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ARTICLE

Research study on seed physical property of Mongolian wheat varieties

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Abstract: Wheat is the main vital cereal crop in Mongolia (Triticum spp.) The size of the seed is one important feature of seed quality. It is directly related to plant growth, seed yield, market factor and harvest efficiency [1]. Equally important are the size and shape of the seed. The seed in the middle of spike ripens fast, after which the upper and lower parts ripen. Even though seeds in the lower part of the spike fill up at the same time as in the middle section of the spike, the seed ripens later. Seeds in the middle part of the spike have good filling and are bigger in size too. Moreover, they are good plantlets. A two year study was conducted in 2019-2020 to determine the effect of seed size on the yield potential of six wheat varieties, including such early maturing varieties (Darkhan-160, Darkhan-131), medium maturing varieties (Darkhan-34, Darkhan-212) and late maturing (Darkhan-144, Darkhan 181) varieties. Seed samples of 6 varieties were separated in to four groups of seed diameter size, 2.0-2.2 mm, 2.2-2.4 mm, 2.4-2.6 mm, and 2.6-2.8 mm respectively. The seedling density was 350 seeds/m^2. The field trial was performed in a completely randomized block design with 3 replications. The 1000 kernel weight in spike parts in tillage stems of varieties, grain yield and seed fraction of the yield were determined by using Grain Scan software.

The best qualified seeds were placed at the medium part of the spike. The 1000 kernel weight of the medium part of Darkhan-181, Darkhan-131, and Darkhan-34 varieties reached 40-43 g and Darkhan-144 variety had the highest 1000 kernel weight (40-47 g). The portions of different seed sizes in yield was significant among the varieties planted. The varieties with longer vegetation period result higher portion of larger seeds in yield as compared to varieties with short vegetation period. The portion of large (>2.4mm) seeds in yield increased from 41.6-46.85% to 72.9-76.8% in different maturity varieties (from early to late medium). Grain yield of plots was increased with uniform large seeds in both years. The use of largest seeds resulted in a more competitive cropping system, improving grain yields by 16.9%. The yield decreased by 4.9% by planting seeds (2.0-2.2 mm) smaller than the control fraction (2.2-2.4 mm). The use of uniform large seeds increased both seedling emergence and grain yield. Results demonstrate that medium and mid-large uniform seeds (>2.2mm and >2.4mm) in accordance with the seed properties of the variety were useful in wheat seed production.

Keywords: *spike; size of seeds; position of seeds; Gain Scan; variety;*

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INTRODUCTION

Weight, filling, seed uniformity, other indices related to shape and size, linear measures including length, width, thickness, shape of seed and coating of seed, condition of hull, smoothness of seed, slip and spillage are involved in the seed physical properties. Seed size is an important physical indicator of seed yield potential, market grade factors and harvest efficiency [2]. Larger seeds tend to produce more vigorous seedlings. In wheat, seed size not only influence the emergence and establishment, but also affect yield components and ultimately grain yield [3, 20]. Seeds with various sizes are significant for overall harvest and quality. The smaller seeds have lower endosperm weight and hence, the root of the embryo, which has good development, is smaller. It has been classified that seeds of 2.2-2.4 mm are considered as small, seeds of 2.6-3.0 mm are medium, and seeds of 3.0-3.25 mm are big seeds [4, 12]. An important agronomic method to increase the physical and biological properties is grading the materials planned to be planted and classified. While planting wheat for seed production, it is important to use big and better filling, as well as high quality seeds. They are significant in commercial production technology [5].

Normally, plants that are derived from big seeds are resistant to various diseases. For instance, the seeds in the peripheral flowers of the middle part spikelet of spikes are larger and have better filling, and the seeds in the center of the spikelet in the upper and lower part of the spikes are smaller and wrinkled [6]. Plants grown from large seeds had greater grain yield than plants grown from unsized or variable-size seed [6, 15, 19]. The seeds become smaller due to either drought or hot weather. Economic entities that had sown seeds with sizes smaller than 2.2 mm in diameter, there have been observed decrease in field germination, subsequently leading to crop yield decline. Seeds with less endosperm have lower percentage of germination, and therefore, non-endospermic seeds are likely to be easily affected by drought and other unfavorable conditions, and the yield tends to be decreased [6,8].

MATERIALS AND METHODS

Location of the experimental plantation: The experiment was conducted in 2019-2020 at an experimental field of the Plant breeding division, Institute of Plant and Agricultural Sciences, Darkhan-Uul aimag in north Mongolia. The field has a typical chestnut soil. Seed samples of 6 varieties were sieved by EML200 machines and placed into four groups of seed diameter size, of 2.0-2.2 mm, 2.2-2.4 mm, 2.4-2.6 mm, and 2.6-2.8 mm respectively.

The experimental design of field trail was a two factorial (6 varieties, four different seed diameter sizes) in randomized block design. Seeds of early maturing varieties of Darkhan-131, Darkhan-160, medium maturing varieties of Darkhan-34 and Darkhan-212, and medium late maturing varieties of Darkhan-144 and Darkhan-181 of wheat used in the experiment. Wheat rows were spaced 0.15 m apart with a sowing density of 350 seeds m2. The experimental plot is one square meter (in total 178.6 m^2) in 3 replications. The 1000 kernel weight in spike parts in tillage stems of varieties, grain yield and seed fraction of the yield were determined. 10 plants per plots were selected for measuring 1000 kernel weight in spike parts in tillage stems of varieties, and seeds sized 2.2-2.4 mm were sown. Spikes were divided into upper, middle and lower parts of every tiller stems of plant and threshed separately (figure 1). The 1000 kernel weight was calibrated on the basis of seed weight and seed number of spike parts. The images of sample with 400-500 seeds spread were captured at 300 dpi and they were proceeded by Grain Scan software following Alex P. Whan., Alison B. Smith, Colin R. Cavanagh., (2014) methodology (figure 2) in order to determine the variety of the seed size rate, basing on the percentage of seed size group of the yield.

Variance analysis was done using XLSTAT software. Treatment means were compared using Duncan's test at 5% and 1% levels of significance and graph drawing was performed by box plot.

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Figure 1. Wheat seed classification of spike parts

RESULTS AND DISCUSSION

Field studies on wheat have shown that seed size has a significant effect on the yield potential and the competitive ability of the crop [7]. Spring wheat is the dominant staple cereal crop, which is cultivated on about 90% of the total agricultural land in Mongolia [8, 10]. According to the data of General Authority for Professional Inspection in 2018, farmers and wheat companies cultivating non-standard seeds (36.3%). It is possible to increase the yield of the plant and also improve its economic benefit simply by improving just one element of technology of planting the variety.

High quality wheat seed is one of the important pre-requisites for a higher yield, which also influences the full biological potential of the new varieties [7, 13]. An important agronomical method that have a positive control on the physical and biological performance is to clean and classify in a good manner the materials to be planted. In order to plant wheat for the purpose of obtaining seeds, it is important that planting must be done using big seeds with full weight and good quality, which is critical for the industrial technology [6, 21].

Statistical test between subjects effect, i.e. the seed size ($F=20.27$, $P\leq0.001$, variety ($F=12.95$, $P\leq0.001$), year ($F=115.86$, $P\leq0.001$) and variety* seed size interaction ($F=1.98$, $P\leq0.02$) has proven to have a significant influence on the grain yield potential. The climatic conditions during the two-years of studies were more or less similar and, were suitable to wheat growth in Mongolia. The average daily temperature during this period was 17.0-17.2^{0}C, and precipitation was 284.2-312.8 mm during the growing season in 2019 and 2020, thanks to which there was no significant difference in the year* seed size and year* variety interaction. Significant influence of different seed sizes on grain yield was observed and the yield varied from 13.1 t/ha to 21.4 t/ha (Figure 3), and significantly enough, it was observed that with the increase in seed size from 2.0-2.2 mm to 2.6-2.8 mm, the grain yield, according to linear regression formula ($y = 0.1295x + 1.3035$), was recorded at 22.7%.

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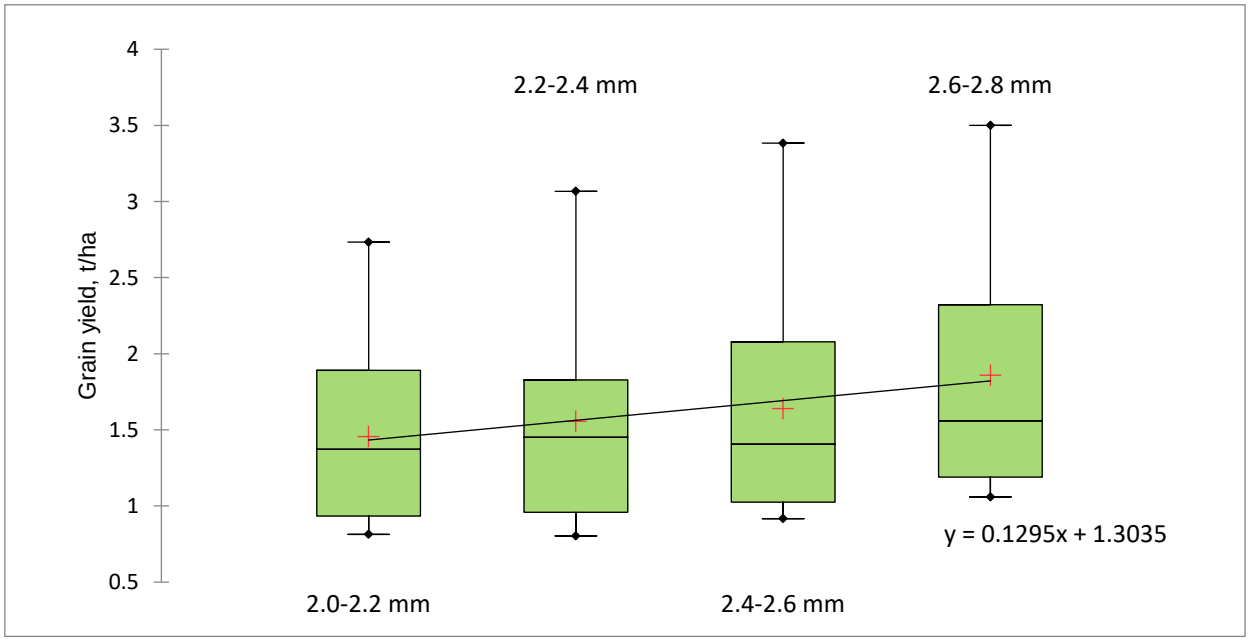

Figure 3. Effect of wheat seed size on grain yield potential

It was also reported in a similar study that the use of small size seed improved grain yields by 18% and the use of small seeds reduced yield by 16% in wheat [1, 12]. As regards chickpea and lentil, it was observed that the yield of plants from large seeds was by 6% higher than medium seeds, and by 10% more than mixed seeds [13, 17]. With regard to barley, it was reported that grain yield significantly declined by 9.8% from large seed compared to very small seed [1, 7]. These results are in agreement with our findings.

Wheat variety difference of seed size position: Seeds of the same spikes are different in size, filling and other indices. For example, seeds in the peripheral flowers of the middle part spikelet of spikes are larger and have better filling, and the seeds in the center of the spikelet in the upper and lower part of the spikes are smaller and wrinkled [4]. When the seeds of upper and lower parts of the same spike are compared, the lower parts have more filling.

In terms of varieties, the Darkhan-144 variety with a late medium maturity has the longest spike with numerous heavy seeds. The 1000 kernel weight of upper and lower parts of the seed was 40-43 g, and seeds of middle part were 44-47 g for the Darkhan-144 variety. As regards the Darkhan-181 variety, the 1000 kernel weight seeds of upper and lower parts of spikes were 36-39 g and middle part ones were 40-43 g respectively.

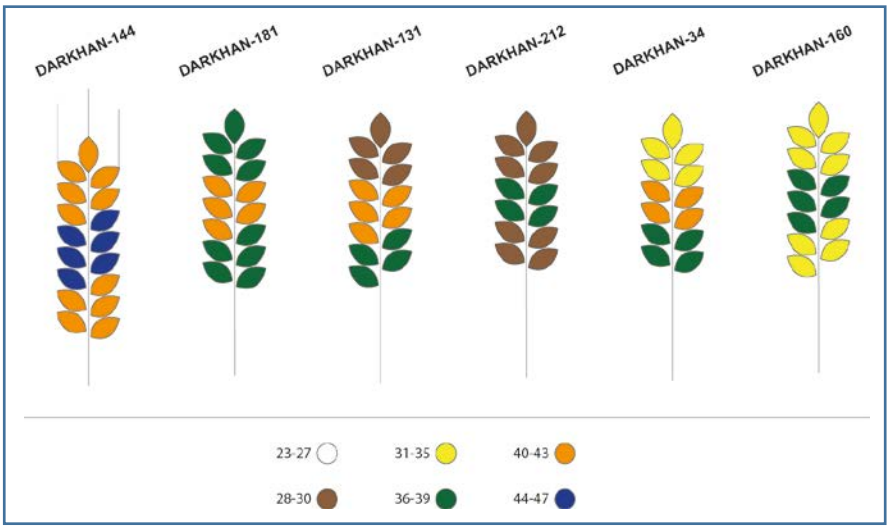

Figure 4. The varietal difference of seed position in spike by 1000 kernel weight/g

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The 1000 kernel weight of Darkhan-131 variety reached 28-30 g at the upper part, 40-43 g in the middle, and 36-39 g at the lower part. Seeds of upper and lower parts of Darkhan-212 variety were 28-30 g and the middle part were 36-39 g. For the Darkhan-34 variety, the 1000 kernel weight were 31-35 g at the upper part , 40-43 g in the middle and 36-39 g at the lower part of spike. As for Darkhan-160 variety, these figures were 31-35 g at the upper and lower parts, and 36-39 g in the middle part respectively (Figure-4). Even though the position of the seeds are quite different, seeds of the middle part of spikes of the Darkhan 181, Darkhan-131 and Darkhan-34 varieties weigh 40-43 g. Middle part seeds of Darkhan-144 variety weigh 40-47 g or is heavier by 3-4 g. This is the highest showing. Study in the seeds of medium part of the spikes are more with 6.8-8.7 g in thousand seed weight and it has been determined that the seeds in the middle part of the spikes have seeds which are the heaviest [4]. Seeds of middle part of the varieties of our study have higher indices than the upper and lower parts. For example, Darkhan-144 is heavier by 4 g, Darkhan-181 – 5 g, Darkhan-131 variety is 5-10 g, Darkhan-212 is higher with 9-12 g, Darkhan-34 is higher with 8-11 g, and Darkhan-160 is higher with 4-5 g.

This result is close to the result of the researches carried out above.

Results of seed size in tiller stems show that seeds of 2.4-2.6 mm size were 71.2%, and small seeds with a diameter of 2.0-2.2 mm were 26.8% in first and main stem of plant (figure 5). According to the order of tillering the number of stems, the content of seeds larger than 2.4 mm decreases to 29.0% and the content of small seeds, which is less than 2.2 mm, increases to 30.4%.

The seed size of second and third tiller stems of plant depends on the maturity. For early and medium matured varieties, the main part of the seeds of second tiller stems were 2.2-2.6 mm seeds (74.4-79.4%), while for medium late matured varieties, the 2.4-2.8 mm seeds was predominant (76.4%). For third tiller stems, the main part of the seeds were 2.0-2.4 mm in early and medium matured varieties, and 2.4-2.8 mm seeds was in the medium late matured varieties respectively. According to the results obtained, the share of medium and large sized seeds is relatively stable for medium late varieties, but for early and medium maturing varieties, the percentage of large sized seeds tends to decrease in second, and especially in the third tiller stems of plant.

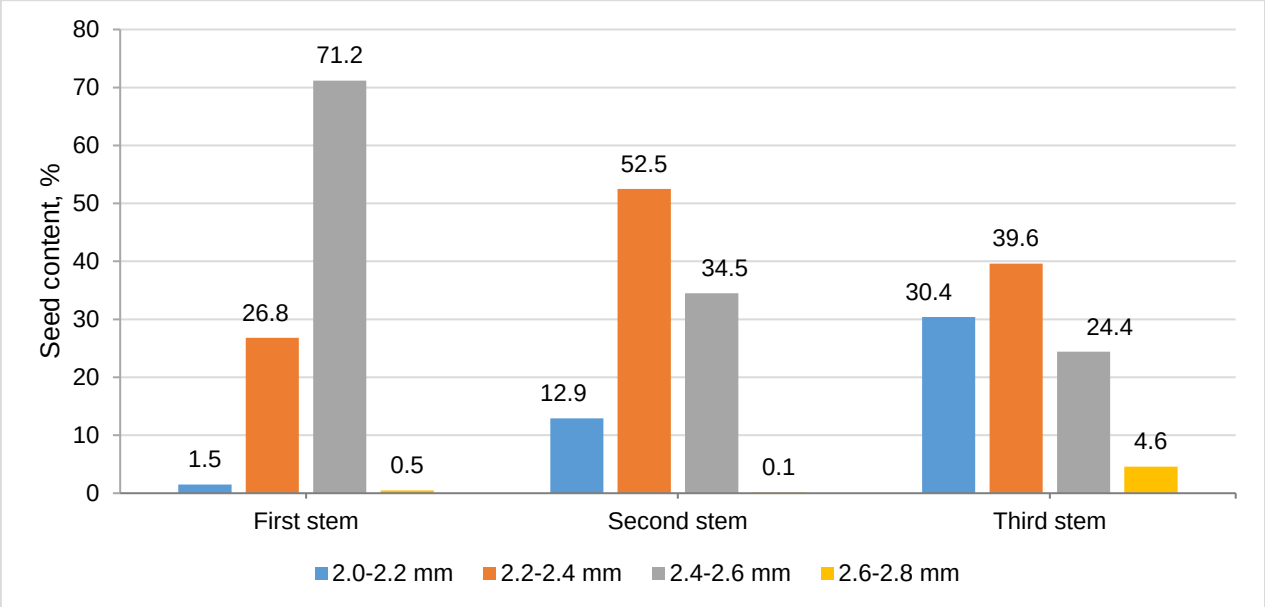

Figure- 5. Seed formation with different sizes in tiller stems of plant, percentage

The result of seed size rate in wheat varieties: Seed grading is difficult in commercial conditions, which requires experienced knowledge of the seed's physical and mechanical properties.

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First of all, since seeds are living organisms, their physical properties are not constant and they vary according to many factors, such as ecological and agro-technical conditions, soil fertility, biological characteristics of the crop and their variety. According to our study, 2.0-2.6 mm size seeds rates 85.5.-90.2% in Darkhan-131 and Darkhan-160 with early maturity varieties, which has been acclimatized in Mongolia, while it has been observed that the amount of 2.4-2.8 mm sized seeds of Darkhan-144 and Darkhan-181 with medium and medium late maturing varieties has increased.

The sizes of medium maturing big and small size seeds varieties have similar indicators. While all other varieties, which are involved in the study, the 2.4-2.6 mm size seeds have 24.9-34.2% or smooth indices, and in the Darkhan-160 and Darkhan-131 varieties, 2.6-2.8 mm size seed rate decreases by 31.3-34.3%. In the year which has suitable moisture and warmth, seed size rates (2.0-2.2 mm) are 0.4%, in the 2.2-2.5 mm seed size, the rates are 8.0%, in the 2.5-2.8 mm size, the rate is 20.3%, the 2.8-3.0 mm size seed rate is 64.2% and the seed size of 3.0 mm or more have a rate of 7.1% [12].

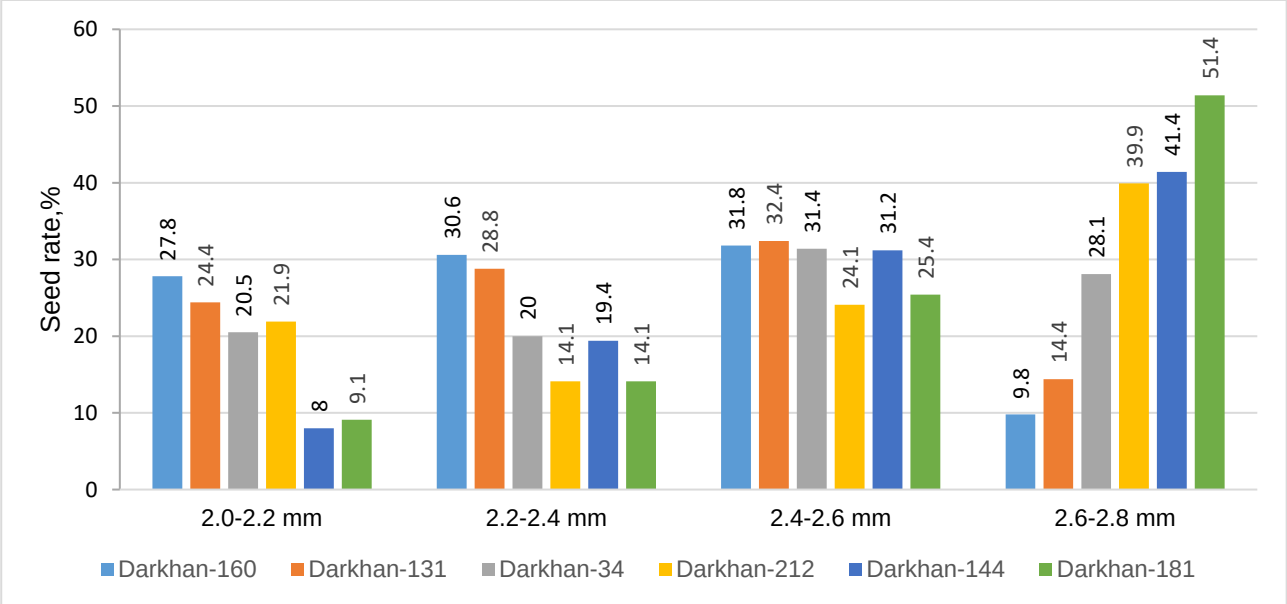

Figure 6. Wheat variety seed size rate

When the experiment sample is classified in size, the seed size rate is for 2.2-2.4 mm is 1.77%, for seeds of 2.4-2.6 mm size the rate 1is 0.5%, further, as regards seed with 2.6-3.0 mm size, the rate is 67.9%, and for seeds with a size of 3.0-3.25 mm, the rate is 17.8%. Seed size also varies significantly. 67% is medium, 19% is small and 1% are really big seeds [5]. In 1998, when the seed of Orkhon variety is classified with its size, 2.6% of the total seeds are less than 2.0 mm, 24.3% have a range of 2.0-2.2 mm, 70.9% of the seeds are 2.5-2.8 mm and only 2.2% is 3.0-3.25 mm [12]. A comparison of the results of the above researches demonstrate that the rate of the seeds more than 2.6 mm tends to decrease in Mongolia and each variety has a different seed size rate.

CONCLUSIONS

- Study assessment showed that seed size has a significant impact on yield, and in this manner, the best category of seed size was related to >2.2mm and >2.4mm in size, whereas the yield of seeds with 2.0-2.2mm size was significantly less than as compared to other sizes. The yield of the planting with seeds of 2.0-2.2 mm was reduced by 4.9% compared to the 2.2-2.4 mm, while the yield of the planting with seeds more than 2.2-2.4 mm in diameter was 4.6-16.9% higher.

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- The heaviest and largest seeds are located at the middle part of the spikes and the 1000 kernel weight of this part were higher by 4.0-12.0 g than the upper and lower parts of the spike. The share of medium and large sized seeds is relatively stable for medium late varieties, but for early and medium maturing varieties, the percentage of large sized seeds tends to decrease in second, especially in the third tiller stems of the plant.

- For the early maturing varieties, Darkhan-131 and Darkhan-160 with a 2.0-2.6 mm size seed, the rate was measured at 85.6-90.2%. As for the medium maturing varieties Darkhan-34 and Darkhan-212, the rate of seeds are smooth, while medium late maturing varieties of Darkhan-144 and Darkhan-181, seeds larger than the average (2.2-2.8 mm) rate was 91.0%, that is, this included the majority of the seeds.

- Results demonstrate that medium and mid-large uniform seeds (>2.2mm and >2.4 mm) in accordance with the seed properties of the variety was useful in wheat seed production.

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