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YIELD PERFORMANCE OF RAPESEED MUTANTS AT M_8 GENERATION

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Abstract

To study the performances of rapeseed mutants based on seed yield and yield attributes experiments was conducted at various locations of Bangladesh. Analysis of variance showed highly significant variations among the mutants and check for most of the characters studied in individual location and combined over locations. Interaction between genotype and location also showed significant variations for all the agronomic traits. Mutant RM20 produce the highest plant height (101.1cm) and mature earlier than all other mutants. At BINA Sub-station farm Ishurdi and Magura all the mutant produce significantly higher number of siliquae plant^{-1} then parent BARI Sarisha-15 and check BARI Sarisha-17. RM-18 and RM-20 produce maximum seeds siliquae^{-1} (30) whereas; the mutant RM07 produced lowest number of seeds siliquae^{-1} (22). Combined means over locations showed that mutants namely RM-18 and RM-20 produced significantly higher seed yield (1551.1 and 1385 kg/ha, respectively). These two mutants had also higher number of siliquae than the mother variety. This suggests that gamma rays irradiation can be fruitfully applied to develop mutants with higher seed yield and other agronomic traits in oleiferous *Brassica*.

Key Words*:* Rapeseed, Mutants and Yield

Introduction

Oils and fats supply calories that help our body to absorb fat-soluble vitamins and K. The sources of fats and oils are vegetable oils, palm oils, industrial oils and animal oils. Vegetable oils are a group of fats that are derived from some cereal grains, and fruits. The major world sources of vegetable oils are soybeans, sunflowers, rapeseed, cotton, and peanuts. Rapeseed represents an argonomically significant oilseed crop belongs to genus Brassica. There are 37 species in the genus Brassica cultivated in different region of the world (Encyclopedia Britannica, 2019). The oil producing B. rapa and B, napus are commonly known as rapeseed, while B. juncea species is familiar as mustard. Rape seed and mustard ranks first among the all oil crops grown in Bangladesh. About 78% of the total oil seed crops cultivated in Bangladesh is mustard (BBS, 2019). In Bangladesh, the average yield of rapeseed is 463.243kg/acre whereas world average is 836.36 kg/acre. Therefore genetic improvement of yield potential is foremost breeding objective for fill up this gap. The primary gene pool of oil seed has a low genetic diversity (Bus *et al.*, 2011). Therefore, new genetic sources and approaches are needed to diversify the genetic basis of rapeseed germplasm, which will make the current breeding programs more effective (Delourme *et al.,* 2013). Mutation is the ultimate source of genetic variation and it also creates a new DNA

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sequence for a particular gene, creating a new allele. It is an effective and simple method for obtaining valuable starting material that can further be used in crop improvement programs. Mutations can be induced by physical or chemical mutagens. Among physical mutagens, gamma rays are the most frequently used, accounting for 64% of the radiation-induced mutant varieties (Maluszynski *et al.*, 2000; Ahloowalia *et al.*, 2004; Jankowicz-Cieslak and Till, 2015). Induced mutation has been successfully used for the improvement of many crops including oilseed. More variability of rapeseed germplasms can be created via mutagenesis (Amosova *et al.,* 2019; Malek *et al.,* 2016; and Sharafi *et al.,*2015). Seed yield is the most important character for considering as a promising variety of a particular crop. Yield is a complex quantitative character governed by large number of genes and is greatly affected by environmental fluctuations. But induced mutations significantly contribute to creating genetic variations (Malek *et al.,* 2016). Henceforth an attempt was made to estimates the yield performance of advanced rapeseed mutant's lines (M_8) at various locations.

Materials and Method

Seeds of rapeseed variety BARI Sarisha-15 were irradiated with 600, 700, 800 and 900 Gy doses of gamma rays using Co^{60} gamma radiation to create genetic variations. Irradiated seeds were sown to grow M_1 generation at BINA, Mymensingh in 2013 for selecting desirable mutants in subsequent generations. Selection was made in each of M_2, M_3 and M_4 generation based on desired agronomic traits. From M_5 generation, two mutants namely RM-07 and RM-10 from 600 Gy, RM-18 from 800 Gy and another one mutant RM-20 from 900 Gy were selected for further evaluation. These four true breeding (homozygous) mutants along with the mother variety BARI Sarisha-15 were evaluated on preliminary yield trial and regional yield trial. Considering there agronomic performance Four M_8 rapeseed mutants were put into this trial to assess their performance through on-station and on-farm trial. For on station trial the experiment was conducted at the experimental farms of BINA HQs farm, Mymensingh and BINA sub-station farms at Nalitabari, Ishurdi, Chapainowabgonj, Rangpur & Magura and also for on farm trials the experiment was conducted at farmer’s field Mymenshing, Jamalpur, Rangpur, Nalitabari, Manikganj, & Magura. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 28th October 2019 to 3th November 2019. Unit plot size was 20m^2 (5m X 4m) with 25cm line to line spacing and 6-8cm from plant to plant within line was maintained. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development.

Data were taken on morphological yield contributing characters such as plant height (avg. of 10 randomly selected representative plants), branches/plant (avg. of 10 randomly selected representative plants) and yield attributes like siliqua length (avg. of 10 randomly selected siliqua of 10 representative plants), siliqua/plant (avg. of 10 randomly selected representative plants) and seeds/siliqua (avg. of 10 randomly selected siliqua of 10 representative plants) and 1000 seed weight (from each experimental plot 1000 seed counted and weighted). All the data were collected from each plot at maturity. Maturity period was counted when approximately 70% siliqua of each plot turned into yellowish brown color. Plot seed yield was taken after proper drying of seeds. Seed yield was taken from all the experimental plots and converted into ton ha^{-1}.

The data were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done following the experimental design with the help of the computer package Statistix 10. 5% level of significance was used to compare mean differences among the treatments (Gomez & Gomez,1984).

Results and Discussion

Analysis of variance indicated highly significant variations (p   0.01) among the mutants and check for most of the studied characters in individual locations and combined over locations indicating the presence of sufficient amount of genetic variability (Table 1). The presence of variability is the prerequisite for any breeding program.

Table 1. Analysis of variance (mean_squares) for quantitative traits in M_8 mutant of rapeseed for genotype, environment and interaction of genotype and environments.

Souece of Variation	Df	MS						
		Days to maturity	Plant height (cm)	Branches $Plant^{-1}$ (no.)	Siliquae $plant^{-1}$ (no.)	Siliquae Length (cm)	Seeds $siliquae^{-1}$ (no.)	Seed yield (kg ha^{-1})
Genotype	5	106.2**	538.8**	1.3*	1263.9**	0.2*	376.7*	1280.6**
Location	11	349.8**	392.7**	21.0^{NS}	8859.4**	13.1^{NS}	800.0^{NS}	2762.8**
Genotype×Location	55	84.7**	44.6**	2.0*	394.7**	0.2*	57.6**	2367.6**

*, ** Signi cant at 5% and 1% levels, respectively

Mean squares for location were not significant for all the traits like branches $plant^{-1}$ (no.), siliquae length (cm) and seeds $siliquae^{-1}$(no.). Mean must be significant when any one of the mean of component is significant. Seed yields, days to maturity, plant height and siliquae $plant^{-1}$ provide significant variation for genotype, location and genotype and location interaction. Significant mean square of genotype indicates the influence of gene to the expression of the characters. There is no way to avoid the effect of location or environments on gene expression. Yield is the most important characters that controlled by many gene. Interaction of multiple gene as well as environment and agronomic practices directly influenced the yield. Significant mean square of yields is expectable for all case that indicates the presence of variation on treated materials. In rapeseed genotypes significant variations for yield have been reported by Mahmud *et al*., 2008; Mondal *et al*. 2018 and Channaoui *et al*., 2019.

Results of mean values of twelve individual locations and combined over locations for all the characters have been presented in Table 2. Maturity period is the most important and frequent character which can be modified in oilseed *Brassica* using induced mutation. Significant differences were observed for days to maturity in different locations. In combined over locations, days to maturity varied from 86 to 90 days. Parent BARI Sarisha-15 and check variety BARI Sarisha-17 required shortest maturity period (86 days) having non-significant difference with each other's. Among the mutants RM-10 and RM-20 required the shortest period of 88 days to mature. While without BINA Headquarters' Farm Mymensingh, BINA sub-station Ishurdi and Chapainawabganj, the mother variety BARI Sarisha-15 took the highest maturity period. Mutant RM-20 required shortest maturity period of 78 days at Jamalpur sub station and longest maturity period of 103 days at Ishurdi sub station. Moreover RM-07 required the longest maturity period having significant difference with other mutants and check at all locations. At Ishurdi sub-station, BARI Sarisha-17 required the longest duration of 99 days to mature. So, in all locations mutants have significantly different maturity period than the mother and check variety. Variation for duration in the mutants of oilseed *Brassica* has been reported by Shah & Rahman (2009) and Malek *et al*., (2012a) which confirm the present result.

The high yielding ability of a variety depends upon some important plant characteristics; short stature is one of them. For plant height semi dwarf plant type is desire because they show somewhat resistance against not only lodging but also other yield increasing characters (Bhuiyan *et. al.,* 2017 and Sayed *et. al.,* 2020).

Table 2: Mean performance of M_8 rapeseed mutants grown at different locations during 2018-2019

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches Plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliquae Length (cm)	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})
BINA HQs	RM07	91.0ab	92.0d	3.0b	104.0b	6.3ab	18.0c	995.0e
Farm,	RM10	91.0ab	99.6bc	3.0b	106.0a	6.5a	19.0bc	1185c
Mymensingh	RM18	92.0a	96.4c	3.0b	93.0d	6.0b	26.0a	1298a
	RM20	92.0a	99.2bc	4.0a	103.0b	6.0b	25.0ab	1232b
	BARI Sarisha-15 (P)	85.0b	101.6b	4.0a	94.0d	5.9b	19.0bc	1008d
	BARI Sarisha-17(CV)	84.0b	104.3a	3.0b	98.0c	6.0b	20.0b	905.0f
Farner's	RM07	92.0b	85.0e	3.0b	95.0b	5.6b	16.0c	965.0e
Field	RM10	80.0e	94.6ab	4.0a	85.0d	5.2d	17.0abc	1078d
Mymensingh	RM18	94.0a	92.6c	3.0b	97.0a	5.8a	17.0bc	1268a
	RM20	81.0de	97.3a	3.0b	89.0c	5.6b	18.0b	1150c
	BARI Sarisha-15 (P)	82.0d	92.2c	4.0a	94.0b	5.3cd	23.0ab	1090d
	BARI Sarisha-17(CV)	84.0c	89.4d	3.0b	84.0d	5.4c	24.0a	1202b
Farner's	RM07	95.0a	90.0d	2.0b	103.0ab	5.8b	18.0c	985.0bc
Field	RM10	83.0e	99.6ab	3.0a	93.0b	5.4c	19.0abc	998.3bc
Manikganj	RM18	93.0b	97.6b	2.0b	105.0a	6.0a	19.0bc	1175ab
	RM20	84.0de	102.3a	2.0b	97.0c	5.5c	20.59d	895.0c
	BARI Sarisha-15 (P)	85.0d	97.2b	3.0a	102.0b	5.5c	25.0ab	1222a
	BARI Sarisha-17(CV)	87.0c	94.4c	2.0b	92.0d	5.5c	26.0a	1288a

Table 2. Continued

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches $Plant^{-1}$ (no.)	Siliquae $plant^{-1}$ (no.)	Siliquae Length (cm)	Seeds $siliquae^{-1}$ (no.)	Seed yield (kg ha^{-1})
Ishurdi	RM07	94.0c	94.6ab	7.0a	45.0c	4.0a	25.0a	1325b
Sub-Station	RM10	91.0d	91.3b	4.0b	46.0c	4.0a	24.0b	1891b
	RM18	91.0d	91.0b	6.0ab	81.0a	4.0a	22.0c	1947a
	RM20	103.0a	103.3a	4.0b	60.0b	4.0a	28.0a	1835b
	BARI Sarisha-15 (P)	101.0ab	101.0ab	5.0ab	44.0c	4.0a	21.0c	1305c
	BARI Sarisha-17(CV)	99.0b	99.3ab	6.0ab	40.0c	4.0a	27.0a	1874b
Magura	RM07	81.0c	100.0b	3.0b	72.0b	4.0a	22.0c	960bc
Sub-station	RM10	90.0a	90.6d	3.0b	84.0a	4.0a	22.0b	1137b
	RM18	82.0c	102.0ab	3.0b	74.0b	4.0a	44.0a	1305a
	RM20	82.0c	105.0a	4.0a	72.0b	4.0a	42.0a	1111b
	BARI Sarisha-15 (P)	88.0b	95.0c	4.0a	55.0c	4.0a	26.0bc	886.7c
	BARI Sarisha-17(CV)	88.0b	100.0b	4.0a	55.0c	4.0a	31.0b	1027bcd
Farmer's	RM07	83.0c	97.0ab	3.0c	87.0bc	4.0a	40.0c	1075d
Filed	RM10	92.0a	90.6c	4.0b	96.0bc	4.0a	40.0c	1281c
Magura	RM18	84.0c	99.0a	5.0a	111.0ab	4.0a	51.0a	1917a
	RM20	89.0bc	102.0a	4.0b	108.0b	4.0a	40.0c	1805b
	BARI Sarisha-15 (P)	91.0b	92.0bc	4.0b	121.0a	4.0a	44.0b	1175c
	BARI Sarisha-17(CV)	90.0b	97.0ab	3.0c	80.0c	4.0a	40.0c	1144d
Rangpur	RM07	85.0a	95.3bc	3.0c	82.0cd	3.0b	21.0c	1137c
Sub-station	RM10	83.0b	94.0bc	4.0b	91.0c	3.0b	30.0b	1167c
	RM18	83.0a	103.0ab	4.0b	103.0b	3.0b	31.0b	1951a
	RM20	83.0b	107.0a	5.0a	106.0b	4.0a	32.0ab	1820b
	BARI Sarisha-15 (P)	84.0ab	102.0ab	4.0b	116.0a	3.0b	21.0c	1190c
	BARI Sarisha-17(CV)	79.0c	93.0c	3.0c	75.0d	3.0b	35.0a	1187c
Farmer's	RM07	90.0a	98.0bc	3.0c	87.0cd	3.0b	22.0c	1137cb
Field	RM10	89.0ab	97.0bc	4.0b	96.0c	3.0b	31.0b	1163c
Rangpur	RM18	87.0b	110.0a	5.0a	111.0ab	4.0a	33.0ab	1433a
	RM20	87.0b	106.6ab	4.0b	108.0b	4.0a	32.0ab	1278b
	BARI Sarisha-15 (P)	88.0ab	105.0abc	4.0b	121.0a	3.0b	22.0c	1190c
	BARI Sarisha-17(CV)	88.0ab	96.3c	3.0c	80.0d	3.0b	36.0a	1187b
Jamalpur	RM07	81.0a	84.5bc	2.0b	53.0a	7.0a	22.0c	1160b
Sub-statuio	RM10	80.0ab	86.3b	3.0ab	54.0a	6.0ab	22.0b	1157b
	RM18	78.0b	91.2a	3.0ab	39.0bc	5.0c	44.0a	1777a
	RM20	78.0b	92.2a	4.0a	46.0b	5.0c	42.0a	1775a
	BARI Sarisha-15 (P)	78.0b	84.87bc	4.0a	41.0bc	6.0ab	26.0bc	1186b
	BARI Sarisha-17(CV)	79.0ab	80.8c	3.0ab	33.0c	5.0c	31.0b	1188b
Chapai-	RM07	91.0ab	98.3bc	3.0c	87.0bc	3.0b	22.0d	1137cb
nawabganj	RM10	91.0ab	97.0bc	4.0b	96.0bc	3.0b	31.0c	1163c
Sub-Station	RM18	92.0a	106.6ab	5.0a	111.0ab	4.0a	33.0b	1567a
	RM20	92.0a	110.3a	4.0b	108.0b	4.0a	32.0b	1483a
	BARI Sarisha-15 (P)	85.0b	105.0bc	4.0b	121.0a	3.0b	22.0d	1190b
	BARI Sarisha-17(CV)	84.0b	96.3bc	3.0c	80.0c	3.0b	36.0a	1187b

Table 2. Continued

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches Plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliquae Length (cm)	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})
Nalitabari	RM07	96.0a	85.0c	4.0b	89.0a	5.0a	16.0c	950.0d
Sub-Station	RM10	94.0b	94.6ab	5.0a	79.0cd	5.0a	17.0abc	1207b
	RM18	94.0b	92.6b	4.0b	91.3a	5.0a	17.0bc	1397a
	RM20	90.0d	97.3a	4.0b	83.0c	4.0b	18.0abc	1260b
	BARI Sarisha-15 (P)	92.0c	92.2b	5.0a	88.0b	4.0b	23.0ab	1087cb
	BARI Sarisha-17(CV)	88.0e	89.4bc	4.0b	78.0d	5.0a	24.0a	1153cb
Farmer's	RM07	95.0ab	85.7b	4.0ab	80.0a	6.0a	17.0c	1033cd
Field	RM10	93.0bc	85.3b	4.0ab	70.0b	5.b	21.0bc	1267bc
Nalitabari	RM18	94.0b	90.6a	3.0b	31.0d	4.0c	24.0b	1533a
	RM20	94.0b	91.7a	5.0a	48.0c	5.0b	28.0a	1300b
	BARI Sarisha-15 (P)	92.0c	85.4b	4.0ab	39.0cd	5.0b	19.0bc	1200c
	BARI Sarisha-17(CV)	96.0a	79.7c	3.0b	31.0d	5.0b	24.0b	867d
Combined	RM07	90.0a	92.1c	3.0b	82cd	4.7a	22.0bc	1072c
Means Over	RM10	88.0b	93.3c	4.0a	83c	4.5b	25.0b	1224c
Locations	RM18	89.0ab	97.7b	4.0a	87.0a	4.5b	30.0a	1551a
	RM20	88.0b	101.1a	4.0a	85.0b	4.5b	30.0a	1385b
	BARI Sarisha-15 (P)	87.0bc	96.1b	4.0a	86.0ab	4.3c	25.0b	1144d
	BARI Sarisha-17(CV)	87.0bc	93.3c	3.0b	68.0d	4.4bc	29.0ab	1184d

P = Parent and CV = Check variety; In a column, values with same letter(s) for individual location/combined means do not differ significantly at 5% level

Plant height may vary due to the genetic effects present among the genotypes as well as the proper agronomic management. A significant variation was observed in plant height. In combined over locations, plant height ranged from 92.1 cm to 101.1 cm. Mutation has strong effect on plant height. Mutant induced taller as well as shorter type plants. Mutant RM-20 produced the highest plant height (101.1 cm) significantly higher than parent BARI Sarisha-15, where as mutant RM-10 and RM-07 produced significantly shortest one. Plant height of BARI Sarisha -17, RM-07 and RM-10 was statistically similar and dwarf than other two mutants as well as parent BARI Sarisha -15. Except BINA farm mutant RM-20 was tallest one, while at farmer's field at Rangpur, both of RM-20 and BARI Sarisha-15 provide statistically similar plant height. Mutant RM-10 showed tallest plant at farmer's field Rangpur. At farmer's field Rangpur, BARI Saridha-17 also showed the shortest plant (96.3cm) which was closely followed by RM-10 and RM-07, whereas RM-07 showed the shortest plant in all other locations. In combined over locations, it was sharply reflect that mutant RM-07 produced the shortest plant height than all other mutants and check variety. Influence of mutation on plant height also obtains by Mondal *et al.,* 2018 and Channaoui *et al.,* 2019.

The number of branches is one of the important selection criteria for oilseed improvement programs. Higher number of branches enables bearing more siliquae per plant and result in higher seed yield. Lowest number of branches/plant was observed in farmer's field Manikganj and higher in BINA Sub-station Ishurdi. At Manikganj, mutant RM-07 produced the highest number of branches/plant (3.0) similar with BARI Sarisha-15. All other mutants including BARI Sarisha-17 produced the lowest number of branches plant^{-1}. At BINA Sub-station Ishurdi, mutant RM-7 produced the highest number of branches plant^{-1} (7) closely followed by RM-18 and BARI Sarisha-17. On an average number of branches plant^{-1} ranged from 3 to 5. Without RM-7 all other mutants produced similar as well as significantly higher number of branches than mother BARI Sarisha-15. The present results having different number of branch in the rapeseed mutants and other oilseed than the mother confirms the findings of Malek *et al.,* 2016; and Bhuiyan *et al.,* 2019.

A significant variation was found among the mutants and mother variety on the number of siliquae plant^{-1} in individual location and combination over locations. It is the most important agronomic character link with seed yield. Considering combined over locations, siliquae plant^{-1} ranged from 68 to 87. At BINA Sub-station farm Ishurdi and Magura, all the mutants produced significantly higher number of siliquae plant^{-1} than the parent BARI Sarisha-15 and check BARI Sarisha-17. At Magura, RM-07 produced the highest number of siliquae plant^{-1} (84) and the mother variety produced the lowest number (55). At Ishurdi, RM-18 produced the highest siliquae plant^{-1} (81) followed by RM-20. Significant differences were also observed for siliquae length in different locations. On an average, the mutant RM-07, produced significantly higher siliquae length than others. Mutants produced RM-10, RM-18 and RM-20 had equal siliquae length and the parent BARI Sarisha-15 was the shortest one. In oilseed Brassica, as a consequence of mutagenesis for siliquae plant^{-1} and siliquae length reported earlier by Malek *et al*., 2016 and Ali *et at.,* 2020.

Like siliquae plant^{-1} another important yield controlling trait is seeds siliquae^{-1}. Number of seeds siliquae^{-1} differ significantly both in individual locations and combined over locations. Mutant RM-07, RM-10 and BARI Sarisha-15 were formed double chamber whereas mutant RM-18, RM-20 and BARI Sarisha-17 were four chambered type siliquae. Double chambered type siliquae have been produced by the mutants RM-07, RM-10 and BARI Sarisha-15. Mutant RM-10 and BARI Sarisha-15 produced similar number of seeds siliquae^{-1}. Four chambered mutant RM-18 and RM-20 produced the highest number of seeds siliquae^{-1}.

Seed yield is the most important character for considering as a promising variety of a particular crop. The mutants RM-18 produced the highest seed yield of 1950 kg ha^{-1} at BINA Sub-station farm Rangpur, while RM-18 gave the lowest seed yield of 1175.0 kg/ha at Manikganj. Combined means over twelve locations showed that three mutants namely RM-10, RM-18 and RM-20 produced significantly higher seed yield (1224.5, 1551.1 and 1385 kg ha^{-1}, respectively) than mother variety BARI Sarisha-15 (1144.2 kg/ha). In location wise performance of yields, Magura showed the best performance followed by Chapainawabganj and Rangpur may be due to the environmental and soil characteristics of a particular location. Maximum seed yield of 1916.7 kg ha^{-1} was obtained from farmer's field at Magura. Considering promising variety of a particular crop, seed yield is the most important trait.

Rapeseed yield varies depending on the variety and favorable ecosyatems with proper agronomic management practices. In rapeseed-mustard and other oilseed mutants having higher seed yield over mother varieties also reported by Zhao *et al.*, 2009; Brave *et al*., 2009; Ali *et al.,*2020 and Mondal *et al.,*2020.

Conclusion

The present study revealed the presence of high levels of variations for different morphological traits including yield attributes. For Oilseed *Brassica*, the most important yield attributes responsible for the increased seed yield are the siliquae number and seed number in siliqua. It was observed that among the mutants and mother variety, mutants RM-18 and RM-20 performed better for seed yield and yield contributing characters which can be selected for further trials to be registered as varieties. These mutants could be served as breeding materials for further genetic improvement of different characters of the rapeseed also. Moreover, this finding suggests that gamma rays irradiation can be fruitfully applied to induce mutants in rapeseed with higher seed yield and other improved agronomic traits.

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