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RESEARCH PAPER

Participatory selection of mung bean (*Vigna radiata* L.) varieties in Eastern Amhara region, Ethiopia

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Abstract

It is one of lowland pulses crop primarily grow in the lowland areas of Ethiopia's Amhara region. A major problem in mung bean production is the lack of improved varieties that are adaptable and resistant to key biotic and abiotic stresses. As a result, these farmers still produce local varieties, which are low-yielding and highly susceptible to both biotic and abiotic stresses. Two potential areas were selected for this study: South Wollo Zone and Oromia Special Zone in the Amhara region. To achieve sustainable high yield on their farms, farmers rely critically on selecting high-yielding genotypes. This study used participatory varietal selection (PVS) to evaluate and select the best adapted mung bean varieties that meet the criteria of farmers' with the aim of accelerating their adoption. The materials have three improved and one local mung bean variety (NVL-01, Boreda, (Rasa), and local (Shewa robit) were evaluated at Dawa Cheffa and Ambasel woredas research site and on farmers' fields. Varietal evaluation and selection were conducted using the participatory mother and baby trial approach. A randomized block design with four replications was employed for the mother trial at the research site. The material was planted in a 5- row plot of 3 m length with a spacing of 0.4 m between rows and 0.05 m between plants. The baby trial approach was conducted farmers as a replication, was planted in a 12- row plot of 5 m length with a spacing of 0.4 m between rows and 0.05 m between plants. The combined ANOVA revealed significant differences among varieties for all studied parameters. Farmers were involved in varietal selection during flowering and at maturity. The most chosen varieties by farmers were Rasa both location but Rasa already popularized farmers adoption scaling up was done. Based on yield potential and selection by both farmers and breeders, Rasa (1731 kg/ha) and Boreda (1690 kg/ha) varieties were ranked first and second, respectively. As their yields were statistically similar, both are recommended for wider dissemination and production in the study areas and similar agro ecologies.

Keywords

Adoption, criteria, farmer, evaluation, location, selection

Introduction

Mung bean (*Vigna radiata* L.) also known as green gram, golden gram, is originated to Bangladesh, India and Pakistan. Pulses can be generally classified in to two groups, highland pulses and low land pulses. As one of the most significant lowland pulse crops, mung bean is grown throughout tropical and subtropical regions globally (Kumari et al. 2012). According to CSA (2021), mung bean is the most significant cash crop among pulses cultivated in Ethiopia. Kassa et al. (2018) noted that smallholder farmers in Ethiopia grow mung bean predominantly in drier marginal environments, where its production capacity remains lower than that of other pulse crops. Ethiopian farmers with limited resources rely on mung bean primarily for food, but

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cultivating it for sale provides a crucial supplemental income. Mung bean is one of the most important pulse crop grown in moisture deficit areas of north-eastern Amhara region of Ethiopia, mung bean is used for household consumption and serves as a source of cash income for families (CSA 2016). Adapted to low water requirements and poor soil fertility, this short-duration crop is considered a 'poor man's crop' due to its low input needs and ease of production. It serves as the chief protein source in the lowland areas of the Amhara region and thrives under adverse weather and soil conditions (Raturi et al. 2015). In North Eastern Amhara, unpredictable rainfall in both amount and distribution, combined with a very short rainy season, frequently exposes crops to moisture deficit during critical growth stages. This often results in low yields or total crop failure, particularly for longer-season crops such as sorghum (it takes a long time). Those crops which are short duration for maturing, drought-tolerant, used for crop rotation and heat-resistant crops are of great interest to farmers in the lowlands of northeastern Amhara, Ethiopia. Zhou et al. (2020) reported its rapid maturity, ability to fix high levels of nitrogen, and tolerance to infertile soils. Mung beans are currently a critical food security resource in the north eastern Amhara, where terminal drought and erratic rainfall have caused moisture deficits, severely impacting late-maturing crops. As an excellent source of protein, mung bean plays a key role in alleviating malnutrition, especially protein deficiency among children, in developing countries of Asia and Africa (Chandra et al. 2019). Ethiopia's mung bean exports have grown rapidly (CSA 2021). According to CSA (2021), Ethiopia exported 30,000 metric ton mung bean; it gets 1.2 billon Ethiopian birr. In Eastern Amhara Region, mung bean is highly cultivated (Belg and Meher season), Its versatility makes it valuable, serving as food, a source of income, a soil fertility enhancer, fodder, and a catch crop.

According to CSA (2021), both national (1.073 t/ha) and regional (1.133 t/ha) average productivity fell substantially below their potential yield. Nevertheless, under experimental conditions, yields in Ethiopia reach up to 2 t/ha, while farmer fields using recommended practices achieve 1.0–1.2 t/ha. Despite rising international demand, Ethiopia faces a significant production gap (CSA 2021). Low land area and yield are largely due to the high reliance on local varieties (grown on over 80% of the pulse cropped area), coupled with limited access to seed suppliers (and thus improved seeds) and poor farmer participation in varietal selection. Thus, involving farmers in the selection process ensures that criteria important to mung bean farmers are not ignored or given insufficient weighting. Despite participatory evaluation of improved mung bean varieties (Rasa (N-26), NVL-01, Borda, Shewarobit) in South Wollo and Oromia Special Zone during the 2022/23 main season, limited farmer awareness of these varieties and lack of access to improved seed hindered widespread adoption. According to CSA (2021), the total land was covered by mungbean 48,022.34 ha which gives 51,568.655 ton, whereas Amhara region land coverage 32,666.15 ha which gives 37,075.497 ton, from this Amhara region accounts 68.02% in area coverage and 71.89% productivity in the country. Consequently, mung bean production and productivity in the South wollo, North Shewa and Oromia special zone are very low (but it covers greater than half of area and production in Amhara region) and the farmers failed to realize the potential benefits. This research was therefore initiated to enhance the adoption and dissemination of the variety in South Wollo, the Oromia Special Zone, and beyond by fostering wider demand and stakeholder linkages, ultimately improving the crop's production and productivity. Therefore, this study aimed to identify the top-performing mung bean varieties aligned with farmer preferences across diverse agro-ecologies in eastern Amhara, Ethiopia.

Materials and methods

Description of the experimental area

Field experiments were conducted during the cropping seasons, of 2022/2023 main cropping season at two woredas representing various mung bean growing agro-ecologies of Eastern Amhara, region, Ethiopia that represent major agro-ecologies which are potential for the production of mung bean. The two locations were Jari and Cheffa which are found along the road side from Addis Ababa to Mekele with a distance of 437 and 342 km from Addis Ababa, respectively. The detailed description of the experimental area is indicated (Table 1)

Experimental materials and design

Experimental materials comprised four mung bean varieties: Rasa, NVL-01, and Boreda (released by agricultural research centers) alongside Showarobit (a popular local variety). A 'mother trial' was established using a randomized complete block design (RCBD) with four replications at

Table 1. Description of the experimental areas.

Location	Altitude (masl)	Soil type	Average- Rainf all (mm)	Temperature		Global position
				Min (°C)	Max. (°C)	Latitude, Longitude
Jari	1680	*Vertisol*	1204.6	11.2	25.6	11°21'36"N, 39°38'42"E
Cheffa	1400	*vertisol*	850	11.6	30.4	10°57'44"N, 39°53'37"E

masl = meter above sea level, mm = millimetre, °C = degree Celsius.
Source: Sirinka Agricultural Research Center (SARC).

the Sirinka Agricultural Research Site (Cheffa and Jari). This trial provided researcher data. Concurrently, three 'baby trials' were conducted for participatory varietal selection to evaluate farmer preferences. Mother trial plots were 6 m² (five rows, each 3 m long, spaced 0.4 m apart, with 5 cm between plants). Baby trial plots for each treatment were 25 m² (5 m × 5 m).

Data collection

Data on agronomic traits; days to flowering, days to maturity and yield and yield components were taken from grandmother trial on plot basis and plant height (cm), number of seed per pod and number of pod per plant on plant basis. Farmers were evaluated and selected based on single-plot observations in on-farm baby trials. Farmer assessments of plant establishment and overall crop performance disease resistant, number of pods, seed color, earliness, uniform maturity, marketability, drought tolerance was assessed using a 5-point scale: 5 = very good, 4 = good, 3 = average, 2 = poor, 1 = very poor.

Results and discussion

Yield and yield component

The combined analysis of variance results demonstrated significant differences among the tested mung bean varieties for all parameters (Table 2). These results are consistent with the previous report by (Tadesse and Shashemene 2021) of significant variation among mung bean genotypes in yield and key yield-related traits: seeds per pod, above-ground biomass, thousand seed weight, and grain yield. Statistical analysis indicated Rasa exhibited superior yield performance, as detailed (Table 2). Studies have reported significant differences in seed yield due to mung bean genotype. Specifically, cultivar significantly influences grain yield, pod length, and hundred seed weight (5%) (Kassa et al. 2018). (Table 2) presents the combined mean seed yields for all tested varieties across environments. Under consistent agronomic management, Rasa produced the highest mean yield (1731 kg/ha), significantly outperforming Boreda (1690 kg/ha). This yield difference suggests underlying genetic variation among the genotypes. Results indicated a numerically higher yield for the Rasa variety compared to the Boreda variety; however, this difference lacked statistical significance. Conversely, the mean seed yield of varieties NVL-01 and Shewa Robit was the lowest and fell below the grand mean. The Rasa variety yielded significantly higher than the local variety Shewa robit. The current results are consistent with (Khatik et al. 2022), who reported that mung bean cultivars significantly affect seed yield. ANOVA revealed that for the overall mean interaction of location and years, only plant height, number of pods per plant, and anthracnose were statistically significant; other traits were non-significant.

In leguminous plants, hundred seed weight is a key morphological trait that enhances both seed and biomass yields. The Rasa and Boreda varieties produced the highest hundred seed weight (5.6 g), significantly exceeding NVL-01 (5.3 g) and the local Shewa Robit variety (3.7 g) (Table 2). These significant variations ($p < 0.05$) in yield-related traits like hundred seed weight align with previous reports on Ethiopian mung bean (Kassa et al. 2018). Rasa had the highest number of pods per plant (15.12), followed by Borda (14.80), NVL 1 (11.95), and Shewa Robit (10.15). This result, consistent with Kumari and Chakraborty (2019), showed that mung bean cultivars significantly influenced the number of pods per plant and plant height. Plant height showed statistically a significant difference from 55.27 (Rasa) to 51.32 (Shewa robit), the straw is very important for animal feed; it is one of farmers' selection criteria for animal feed. Plant height varied significantly among the mung bean varieties across the test environments, aligning with the findings of Tadesse and Shashemene (2021), reporting a range of 40.53 cm (NVL-01) to 56.90 cm (Arkebe). Significant differences in seeds per pod were observed among the varieties (Table 2). Rasa produced the highest number (11.70), followed by Borda (11.13) and NVL-01 (9.83), while Shewa robit yielded the lowest (9.28). This finding agrees with studies reporting that differences in seeds per pod among cultivars may stem from genetically determined variation (Teame et al. 2017), consistent with experimental results that demonstrate genetic differences between varieties create this variation (Tadesse and Shashemene 2021).

Table 2. Combined mean of Mung bean Varieties at two location, (2022–2023).

SN	Treatments	DF	DM	PH	NPP	NSP	HSW	SY(kg/ha)	Ant.	CLS
1	N-26	49.50^{c}	78.12^{c}	55.27^{a}	15.12^{a}	11.70^{a}	5.550^{a}	1731^{a}	1.875^{a}	1.875^{a}
2	Boreda	46.75^{b}	76.00^{c}	54.70^{a}	14.80^{a}	11.13^{a}	5.562^{a}	1690^{a}	2.250^{ab}	1.750^{a}
3	NVL-01	45.88^{b}	73.25^{b}	52.02^{b}	11.95^{b}	9.83^{b}	5.250^{a}	1225^{b}	2.750^{b}	2.000^{a}
4	Shewarobit	44.12^{a}	70.38^{a}	51.32^{b}	10.15^{c}	9.28^{b}	3.662^{b}	1020^{c}	3.500^{c}	2.875^{b}
	GM	47	74	53.48	13.01	10.48	5.006	1416.5	2.594	2.12
	Treat	**	*	**	**	*	**	**	**	*
	Location	**	**	**	**	*NS*	**	*	**	**
	Treat *Loc	*NS*	*NS*	*	*	*NS*	*NS*	*NS*	*	*NS*
	CV%	2.4	2.0	3.2	8.7	10.8	10.9	11.7	18.6	27.2

Note: LP = Large pod number, Y = Yield, Er = Earliness, Ss = Seed size, SC = Seed color, M = Marketability, DR = Disease resistance, Dt = Drought tolerance, Um = uniform maturity and St = Straw biomass.

Table 3. Pair wise ranking matrix of attributes ranking for Mung bean varieties at Dawa cheffa.

Parameters	Pn	Y	Er	Ss	Sc	M	Dr	Dt	Pc	St	Weight	Rank
Pod number		Pn	Er	Pn	Pn	Pn	Dr	Pn	Pn	Pn	7	2nd
Yield			Y	Y	Y	M	Dr	Y	Y	Y	6	3rd
Earliness				Er	Sc	M	Dr	Er	Er	Er	5	4th
Seed size					Sc	Ss	Dr	Dt	Pc	Ss	2	5th
Seed color						Sc	Dr	Dt	Sc	Sc	6	3rd
Marketability							Dr	Dt	M	M	5	4th
Disease resistance								Dr	Dr	Dr	9	1st
Drought tolerance									Dt	Dt	5	4th
Uniform maturity										Um	1	6th
Straw/biomass											0	7th

Note: Pn = Pod number, Y = Yield, Er = Earliness, Ss = Seed size, SC = Seed color, M = Marketability, DR = Disease resistance, Dt = Drought tolerance, Um = uniform maturity and St = Straw biomass.

Major production constraints of mung bean are lack of resistance to the major biotic constraints. Disease likes Cercospora leaf spot, Anthracnose and powdery mildews are the most important disease, from our observation the Shewa robit and NVL-01 varieties were highly infected with Cercospora leaf spot disease and Anthracnose, which mean Rasa is more tolerant than that of Shewa robit (Table 2). According to Nair et al. (2019) important diseases including yellow mosaic virus, dry root rot, Cercospora leaf spot (CLS), and anthracnose continue to severely limit mung bean productivity in the study region.

Farmer-led variety evaluation and selection criteria

Participatory variety selection, the adoption of new varieties occurs significantly more quickly under participatory variety selection (PVS) than it does under the official system, the selection criteria were set by farmers based on discussion. Farmers with extensive experience growing mung bean, representing their communities, participated in the evaluation. They weighted the relatively similar selection criteria for the two Woredas according to their interests. Farmer selection criteria for the study sites were established through broad discussions, while varietal evaluation and selection were conducted using baby trials. Male and female participants were evaluated together. A total of 39 farmers participated in the participatory varietal selection process: 19 male-headed and 4 female-headed households in Dawa Cheffa, and 16 male-headed households in Ambasel district (which had no female participants) (Table 9). The selection criteria suggested by farmers were as follows: pod number, seed yield, earliness, seed size, seed color, marketability, disease resistant, drought tolerance, uniform maturity and straw/biomass. Farmers across test sites identified 10 critical traits in Dawa Cheffa and 9 in Ambasel woreda (Jari), where uniform maturity for harvesting is less critical. Farmers applied largely consistent selection criteria across test sites, with some variation in the specific traits prioritized or their relative rankings. We used pair-wise matrix ranking to prioritize farmers' selection criteria. The following traits were identified/ proposed as very important criteria for pairwise ranking: pod number, seed yield, earliness, seed size, seed color, marketability, disease resistance, drought tolerance, uniform maturity, and straw/biomass. Across all test sites, disease resistance was considered the primary selection criterion for each mung bean variety. Pod number was the second most important selection criterion in mung bean growing areas. Farmers ranked disease resistant and large pod number in the first and second places, respectively. The third selection criteria were seed yield and seed color. Straw/biomass was given least rank by farmers. Therefore, while farmers consider many traits, they frequently rely on a core set for evaluation, a pattern that needs recognition. This aligns with earlier mung bean studies reporting farmers use a limited combination of traits to assess new genotypes (Yasin and Demelash 2021). Selection priorities depend on the demand for income generation in the local market and for home consumption (Tables 3, 6).

Variety selection by farmers through direct matrix ranking

Participating farmers were given an explanation of the ranking process. Farmers weighed their criteria before going to the selecting procedure. Mung bean varieties were ranked according to their morphological performance, as shown in Tables 5, 8. To find out farmers' preferred varieties, (Assefa et al. 2021) ranking method was adopted. The varieties were ranked accordingly (the first selected Rasa (79) followed by the Boreda variety (81), Shewa robit (105) and the least one is , NVL- 01 (125) at Dawa cheffa and (the first selected Rasa (65) followed by the Borda variety (73), NVL- 01 (114) and the least one is Shewa robit (128) at Ambasel (Table 7). Direct matrix ranking and preferential scoring were the two procedures used to rank the varieties. Direct matrix ranking effectively identified key traits of interest. A comparison matrix was prepared showing the Mungbean varieties (listed vertically) against the selection criteria (listed horizontally). Participants were briefed on the ranking procedure. For each variety, farmers ranked each criterion on a scale from 1 (very good) to 5 (extremely poor). Any disagreements were resolved through discussion and consensus among the farmers themselves, without intervention from researchers or experts. Using direct matrix ranking, farmers first assigned

Table 4. Sum score given to each variety (1 to 5) scale based on each criterion in Dawa cheffa district (Cheffa).

Variety	Pn	Y	Er	Ss	Sc	M	Dr	Dt	Um	St
Borda	35(1)	42(1)	42(1)	50(4)	47(3)	37(3)	25(1)	50(1)	47(2)	37(2)
N-26(Rasa)	45(2)	47(2)	47(2)	40(3)	42(1)	35(2)	32(2)	82(2)	55(3)	35(1)
Shewarobit	55(4)	54(4)	61(4)	25(1)	52(2)	30(1)	39(4)	84(4)	44(1)	45(3)
NVL-1	48(3)	52(3)	52(3)	29(2)	59(4)	42(4)	37(3)	92(3)	65(4)	54(4)

Table 5. Final acceptability rank of mung bean varieties at Dawa cheffa district (Cheffa).

Variety	Criteria with their weights										Score	Rank
	Pn (2)	Y (3)	Er (4)	Ss (5)	Sc (3)	M (4)	Dr (1)	Dt (4)	Um (6)	St (7)		
Borda	2	3	4	20	9	12	1	4	12	14	81	2nd
N-26	4	6	8	15	3	8	2	8	18	7	79	1st
Shewarobit	8	12	16	5	6	4	4	16	6	28	105	3rd
NVL-1	6	9	12	10	12	16	3	12	24	21	125	4th

Table 6. Pair wise ranking matrix of attributes ranking for mung bean varieties at *Ambasel woreda* (Jari).

Parameters	Pn	Y	Er	M	Sc	Ss	Dr	Dt	St	Weight	Rank
Pod number		Pn	Pn	Pn	Pn	Pn	Dr	Pn	Pn	7	2nd
High Yield			Y	Y	Y	Y	Dr	Y	Y	6	3rd
Earliness				M	Sc	Ss	Dr	Er	Er	2	6th
Marketability					Sc	Ss	Dr	M	M	3	5th
Seed color						Ss	Dr	Dt	Sc	3	5rd
Seed size							Dr	Dt	Ss	4	4th
Disease resistance								Dr	Dr	8	1st
Drought tolerance									Dt	3	5th
Straw quantity										0	7th

Table 7. Sum score given to each variety (1 to 5) scale based on each criterion in Ambasel district (Jari).

Variety	Pn	Y	Er	M	Sc	Ss	Dr	Dt	St
Borda	19(2)	27(2)	34(3)	29(2)	42(1)	32(1)	32(2)	50(2)	45(2)
NVL-1	22(3)	34(3)	28(1)	40(3)	52(3)	38(3)	37(3)	92(4)	61(4)
N-26	17(1)	22(1)	47(4)	25(1)	47(2)	35(2)	25(1)	42(1)	35(1)
Shewarobit	35(4)	42(4)	31(2)	52(4)	59(4)	40(4)	39(4)	84(3)	56(3)

Table 8. Final acceptability rank of mung bean varieties at Ambaasel district (Jari).

	Criteria with their weights									
Variety	Pn (2)	Y (3)	Er (6)	M (5)	Sc (5)	Ss (4)	Dr (1)	Dt (5)	St (7)	Total Score	Final Rank
Borda	4	6	18	10	5	4	2	10	14	73	2nd
NVL-1	6	9	6	15	15	12	3	20	28	114	3rd
N-26	2	3	24	5	10	8	1	5	7	65	1st
Shewarobit	8	12	12	20	20	16	4	15	21	128	4th

Table 9. Total participants during participatory mung bean selection.

Location	Farmers			Development Agents			Researchers		
	M	F	T	M	F	T	M	F	T
Dawa cheffa	19	4	23	1	-	1	3	-	3
Ambasel (Jari)	16	-	16	1	-	1	3	-	3

a relative importance weight (1 = less important, 2 = important, 3 = very important) to each selection criterion. Then, based on these weights and through group consensus, they rated the performance of each variety against every trait. To calculate the total score for each variety, we multiplied its score for each character by that character's relative weight and then summed these weighted scores across all characters. The mung bean varieties were ranked using pairwise comparison, which inherently incorporates both direct matrix and pairwise ranking approaches.

To evaluate farmers' thoughts and perceptions of the cultivars, a matrix ranking system was employed. The most desirable variety is the one with the lowest rank index, using the Amhara Agricultural Research Institution's Guideline for Participatory Varietal Selection (Assefa et al. 2021).

In the evaluation matrix applied at Dawa Cheffa, the total scores ranged from 79 to 125. The top score given to the variety NVL-01 (125) followed by Shewa robit (105), Boreda (81) and Rasa (79). Using direct matrix ranking, Dawa Cheffa farmers selected Rasa and Borda as the best varieties, while NVL-01 was the least preferred. When come to Ambasel woreda, Jari testing site Rasa and Borda selected mung bean varieties. The direct matrix, the total sum score ranged from 65 to 128. The highest score given to the variety Shewa robit (128) followed by NVL-01 (114), Borda (73) and Rasa (65). The result of farmers' preference analysis showed that the top two varieties that were



Figure 1. Participant farmers during selection process at flowering.



Figure 2. Participant farmers during selection process at maturity.

preferred by farmers' are Rasa and Boreda varieties with ranks 1st and 2nd at both district respectively (Tables 5, 8), while Shewa robit is the least chosen mung bean varieties.

Pre-scaling up of the selected improved mung bean varieties

The pre-scaling of the selected varieties (Rasa) was held at Dawa Cheffa and Ambasel. We selected farmers and supplied them with seeds of the chosen varieties. The program's success hinges on effective initial technology orientation for participants and phased implementation of follow-up activities. Before the pre-scaling activity commenced, Sirinka Agricultural Research researchers provided training to farmers, development agents, and woreda agricultural office experts on the recommended mung bean seed production and management package. A multi-disciplinary team of researchers, policy makers, and agricultural experts conducted regular field inspections to observe progress, address problems, and advice on proper field and crop management from land selection through harvest.

Conclusion and recommendation

Mung bean is extensively cultivated as a cash crop in the lowland regions of northeastern Amhara. However, productivity was severely limited by the lack of improved high-yielding varieties and significant insect and disease infestations. Mung bean, a recently introduced crop, is now being cultivated in Ethiopia. Introducing newly released, high-yielding varieties significantly boosts mung bean production, enhancing agricultural output and productivity. Rasa and Boreda mung bean varieties exceeded the grand mean yield in combined analyses of farmer fields and testing sites across eastern Amhara, Ethiopia. The Rasa variety produced the highest yield (1731 kg/ha), while Shewa Robit mung bean yielded the lowest (1020 kg/ha). Based on farmer field evaluations, these varieties ranked first and second in choice and were accepted by



Figure 3. Pre-scaling up of the selected improved mung bean varieties N-26.

farmers due to their high seed yield and disease resistance. Farmer involvement improved interaction among researchers, extension agent, and farmers. Analysis of biological data and farmer selection traits leads to the recommendation of Rasa and Boreda primarily for commercial cultivation purposes. Therefore, based on the findings, adopting newly released high-yielding, disease-resistant, and insect-resistant varieties is crucial for increasing agricultural production and productivity in the area. Furthermore, farmer participation in variety development is vital for future breeding efforts.

Conflict of interest

This manuscript has no any conflict of interest because it is our regular work in our research center.

Data availability statement

All data are collected and analyzed from our research process.

Funding statement

There is no funding conflict.

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