1.5 g litre^{-1} as a foliar application.

After preparation of the permanent experimental field, 30 days old seedlings were transplanted manually into 15 m^2 subplots by maintaining 15 cm X 15 cm spacing and 2-3 seedlings hill^{-1}. The herbicide Saturn 50% [S-(4-Chlorophenol methyl) diethyl carbamothioate] was applied at the rate of 5 L ha^{-1} at seven DAT. Plots were kept flooded till 2-3 weeks before harvesting. All other agronomic practices were followed as recommended.

Rice straw composting

Rice straw compost was prepared in heap (2 x 1.5 x 1.5 m^3) from rice straw and farm yard manure, and decomposed them for three months. Rice straw was collected from a local farm. Chemical analysis of the finished compost is presented in *Table 2*.

Table 2 - Chemical analyses of the rice straw compost in 2012 and 2013

Seasons	C (%)	N (%)	C:N ratio	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)
2012	35	1.75	20.00	0.44	0.63	480	190	38
2013	30	1.80	16.67	0.59	0.81	580	290	68

Measurements of rice grain quality

Hulling, milling output and head rice percentages were estimated according to the methods reported by Adair (1952). Hulling percentage: 150 g cleaned rough rice samples at moisture content 12-14% were estimated using experimental Huller machine.

$$\text{Hulling}(\%) = \frac{\text{Wt. of brown rice}}{\text{Wt. of rough rice}} \times 100$$

Milling percentage: Brown rice was consequently milled using MC Gill Miller No. 2. The sample was milled for 60 sec. The milled rice sample was then collected and the weight was taken and percentage of total milled rice was computed.

$$\text{Milling}(\%) = \frac{\text{Wt. of milled rice}}{\text{Wt. of rough rice}} \times 100$$

Broken rice percentage: Whole grains were separated from the total milled rice using a rice sizing device. The separation of these particles is termed as grading. However, the broken grains are fragments of grains, the lengths of which are less than $^3/_4$ of the whole grains after separated into two different sizes. The amount of broken rice yield is then calculated as:

$$\text{Broken rice}(\%) = \frac{\text{Wt. of broken rice}}{\text{Wt. of milled rice}} \times 100$$

Amylose content: Amylose content in milled rice grain was estimated according to Juliano (1971).

Statistical analysis

The obtained data were subjected to analyses of variance according to Gomez and Gomez (1984). Treatments means were compared by Duncan"s Multiple Range Test (Duncan, 1955). All statistical analysis was performed using analysis of variance technique by means of "MSTATC" computer software package.

RESULTS AND DISCUSSION

In this research, efforts were made to improve quality traits of rice by organic and inorganic sources of nutrients and antioxidant application. The quality parameters of the rice grain were influenced significantly by the nutrient sources.

Hulling percentage

Hulling percentage (HP) significantly increased with increasing nitrogen levels in the two seasons. The highest values of hulling percentage were observed at 165 kg N ha^{-1}, followed by 110 kg N ha^{-1} (*Table 3*). This increase could be attributed due to the application of nitrogen increased grain-filling rate consequently decreased the hull thickness. These findings are in close agreement with those of reported by Metwally *et al.* (2011b). Earlier similar results were also reported by Srivastava *et al.* (2009) and Kandil *et al.* (2010), who obtained marked increase in milling, hulling and head rice percentages when applied nitrogen level was up to 192 kg N ha^{-1}. Ebaid and El-Hissewy (2000) indicated that increasing nitrogen fertilizer levels from 0 up to 165 kg N ha^{-1} significantly increased hulling percentage in Sakha 101 rice cultivar.

A significant difference in HP was observed due to compost application and it increased with increasing compost up to 7 t compost ha^{-1}. However, there was no significant between 3.5 and 7 t compost ha^{-1} on HP in the second season only. This is in agreement with Srivastava *et al.* (2009) and Muhammad *et al*. (2008) in rice. The available nutrients might have helped in enhancing leaf area, which thereby resulted in higher photo-assimilates and more dry matter accumulation.

Results showed that the foliar spraying of ascorbic acid gave a significant increase in HP in the two seasons (*Table 3*). The highest values of HP were obtained by implementation of three times ascobien spraying in both seasons, but there were no significant differences between two and three times foliar spraying of ascobien in the second season. The lowest values were recorded under control condition (withing spraying of ascobien). Similar results were also reported by Taha Hanan (2008) and El-Tayed (2005), who reported that the foliar spraying ascorbic acid significantly increased rice quality.

Combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure quality crop. The interaction between nitrogen and compost had a significant effect on hulling percentage in 2013. The highest values of HP were recorded with the combination of 165 kg N and 3.5 or 7 t compost ha^{-1}. There were no significant deference between 110 and 165 kg N combined with 7 t compost ha^{-1}. Moreover, the lowest values of HP were obtained under zero nitrogen and zero compost combination (*Table 4*). Saha *et al.* (2007) reported that inorganic sources of nutrients influenced more than organic sources on crop growth and quality. Data in *Table 5* indicated that there was a significant effect on HP in the two seasons due to the interaction effect of nitrogen levels and ascobien spraying frequencies. The highest values of HP were obtained at three times ascobien spraying along with 165 kg N ha^{-1} in the first season. While, there were no significant differences on HP among ascobien treatments at 165 kg N ha^{-1} in 2013. Whereas, the lowest values of HP were detected without nitrogen fertilizer at all ascobien treatments.

Table 3 - Hulling, milling, broken rice and amylose percentages of rice cv. Sakha 106 as influenced by nitrogen, compost and foliar application of ascobien in 2012 and 2013 seasons

Factor	Hulling (%)		Milling (%)		Broken rice (%)		Amylose (%)	
	2012	2013	2012	2013	2012	2013	2012	2013
Kg N ha^{-1} (N)								
0	84.48d	82.11c	71.59d	71.45d	11.42a	11.10a	15.26d	15.30c
55	85.06c	82.43b	73.45c	71.80c	9.19b	10.45b	15.72c	15.50b
110	85.63b	82.66ab	74.81b	72.14b	8.58b	9.72c	16.16b	15.66b
165	86.34a	82.87a	76.71a	72.51a	8.58b	8.88d	16.84a	15.83a
F-test	**	*	**	**	**	**	*	*
Compost t ha^{-1}(C)								
0	84.75c	82.30b	73.35b	71.69b	10.02a	11.00a	15.35b	15.42b
3.5	85.48b	82.53ab	74.23a	71.99ab	9.33b	9.78b	16.15a	15.59ab
7	85.91a	82.72a	74.83a	72.24a	8.98b	9.34b	16.48a	15.71a
F-test	*	*	**	*	**	**	*	*
Ascobien (A)								
0	84.55c	82.39b	73.26b	71.82b	10.30a	10.83a	15.49b	15.48b
2 times	85.37b	82.52ab	73.93b	71.98ab	9.34b	10.09b	16.09a	15.57ab
3 times	86.22a	82.64a	75.23a	72.12a	8.68c	9.20c	16.40a	15.67a
F-test	**	*	**	**	**	**	*	*
Interaction								
NxC	NS	*	*	NS	**	**	NS	NS
NxA	**	**	**	*	**	**	NS	NS
CxA	*	NS	NS	*	**	**	NS	NS
NxCxA	NS	NS	NS	NS	NS	NS	NS	NS

*, ** and NS indicate $p \leq 0.05$, $p \leq 0.01$ and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

Table 4 - Hulling, milling and broken rice percentages of rice cv. Sakha 106 as influenced by the interaction between nitrogen rate and compost rate in 2012 and 2013 seasons

KgN ha^{-1}	Compost / t ha^{-1}	Hulling (%)	Milling (%)	Broken rice (%)	
		2013	2012	2012	2013
0	0	81.79 f	70.25 g	12.53 a	11.95 a
	3.5	82.17 e	71.86 f	11.18 b	10.85 b
	7	82.37 de	72.66 ef	10.57 bc	10.50 bc
55	0	82.22 e	73.00 ef	9.780 cd	10.30 bcd
	3.5	82.44 cde	73.22 def	8.990 de	9.980 cde
	7	82.62 bcd	74.12 cde	8.780 de	9.600 ef
110	0	82.49 cde	74.16 cde	8.960 de	10.43 bc
	3.5	82.67 bcd	74.81 bcd	8.500 e	9.480 ef
	7	82.83 ab	75.46 abc	8.280 e	9.240 fg
165	0	82.71 bc	76.00 ab	8.790 de	9.830 def
	3.5	82.86 ab	77.05 a	8.640 de	8.790 g
	7	83.05 a	77.08 a	8.300 e	8.010 h

Means of each column designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

Table 5 - Hulling, milling, broken rice and amylose percentages of rice cv. Sakha 106 as affected by the interaction between nitrogen rate and foliar application of ascobien in 2012 and 2013 seasons

Kg N ha^{-1}	Ascobien spray	Hulling (%)		Milling (%)		Broken rice (%)	
		2012	2013	2012	2013	2012	2013
0	0	83.46 g	81.90 f	70.61 h	71.27 i	12.87 a	11.88 a
	2 times	84.51 ef	82.16 ef	71.78 g	71.49 h	11.63 b	11.46 a
	3 times	85.46 cd	82.28 de	72.38 fg	71.58 gh	9.770 d	9.96 bcd
55	0	84.06 f	82.31 de	72.66 fg	71.65 gh	10.50 c	11.53 a
	2 times	85.11 de	82.44 cde	72.94 f	71.78 fg	8.750 ef	10.33 bc
	3 times	86.02 bc	82.53 bcd	74.74 de	71.96 ef	8.480 ef	9.500 de
110	0	85.02 de	82.57 bcd	74.27 e	71.99 e	8.980 ef	10.37 b
	2 times	85.52 cd	82.66 bc	74.34 e	72.12 de	8.490 ef	9.770 cd
	3 times	86.35 b	82.76 abc	75.81 bc	72.30 cd	8.280 ef	9.030 ef
165	0	85.66 cd	82.78 ab	75.49 cd	72.38 bc	9.010 e	9.520 de
	2 times	86.34 b	82.84 ab	76.64 b	72.52 ab	8.500 ef	8.810 fg
	3 times	87.03 a	83.00 a	78.00 a	72.65 a	8.220 f	8.310 g

Means of each column designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

Table 6 - Hulling, milling, broken rice and amylose percentages of rice cv. Sakha 106 as influenced by the interaction between compost and ascobien in 2012 and 2013 seasons.

Compost (t ha^{-1})	Ascobien spray	Hulling (%)	Milling (%)	Broken rice (%)	
		2012	2013	2012	2013
0	0	83.65 e	71.54 g	11.18 a	11.79 a
	2 times	84.99 d	71.68 fg	9.780 bc	11.13 b
	3 times	85.61 bc	71.85 ef	9.090 def	10.09 cd
3.5	0	84.75 d	71.83 ef	10.09 b	10.58 c
	2 times	85.26 cd	71.97 de	9.330 cde	9.790 de
	3 times	86.43 a	72.17 bc	8.560 fg	8.960 fg
7	0	85.26 cd	72.09 cd	9.620 bcd	10.11 cd
	2 times	85.87 b	72.28 ab	8.920 efg	9.360 ef
	3 times	86.61 a	72.35 a	8.410 g	8.550 g

Means of each column designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

Data in *Table 6* indicated that there was a significant effect on HP in the first season only due to the interaction effect between different levels of compost and ascobien. The highest values of hulling percentage were obtained when applied three times ascobien with 7 t ha^{-1} compost. Moreover, the lowest values of hulling percentage were detected when plants did not receive ascobien and compost. The increase in rice quality in response to application of organic and chemical fertilizers is probably due to enhanced availability of nutrients (Siavoshi *et al.,* 2011).

Milling percentage

Different levels of nitrogen, compost and ascobien increased the milling percentage (MP) in the two seasons (*Table 3*). The application of nitrogen at the rate of 165 kg ha^{-1} produced the highest milling percentage, compared with other N levels in two consecutive years. The increase in MP may be due to the increase in metabolite substances in grains, which are attributed with the increasing nitrogen levels. These findings are in close agreement with those reported by Metwally *et al.* (2011a) and Ebaid and El-Hissewy (2000).

There were apparent differences in milling percentage due to compost application. There was a significant increase in MP with increasing compost level from zero to 7 t ha^{-1}, although was no significant difference between 3.5 and 7 t compost ha^{-1} on MP in 2012 and 2013 (*Table 3*). Srivastava *et al.* (2009) observed the similar results. Organic sources offer more balanced nutrition to the plants, especially micro nutrients, which positively influenced the grain quality (Miller, 2007).

Milling percentage was influenced significantly by the foliar application of ascobien in the two seasons. The highest values of MP were obtained by the three times spraying of ascobien in both seasons. There were no significant difference between two or three times foliar spray of ascobien in the second season. Similar results were obtained by Taha Hanan (2008). The improvement in grains quality characters may be due to the role of antioxidants from ascobien in maintaining balanced plant growth as previously mentioned by Seadh and El-Metwally (2015).

The interaction between nitrogen and compost had a significant effect on milling percentage in the first season only (*Table 4*). The highest MP were obtained with the highest level of N 165 kg ha^{-1}, alone or combined with 3.5 or 7 t compost ha^{-1}. There was no significant difference between 110 or 165 kg N ha^{-1}, combined with 7 t compost ha^{-1}. Moreover, the lowest values of MP were obtained when nitrogen and compost were not applied. There was a significant effect on milling percentage in the two seasons due to the interaction effect between nitrogen fertilizer and ascobien (*Table 5*). The highest values of milling percentage were obtained when ascobien was applied three times with the application of nitrogen at the rate of 165 kg N ha^{-1} in the two seasons. There were no significant differences between two and three times of ascobien foliar application in the second season only. The lowest values of milling percentage were detected when plants did not receive nitrogen fertilizer at all ascobien application. The interaction effects between compost and ascobien on MP were in the second seasons only. Results showed that there was a significant effect on milling percentage in the first season, due to the interaction between compost and ascobien. Application of compost rate (7 t/ha^{-1}) in combination with two or three times of ascobien spraying were produced the highest values of milling percentage.

Broken rice percentage

Broken rice percentage was significantly influenced by all the treatments over control (*Table 4*).

Broken rice percentage was significantly controlled by the application of nitrogen in the two seasons. Increasing nitrogen fertilizer from 0 to 165 kg N ha^{-1} decreased significantly broken rice percentage. Moreover, the highest values of broken rice percentage recorded when nitrogen was not applied. This result was also documented by Srivastava *et al.* (2009) and Ebaid and El-Hissewy (2000).

Compost rate influenced significantly on broken rice percentage in both seasons and it decreased with increasing compost. The lowest broken rice percentage was obtained at 7 t compost ha^{-1}, followed by (3 tha^{-1}). Pandey *et al.* (1999) found higher head rice per cent with the application of of 10 t compost ha^{-1}.

Foliar application of ascobien significantly influenced on broken rice percentage in both seasons. The highest broken rice percentage was recorded without ascobien. Three times application of ascobien decreased broken rice percentage, followed by two or three times application. Similar results were obtained by Taha Hanan (2008).

The interaction between nitrogen and compost levels had a significant effect on broken rice percentage in both seasons (*Table 4*). The minimum broken rice percentages were recorded with the combination of nitrogen and compost, and it decreased with increasing the rate of nitrogen and compost in two seasons. On the other hand, broken rice percentage was achieved the maximum under control condition of nitrogen without compost was applied. Srivastava *et al.* (2009) reported that common application of mineral fertilizer and farmyard manure significantly led to lower grains degradation. The highest values of broken rice percentage were recorded without ascobien and nitrogen implemented plants that are under control conditions. While application of nitrogen and ascobien was decreased broken rice. Compost and ascobien also significantly reduced the degradation of rice grains and 3.5 or 7 t compost ha^{-1} with three times spraying of ascobien produced the lowest broken rice percentage in both seasons (*Table 6*).

Amylose content

Amylose content is improved due to application of nutrients sources (*Table 3*). Data in Amylose content of rice grains gradually increased with increasing nitrogen application and 165 kg N ha^{-1} produced the highest amount of amylose in rice grains. Ebaid and El-Hissewy (2000) indicated that increasing nitrogen fertilizer levels from 0 up to 165 kg N ha^{-1} significantly increased amylose content in Sakha101 rice cultivar. Maqsood *et al.* (2013) also confirmed these results. Young (2006) confirms the existence of negative correlation between nitrogen amount and amylose content.

Compost also significantly increased the amylose content of Sakha 106 rice variety in the two seasons (*Table 3*). Application of compost at 3.5 or 7 t/ha^{-1} increased significantly amylose content, compared with plants under control. The increase due to enough nutrition can be explained in terms of possible increase in nutrient absorption capacity of plant as a result of better root development and increased translocation of carbohydrates (Singh and Agarwal, 2001).

Foliar application of ascobien significantly influenced the amylose content of Sakha 106 rice in the two seasons (*Table 3*). The lowest values were recorded without ascobien (control). Bakry *et al.* (2013) found that application of antioxidants improved grain qualities of rice.

CONCLUSION

Nutrients sources have a significant influence on quality in rice. Application of 110 kg N ha^{-1}, 7 t ha^{-1}compost and two or three spraying with ascobien, or 110 kg N ha^{-1}, 3.5 t ha^{-1} compost and three times spraying or 55 kg N ha^{-1}, 7 t ha^{-1} compost and two times spraying could be recommended for optimum grain quality characteristics of Sakha 106 rice variety. The result also indicated that compost along with foliar application of ascobien can be saved from 50 to110 kg N ha^{-1}, without reducing grain quality.

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