Model of high-productive varieties in forage pea

Модел на високопродуктивни сортове фуражен грах

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Abstract

A linear equation of regression was used for establishment of the influence of quantitative characteristics on the grain productivity in forage pea and for development of a model for breeding work. The model for pea plant with high productivity was characterized by average height of 60–70 cm, 8–10 formed pods, 30–40 seeds per plant and 160–260 g in regard to 1000-seed weight.
The obtained results showed that the greatest effect on grain productivity had the seed number per plant, first pod height and 1000-seed weight. Kristal variety had high ecological plasticity and could be considered as close to an ideal type, suitable for growing under wide range of environments. Pleven 4 and Rezonator were determined as high-productive varieties and with low stability, Kerpo and Pikardi - as low-productive but stable varieties. Druzba was identified as unstable and low-productive variety.

Keywords: peas, Pisum sativum L., productivity, quantitative characteristics, regression, stability

Резюме
Линейно уравнение на регресия е използвано за установяване влиянието на количествени характеристики върху продуктивността на зърно при фуражният грах и създаване на модел за нуждите на селекцията. Моделът за растение грах с висока продуктивност се характеризира със средна височина 60–70 cm, образува 8–10 боба, 30–40 семена и маса на 1000 семена 160–260 g.
Получените резултати показват, че върху формирането на продуктивността на зърно най-голямо и математически доказано влияние оказват брой семена на растение, височина на залагане на първи боб и маса на 1000 семена. Kristal е с висока екологична пластичност и може да се разглежда като близък до идеала за сорт, подходящ отглеждане в по-широки екологични области. Сортовете Pleven 4 и Rezonator са определени като високопродуктивни и с ниска стабилност, Kerpo и Pikardi като нископродуктивни но стабилни, а Druzba като нископродуктивен и нестабилен.

Ключови думи: грах, количествен признак, стабилност, *Pisum sativum* L.,

Разширено резюме

Проучването е проведено във Второ опитно на Института по фуражните култури-Плевен през периода 2007-2009 година. Целта на изпитването е да се установи влиянието на количествени признаци върху продуктивността от зърно при фуражния грах чрез създаване на регресионен модел за бъдещи селекционни програми. Растителният материал обект на изследването включва шест сорта пролетен фуражен грах с нормален тип листа – български: Pleven 4, Kristal, Picardi, Druzba и Kerpo; украински: Rezonator. Сравнителният полски опит изведен по блоковия метод в четири повторения с големина на опитната парцелка 5 m2. Сеитбата е извършена в оптимални за културата срокове с 120 кълн. с.*m-2, при междуредово разстояние 11 cm и дълбочина на засяване 5 cm. Върху 20 рандомизирано взети растения от всеки сорт (от първо и трето повторение) са анализирани признаците височина на растение, височина на първи боб, брой бобове, семена и фертилни възли на растение, брой семена в боб, маса на 1000 семена и тегло на семената от растение. Получените резултати от проведения анализ показват, че линейният компонент в регресията на продуктивността зърно от растение по отношение на проучваните количествени показатели е значителен и достоверен. Най-висок относителен дял върху продуктивността на зърно от растение оказва признакът брой семена (+ 0.324) и брой фертилни възли на растение (+0.113). Установена е стабилността на добива на зърно на проучваните сортове. За условията на Плевен сорт Kristal е най-стабилен. Селекционен интерес представлява и сорта Rezonator, който е високо продуктивен.

Ключови думи: продуктивност, регресионна зависимост, адаптивност

Introduction

Peas (*Pisum sativum* L.) are grown for forage, grain (feed and food) and vegetable purposes. Consequently, peas have been differentiated in distinct types including for forage and grain (Cousin, 1997; Bilgil, 2010). Among legumes,the pea is the second most important grain legume crop in the world, which is widely used in human nutrition and as fodder (Cristou, 1997). In the past, plant breeding programs were focused mostly on developing high yielding cultivars. Recently the development of cultivars which are adapted to different environmental conditions is ultimate aim of a plant breeder in the crop improvement programs (Muhammad, et al., 2003; Mulusew, et al., 2009; Pratap and Kumar, 2011).

Despite the enormous success in this direction the need and the opportunities for the more farther improving and selecting of new cultivars continue being main task, under continuously changing conditions of cultivation and the absence of suitable cultivars for them (Sood and Kalia, 2006; Togay et al., 2008).

For increasing the productive potential of the pea is needed to be developed models for selection of genetic substantial characteristics. Their combination in breeding process will bring to desired genotype. The information for the mutability and interaction of the quantitative characteristics in the plants population have exceptional meaning for increasing the effectiveness of the selection work. One of the popular methods for clarifying the concrete type of investigated relationships in

biological objects is carried with the methods of regression analysis, which give opportunity for prognoses (Mosjidis, et al., 1981).

The yield performance of plants is controlled by the genetic capacity of a plant, the environment and their interaction. High and stable seed yield performances are the main objectives in plant breeding programs (Tan, et al., 2012). The genotype must show good performance across a range of environments to be widely accepted. The genotypes respond to changes in the environmental conditions such as temperature, rainfall, soil type (Fehr, 1993; Mustafa, et al., 2012).

The objectives of this study were to determine the influence of quantitative characteristics on the grain productivity in forage pea varieties through development of the regression model for future selection programs.

Materials and methods

The investigation was performed during the period 2007-2009 in the second experimental field of the Institute of Forage Crops, Pleven, Bulgaria, situated in the Central part of the Danube hilly plain. The field comparative variety trial was carried out by the block method in four replications and plot size of 5 m^2. Each plot included 11 rows with a row spacing 20 cm and sowing rate 120 germinable seeds per m^{-2}. The sowing was made by hand at depth of 5 cm. The forage pea is grown by approved technology of the Institute of forage Crops, Pleven. The object of the study were six varieties of spring forage pea (*Pisum sativum* ssp*. sativum L*.) with normal leaves type from of our collection – Pleven 4, Kristal, Picardi, Druzba, Kerpo (Bulgarian varieties) and Rezonator (Ukrainian variety). As a standard variety was used the Bulgarian variety Pleven 4 officially acknowledged by the State variety commission in Bulgaria. The follow traits were studied: plant height; first pod height; number of pods per plant; seed number per plant; fertile nodes per plant; seeds per pod; 1000-seed weight; seed weight per plant. In the technological maturity were analyzed 20 plants (10 plants from first and third repetition). For the stability analysis was used coefficient of variation (VC,%) as stability parameter (Francis and Kannenberg, 1978).

The data were processed statistically by classical analysis of variance (ANOVA) with using of software STATGRAPHICS Plus for Windows Version 2.1.

Results

The results of carried out analysis showed that the linear component in the regression of grain productiveness from plant in respect of the investigated quantitative traits is significant and reliable (Table 1).

From the complex study of the traits is obtained model (1) which demonstrated the complexity character of the change of productivity depending on the variation of investigated quantitative traits.

The common type of the obtained equation of regression was:

(1) $Y = -3{,}29791 - 0{,}0984322 * X_1 + 0{,}0684032 * X_2 - 0{,}217038 * X_3 + 0{,}324777 * X_4 + 0{,}113865 * X_5 - 0{,}0964969 * X_6 + 0{,}0202564 * X_7$

Table 1 Regression analysis (ANOVA) of the grain productivity per plant in regard to the quantitative traits

Таблица 1 Регресионен анализ (ANOVA) на продуктивността на зърно от растение по отношение на количествените показатели

Dispersion	df	SS	MS	F	Signif. F
Regression	7	449,3588	64,19411	267,7985	1,46E-10
Residual	11	2,636815	0,23971		
Total	18	451,9956			

Where: У – is seed weight per plant; X_1 – plant height; X_2 – first pod height; X_3 – number of pods per plant; X_4 – seed numbers per plant; X_5 – fertile nodes per plant; X_6 – seeds per pod; X_7 – 1000-seed weight;

The applied analysis showed that for formation of the grain thehighest influence had the numbers of seed per plant (0.32) and fertile nodes per plant (0.11), followed by first pod height (0.068).

The plant height in pea was in relationship with the mechanized agriculture; therefore varieties with average high stem and with lodging resistance are for preference.

Above determinate parameters too great plant height had negative influence on the grain productiveness – prolong time for ripening, which make difficult the gathering of the harvest. This could be provided in varieties with short and great number of internodes per plant, which secure minimum permissible distance between the first pod of the plant and the land surface. In the regression equation (1) the dependence between the productivity and plant height was with negative value i.e. every increasing of the plant height led to decrease in the productivity by 0.098 g. Reverse of the considered indicator the increase of first pod hight led to increase of the productiveness by 0.068 g. The highest relative share on grain productiveness had the indicator of seed numbers per plant. The individual productiveness is increased by nearly 0.32 g. if the number of seeds is increased by an unit.

Weaker influence had the indicators: number fertile nodes per plant (0.11), 1000-seed weight (0.020) and seeds per pod (-0.096), as for the last indicator the coefficient of regression was negative (Table 2).

The graphical representation of the relations between the productiveness and the investigated quantitative components allowed by enough approximation to be obtained theoretical results and to determine the basic regularity between studied traits (Figure 1).

The seed productiveness of plant decreased at plant height above 60–70 cm and first pod height above 30 cm. The optimal value for fertile nodes per plant was 5–6.

Table 2 Regression coefficients of the grain productivity per plant in regard to the quantitative traits

Таблица 2 Регресионни коефициенти на продуктивността на зърно от растение по отношение на количествените показатели

Trait	Coefficients	St. Error	t Stat	P-value	Lower 95%	Upper 95%
plant height, cm	- 0,098432	0,036403	-3,76049	0,003152	-0,21702	-0,05677
height to first pod, cm	0,0684032	0,022414	3,528573	0,004727	0,029756	0,128421
pods number per plant	- 0,217038	0,308698	-1,42202	0,182751	-1,11841	0,240466
seed number per plant	0,324777	0,059624	7,430428	1,31E-05	0,311799	0,574262
fertile nodes per plant	0,113865	0,286713	-0,03457	0,973045	-0,64096	0,62114
seeds per pod	-0,096496	0,244907	-2,49216	0,029921	-1,14938	-0,07131
1000 seed weight, g	0,017571	0,003634	4,835319	0,000523	0,009573	0,025569

In the represented graphic the influence of the 1000-seed weight was significant although it was very low. Its parameter were in limits from 160 to 260 g. In this interval each increase led to rising of the productivity.

In this study the number of seeds per pod had action with opposite direction in comparison with 1000-seed weight, which probably was at the expense of average size of seed.

The economic importance of stability for cultivation of a variety was recognized in 1917 by Roemer (in Becker, 1981), who used the variance across environments for yield stability. Francis and Kannenberg (1978) proposed the use of the coefficient of variation (CV) as a measure of genotype stability. In this procedure, stable genotypes had a low CV and show biological (static) stability (Dehghani, et al., 2008).

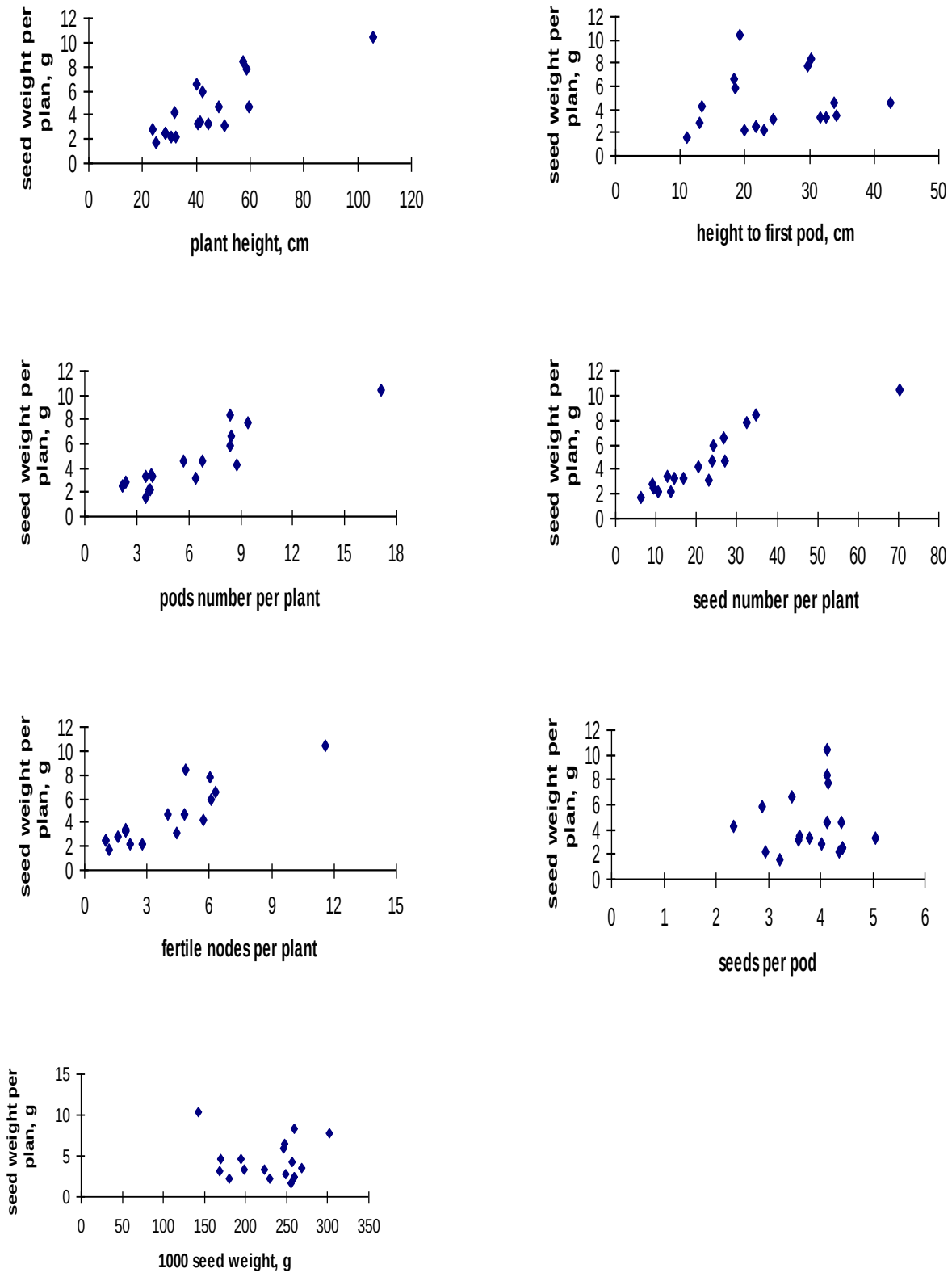

Figure 1. Dependence between the grain productivity per plant and quantitative traits

Фигура 1. Зависимост между продуктивността на зърно от растение и количествените признаци

The distribution of forage pea varieties in regard to their grain productiveness and stability (expressive by the variation coefficient - VC) is represented on Figure 2. The mean values of productiveness and VC separate the coordinate system of four quadrants. The varieties with high ecological plasticity (Kristal) are situated in first quadrant. They are the most suitable for the selection. Varieties from second quadrant (Pleven 4 and Rezonator) are also Interesting because they have high productiveness and low stability (high variability).

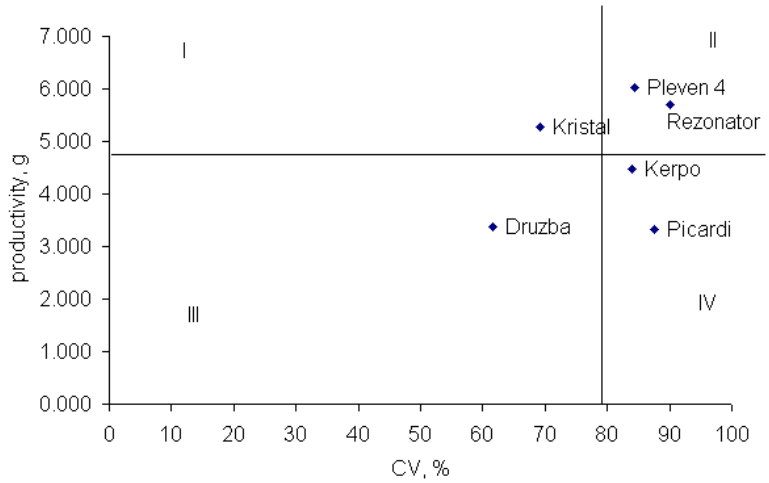

Figure 2. Stability (according Francis and Kannenberg, 1978) and distribution of the varieties in regard to grain productiveness

Фигура 2. Стабилност (съгласно Francis and Kannenberg, 1978) и разпределение на сортовете по продуктивност на зърно.

They are responsive only under favorable conditions. The varieties from third quadrant (Druzba) are low productive and ecological unstable. The varieties in fourth quadrant (Kerpo and Pikardi) are low productive but stable.

Discussion

Similar results are reported from Mosjidis, et al., (1981), Kalapchieva, (2013). They used the regression coefficient for predicting the time for pea harvesting. According them the time for gathering could be established through the morphological traits: number of fertile nodes per plant and pods per fruit stalk.

In analysis of the parental components F_1 and F_2 generations Sharma et al., (2000), Srivastava et al., (2000) reported that themain yield components in pea were: number of pods per plant, seeds per pod and average size of seed. In our models the traits pods per plant and seeds per pod were less considerable. The variant which will have the highest productive is the plant with 8-10 pods situated mainly by to per fruit stalk, with 4 seeds per pod and with 30-40 seeds per plant.

Ardelean, et al., (1989), Dev, et al., (1995) and Ranalli, et al., (1997) determined the trait seed per pod as the most stable component of the yield. According to these

authors in the choice of initial selection material must take an attention not only the average seed numbers per pod but and maximal numbers of seeds per pod.

The models for selection of high productiveness varieties in forage pea showed that the productive can be raised by increasing seed numbers per plant and 1000-seed weight.

The obtained linear equation of regression gives notion for the main indicators which must take into consideration in the choice of selection material in the breeding programs and optimal combination of the wanted qualitative in a new variety forage pea. The obtained results demonstrate that the model for pea plant with high productivity is characterized by average height from 60–70 cm, 8–10 pods, 30–40 seeds per plant and 1000-seed weight in limits 160–260 g.

The field pea cultivar Kristal showed high ecological plasticity and could be considered close to an ideal type, suitable for growing over a wide range of environments. Pleven 4 and Rezonator were determined as varieties with high average productiveness and low stability, and Kerpo and Pikardi - as low productive but stable. Druzba was identified as unstable and low productive.

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