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ADVANCED CORRELATION ANALYSIS OF THE PERFORMANCE OF PEA VARIETIES

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The article presents the path coefficients between yield and its components in pea varieties. Most high positive direct effects were obtained only for the trait "number of seeds per plant". In the other cases, differences in the performance of the varieties studied were confirmed by both positive and negative high values of direct effects. Out of the total number of calculated values, significant Spearman coefficients for both direct and indirect effects of the trait "seed weight per plant" were obtained only in 16 pairs of comparisons. Thus, correlation coefficients, path analysis and Spearman rank correlation coefficients allow not only the determination of the general trend of interactions between traits in the aggregate, but also the determination of the significance of differences between genotypes.

Key words: *Pisum sativum L., path coefficient analysis, plant breeding, Spearman coefficient correlation.*

Introduction. The issue of identity or distinctness between performance characteristics as matrices in various accessions as well as of matrices of their correlation coefficients and path coefficients is important for breeding practice. Such information can be useful when one selects accessions for crossings and searches for unique genotypes.

Literature review. Grain legumes have been an integral part of the human diet for centuries, but their nutritional potential is often underestimated, and consumption remains low. These crops are worth much more attention as they are essential for healthy diets, sustainable food production and food security [1]. In 2018, the global production of grain legumes amounted to 92277 Mt, of which pea (*Pisum sativum* L.) accounted for 13534 Mt [2]. Ukraine is one of the top ten pea producers in the world, and a significant part of Ukrainian pea is exported.

Pea is a crop that is used directly for both food and forage purposes, and also increases soil fertility due to its nitrogen-fixing ability. Pea seeds contain sufficient amounts of protein, carbohydrates, dietary fiber [3].

When selecting and developing varieties with high yields and adaptability, one should take into account relationships between traits [4, 5], as well as their direct and indirect effects that determine the performance [6]. For example, for common beans (*Phaseolus vulgaris* L.), in studies conducted by Jasim and Esho [7] and Onder M. et al. [8], completely different results were obtained. Thus, in the former the number of beans per plant, weight of seeds per plant, weight of 1000 seeds and number of seeds per bean has the greatest influence, and in the latter - biological yield, yield index, number of main branches per plant and number of days before flowering. For sunflower in the study by Gjorgjieva B. et al. [9] the results of correlation and path analysis showed that the efficiency of choosing the yield of seeds of sunflower hybrids should increase due to the selection of seeds on the basis of the weight of 1000 seeds. For green pea (*Pisum sativum* L.), the yield of pods has a high positive correlation with their number and weight [1] (10/9) and in the study of Singh et al. [11]) for 55 genotypes of peas (*Pisum sativum* L.) according to the results of correlation and path analysis was also proved that the mass of green pods from the plant and pod length have a significant positive correlation and direct positive effect on seed yield. Fikreselassie in 2012 [12] researched pea varieties by genotypic analysis and determined that the yield index and biomass yield had a significant direct impact on seed yield. The same results Ayer D. et al. [13] obtained for wheat. Yagdı K. [14] determined for *Triticum Durum* Desf. during the four years of research, that only a features " mass of seeds per ear" had a positive effect on yield. On average, for four years the direct positive contribution was made by the indicators "plant density", "mass of seeds per ear" and "mass of 1000 seeds" – 0.312; 0.295 and 0.286, respectively.

The issue of identity both of trait matrices of different varieties and of matrices of their correlation and path coefficients is no less important. Basing on this, we analyzed the correlation and path coefficients between the performance and its components for pea varieties bred by the Plant Production Institute named after VYa Yuriev of NAAS (Ukraine) during 2002–2018.

Materials and methods. The field experiments were carried out in scientific crop rotation of the Plant Production Institute (PPI) nd. a VYa Yuriev NAAS located in the Kharkiv Region of the Kharkiv Oblast (village Elitne, Ukraine (49º59'39 " N lat., 36º27'09 " E, height above sea level – 209 m) in 2014–2016. The farming technics that are conventional for this crop were applied.

Fourteen pea varieties bred at the PPI nd. a VYa Yuriev and included in the State Register of Plant Varieties Suitable for Dissemination in Ukraine were taken as the test material: leafless grain varieties – Kharkovskiy Etalonnyy (entered in the Register in 2002), Modus (2004), Efektnyy (2006), Deviz (2007), Hlians (2008), Tsarevich (2008), Chekbek (2009), Oplot (2011), Otaman (2011), Mahnat (2012), Metsenat (2014), Korvet (2016), and Haiduk (2018): and a grain/mowing variety – Heizer (2015).

The accessions were sown with manual planters with an interrow spacing of 0.15 m. Sheaf samples were taken when the plants were in full maturity. The following performance components were measured on the selected plants: the stem length (cm) of the whole plant (HPl) and of the vegetative part (HV), the number of productive (G) and vegetative (V) nodes, the number of pods (Pd), the number of seeds – total (S), on the first (S1), second (S2) and third (S3) productive nodes, and the seed weight (g) per plant (MSPl).

The path correlation coefficients were computed, as Dewey and Lu described [15].

To assess the contingency of the series both of genotypic and of path coefficients, the Spearman rank coefficient was used sensu Rao G. Nageswara [16]. To assess the significance, a table of critical values for Spearman coefficient was used.

Results. The correlations between the "seed weight per plant" trait and the performance components in this sample showed that the coefficient values in the varieties varied to a large extent (Table 1).

For example, the genotypic correlation coefficient for the "seed weight per plant" - "number of pods" trait pair varied from r = 0.91 to r = –0.05. It should be noted that in this sample, the greatest number of significant values of the correlation coefficients with strong relationship was recorded for the "seed number per plant" trait: for 10 of 14 varieties.

For the trait "the number of seeds on the first productive node", the correlation coefficients were insignificant, and the relationship strength ranged from weak to medium, except for variety Haiduk (r = 0.69). The same trend was observed for the correlation coefficients for the "seed weight per plant" - "number of seeds on the second productive node" trait pair, except for varieties Heyzer (r = 0.79) and Korvet (r = 0.68).

A high positive contribution of the "the number of vegetative nodes" trait was noted in varieties Modus (r = 0.83), Hlians (r = 0.76), Otaman (r = 0.68), and Metsenat (r = 0.74), As to the other traits, their relationship with the "seed weight per plant" trait was of medium or weak, regardless of direction.

Table 1.

Genotypic correlation coefficients between the "seed weight per plant" trait and the performance components.

Variety	Pd[1]	S	S1	S2	S3	V	G	HPl	HV
Kharkovskiy Etalonnyy	0.53	0.76*	-0.01	0.21	0.68*	0.32	-0.16	0.45	-0.09
Modus	0.91*	0.95*	0.18	0.29	0.69*	0.83*	-0.60	-0.23	-0.65*
Efektnyy	0.74*	0.95*	0.26	0.48	0.75*	0.63	-0.40	0.20	-0.31
Deviz	0.56	0.88*	0.47	0.62	0.40	0.40	-0.41	0.36	-0.22
Hlians	0.86*	0.91*	0.50	0.15	0.42	0.76*	-0.64*	0.41	-0.59
Tsarevich	0.42	0.88*	0.11	0.22	0.68*	0.27	0.04	0.40	0.33
Chekbek	0.03	0.30	0.06	0.35	0.31	-0.23	-0.30	0.13	0.04
Oplot	0.51	0.90*	0.63	0.62	0.72*	0.40	-0.52	-0.43	-0.11
Otaman	0.84*	0.87*	0.07	0.54	0.50	0.68*	0.16	0.65*	0.31
Mahnat	-0.05	0.49	0.07	0.58	0.63	-0.32	-0.30	-0.02	-0.07
Metsenat	0.82*	0.54	0.09	0.59	0.37	0.74*	-0.23	0.35	-0.15
Heizer	0.24	0.72*	0.58	0.79*	0.49	0.16	0.04	-0.14	-0.09
Korvet	0.77*	0.89*	-0.20	0.68*	0.39	0.62	0.31	0.50	0.57
Haiduk	0.55	0.91*	0.69*	0.59	0.46	0.25	0.52	0.49	0.58

Note. * – significance level is 5%; $r \geq 0{,}64$; Pd[1] – number of pods; S – number of seeds of total, S1 – the number of seeds on the first, S2 – second and S3 – third productive nodes; V – number of vegetative nodes, G – number of productive nodes; HPl – whole plant, HV – vegetative part.

To determine the consistency between the correlation matrices for the varieties in the sample under investigation, the Spearman correlation coefficients were computed. These coefficients, confirming the matrix identity for the varieties in the sample, were significant in 66 comparison pairs or in 36% of the total number (182 pairs) of the computed values (Table 2). As tor the matrix for variety Haiduk, there were no significant values; all the Spearman correlation coefficients were low and insignificant.

Table 2.

Consistency between the genotypic correlation matrices (Spearman correlation coefficients)

Varieties	Modus	Efektnyy	Deviz	Hlians	Tsarevich	Chekbek	Oplot	Otaman	Mahnat	Metsenat	Heizer	Korvet	Haiduk
	2	3	4	5	6	7	8	9	10	11	12	13	14
1**	0.82*	0.90*	0.63	0.77*	0.90*	0.48	0.65	0.77*	0.52	0.63	0.33	0.55	-0.03
2		0.93*	0.78*	0.90*	0.60	0.22	0.68*	0.78*	0.28	0.83*	0.58	0.67*	0.08
3	0.93*		0.90*	0.60	0.22	0.68*	0.78*	0.28	0.83*	0.58	0.67*	0.08	0.08
4	0.78*	0.90*		0.70*	0.43	0.60	0.83*	0.53	0.63	0.67*	0.87*	0.62	0.57
5	0.90*	0.60	0.70*		0.60	1.00	0.65	0.70*	0.17	0.70*	0.42	0.53	0.17
6	0.60	0.22	0.43	0.60		0.42	0.52	0.70*	0.42	0.43	1.00	0.57	0.00
7	0.22	0.68*	0.60	1.00	0.42		0.65	0.13	0.93*	0.18	0.58	0.20	0.33
8	0.68*	0.78*	0.83*	0.65	0.52	0.65		0.27	0.75*	0.40	0.83*	0.30	0.45
9	0.78*	0.28	0.53	0.7*	0.70*	0.13	0.27		0.03	0.78*	0.15	0.88*	-0.03
10	0.28	0.83*	0.63	0.17	0.42	0.93*	0.75*	0.03		0.13	0.67*	0.07	0.37
11	0.83*	0.58	0.67*	0.70*	0.43	0.18	0.40	0.78*	0.13		0.42	0.73*	-0.11
12	0.58	0.67*	0.87*	0.42	1.00	0.58	0.83*	0.15	0.67*	0.42		0.32	0.57
13	0.67*	0.08	0.62	0.53	0.57	0.20	0.30	0.88*	0.07	0.73*	0.32		0.25

Note. * – significance level is 5%; $r \geq 0{,}67$; 1** – Kharkovskiy Etalonnyy

When analyzing direct and indirect effects of the "seed weight per plant" trait using path coefficients, we established high residual effects in some varieties (Kharkovskiy Etalonnyy (P_0 = 0.45), Tsarevich (P_0 = 0.40), Chekbek (P_0 = 0.49), Otaman (P_0 = 0.70), Mahnat (P_0 = 0.42), Heyzer (P_0 = 0.36), indicating the influence of unaccounted relationships in the sample under investigation. As to the other varieties, the contribution of unaccounted factors was low: Modus (P_0 = 0.00), Efektnyy (P_0 = 0.06), Deviz (P_0 = 0.19), Hlians (P_0 = 0.29), Oplot (P_0 = 0.17), Metsenat (P_0 = 0.00), Korvet (P_0 = 0.16), and Haiduk (P_0 = 0.27).

When analyzing the direct effects in the studied varieties, we found no unambiguous influence of any individual trait on the performance (Table 3).

Table 3.

Direct effects of the "seed weight per plant" trait

Variety	Pd	S	S1	S2	S3	V	G	HPl	HV
Kharkovskiy Etalonnyy	-0.09	0.51	0.26	0.13	0.20	-0.02	-0.10	0.57	-0.31
Modus	-0.20	1.37	0.00	-0.08	-0.04	-0.35	-0.54	0.15	0.16
Efektnyy	0.43	1.18	0.17	-0.21	-0.10	-0.82	-0.11	0.46	-0.23
Deviz	-0.25	1.67	-0.40	-0.13	-0.32	-0.45	-0.46	0.19	0.22
Hlians	0.77	-0.03	0.42	0.09	0.26	-0.23	0.09	0.25	-0.15
Tsarevich	-0.14	1.57	-0.26	-0.09	-0.48	-0.24	0.05	-0.54	0.44
Chekbek	0.75	0.51	-0.58	0.49	-0.18	-1.21	-0.50	0.48	-0.55
Oplot	0.05	1.35	-0.09	0.07	-0.26	-0.52	-0.35	-0.01	0.21
Otaman	-0.39	-0.70	0.06	1.34	0.64	1.37	0.33	0.16	-0.75
Mahnat	-0.33	-0.40	0.29	0.28	0.83	-0.56	-0.35	0.95	-1.05
Metsenat	0.07	2.27	-1.96	-0.32	-0.01	0.32	-0.28	-0.58	0.54
Heizer	1.16	-0.09	0.40	0.53	0.18	-0.77	0.28	-0.58	0.44
Korvet	-0.04	1.46	0.05	-0.03	-0.24	0.09	-0.08	-0.85	0.37
Haiduk	-0.09	0.96	0.64	-0.22	0.22	0.07	-0.10	-0.25	-0.19

Note. Pd[1] – number of pods;, S – number of seeds of total, S1 – the number of seeds on the first, S2 – second and S3 –third productive nodes; V – number of vegetative nodes, G – number of productive nodes; HPl – whole plant, HV – vegetative part.

Thus, the largest number of high positive direct effects was only obtained for the “number of seeds per plant” trait, In the other cases, both positive and negative high direct effects confirm differences in mechanisms of the performance formation in the varieties under investigation.

Analysis of the direct effects of the "seed weight per plant" trait in this sample, which was conducted with Spearman correlation coefficients (r_s), revealed differences in the relationship strength and direction, while the coefficient values varied from r_s = 0.92 to r_s = –0.78 upon pair comparisons.

The Spearman coefficients, confirming the matrix identity for the varieties in this sample, were significant only in 16 comparison pairs or in 8% of the total number of the computed values.

In several cases, the indicator of relationship between the series was negative, however, significant: for the pairs Modus-Otaman (r_s = - 0.67), Tsarevich -Mahnat (r_s = - 0.78), Mahnat and Metsenat (r_s = - 0.78), Mahnat-Korvet (r_s = - 0.78) and Oplot-Otaman (r_s = - 0.70). The coefficients were positive and significant between the following varieties: Kharkovskiy Etalonnyy-Effektnyy (r_s = 0.68), Modus-Deviz (r_s = 0.85), Modus-Oplot (r_s = 0.73), Deviz-Oplot (r_s = 0.92), Hlians-Mahnat (r_s = 0.74), and Tsarevich-Korvet (r_s = 0.70). As to varieties Hlians, Chekbek, Heyzer and Haiduk, all the Spearman coefficients were low and insignificant.

Like with the direct effects, no unidirectional contributions of indirect effects was observed (Table 4).

Table 4.

The sum of indirect effects of the "seed weight per plant" trait

Variety	Pd	S	S1	S2	S3	V	G	HPl	HV
Kharkovskiy Etalonnyy	0.62	0.26	-0.27	0.08	0.48	0.34	-0.06	-0.11	0.22
Modus	1.11	-0.42	0.18	0.37	0.73	1.17	-0.06	-0.38	-0.81
Efektnyy	0.31	-0.22	0.09	0.60	0.85	1.45	-0.29	-0.26	-0.08
Deviz	0.80	-0.79	0.87	0.75	0.72	0.85	0.05	0.17	-0.43
Hlians	0.09	0.93	0.08	0.06	0.16	0.99	-0.74	0.15	-0.44
Tsarevich	0.56	-0.69	0.37	0.31	1.16	0.51	-0.01	0.94	-0.11
Chekbek	-0.72	-0.21	0.63	-0.15	0.49	0.99	0.21	-0.35	0.59
Oplot	0.47	-0.46	0.72	0.55	0.98	0.92	-0.17	-0.41	-0.32
Otaman	1.23	1.56	0.01	-0.80	-0.14	-0.70	-0.17	0.49	1.06
Mahnat	0.28	0.90	-0.22	0.30	-0.20	0.24	0.05	-0.97	0.98
Metsenat	0.75	-1.74	2.05	0.91	0.38	0.41	0.05	0.93	-0.69
Heizer	-0.92	0.81	0.18	0.25	0.31	0.93	-0.25	0.44	-0.52
Korvet	0.81	-0.58	-0.25	0.71	0.63	0.53	0.39	1.34	0.20
Haiduk	0.64	-0.05	0.05	0.81	0.23	0.18	0.62	0.74	0.77

Note. Pd[1] – number of pods, S – number of seeds of total; S1 – the number of seeds on the first, S2 – second and S3 –third productive nodes; V – number of vegetative nodes, G – number of productive nodes; HPl – whole plant, HV – vegetative part.

High sums of the indirect effects for the "seed weight per plant" trait with different directions were observed in all the varieties, but for different performance components. The Spearman coefficients for the indirect effects were also significant in only 16 comparison pairs - 8% of the total number of the computed values. The significant Spearman coefficients for the varieties in the studied sample ranged from $r_s = 0.82$ to $r_s = -0.70$. There were significant positive coefficients only between the matrices of varieties Modus-Effektvnyy ($r_s = 0.78$), Modus-Deviz ($r_s = 0.78$), Modus-Oplot ($r_s = 0.80$), Effektvnyy-Oplot ($r_s = 0.82$), Deviz-Oplot ($r_s = 0.75$), Deviz-Metsenat ($r_s = 0.77$), Hliance-Heyzer ($r_s = 0.78$), and Tsarevich-Korvet ($r_s = 0.73$), but the the Tsarevich-Mahnat pair the coefficient was negative ($r_s = -0.70$).

Thus, the matrices of the direct and indirect effects of path coefficients were identical for pairs Modus-Deviz, Modus-Oplot, Deviz-Oplot, Tsarevich-Korvet, and Tsarevich-Mahnat. At the same time, the Spearman coefficients for genotypic correlation in the test pairs were significant only for the pairs Modus-Deviz, Modus-Oplot, and Deviz-Oplot.

Discussion. Our analysis showed that in the experimental sample, high positive direct effects were only obtained for the “number of seeds per plant” trait in 8 varieties out of 14. In Metsenat, this indicator was the highest – 2.27. The direct effects of this trait were not high in the other varieties. As publications show, during the performance formation in different representatives of the legume family, in particular, in chickpea, the “number of seeds per plant” trait also had the greatest direct effect [17]; in other studies, the harvesting index had the greatest direct effect [18]. In 84 pigeon pea (*Cajanus cajan* L.) genotypes [19], the trait “number of seeds per plant” also had the greatest direct effect on the performance, while Bal et al. [20], demonstrated on other *Cajanus cajan* (L.) Millsp. accessions as well as on chickling vetch (*Lathyrus sativus* L.) that both direct and indirect effects on the performance were low and bidirectional [21]. Khan et al [22] reported that in 46 pea (*Pisum sativum* L.) genotypes the greatest direct effects on the seed productivity, like in chickpea and pigeon pea, were exerted by the “number of seeds per plant” and “1000-seed weight” traits, Similar results were reported by Ton et al. [23] for 14 pea lines and 6 varieties. In contrast to these researchers, both Lal et al. [24] and Rasaei et al. [25] showed that it was the harvesting index that had the greatest direct effect on the seed productivity in pea.

On the contrary, Senthamizh Selvi et al. [26] showed that the “individual pod weight” trait of the 22 traits studied in pea had the greatest both direct and indirect effects. Kumar et al. [27] reported that the "number of pods per plant" exerted the greatest direct effect on the performance upon evaluating both genotypic and phenotypic correlation coefficients. This trait had the largest direct effect in studies carried out by Saleem et al. [28] and Sarutayophat [29], unlike the results obtained by Tofiq et al. [30]). In our study, the "number of pods per plant" trait had the greatest direct effect only in Heyzer (1.16); the effect was also quite high only in Hlians (0.77) and Chekbek (0.75). As to the other varieties, the direct effect of this trait, being both positive and negative, was not high.

In studies carried put by Togay et al. [31] and Kumar et al. [32], the direct effect of the "plant height" trait was negative, but not high (–0.106 and –0.3092, respectively), like the indirect effects (-0.2569 – -0.0965 (30) and -0.058 – -0.026 (31), and did not significantly contributed to the seed productivity. Our results show differences in the magnitude of both direct and indirect effects. Thus, the ranges of the direct effects of the "stem length" and "length of the vegetative part" traits were large and amounted to -0.85 – -0.95 and -0.97 – -1.34, respectively. The indirect effect ranges were -1.05 – -0.54 and -0.81 – -1.06, respectively, Thus, we can say that the influence of the "stem length" and "length of the vegetative part" traits can be considerable in some varieties,

Such differences in the characteristics that determine the direct effects in the cited publications can be explained both by different genetic nature of the studied objects and by influence of the meteorological conditions during the growing period and plant cultivation technologies. It should be noted that most researchers establish relationships between morphological traits in aggregate samples. This gives a general description of the relationship without individualization,

Conclusions. Thus, the correlation coefficients, path analysis and the Spearman rank correlation coefficients make it possible to determine not only the general trends in interactions between traits in the aggregate, but also to establish the significance of differences between genotypes. This approach will allow breeders selecting parents for hybridization to avoid "saturation" with homotypic material, which is necessary to increase the breeding efficiency at the early stages.

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РОЗШИРЕНИЙ КОРЕЛЯЦІЙНИЙ АНАЛІЗ СОРТІВ ГОРОХУ

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Мета. Важливим є питання ідентичності або відмінності як матриць ознак різних зразків, так і матриць їх коефіцієнтів кореляції та шляхових коефіцієнтів. Нами проведено порівняльний аналіз кореляційних матриць та матриць шляхових коефіцієнтів між

продуктивністю та її компонентами для сортів гороху, виведених Інститутом рослинництва імені В.Я. Юр'єва НААН (Україна) у 2002–2018 рр.

Матеріали та методи. Польові випробування проводили у 2014–2016 рр. у науковій сівозміні Інституту рослинництва (ІР) імені. В.Я. Юр'єва НААН у Харківської області. Як досліджуваний матеріал використано 14 сортів гороху, виведених в ІР імені В.Я. Юр'єва і внесених до Державного реєстру сортів рослин, придатних для поширення в Україні. Коефіцієнти кореляції шляху були розраховані відповідно до опису Dewey і Lu. Коефіцієнт рангу Спірмена sensu Rao G. Nageswara використовувався для оцінки тотожностей рядів як генотипічних, так і шляхових коефіцієнтів. Для оцінки значущості використовували таблицю критичних значень коефіцієнта Спірмена.

Результат і обговорення. Високі достовірні коефіцієнти генотипічної кореляції із сильним зв'язком зафіксовано за ознакою «кількість насінин на рослину»: для 10 із 14 сортів. Для визначення узгодженості між кореляційною матрицею для сортів у досліджуваній вибірці розраховано коефіцієнт кореляції Спірмена. Достовірні значення коефіцієнтів Спірмена були у 66 парах порівняння із загальних 182. Всі коефіцієнти кореляції Спірмена для матриці сорту Гайдук були низькими та незначними. При аналізі показників як прямих, так і непрямих ефектів для сортів з вибірки не було встановлено односпрямованого впливу однієї ознаки на продуктивність. Найбільш високі позитивні значення прямого ефекту отримано лише для ознаки «кількість насінин на рослину». В інших випадках як позитивні, так і негативні високі значення прямих ефектів є підтвердженням відмінностей у продуктивності досліджуваних сортів. Коефіцієнти кореляції Спірмена, розраховані для визначення узгодженості між кореляційними матрицями шляхових коефіцієнтів для сортів у вибірці, були значущими лише у 16 пар порівнянь (для прямих і непрямих ефектів) із загальної кількості розрахункових значень. Коефіцієнти коефіцієнт кореляції Спірмена для прямих ефектів коливалися від r_s = 0,92 до r_s = -0,78, а для непрямих ефектів від r_s = 0,82 до r_s = -0,70 у попарних порівняннях. Таким чином коефіцієнт кореляції Спірмена можна використовувати для оцінки відмінностей у силі та напряму зв'язків між ознаковими матрицями зразків. Відмінності у характеристиках, що визначають прямі ефекти, між нашими результатами і представленими у цитованих публікаціях можна пояснити як різною генетичною природою об'єктів дослідження, так і впливом метеорологічних умов у період вегетації та технологій вирощування рослин. Зауважимо, що більшість дослідників встановлюють взаємозв'язки між морфологічними ознаками у сукупних зразках. Це призводить до узагальненого опису зв'язків без необхідності індивідуалізації.

Висновки. Коефіцієнти кореляції, аналіз шляхів і коефіцієнти рангової кореляції Спірмена дозволяють не тільки визначити загальну тенденцію взаємодії між ознаками в сукупності, але й значущість відмінностей між генотипами

Ключові слова: *Pisum sativum L., шляховий аналіз, селекція, коефіцієнти кореляції Спірмена.*

ADVANCED CORRELATION ANALYSIS OF THE PERFORMANCE OF PEA VARIETIES

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Aim. The question of the identity or difference of both the matrices of characteristics of different accessions and the matrices of their correlation coefficients and path coefficients is important. We carried out a comparative analysis of correlation matrices and matrices of path coefficients between productivity and its components for pea varieties bred by the Institute of Plant Production na V.Ya. Yuryev National Academy of Sciences (Ukraine) in 2002-2018.

Materials and methods. The field trials were carried out in the years 2014-2016 in the scientific crop rotation of the Institute of Plant Production na V.Ya. Yuryev (PPI) in the Kharkiv region. 14 varieties of peas own breeding of PPI and included in the State Register of Plant Varieties which are suitable for distribution in the Ukraine were used as research material. The path correlation coefficients were calculated in accordance with the description of Dewey and Lu. The Spearman's rank coefficient sensu Rao G. Nageswara was used for the assessment of the series identity of both genotypic and path coefficients. The table of critical values of Spearman's coefficient was used for the assessment of significance.

Result and discussion. Highly reliable genotypic correlation coefficients with strong association were recorded for the trait "number of seeds per plant": 10 out of 14 varieties. To determine the consistency of the correlation matrix for the researched varieties, Spearman's correlation coefficient was calculated. Reliable values of Spearman's coefficients were found for 66 pairs of comparisons out of a total of 182. All the Spearman's correlation coefficients for the matrix of varieties in Hajduk were low and not significant. There was no unidirectional influence of any trait on productivity in the analysis of direct and indirect effect indicators for the varieties in the sample. Only the trait "number of seeds per plant" had the highest positive values of direct effect. In other cases, differences in the productivity of the varieties studied are confirmed by both positive and negative high values of direct effects. Spearman's correlation coefficients, calculated to determine agreement between path coefficient correlation matrices for varieties in the sample, were significant in only 16 pairwise comparisons (for direct and indirect effects) of the total calculated. Spearman's correlation coefficients for direct effects ranged from r_s = 0.92 to r_s = -0.78 and for indirect effects from r_s = 0.82 to r_s = -0.70 in pairwise comparisons. Thus, differences in the strength and direction of the relationships between the characteristic matrices of the samples can be assessed using Spearman's correlation coefficient. The differences in the characteristics determining the direct effects between our results and those of the cited publications can be explained both by the different genetic nature of the research objects and by the influence of meteorological conditions during the growth period and plant cultivation technologies. Note that most researchers tend to correlate morphological traits in aggregated samples. This leads to a generalised description of the relationship without the need for individualisation.

Conclusions. Correlation coefficients, path analysis and Spearman's rank correlation coefficients allow determination not only of the general trend of interaction between traits in the population, but also of the significance of differences between genotypes.

Key words: *Pisum sativum L., path coefficient analysis, plant breeding, Spearman coefficient correlation.*