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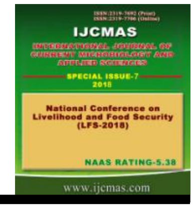


## Original Research Article

# Genetic Divergence and Correlation of Tuber Characteristics in Bunda Germplasm (*Colocasia esculenta* var. esculenta) of Bihar

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**Keywords**

*Colocasia esculenta*, Bunda germplasm, Genetic variability, Correlation, Genetic divergence.

**A B S T R A C T**

An experiment was conducted to study tuber diversity present in Bunda germplasm collections of Bihar. Altogether, 28 germplasm of Bunda were analyzed regarding tuber characteristics for genetic divergence and correlation among studied characters. Data for five quantitative tuber characteristics were statistically analyzed for genetic variability parameters and their association as per the standard methods. Significant positive correlation of tuber yield has been found with tuber girth and average tuber weight in contrast to tuber length suggesting that yield improvement in Bunda tubers is possible by considering selection for these traits. Minimum differences were observed for tuber length and girth in genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) values showing that the phenotypic expression of all the genotypes is under genetic control. Tuber length, tuber girth and tuber yield exhibited high heritability estimates along with high genetic advance, hence selection for these traits may be useful due to presence of additive gene action for these traits. Principal component (PC) values revealed that variation in PCA-1 was mainly associated with tuber length, tuber girth and tuber yield. All the genotypes were clustered into six different clusters revealed the presence of genetic divergence among these genotypes for tuber characteristics. Relatively high inter-cluster distances present in between clusters 3 and 4 showed greater genetic distance among the genotypes. Genetic diversity studies revealed that tuber length and girth alongwith tuber yield has to be taken as major criteria for genetic divergence in Bunda genotypes.

## Introduction

Bunda/Kanda is an important tuber crop belonging to family Aracea that are primarily grown in sub-tropical parts and mainly used for vegetable purposes in many states of India. Root and tuber crops species commonly used for human food and feed for animals besides having industrial values for making starch alongwith medicinal values. Among different species of tubers, *Colocasia* species like *esculenta* var. esculenta commonly known as Bunda or Kanda or Dasheen is an edible aroid distributed from east India to Formosa and the Soloman Islands (Spencer, 1966). All the vegetative portions such as leaves and its petiole are commonly used as green vegetables and its starch riched tubers are generally used for preparations of tasty vegetable recipes especially in the festivals. In Bihar, Bunda tubers are harvested in the months of August to October, when there is scarcity of vegetables in the market creating importance of this crop.

*C. esculenta* var. esculenta having large central corm with a few cormel buds can be grown in a wide range of environmental conditions at different moisture conditions. It has been observed that tuber size (corm) varies on the basis of soil types as large corm size has been recorded in loose soils (sandy loam to sandy soils) as compared to heavy soils having more clay particles. Although, genetic diversity present in this crop play important role in the expression of tuber characteristics. An attempt has been made by evaluating genetic variability of Bunda germplasm (28 accessions) collections made from different places of Bihar at Tirhut College of Agriculture, Dholi on the basis of variable characteristics.

## Materials and Methods

An experiment was conducted to assess the genetic variability and divergence among 28 germplasm of Bunda collected from different geographical regions of Bihar. The experiment was conducted in Randomized Block Design in three replication during 2015-16 (March to September) at the research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur, Bihar. The observations were recorded on tuber characteristics on five randomly selected plants based on the descriptors provided by the Central Tuber Crop Research Institute, Thiruvananthapuram.

The soil of experimental site is sandy loam, basic in reaction ($p^H$ - 8.1) with available N (233.6 kg/ha.), available P (18.0 kg/ha.) and available K (142.5 kg/ha.). Weather conditions during cropping season were moderate with total rainfall received 870 mm, maximum and minimum temperature ranged from 30-38 $^0$C and 22-26 $^0$C, respectively and relative humidity was ranging from 50 to 98 %. The crop was supplied 80:60:80 kg of NPK $ha^{-1}$ as per recommended doses. Standard cultural practices were applied during the crop period. Data for five quantitative tuber characteristics were statistically analyzed for genetic variability parameters and their association as per the standard methods. Genetic divergence analysis was performed as per Mahalanobis $D^2$ statistics and clustering of genotypes was done by using Tochers method (Rao, 1952).

## Results and Discussion

Tuber yield is an ultimate complex trait which is influenced by several interdependent quantitative traits which are less influenced by environmental fluctuations. Selection for tuber yield per se may not be effective as it is highly influenced by environmental deviations. Therefore, selection for yield components influencing directly or indirectly to yield but are less influenced by the environment may be taken into consideration. On the basis of mean performance for tuber characteristics large variations were obtained for tuber length and girth, number of buds on tuber alongwith average tuber weight and tuber yield, which are considered as economical traits in case of Bunda germplasm.

The range, genotypic variances, PCV, GCV, ECV, heritability (Broad sense) and genetic advance is presented in Table-1. Among studied tuber characteristics, range values revealed wide differences for tuber size and yield, which offers ample scope for the use of these germplasm in development of promising variety. On perusal of table, range values for tuber parameters revealed wide differences for tuber size and yield, which offers ample scope for the use of these germplasm in development of promising variety.

Mean sum of squares values were also found to be highly significant for tuber characteristics presenting sufficient variability among the studied germplasm and provide better opportunity of selection for these traits. PCV values were observed higher than GCV values for tuber length and girth, number of buds in each tuber, average tuber weight and tuber yield exhibiting the role of environmental variations in expression of these tuber characteristics.

Minimum differences were observed for tuber length and girth in GCV and PCV values showing that the phenotypic expression of all the genotypes is under genetic control and there is very little influence of environment for expression of these two traits. Mukherjee et.al. (2003) and Singh et.al. (2004) also reported similar findings in their studies for genetic variability in Bunda genotypes. Higher ECV values as compared to GCV values were obtained for number of buds and average tuber weight indicated the effect of environmental factors in expression of these traits suggesting direct selection for these traits will not be effective. These two traits were also having comparatively less heritability coupled with less genetic advance which indicates influence of environment and non-additive gene action, therefore showing ineffective response towards selection. However, tuber length, tuber girth and tuber yield exhibited high heritability estimates alongwith high genetic advance, hence selection for these traits may be useful due to presence of additive gene action for these traits.

Genetic association of tuber characteristics have been observed in the form of genotypic, phenotypic and environmental correlation coefficients (Table-2). Significant positive correlation of tuber yield has been found with tuber girth and average tuber weight indicated that selection for these two traits will help in yield improvement. However, tuber length has negative significant correlation with tuber yield showing negative effect of large tuber length for increase in tuber yield. Tuber length was found to be negatively correlated with tuber girth at genotypic and phenotypic level suggesting that if tuber grows in length than tuber girth will be affected in negative direction. In present study, in general the estimates of genotypic correlation coefficients were found higher than phenotypic correlation coefficient indicating that observed characters are associated by their concerning linked genes and less affected by environmental factors. However, little effect of environmental correlation coefficient has been observed for tuber characteristics except for tuber length and average tuber weight. Among remaining tuber characters like number of buds on each tuber was found genotypically associated with tuber girth, average tuber weight and also with tuber yield.

Overall, tuber length and tuber girth was found negatively correlated with each other and number of buds in each tuber showed positive and significant correlation with average tuber weight and tuber girth indicated that small sized tubers with good tuber weight not only contribute for increase in yield but also provide more number of planting materials through buds for multiplication in the next generation. Similar reports have been made by Kumar, et.al. (2013) in case of Colocasia genotypes. It seems that little work has been reported in terms of character association in case of Bunda crop.

Mean performance of Bunda germplasm for tuber yield and other characteristics

| Sl.No. | Germplasm (Accession) | Tuber Length (cm) | Tuber Girth (cm) | Buds/ Tuber | Tuber Avg. Weight (kg) | Tuber Yield (t/ha.) |
|---|---|---|---|---|---|---|
| 1. | TCAB-1 | 35.0 | 23.1 | 6.4 | 1.3 | 25.6 |
| 2. | TCAB-2 | 36.3 | 29.6 | 5.1 | 1.2 | 23.0 |
| 3. | TCAB-3 | 48.4 | 16.2 | 5.4 | 0.7 | 13.8 |
| 4. | TCAB-4 | 42.3 | 23.1 | 9.1 | 1.5 | 28.5 |
| 5. | TCAB-5 | 42.4 | 21.1 | 7.1 | 1.3 | 25.4 |
| 6. | TCAB-6 | 36.3 | 25.0 | 6.8 | 1.2 | 27.6 |
| 7. | TCAB-7 | 33.3 | 23.6 | 6.0 | 1.3 | 29.3 |
| 8. | TCAB-8 | 42.6 | 27.4 | 9.1 | 1.5 | 27.7 |
| 9. | TCAB-9 | 44.1 | 16.8 | 7.0 | 1.1 | 14.5 |
| 10. | TCAB-10 | 37.8 | 22.5 | 7.3 | 1.3 | 26.7 |
| 11. | TCAB-11 | 35.2 | 25.0 | 8.0 | 1.2 | 27.7 |
| 12. | TCAB-12 | 37.8 | 23.5 | 8.4 | 1.4 | 26.8 |
| 13. | TCAB-13 | 41.2 | 22.7 | 7.2 | 0.9 | 26.9 |
| 14. | TCAB-14 | 38.2 | 23.7 | 7.8 | 1.4 | 28.0 |
| 15. | TCAB-15 | 38.1 | 25.3 | 9.0 | 1.1 | 25.8 |
| 16. | TCAB-16 | 47.3 | 17.8 | 7.5 | 1.3 | 18.3 |
| 17. | TCAB-17 | 44.8 | 25.1 | 9.1 | 1.4 | 22.1 |
| 18. | TCAB-18 | 42.4 | 20.7 | 7.9 | 1.4 | 22.9 |
| 19. | TCAB-19 | 35.4 | 27.6 | 7.9 | 1.2 | 24.1 |
| 20. | TCAB-20 | 37.4 | 24.9 | 8.1 | 1.2 | 27.0 |
| 21. | TCAB-21 | 37.2 | 24.9 | 7.5 | 1.4 | 27.2 |
| 22. | TCAB-22 | 33.0 | 25.5 | 7.7 | 1.2 | 25.0 |
| 23. | TCAB-23 | 35.1 | 26.1 | 8.9 | 1.3 | 25.9 |
| 24. | TCAB-24 | 33.1 | 23.4 | 8.2 | 1.2 | 27.3 |
| 25. | TCAB-25 | 36.6 | 22.8 | 8.5 | 1.2 | 26.3 |
| 26. | TCAB-26 | 40.6 | 21.7 | 9.2 | 1.3 | 24.8 |
| 27. | TCAB-27 | 35.4 | 20.5 | 7.2 | 1.3 | 27.6 |
| 28. | TCAB-28 | 40.4 | 22.6 | 8.4 | 1.1 | 24.5 |
| | **Mean** | **38.8** | **23.3** | **7.7** | **1.2** | **25.0** |
| | C.V. | 6.9 | 11.1 | 18.0 | 15.7 | 11.1 |
| | S.E. | 1.5 | 1.5 | 0.8 | 0.1 | 1.6 |
| | C.D. 5% | 4.4 | 4.2 | 2.3 | 0.3 | 4.6 |

**Table.1** Range, coefficient of variability (ECV, GCV and PCV), heritability and genetic advance for different characteristics in Bunda

| | Tuber Length (cm) | Tuber Girth (cm) | Buds/ Tuber | Tuber Avg. Weight (kg) | Tuber Yield (t/ha .) |
|---|---|---|---|---|---|
| Range | 33.0 - 48.4 | 16.2 – 29.6 | 5.1 – 9.2 | 0.7 -1.5 | 13.8 – 29.3 |
| ECV | 6.88 | 11.10 | 17.97 | 15.67 | 11.14 |
| GCV | 10.07 | 11.50 | 9.69 | 10.07 | 13.85 |
| PCV | 12.19 | 15.98 | 20.41 | 18.63 | 17.78 |
| $h^2$ (Broad Sense) | 0.68 | 0.52 | 0.23 | 0.29 | 0.61 |
| Genetic Advance | 6.65 | 3.97 | 0.73 | 0.14 | 5.56 |

**Table:2** Genotypic, Phenotypic and Environmental Correlation coefficients of different tuber characteristics in Bunda genotypes

| Character | Correlation | Tuber Length (cm) | Tuber Girth (cm) | Buds/ Tuber | Tuber Avg. Weight (kg) | Tuber Yield (t/ha.) |
|---|---|---|---|---|---|---|
| **Tuber Length (cm)** | **Genotypic** | 1.0000 | -0.7344** | 0.0118 | -0.2915 | -0.8559** |
| | **Phenotypic** | | -0.4332** | 0.0599 | -0.0995 | -0.4423** |
| | **Environment** | | 0.0080 | 0.1114 | 0.0645 | 0.3068** |
| **Tuber Girth (cm)** | **Genotypic** | | 1.0000 | 0.3555* | 0.5690** | 0.7510** |
| | **Phenotypic** | | | 0.1147 | 0.2146* | 0.4452** |
| | **Environment** | | | -0.0111 | -0.0113 | 0.0556 |
| **Buds/ Tuber** | **Genotypic** | | | 1.0000 | 0.8935** | 0.5958** |
| | **Phenotypic** | | | | 0.2345* | 0.1367 |
| | **Environment** | | | | 0.0070 | -0.1519 |
| **Tuber Avg. Weight (kg)** | **Genotypic** | | | | 1.0000 | 0.5125** |
| | **Phenotypic** | | | | | 0.5171** |
| | **Environment** | | | | | 0.5712** |

**Table.3** Multivariate analysis for five tuber parameters

| | 1 Vector | 2 Vector | 3 Vector |
|---|---|---|---|
| **Eigen Value (Root)** | **2.834** | **1.050** | **0.550** |
| **% Var. Exp.** | **56.683** | **21.007** | **11.000** |
| **Cum. Var. Exp.** | **56.683** | **77.690** | **88.689** |
| Tuber Length (cm) | 0.484 | 0.467 | 0.005 |
| Tuber Girth (cm) | -0.481 | -0.098 | -0.392 |
| Buds/ Tuber | -0.359 | 0.613 | 0.626 |
| Tuber Avg. Weight (kg) | -0.381 | 0.550 | -0.571 |
| Tuber Yield (t/ha .) | -0.511 | -0.306 | 0.359 |

**Table.4** Inter and intra cluster distances: Tocher's method

| | 1 Cluster | 2 Cluster | 3 Cluster | 4 Cluster | 5 Cluster | 6 Cluster |
|---|---|---|---|---|---|---|
| **1 Cluster** | **1.096** | 4.441 | 1.860 | 22.284 | 3.737 | 4.846 |
| **2 Cluster** | | **2.226** | 8.182 | 12.258 | 5.668 | 6.611 |
| **3 Cluster** | | | **0.000** | 28.970 | 5.312 | 6.099 |
| **4 Cluster** | | | | **2.398** | 19.282 | 19.309 |
| **5 Cluster** | | | | | **0.000** | 8.264 |
| **6 Cluster** | | | | | | **0.000** |

NB: Bold values are for Intra Cluster distances

**Table.5** Clustering of 28 bunda genotypes : Tocher's Method

| Cluster | Number of genotypes | Genotypes |
|---|---|---|
| **1** | **15** | TCAB-14, TCAB-21, TCAB-10, TCAB-12, TCAB- 20, TCAB-25, TCAB-11, TCAB-6, TCAB-1, TCAB-23, TCAB-15, TCAB-22, TCAB-19, TCAB-27, TCAB-24 |
| **2** | **7** | TCAB – 26, TCAB -28, TCAB -4, TCAB -5, TCAB -18, TCAB -8, TCAB -17 |
| **3** | **1** | TCAB – 7 |
| **4** | **3** | TCAB – 9, TCAB – 16, TCAB – 3 |
| **5** | **1** | TCAB – 2 |
| **6** | **1** | TCAB – 2 |

**Table.6** Cluster Means for different tuber characteristics

| | Tuber Length (cm) | Tuber Girth (cm) | Buds/ Tuber | Tuber Avg. Weight (kg) | Tuber Yield (t/ha .) |
|---|---|---|---|---|---|
| **1 Cluster** | 36.109 | 24.256 | 7.851 | 1.256 | 26.578 |
| **2 Cluster** | 42.219 | 23.095 | 8.562 | 1.357 | 25.119 |
| **3 Cluster** | 33.333 | 23.567 | 6.000 | 1.333 | 29.267 |
| **4 Cluster** | 46.600 | 16.922 | 6.633 | 1.022 | 15.522 |
| **5 Cluster** | 41.200 | 22.667 | 7.233 | 0.867 | 26.867 |
| **6 Cluster** | 36.267 | 29.633 | 5.100 | 1.200 | 23.033 |

**Table .7** Contribution of tuber characteristics towards total genetic divergence

| Source | Contribution % |
|---|---|
| 1. Tuber Length (cm) | 28.84 |
| 2. Tuber Girth (cm) | 14.55 |
| 3. Buds/ Tuber | 8.73 |
| 4. Tuber Avg. Weight (kg) | 9.79 |
| 5. Tuber Yield (t/ha .) | 38.10 |

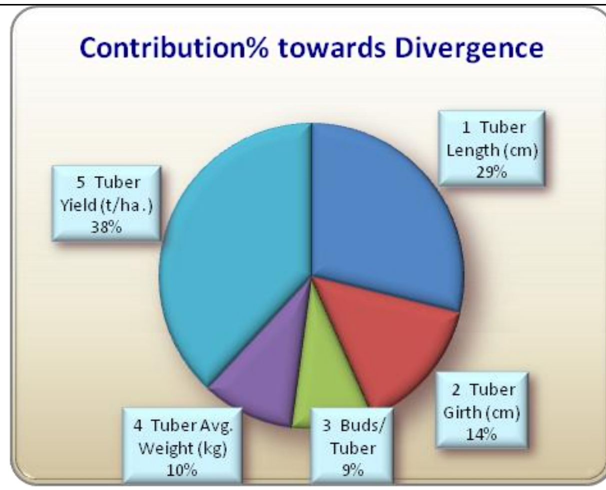
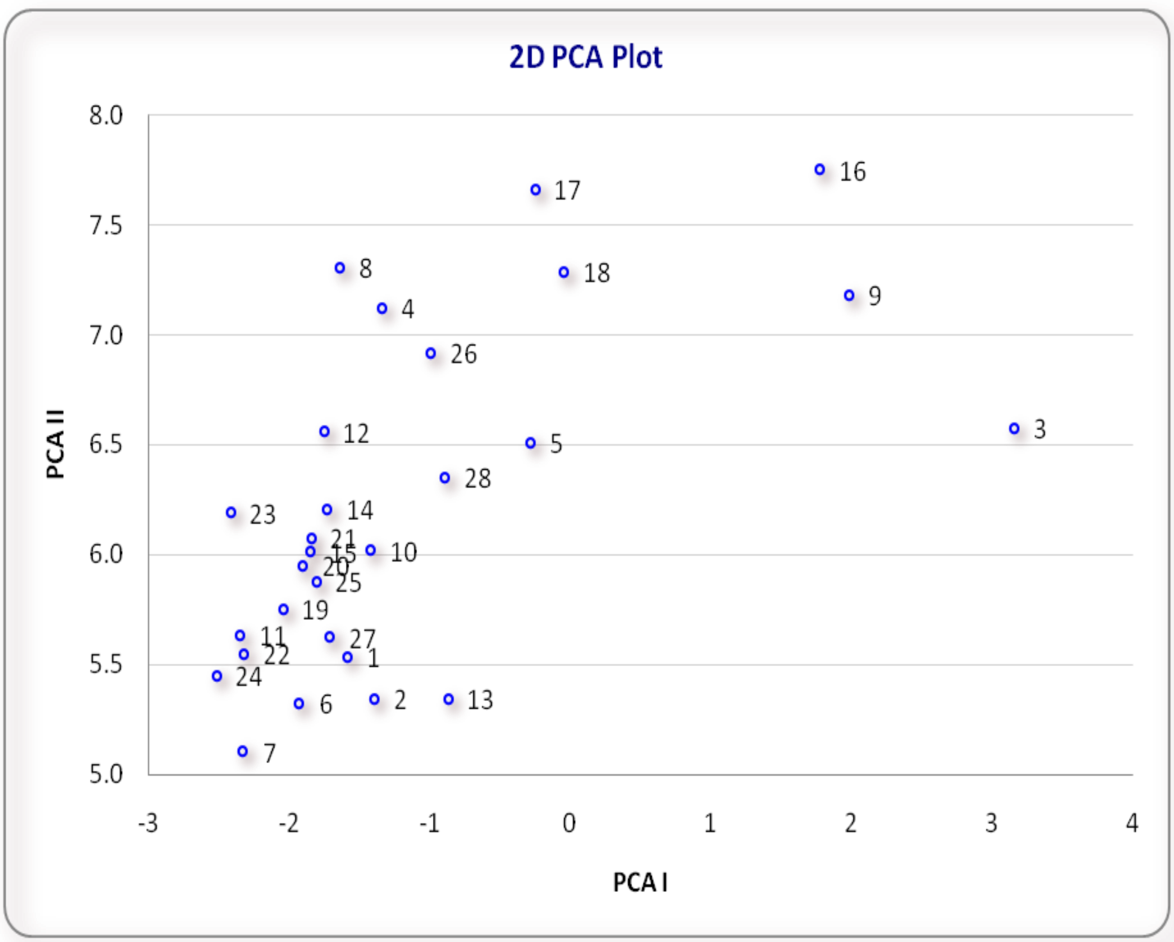



**Fig.1** Distribution of 28 genotypes plotted in 2D PCA plot



The multivariate analysis presented in table-3, revealed that the first two principle components (PC1 and PC2) gave Eigen value (Root) more than 1.0 and cumulatively accounted for 77.69% of the total variations present for five tuber parameters. The association of considered tuber characteristics with specific principal component (PC) values presented in the table revealed that variation in PCA-1 was mainly associated with tuber length, tuber girth and tuber yield. In PCA-2 and PCA-3, variation was found mainly associated with buds number per plant and average weight of tuber. Distribution of 28 genotypes have been plotted in 2D PCA plot given in figure-1 on the basis of PCA-1 and PCA-2 showing relative positions of these diverse genotypes. Similar trends were reported by Beevi *et.al.* (2010) in taro genotypes.

On the basis of $D^2$ statistics calculated as Mahalanobis Euclidean distance (Table-4) and clustering of genotypes done as suggested by Tochers method, all the genotypes has been classified into six clusters (Table-5). Cluster 1 included highest number of genotypes i.e. 15, cluster 2 included 7 genotypes and cluster 4 consisted of 3 genotypes, however, cluster 3, 5 and 6 were monogenotypic. Among these clusters, maximum intra cluster distance of 2.40 was estimated for cluster 4 followed by cluster 2 and 1 with estimates of 2.23 and 1.10, respectively. These results indicated lower level of variation for tuber characteristics among the genotypes present in each cluster. However, maximum inter cluster distance was observed among cluster 3 and 4 (28.97) followed by 22.28 for cluster 1 and 4 and approximately 19.3 in between cluster 4 with cluster 5 and 6. All the genotypes were clustered into six different clusters revealed the presence of genetic divergence among these genotypes for tuber characteristics. Relatively high inter-cluster distances present in between clusters 3 and 4 showed greater genetic distance among the genotypes and validate the need of present study for assessing diversity among Bunda germplasm collections at Dholi, Bihar. Such information's were lacking in the tuber crops like Bunda.

On perusal of cluster mean values in table-6, highest cluster mean for tuber length (46.60) was found in cluster 4 and highest cluster mean value for tuber girth (29.63) was obtained in cluster 6. However, for most of the tuber characteristics average mean value was obtained in cluster 3 comprising maximum number of genotypes. Selection of genotypes for higher yield and contributing traits may be done through respective clusters.

In relation to contribution of tuber characteristics towards total genetic divergence mentioned in table-7, maximum contribution for genetic divergence was found through tuber yield (38.10%) followed by tuber length and tuber girth 28.84% and 14.55%, respectively, suggesting that these tuber characteristics might be considered in genetic diversity evaluation programmes.

On the basis of overall studies regarding genetic variability estimates and association of tuber traits under study, high tuber girth and tuber weight are to be considered for selection of high yielding genotypes in contrast to tuber length. Genetic diversity studies revealed that tuber length and girth alongwith tuber yield has to be taken as major criteria for genetic divergence in Bunda. Sufficient diversity for selection of promising Bunda genotypes has been observed in present Bunda germplasm collections at Dholi centre of Bihar.

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