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Response on yield and protein content of fine aromatic rice varieties to integrated use of cowdung and inorganic fertilizers

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ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from June to December 2014-2015 to evaluate the effect of integrated use of inorganic fertilizers with cowdung on the yield and quality of fine aromatic rice. The experiment consisted of three varieties of aromatic fine rice viz. Kalizira, Binadhan-13 and BRRI dhan38 and six nutrient management viz. Control (F_0), BINA recommended inorganic fertilizer dose 150-120-80-60-10 kg $ha^{-1}$of Urea-TSP-MOP-Gypsum-$ZnSO_4$, respectively (F_1), 75% inorganic fertilizers + cowdung 5 t ha^{-1} (F_2), 75% inorganic fertilizers + cowdung 10 t ha^{-1} (F_3), 50% inorganic fertilizers + cowdung 5 t ha^{-1} (F_4), and 50% inorganic fertilizers + cowdung 10 t ha^{-1} (F_5). The experiment was laid out in a randomized complete block design with three replications. The effect of interaction between variety and nutrient management showed significant variation on grain yield and quality. The highest grain yield (3.92 t ha^{-1}) and grain protein content (9.88%) were obtained from Binadhan-13 fertilized with 75% inorganic fertilizers + cowdung 10 t ha^{-1} while the lowest grain yield (1.52 t ha^{-1}) and grain protein content (6.42%) was found in control treatment (no manures and no fertilizers) in Kalizira. Maximum benefit cost ratio (1.94) was found from Binadhan-13 with the combination of 75% inorganic fertilizers + cowdung 5 t ha^{-1}, which was similar (1.93) to the treatment combination of 75% inorganic fertilizers + cowdung 10 t ha^{-1}.

***Keywords*:** Aromatic fine rice, grain yield, protein content

Rice (*Oryza sativa* L.) contributes 95 per cent of the total food production in Bangladesh. About 77 per cent of cropped area of Bangladesh is used for rice production, with annual production of 33.83 million ton from 11.41 million ha of land which contributes about 19.60 per cent of the country's GDP (BBS, 2013). Total aromatic rice production is about 0.30 million tons from 0.16 million ha of land in Bangladesh in 2013. In Bangladesh, a number of fine rice cultivars are grown *viz*. Chinisagar, Badshabhog, Kataribhog, Kalizira, Tulsimla, Dulabhog, Basmati, Banglamati (BRRI dhan50), BRRI dhan 34, BRRI dhan37 and BRRI dhan 38 and the newly BINA released variety Binadhan-13. Some of them have special appeal for their aroma. These varieties are cultivated by the farmers for domestic consumption to meet the local demand mainly but very little for export purpose. The productivity of aromatic fine rice in Bangladesh is very low due to mainly proper nutrient management. Since fertilizer is an expensive and precious input, determination of appropriate doses would be both economical and appropriate to enhance productivity for constant profit (Subudhi *et al.*, 2006). Therefore, integrated plant nutrient management is imperative for quality aromatic rice production in a sustainable way. The application of cowdung to soil is considered as a good management practice in any agricultural production system because of the stimulation of soil microbial growth and activity, subsequent mineralization of plant nutrients, and increased soil fertility and quality (Islam *et al.*, 2007). Growth, yield and yield contributing characters were significantly influenced by the nutrient management. The application of 75 per cent of recommended dose of inorganic fertilizers + 50 per cent cowdung showed superiority in terms of the yield and quality of aromatic rice (Sarkar *et al.*, 2014). In all the agricultural system, there is a loss of plant nutrients. Nutrient mining, depletion of soil organic matter and reduction in soil aggregates have been identified as reasons of yield stagnation or decline in the productivity of crops (Rahman and Yakupitiyage, 2006). In Bangladesh, nutrient stresses of soils are increasing due to extensive use of chemical fertilizers. Now the organic matter content is below 1.5 per cent in most of the areas and in many cases it is less than 1 per cent (BARC, 2012). The efficient nutrient management increases crop yield and at the same time reduces fertilization cost. It is, therefore essential to find out the suitable rate of inorganic fertilizers along with organic means for efficient utilization nutrients to augment better yield performance and quality of fine aromatic rice.

MATERIALS AND METHODS

The experiment was conducted during June to December 2014-2015 at the Agronomy Field Laboratory, Bangladesh Agricultural University,

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Mymensingh. Geographically the experimental site is located at 24°75' N latitude and 90°50' E longitude at an altitude of 18 m above MSL. The site belongs to the non-calcareous dark gray floodplain soil under the Old Brahmaputra Floodplain (AEZ 9). The field is a medium high land with well drained silty-loam texture having pH 6.5, available N 0.10 per cent, P 16.72 ppm, K (milliequivalent/100g soil) 0.12, S 14.2 ppm and low in organic matter content (1.29 per cent). Cowdung contains 0.57 per cent N, 0.47 per cent P_2O_5, 0.69 per cent K_2O, 0.23 per cent S and other nutrients in small quantity (Husan *et al.*, 2014). The parent material of the experimental site was Old Brahmaputra River borne deposits. The experiment consisted of three varieties of aromatic fine rice *viz*. Kalizira, Binadhan-13 and BRRI dhan38 and six nutrient managements *viz*. Control (F_0), BINA recommended inorganic fertilizer dose 150-120-80-60-10 kg ha^{-1} of Urea-TSP-MOP-Gypsum-$ZnSO_4$, respectively (F_1), 75 per cent inorganic fertilizers + cowdung 5 t ha^{-1} (F_2), 75 per cent inorganic fertilizers + cowdung 10 t ha^{-1} (F_3), 50 per cent inorganic fertilizers + cowdung 5 t ha^{-1} (F_4), and 50 per cent inorganic fertilizers + cowdung 10 t ha^{-1} (F_5). The experiment was laid out in a randomized complete block design with three replications. There were 54 unit plots in the experiment. The size of unit plot was 4.0 × 2.5 m. The distances between blocks and plots were 1 m and 75 cm, respectively. The land was fertilized as per treatment specification. At the time of final land preparation, each unit plot was fertilized with recommended level of cowdung in the respective plots according to treatment. The cowdung was mixed thoroughly with the soil. The amount of whole phosphorus, potassium, sulphur and zinc were applied in the form of triple superphosphate (TSP), muriate of potash (MOP), gypsum and zinc sulphate, respectively at final land preparation. Urea was applied in three equal splits at 15, 35 and 50 days of transplanting (DAT). The crop was harvested at full maturity. The date of harvesting was confirmed when 90 per cent of the grain became golden yellow in color. Five hills (excluding border hills) were selected randomly from each unit plot and uprooted before harvesting for recording data. Grain and straw weights were recorded from five hills and it was added to the final plot yield. After sampling the whole plot was harvested. The harvested crop of each plot was separately bundled, properly tagged and then brought to threshing floor. The harvested crop was then threshed by pedal thresher and the fresh weights of grain and straw were recorded plot-wise. The grains were cleaned and sun dried to a moisture content of 14 per cent. Finally the grain and straw yields per plot were converted into t ha^{-1}. All the collected data were analyzed following the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Varietal performance

Plant height, yield contributing characters, yield and protein content were significantly influenced by variety. The tallest plant (139.50 cm) was found in Kalizira, which was statistically identical to Binadhan-13 (137.70 cm). The shortest plant (118.40 cm) was obtained from BRRI dhan38 (Table 1). Variation in plant height might be due to difference in genetic make-up of the variety. This result was supported by Tyeb *et al.* (2013) and Sarkar *et al*. (2014). The highest number of effective tillers hill^{-1} (11.20) and grains panicle^{-1} (146.50) were found in Binadhan-13 followed by BRRI dhan 38. The lowest values were recorded in Kalizira. The variation in number of effective tillers hill^{-1} and grains panicle^{-1} as assessed might be mostly due to genetic variation among the varieties. Similar results were reported elsewhere (Islam *et al.*, 2015, Shaha *et al.*, 2014 and Sarkar *et al*., 2014). The highest 1000-grain weight (13.67 g) was found in BRRI dhan38, which was statistically identical with Binadhan-13 (13.45 g) and the lowest one (11.85 g) was found in Kalizira (Table 1). The variation in weight of 1000 grains might be due to different sizes of spikelets that were partly controlled by genetic make-up of the varieties. Similar views were also expressed elsewhere (Jisan *et al.,* 2014 and Sarkar *et al.*, 2014). Binadhan-13 produced the highest grain yield (3.37 t ha^{-1}) followed by BRRI dhan38 (3.22 t ha^{-1}) and Kalizira produced the lowest (2.32 t ha^{-1}) grain yield. Grain yield differences might be due to production potential of genetic characteristics of the varieties. Variable grain yields obtained in different varieties were also reported elsewhere (Ray *et al.*, 2015, Shaha *et al*., 2014 and Sarkar *et al*., 2014). Binadhan-13 produced the highest yield contributing characters that led to the highest grain yield. The highest straw yield (5.85 t ha^{-1}) was also obtained from Binadhan-13 where the lowest one (5.00 t ha^{-1}) from Kalizira (Table 1). The highest number of effective tillers hill^{-1} and other vegetative characters were responsible for the highest straw yield. These results are consistent with those obtained by Chowdhury *et al.* (1993) and Jisan *et al.* (2014). They reported that straw yield differed due to varietal characteristics. Harvest index was significantly influenced by variety. The highest harvest index (36.30 %) was obtained from BRRI dhan38, which was statistically identical with Binadhan-

13 and the lowest one (30.82 per cent) was obtained from Kalizira (Table 1). Kabir *et al.* (2004) and Tyeb *et al*. (2013) reported variable harvest index among the varieties. Grain protein content was significantly influenced by variety. The highest grain protein content (9.41 per cent) was obtained from Binadhan-13 followed by BRRI dhan38 (8.50 per cent) and the lowest one (8.12 per cent) was obtained from Kalizira. Protein content of grains varied due to genetic make-up of varieties. The result was consistent with Ray *et al.* (2015) and Sarkar *et al.* (2014).

Effect of nutrient management

Plant height, yield contributing characters, yield and protein content were significantly affected by nutrient management. The highest plant height (137.80 cm) was recorded in treatment F_3 (75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}), which was statistically *at par* with F_1 (BINA recommended doses of inorganic fertilizers). The lowest plant height (122.8 cm) was obtained in control treatment F_0 (no cowdung and no inorganic fertilizers). Rice cultivars increased plant height with fertilizers (Ranawake, 2015). Cowdung induced exuberant vegetative growth and resulted in the highest plant height. There were significant differences due to nutrient management in terms of effective tillers hill^{-1} and number of grains panicle^{-1}. Number of effective tillers hill^{-1} ranged from 6.16 to 12.53 for different levels of cowdung with inorganic fertilizers. The highest number of effective tillers hill^{-1} (12.53) and grains panicle^{-1} (151.60) were obtained in the treatment F_3 (75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) followed by F_2 (75 per cent inorganic fertilizer + cowdung 5 t ha^{-1}). The lowest number of effective tillers hill^{-1} (6.16) and grains panicle^{-1} (117.60) were recorded in the control treatment. Integration of manure and inorganic fertilizer enhanced number of effective tillers hill^{-1} and grains panicle^{-1} also reported elsewhere (Shaha *et al.*, 2014 and Sarkar *et al.*, 2014). The highest 1000-grain weight (13.17 g) was recorded from F_3 (75 per cent inorganic fertilizer + cowdung 10 t ha^{-1} followed by F_2 (75 per cent inorganic fertilizers + cowdung 5 t ha^{-1}) and the lowest one (12.53 g) was found in control. The highest grain yield (3.42 t ha^{-1}) was produced in the treatment F_3 (75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) followed by F_2 (75 per cent inorganic fertilizers + cowdung 5 t ha^{-1}) and the lowest grain yield (2.02 t ha^{-1}) was recorded in control treatment. Integrated use of manure and reduction of recommended dose of inorganic fertilizer enhanced grain yield was also reported by Islam *et al.* (2015). The straw yields ranged from 4.13-6.11 t ha^{-1}. The highest straw yield (6.11 t ha^{-1}) was produced in the treatment F_3 (75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) followed by F_5 (50 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) and the lowest straw yield (4.13 t ha^{-1}) was produced in controlled treatment (Table 12). Similar trend was also reported by Sarkar *et al.* (2014). The highest harvest index (35.61 per cent) obtained from nutrient management treatment F_2 (75 per cent inorganic fertilizer + cowdung 5 t ha^{-1}), which was statistically *at par* with F_3 (75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) and F_5 (50 per cent inorganic fertilizer + cowdung 10 t ha^{-1}). The lowest one (33.92 per cent) was obtained from F_4 (50 per cent inorganic fertilizer + cowdung 5 t ha^{-1}) which is statistically *at par* with F_0 (control treatment) (Table 2). Grain protein content varied significantly due to nutrient management. Grain protein content ranged from 7.39 to 9.38 per cent due to application of different doses of fertilizers and manures. The highest grain protein content (9.38 per cent) was found in treatment F_3 (75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) followed by F_2 (75 per cent inorganic fertilizer + cowdung 5 t ha^{-1}). The lowest grain protein content (7.39 per cent) was observed in treatment F_0 (no manures and no fertilizers). Similar results were reported by Sarkar *et al.* (2014).

Interaction effect

Yield contributing characters, yield and protein content were significantly affected by nutrient management. Interaction of variety and nutrient management exerted significant influence on effective tillers hill^{-1}. The highest number of effective tillers hill^{-1} (13.58) and grains panicle^{-1} (163.4) were observed in $V_2 \times F_3$ (Binadhan-13 × 75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) followed by $V_2 \times F_2$ (Binadhan-13 × 75 per cent inorganic fertilizer + cowdung 5 t ha^{-1}) (12.48) and 154.60, respectively. The lowest number of effective tillers hill^{-1} (4.78) and grains panicle^{-1} (108.30) were found in the combination $V_1 \times F_0$ (Kalizira × control with no cowdung and inorganic fertilizers) (Table 3). Sarkar *et al.* (2014) also reported similar results. The highest grain yield (3.92 t ha^{-1}) was obtained from the combination $V_2 \times F_3$ (Binadhan-13 × 75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) followed by $V_3 \times F_3$ (BRRI dhan 38 × 75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) and the lowest grain yield (1.52 t ha^{-1}) was obtained from the combination $V_1 \times F_0$ (Kalizira and no manure and no fertilizer). Integrated use of manure and inorganic fertilizers encourage the production of effective tillers hill^{-1} and grains panicle^{-1} resulting in higher grain yield (Islam *et al.*, 2015 and Sarkar *et al.*, 2014). The highest straw yield (6.32 t ha^{-1}) was obtained from the interaction of $V_2 \times F_3$

(Binadhan-13 × 75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) which was statistically identical with $V_2 \times F_5$ (Binadhan-13 × 50 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) and $V_3 \times F_3$ (BRRI dhan38 × 75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) whereas, the lowest one (3.60 t ha^{-1}) was in the combination of $V_1 \times F_0$ (Kalizira × no manure and no fertilizer). Mishra *et al.* (2003) and Sarkar *et al.* (2014) reported that straw yield differed due to interaction effect of variety and nutrient management. Harvest index varied 30.04 per cent to 38.20 per cent due to interaction of variety and nutrient management. The highest harvest index (38.20 per cent) was observed in the interaction between interaction of $V_2 \times F_3$ (Binadhan-13 × 75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) which was statistically at par with the interaction $V_2 \times F_1$ (Binadhan-13 × BINA recommended inorganic fertilizers), $V_2 \times F_2$ (Binadhan-13 × 75 per cent inorganic fertilizer + cowdung 5 t ha^{-1}), $V_3 \times F_1$ (BRRI dhan38 × BINA recommended inorganic fertilizers), $V_3 \times F_2$ (BRRI dhan38 × 75 per cent inorganic fertilizer + cowdung 5 t ha^{-1}), $V_3 \times F_3$ (BRRI dhan 38 × 75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}), and $V_3 \times F_5$ (BRRI dhan38 × 50 per cent inorganic fertilizer + cowdung 10 t ha^{-1}), respectively and the lowest one (30.04 per cent) was recorded in the interaction between $V_1 \times F_1$ (Kalizira × BINA recommended inorganic fertilizer) (Table 3). This was mainly due to less grain and straw yields of variety Kalizira with different levels of inorganic fertilizer and cowdung. Grain protein content was significantly affected by the interaction between variety and nutrient management. The highest grain protein content (9.88 per cent) was obtained from the interaction of $V_2 \times F_3$ (Binadhan-13 × 75 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) which was statistically identical with the interaction $V_2 \times F_1$ (Binadhan-13 × BINA recommended inorganic fertilizers), $V_2 \times F_2$ (Binadhan-13 × 75 per cent inorganic fertilizer + cowdung 5 t ha^{-1}) and $V_2 \times F_5$ (Binadhan-13 × 50 per cent inorganic fertilizer + cowdung 10 t ha^{-1}) and the lowest one (6.42%) was in the combination of $V_1 \times F_0$ (Kalizira × control with no cowdung and inorganic fertilizers) (Table 3).

Table 1: Effect of variety on yield contributing characters, yield and protein content of fine aromatic rice

Variety	Plant height (cm)	Effective tillers hill^{-1} (No.)	Grains panicle^{-1} (No.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Protein content (%)
V_1-Kalizira	139.50a	8.775c	129.60c	11.86b	2.320c	5.008c	31.82b	8.12c
V_2-Binadhan-13	137.70a	11.20a	146.50a	13.45a	3.370a	5.850a	35.97a	9.41a
V_3-BRRI dhan38	118.40b	9.782b	134.40b	13.67a	3.220b	5.620b	36.30a	8.50b
CV%	**3.40**	**3.09**	**2.74**	**3.16**	**3.02**	**3.65**	**3.53**	**2.60**

Note: In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT at 1% level of probability.

Table 2: Effect of nutrient management on yield contributing characters, yield and protein content of fine aromatic rice

Nutrient management	Plant height (cm)	Effective tillers hill^{-1} (No.)	Grains panicle^{-1} (No.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Protein content (%)
F_0	122.8d	6.163f	117.6e	12.53b	2.02e	4.133d	34.23b	7.39e
F_1	134.8ab	10.53c	140.5bc	13.09a	3.09c	5.707bc	34.01b	8.95bc
F_2	133.0bc	10.94b	141.8b	13.10a	3.21b	5.693bc	35.61a	9.07b
F_3	137.80a	12.53a	151.6a	13.17a	3.42a	6.113a	35.59a	9.39a
F_4	129.70c	9.38e	131.6d	13.00a	2.96d	5.533c	33.92b	8.47d
F_5	133.10bc	9.97d	137.7c	13.07a	3.11c	5.777b	34.80ab	8.80c
Significance	**	**	**	*	**	**	*	**
CV%	**3.40**	**3.09**	**2.74**	**3.16**	**3.02**	**3.65**	**3.53**	**2.60**

*Note: *, ** = Significant at 5% and 1% level of probability, respectively.*

Table 3: Interaction effect of variety and nutrient management on yield contributing characters, yield and protein content of fine aromatic rice

Variety × Nutrient management	Plant height (cm)	Effective tillershill^{-1} (No.)	Grains panicle^{-1} (No.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Protein content (%)	B:C
$V_1 \times F_0$	126.3	4.78k	108.30k	11.44	1.52k	3.60 j	34.70cde	6.420l	1.07
$V_1 \times F_1$	144.6	9.51g	136.40efg	11.95	2.44hi	5.00gh	30.04g	8.430ghi	1.42
$V_1 \times F_2$	142.3	9.55g	129.50ghi	11.98	2.52gh	5.38f	31.34fg	8.640gh	1.45
$V_1 \times F_3$	147.6	11.60c	142.60cde	12.05	2.65g	5.72e	31.58fg	9.100def	1.42
$V_1 \times F_4$	136.6	8.25i	126.70i	11.86	2.34i	5.05fgh	31.66fg	7.970j	1.39
$V_1 \times F_5$	139.4	8.96h	133.90fgh	11.89	2.45hi	5.30fg	31.60fg	8.180ij	1.35
$V_2 \times F_0$	132.3	8.33i	126.30i	13.10	2.36hi	4.75h	33.10ef	8.340hij	1.47
$V_2 \times F_1$	140.4	11.80c	149.30bc	13.55	3.51cd	6.18abc	36.20abcd	9.670ab	1.91
$V_2 \times F_2$	136.1	12.48b	154.60b	13.48	3.64bc	5.90cde	38.10ab	9.740a	1.94
$V_2 \times F_3$	142.3	13.58a	163.40a	13.61	3.92a	6.32a	38.20a	9.880a	1.93
$V_2 \times F_4$	135.6	10.22e	139.80def	13.44	3.30f	5.80de	34.00de	9.280bcd	1.82
$V_2 \times F_5$	139.4	10.82d	145.60cd	13.51	3.49cd	6.150abcd	36.20abcd	9.570abc	1.79
$V_3 \times F_0$	109.8	5.38j	118.30j	13.06	2.18j	4.050i	34.90cde	7.420k	1.34
$V_3 \times F_1$	119.3	10.29de	135.90efg	13.78	3.32ef	5.94bcde	35.80bcd	8.760fg	1.71
$V_3 \times F_2$	120.7	10.78d	141.30de	13.84	3.47de	5.80de	37.40ab	8.840efg	1.73
$V_3 \times F_3$	123.6	12.42b	148.80bc	13.86	3.70b	6.30ab	37.00abc	9.180cde	1.73
$V_3 \times F_4$	116.9	9.67fg	128.40bc	13.70	3.25f	5.75e	36.10abcd	8.150ij	1.69
$V_3 \times F_5$	120.4	10.15ef	133.50fgh	13.80	3.40def	5.88cde	36.60abc	8.650gh	1.64
Significance	**NS**	**	*	**NS**	*	*	**	*	-
CV%	**3.40**	**3.09**	**2.74**	**3.16**	**3.02**	**3.65**	**3.53**	**2.60**	-

*Note: *, ** = Significant at 5% and 1% level of probability, respectively.*

This result occurred due to effect of integrated use of inorganic fertilizers and manure on grain. Similar results were reported by Sarkar *et al.* (2014). The authors found that grain protein content increased due to combined application of manure and inorganic fertilizers.

Economics

The benefit cost ratio was measured and maximum benefit cost ratio (1.94) was found in Binadhan-13 with the combination of 75% inorganic fertilizers + cowdung 5 t ha^{-1} which was similar (1.93) to the treatment combination of 75% inorganic fertilizers + cowdung 10 t ha^{-1} and minimum was found in Kalizira because of less grain and straw yields (Table 3).

Among the three varieties Binadhan-13 performed the best for grain yield compared to Kalizira and BRRI dhan38. It can be conducted that Binadhan-13 fertilized with cowdung @ 10 t ha^{-1} combined with 75% inorganic fertilizers appeared as the promising management practice in terms of grain yield and protein content.

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