Assessing the relationship between yield component in pea (*Pisum sativum* L.) cultivars using correlation and path analysis under Sulaimani condition

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Abstract:

Correlation and path analysis studies were conducted during the winter season of 2017-2018 and spring season of 2018. The present experiment was conducted to study the availability and determines the relative importance of primary and secondary traits in field pea, through the association among the characters viz. (No. of pods. plant^{-1} - Weight of pods. plant^{-1}(g) – Pod length. plant^{-1} (cm) - No. of seeds pod^{-1} - Weight of seeds pod^{-1} (g) - Weight of seeds. plant^{-1} (g) - 100 seed Weight (g) - Biological yield. plant^{-1} (g) - Harvest index and Seed yield (Kg ha^{-1}) The experimental material comprised of 4 field pea varieties viz. (Americana, Jeza, Pakland and Avola). From each plot, five competitive plants were selected randomly for recording observation for all quantitative characteristics. The results were summarized as follow, highly significant and positive association were recorded between seed yield with other characters except for the character 100 seed weight which was not significant at winter season and significant at spring season, but not significant with harvest index at both seasons. The highest positive direct effect in seed yield produced by the weight of seeds per plant at both seasons, while the highest positive indirect effect in seed yield recorded by weight of seeds per plant via weight of pods per plant at both seasons.

Keywords: Field pea, *Pisum sativum*, Quantitative Characters, Correlation, Path Aanalysis

تقييم العلاقة بين مكونات الحاصل لبعض اصناف البازلاء (*Pisum sativum* L.) بأستخدام الأرتباط و تحليل المسار تحت ظروف المنطقة السليمانية

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المستخلص:

اجريت هذه الدراسة لتقييم الارتباط و تحليل المسار خلال الموسم الشتوي 2017–2018 و موسم الربيعي 2018. و اجريت هذه التجربة لدراسة تقيم و تحديد الأهمية النسبية للصفات الأولية والثانوية في البازلاء

الحقلية من خلال الأرتباط بين الصفات (عدد القرنات/النبات، وزن القرنات.النبات$^{-1}$(غم)، معدل طول القرنات.النبات$^{-1}$ (سم)، عدد البذور.القرنة$^{-1}$، وزن البذور.القرنة$^{-1}$(غم)، وزن البذور.النبات$^{-1}$ (غم)، وزن 100 بذرة (غم)، الوزن البيولوجي. النبات$^{-1}$ (غم)، دليل الحصاد و حاصل البذور (كغم.هكتار$^{-1}$). تتكون المادة التجريبية من 4 اصناف من البازلاء الحقلية (أمريكانا، جيزا، باكلاند، أفولا). من كل قطعة التجريبية، تم اختيار خمس نباتات بشكل عشوائي لتسجيل الملاحظات لجميع الصفات الكمية. تم تلخيص النتائج على نحو التالي، سجلت ارتباط موجب عالية المعنوية بين حاصل البذور مع جميع المكونات الأخرى بأستثناء وزن 100 بذرة والتي تصل الى حدود المعنوية في الموسم الشتوي وتكون معنوي فقط في الموسم الربيعي. ولم يكن هناك علاقة معنوية بين حاصل البذور و دليل الحصاد لكلا الموسمين. سجل وزن البذور.النبات$^{-1}$ أعلى تأثير مباشر و موجب على حاصل البذور لكلا الموسمين. في حين، ان اعلى تأثير غير مباشر و موجب في حاصل البذور سجلت من قبل وزن البذور.النبات$^{-1}$ خلال وزن القرنات. النبات$^{-1}$ لكلا الموسمين.

كلمات مفتاحية: البازلاء الحقلية، *Pisum sativum*، الصفات الكمية، الأرتباط، تحليل المسار.

Introduction:

Field pea is legume crop, grown in rabi season. Its fresh pods are eaten as a vegetable, which is also a rich source of protein (Thaler & Stein, 2003). Its seeds contain 27% protein, (42.65%) complex carbohydrates (Urbano et al., 2003). There is an urgent need to develop improved varieties. The presence of variability in the material is important to improve quantitative characters and their mutual association with seed yield (Kosev, 2014) and (Garima & Lavanya, 2012). (Dixit, Singh, & A.P., 2002) Reported that seed yield per plant was positively and significantly associated with pods per plant, harvest index, and primary branches per plant. The amount of variation present for a character in the breeding materials, broaden its scope for improvement through selection. (Arya, Malik, Kumar, & Dhari, 2004) Reported that grain yield was significantly and positively correlated with a number of nodes and plant height. The grains per pod, pods per plant, and harvest index have a positive and high correlation with the grain yield. The results of the path analysis revealed that the most direct effect and positive on grain yield were related to, harvest index and the most indirect effect and positive was related to the trait of pods per plant, through harvest index. As a result, the harvest index can have an important influence on the yield. (Rasaei et al., 2011) A significant and positive correlation was observed between seed yield per plant with harvest index, biological yield per plant, plant height, number of seeds per pod, number of primary branches per plant, number of pods per plant and 100-seed weight. (Mahanta, Senapati, Samal, & Dhal, 2001), (Sandeep Kumar Singh et al., 2018) and (J. D. Singh & Singh, 2006) emphasized the importance of No. of pods.plan^{-1} in determining seed yield in field pea. Several workers, including (Arya et al., 2004), (D. Singh & Mishra, 2002), (G. Singh, Singh, Singh, & Singh, 2003), (J. D. Singh & Singh, 2005), (J. D. Singh & Singh, 2006), (S K Singh & Srivastava, 2001), (Vikas & Singh, 1999) and (Tiwari, Singh, Kumar, Nigam, & Singh, 2001) reported the inter- association of plant height with seed yield.plant^{-1}.

No. of pods/plant exerted a highest direct effect on seed yield. This confirms that No. of pods/plant is a highly reliable component of yield. The objective of the present study was to find out the relative importance of various yield traits for seed yield and to evaluate promising genotypes by mean of correlation and to find genetically diverse genotypes which can be used further in a various breeding program in developing wide yielding varieties.

Materials and methods:

A study on morphological traits of pea varieties was carried out at Qliasan research farm – college of agricultural science,university of Sulaimani during two different seasons, first winter 2018-2019 and spring 2019. Four promising genotypes (Americana, Pakland, Avola and Jeza) were planted in a split plot arrangement with RCBD with three replications. The net plot size consists of four rows with (30 cm) row to row and 10 cm plant to plant spacing, with 4 m long. From each plot, five plants were chosen randomly for recording all quantitative traits, and then the grain yield was counted. Harvesting was performed as hand-done on May 15/ 2019, when the pods were until light green and containing soft and fresh grains. Data were recorded for the following quantitative characters:

1- Number of pods per plant: Total number of pods per plant in each plant were counted at the time of maturity and averaged.

2- Weight of pod per plant: Total weight of pods per plant in each plot were weighted and averaged.

3- Pod length: ten pods were randomly taken from the total pods of five randomly selective plants from each plot. The average length of each pod was estimated.

4- Number of seeds per pod: ten pods were randomly taken from total pods of five selected plants from each germplasm. A total number of seeds of these pods were counted and their mean value was expressed as the number of seeds per pod.

5- Weight of seed per pod: the seeds of selected pods from each plot were weighted in grams and averaged.

6- Weight of seed per plant: the total seeds per five selected plants were weighted in grams for each plot and averaged.

7- 100-seed weight (g): The seeds of chosen plants from each plot were mixed to form a sample to estimate the weight of 100 seeds in gram.

8- Biological yield per plant (g): At maturity, the whole five chosen plants were dried and weighted in grams and averaged.

9- Harvest index: It was computed as follows: Harvest index = Seed weight per plant g / Biological weight per plant (g).

10- Seed yield per plant (g): The seeds were taken from the selected plants and weighted in grams, and then the average was taken and converted to Kg.hectare^{-1}.

The correlation coefficient calculated to fix the degree of the association of characters pea yield and among themselves. This correlation was calculated by depending on using the formula given by (R. K. Singh & Chaudhary, 1985), and path coefficient analysis was carried out as suggested by (Arbuckle, Amos, & Guide., 2009), (Dewey

& Lu, 1959), (R. K. Singh & Chaudhary, 1985) and (Soomer, 2010) Analysis of Moment Structures AMOS Ver. 18 Software).

Results:

The estimation of the simple correlation coefficient among the ten characters of field pea varieties conducted at winter season is presented in table (1). At phenotypic level number of pods per plant recorded highly significant and positive correlation with weight of pods per plant (0.807), weight of seeds per plant (0.904), biological weight per plant (0.783) and seed yield (0.904), while significant and positive correlation was recorded between the number of pods per plant with a number of seeds per pod (0.444) and weight of seeds per pod (0.418). The association between No. of pods.plant^{-1} and biological weight.plant^{-1} and 100 seed weight was positive and significant, but the association between No. of pods.plant^{-1} and No. of seeds.pod^{-1} was negative and significantly. The correlation between 100 seed weight and No. of seeds.pod^{-1} was significantly negative (Ciftci, Togay, Togay, & Dogan, 2004) and (Togay, Togay, Yildirim, & Dogan, 2008). Also (Patel, Patel, Prajapati, Tikka, & Patel, 2006) reported a positive correlation between a number of pods per plant and seed yield per plant. Previously (Esmail, Abdulkhaleq, Hama, & Karem, 2015) confirmed that the number of pods.plant^{-1} associated positively and high significantly with weight of pods.plant^{-1}, biological weight.plant^{-1} and weight of seeds.plant^{-1} recording 0.691, 0.646 and 0.859 respectively, and correlated negatively and significantly with pod length recording -0.472, while it correlated positively and significantly with harvest index recording 0.419, Concerning to weight of pods per plant highly significant and positive correlation was exhibited with pod length (0.682), weight of seed per pod (0.786), weight of seeds per plant (0.948), biological weight per plant (0.994) and seed yield (0.948), but significant and positive correlation was recorded between weight of pods per plant and number of seeds per pod (0.427). (30) indicated that the character weight of pods/plant it correlated positively and high significantly with biological weight.plant^{-1} and weight of seeds.plant^{-1} recording 0.613 and 0.839 respectively, while it correlated positively and significantly with harvest index recording 0.413. The character pod length produced highly significant and positive correlation with each of number of seeds per pod (0.626), weight of seeds per pod (0.901), weight of seeds per plant (0.646), biological weight per plant (0.705) and seed yield (0.646) significant and positive correlation of pod length with number of seeds per pod was observed previously suggesting that increase in pod length accommodate more seeds per pod which would ultimately result in increase seed yield per plant (Kumar & Ojha, 1997). (Esmail et al., 2015) also signified a positive and highly significant correlation between pod length with a weight of seeds per pod and 100 seed weight. In the same table the character number of seed per pod associated high significantly and positively with weight of seeds per plant and seed yield (0.520) for both, while it correlated significantly and positively with weight of seed per pod (0.445) and biological weight per plant (0.414) and, however negative and significant association of weight of seeds per pod was observed with 100 seed weight (-0.418). (Salehi, Faramarzi, & Mohebalipour, 2010) reported that an only number of seeds per

pod affected the grain yield and mostly direct and positive effects were related to traits number of grains per pod and harvest index. Thus the yield could be increased through pods per plant, and number of seeds because taller plants involve greater number of pods per plant, number of seeds per pod and ultimately yield per plant. A highly significant and positive correlation was noticed between the weight of seeds per pod and each of weight of seeds per plant (0.751), 100 seed weight (0.619), biological weight per plant (0.798) and seed yield (0.751). Weight of seeds per plant showed a highly significant and positive correlation with biological weight per plant (0.937) and seed yield (0.998). A significant and positive correlation between 100 seed weight with biological weight per plant was recorded (0.417). Biological weight per plant showed a highly significant and positive correlation with seed yield (0.937). (Patel et al., 2006) also confirmed a positive correlation between seed yield per plant with a number of pods per plant, and pod length, at the genotypic and phenotypic level. Seed yield per plant showed highly significant and positive correlation with a number of seeds per pod (0.3034), pod length (0.370), biological yield per plant (0.7881) and harvest index (0.6807); positive association with 100 seed weight (0.1897) and remaining characters showed negative non significant (Prasad, Nath, Yadav, Yadav, & Verma, 2018).

Table 1: Simple correlation among all pairs of Characters at winter season.

Characters	No. of Pod.plant^{-1}	Weight of pod.plant^{-1} (g)	Pod Length.plant^{-1} (cm)	No.of Seed.pod $^{-1}$	weight of seed.pod^{-1} (g)	Weight of seed.plant^{-1} (g)	100 seed weight (g)	Biological weight.plant^{-1} (g)	Harvest Index	Seed Yield (kg ha^{-1})
No. of Pod.plant^{-1}	**1**									
Weight of pod. plant^{-1} (g)	**0.807****	**1**								
Pod Length.plant^{-1} (cm)	0.310	**0.682****	**1**							
No.of Seed.pod^{-1}	**0.444***	**0.427***	**0.626****	**1**						
weight of seed.pod^{-1}(g)	**0.418***	**0.786****	**0.901****	**0.445***	**1**					
Weight of seed.plant^{-1} (g)	**0.904****	**0.948****	**0.646****	**0.520****	**0.751****	**1**				
100 seed weight (g)	0.015	0.394	0.364	**-0.418***	**0.619****	0.286	**1**			
Biological weight.plant^{-1} (g)	**0.783****	**0.994****	**0.705****	**0.414***	**0.798****	**0.937****	**0.417***	**1**		
Harvest Index	0.168	-0.054	-0.019	0.304	-0.049	0.069	-0.293	-0.095	**1**	
Seed Yield (kg ha^{-1})	**0.904****	**0.948****	**0.646****	**0.520****	**0.751****	**0.998****	0.286	**0.937****	0.069	**1**

****Correlation is significant at the 0.01 level**

***Correlation is significant at the 0.05 level**

Data in the table (2) illustrate the simple correlation coefficient among all pair's characters at spring season. Number of pods per plant recorded highly significant and positive correlation with each of weight of pods per plant (0.902), number of seeds per pod (0.589), weight of seeds per pod (0.705), weight of seeds per plant (0.925), biological weight per plant (0.852), harvest index (0.549) and seed yield (0.925) however significant and positive correlation was recorded between the number of pods per plant pod length (0.457) previously (30) revealed that No. of pods.plant^{-1} had the maximum correlation coefficient and direct effect on seed yield and the conforming indirect effect through plant height and 100 seed weight. It was noticed that the character weight of seeds.plant^{-1} associated positively and highly significantly with the character No. of pods.plant^{-1}, weight of pods.plant^{-1}, biological weight.plant^{-1} and harvest index recording (0.857, 0.839, 0.694 and 0.505) respectively. The character biological weight.plant^{-1} and harvest index showed maximum positive direct effect in weight of seeds.plant^{-1} reached (0.630 and 0.456) respectively, the character No. of pods.plant^{-1} showed the highest positive indirect effect in weight of seeds.plant^{-1} via harvest index recording (0.191). The character weight of pods per plant recorded a highly significant and positive correlation with pod length (0.708) , number of seeds per pod (0.617) m weight of seed per pod (0.911), weight of seeds per plant (0.996) , 100 seed weight (0.556), biological weight per plant (0.985) and seed yield (0.996). Highly significant and positive correlation between pod length with each of number of seed per pod (0.720), weight of seeds per pod (0.873), weight of seeds per plant (0.687), biological weight per plant (0.729) and seed yield (0.687) was noticed, however significant and positive correlation was observed between pod length and 100 seed weight (0.516). A number of seeds per pod associated high significantly and positively with the weight of seed per pod (0.650), the weight of seed per plant (0.637), biological weight per plant (0.572) and seed yield (0.637). Weight of seeds per pod recorded highly significant and positive correlation with weight of seeds per plant (0.890), 100 seed weight (0.696), biological weight per plant (0.896) and seed yield (0.890). Weight of seeds per plant produced highly significant and positive correlation with biological weight per plant (0.976), and seed yield (0.997), however significant and positive correlation was recorded between weight of seeds per plant and 100 seed weight (0.510). The character 100 seed weight showed a highly significant and positive correlation with biological weight per plant (0.566) and significant and positive correlation with seed yield (0.510) (Arya et al., 2004), (Gul, Sumerli, Bicer, & Yilmaz, 2005), (Mahanta et al., 2001), (Patel et al., 2006), (J. D. Singh & Singh, 2004) and (S. P. Singh, 1999) reported previously that the 100 seed weight exhibited significant and positive association with grain yield/plant. The association between biological weight per plant and seed yield was highly significant and positive (0.976). Earlier reports in field pea have also indicated the existence of a strong positive association of seed yield per plant with harvest index and biological yield(Vikas & Singh, 1999) and (Tyagi & Srivastava, 2002) .

Table 2: Simple correlation among all pairs of characters at spring season.

Characters	No. of Pod.plant^{-1}	Weight of pod.plant^{-1} (g)	Pod Length.plant^{-1} (cm)	No. of Seed.pod^{-1}	weight of seed.pod^{-1} (g)	Weight pf seed.plant^{-1} (g)	100 seed weight (g)	Biological weight.plant^{-1} (g)	Harvest Index	Seed Yield (kg ha^{-1})
No. of pod.plant^{-1}	**1**									
Weight of pod.plant^{-1} (g)	**0.902****	**1**								
Pod Length.plant(cm)	**0.457***	**0.708****	**1**							
No. of Seed.pod^{-1}	**0.589****	**0.617****	**0.720****	**1**						
weight of seed.pod^{-1} (g)	**0.705****	**0.911****	**0.873 ****	**0.650****	**1**					
Weight pf seed.plant^{-1} (g)	**0.925****	**0.996****	**0.687****	**0.637****	**0.890****	**1**				
100 seed weight (g)	0.340	**0.556****	**0.516***	-0.041	**0.696****	**0.510***	**1**			
Biological weight.plant (g)	**0.852****	**0.985****	**0.729****	**0.572****	**0.896****	**0.976****	**0.566****	**1**		
Harvest Index	**0.549****	0.369	0.055	0.347	0.322	0.403	0.154	0.236	**1**	
Seed Yield (kg ha^{-1})	**0.925****	**0.996****	**0.687****	**0.637****	**0.890****	**0.997****	**0.510***	**0.976****	0.403	**1**

****Correlation is significant at the 0.01 level**

***Correlation is significant at the 0.05 level**

Path coefficient analysis was estimated on phenotypic levels to resolve the direct and indirect effects of different characters on seed yield as presented in table (3) for the winter season. At the phenotypic level, the highest positive direct effect on seed yield was recorded by weight of seed per plant (1.0001). The maximum direct effect in negative direction was exerted by the weight of seed per pod (-0.00008), this confirmed that the direct contribution of these traits was too low to be considered by any consequences. Concerning to the estimation of indirect effects all the triads in seed yield it was found that the highest positive indirect effect recorded by weight of seeds per plant via weight of pods per plant reached (0.948), and followed by (0.937 and 0.904) also for weight of seeds per plant via biological weight per plant and number of pods per plant respectively. The negative value of the indirect effect of the traits in seed yield was too low to be considered by any results Correlation and path analysis indicated that harvest index, biological yield per plant, number of seeds per pod, pod length and 100-seed weight, had true relationship with seed yield and they are the major yield contributing traits (Prasad et al., 2018).

Table 3: Simple path coefficient analysis illustrates direct (diagonal values) and indirect effects on seed yield for winter season.

Characters	No. of Pod.plant^{-1}	Weight of pod.plant^{-1} (g)	pod length.plant^{-1} (cm)	No. of seed.pod^{-1}	weight of seed.pod^{-1} (g)	weight of seed.plant^{-1} (g)	100 seed weight (g)	Biological weight.plant^{-1} (g)	Harvest index
No. of Pod.plant^{-1}	-6.35E-05	-6.11E-05	1.13E-05	2.60E-06	-3.35E-05	9.04E-01	6.73E-07	3.40E-05	1.10E-06
Weight of pod.plant^{-1} (g)	-5.12E-05	-7.57E-05	2.48E-05	2.50E-06	-6.29E-05	9.48E-01	1.79E-05	4.32E-05	-3.54E-07
Pod Length.plant^{-1} (cm)	-1.97E-05	-5.17E-05	3.63E-05	3.66E-06	-7.21E-05	6.46E-01	1.66E-05	3.07E-05	-1.24E-07
No. of Seed.pod^{-1}	-2.82E-05	-3.23E-05	2.28E-05	5.85E-06	-3.56E-05	5.21E-01	-1.90E-05	1.80E-05	1.99E-06
weight of seed.pod^{-1} (g)	-2.66E-05	-5.95E-05	3.27E-05	2.61E-06	-8.00E-05	7.51E-01	2.81E-05	3.47E-05	-3.21E-07
Weight pf seed.plant^{-1} (g)	-5.74E-05	-7.18E-05	2.35E-05	3.04E-06	-6.01E-05	1.00E+00	1.30E-05	4.07E-05	4.50E-07
100 seed weight (g)	-9.41E-07	-2.98E-05	1.32E-05	-2.44E-06	-4.95E-05	2.86E-01	4.55E-05	1.81E-05	-1.91E-06
Biological weight.plant^{-1} (g)	-4.97E-05	-7.53E-05	2.56E-05	2.42E-06	-6.38E-05	9.37E-01	1.89E-05	4.35E-05	-6.18E-07
Harvest Index	-1.07E-05	4.10E-06	-6.89E-07	1.78E-06	3.92E-06	6.88E-02	-1.33E-05	-4.11E-06	6.54E-06

The estimation of Path coefficient analysis for spring season illustrated in the table (4). The highest positive direct effect was (1.0008) recorded by weight of seeds per plant, the character weight of seeds per pod recorded maximum negative direct effect in seed yield reached (-0.00046). It was confirmed that all negative direct effects in seed yield were too low to be considered by any sequences. The results of indirect effects represented in the same table indicated that the highest positive indirect effect was (0.997) recorded by weight of seeds per plant via weight of pods per plant and followed by (0.976 and 0.925) for also weight of seeds per plant via biological weight per plant and number of pods per plant respectively. (Esmail et al. 2015) also reported biological weight per plant and harvest index exhibited maximum positive direct effect in weight of seeds per plant recording (0.630 and 0.456) respectively. (A. Singh, Lavanya, & Roopa., 2014) also reported that biological yield per plant, harvest index, and plant height had a positive and direct effect on grain yield per plant. Similarly, days to 50% flowering and pod length had a positive and direct effect on grain yield per plant. (Bashir, Ishtiaq, Fiaz, & Sajjad, 2014) also reported that 100– seed weight and a number of seed per pod had a maximum direct effect on grain yield per plant.

Table 4: Path coefficient analysis illustrates direct (Diagonal Values) and indirect effects on seed yield for spring season.

Characters	No. of Pod.plant^{-1}	Weight of pod.plant^{-1} (g)	pod length.plant^{-1} (cm)	No. of seed.pod^{-1}	weight of seed.pod^{-1} (g)	weight of seed.plant^{-1} (g)	100 seed weight (g)	Biological weight.plant^{-1} (g)	Harvest index
No. of Pod.plant^{-1}	-0.00013	-0.00035	5.4791E-05	4.21E-05	-0.00032	0.925846	5.61415E-05	-5.96612E-05	-2.7473E-05
Weight of pod.plant^{-1} (g)	-0.000117308	-0.00039	8.4948E-05	4.40E-05	-0.00042	0.997126	9.17035E-05	-6.89473E-05	-1.84485E-05
Pod Length.plant^{-1} (cm)	-5.93569E-05	-0.00028	0.00012	5.14E-05	-0.0004	0.68719	8.51038E-05	-5.10326E-05	-2.75444E-06
No. of Seed.pod^{-1}	-7.65726E-05	-0.00024	8.64223E-05	7.14E-05	-0.0003	0.637865	-6.70033E-06	-4.00677E-05	-1.73472E-05
weight of seed.pod^{-1} (g)	-9.16715E-05	-0.00036	0.000104749	4.64E-05	-0.00046	0.891159	0.000114823	-6.27251E-05	-1.60952E-05
Weight pf seed.plant $^{-1}$ (g)	-0.000120265	-0.00039	8.23978E-05	4.55E-05	-0.00041	1.000789	8.40887E-05	-6.83104E-05	-2.01278E-05
100 seed weight (g)	-4.42327E-05	-0.00022	0.000	-2.90E-06	-0.00032	0.510031	0.000165	-3.9616E-05	-7.71417E-06
Biological weight.plant^{-1} (g)	-0.000110799	-0.00038	8.74845E-05	4.09E-05	-0.00041	0.976633	9.33805E-05	-0.00007	-1.18112E-05
Harvest Index	-7.14299E-05	-0.00014	6.61065E-06	2.48E-05	-0.00015	0.402874	2.54568E-05	-1.65357E-05	-0.00005

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