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Research Article

The Relationship between Yield and Heritability in Ten Genotypes of Faba Bean (*Vicia faba L.*)

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ABSTRACT

Ten genotypes of faba bean were evaluated for yield and estimate the heritability. Randomized complete block design used for the experiment conducted in experimental farm of Khartoum university faculty of agriculture during winter season 2014-2015. The tested traits were plant height, number of pods per plant and 100- seed weight. Data were recorded after maturity stage. Analysis of variance illustrated there were height significant value ($p<0.01$) among lines in number of pods per plant and lengths. The results of characters indicated that genotype 10400 gave highest grain yield (699.2 kg/ha) moreover, it also obtained greatest value of plant length (84.4 cm) whereas genotype 10480 carried biggest number of pods between them (29 pods/plant). Heritability appeared highly ($h^2<0.65$) in both plant height (0.74) and number of pods (0.77). The results refer to the relationship between genetic, environment and interaction among them. This study concluded to detect about the yield rising relationship with heritability, large grain size reduces quantum of seeds in plant also increase seed weight hence yield in addition, importance of completing breeding process for genotype (10400).

Keywords: Faba bean; Yield criteria; Heritability; Seed size; Nutrients elements; Interaction

INTRODUCTION

Faba bean (*Vicia faba* L.) comes from the most important legumes seed and good resource of protein, starch, cellulose, and minerals [1] for human and animals feed in Africa as general and Sudan as specific where, it considers the main meal at breakfast [2]. Universally, China takes the lead in productivity of crop by 65%, the Arabian country noteworthy is Egypt, Morocco, Sudan, Tunis, Algeria and Syria, and yield is quite poor in the Sudan and developing countries [3]. By botanical classification the crop divided into three major types small round seeds (1 cm), medium size seeds (1.5 cm) and large flat seeds (2.5 cm) [4], is a diploid plant with 2n=2x=12 chromosomes [5]. Different from self-pollinated legumes, faba bean productivity is hindered by its reproductive mode as the crop is partly self- and partly cross-pollinated species (mix-mating). Both self- and cross-pollination are carried out by pollinating insects; Partial pollination is the perfect description of the process that occurs in the crop and depends on varieties and environment in addition [6]. The suitable season for sowing is winter and prefers harvesting early before the temperature becomes higher to avoid yield reduce quality and spread the diseases [7]. Faba bean has ability to fix the atmospheric nitrogen due to the good symbiotic relationship between it and rhizobium bacteria (may fix about 130-160 N/HA) that contributing in to increase the content of nitrogen in soil also enhance ability of crop rotation [8]. Moreover, the nature of plant and amount of genetic variability with interaction between both inheritance and environment very necessary for breeding program [9].

Plant height, number of pods and 100-seed weigh all these characters contributing in yield compound and recognized as quantitative traits [10]. Many studies adopted the importance of heritability, it reflects the quantity of morphological variation so, the information about genetic variation and heritability very interesting point; lead to success breeding programs [11]. Efficiency of heritability centered in predicts the proportion of characters pass from generation to other in offspring therefore; the direction to makes improvement by selection processing to select elite categories will be easy [12]. In this present study, we evaluated yield of genotypes which associated with specific criteria and inheritance of them.

MATERIALS AND METHODS

Genetic material

Hudeiba/93, Ed-damer, Selaim, Shabah and Bassabier, five open-pollinated local Sudanese faba bean cultivars entered into composition of ten genotypes used in this research after different

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generations of breeding processes. The genotypes were 10400, 10416, 10418, 10445, 10448, 10471, 10480, 10496, 10517 and 451. Bees were inserted to increase the potential of open pollination.

Location of experiment

Khartoum university experimental farm (shambat) used for that, it located between (15°.40' N) latitude- (32°.32'E) longitude and altitude 380 m above sea level, temperature in that location has special degree due to type of season however, it is hot in summer (38°C- 42°C), temperate in winter (21°C-30°C) and sleazily rainy (100-200 mm) during (July and September) [6].

Land of experiment

The soil classified as heavy clay. Ten genotypes were grown in a plot of two ridges with length 2 m, 60 cm a part in the east direction

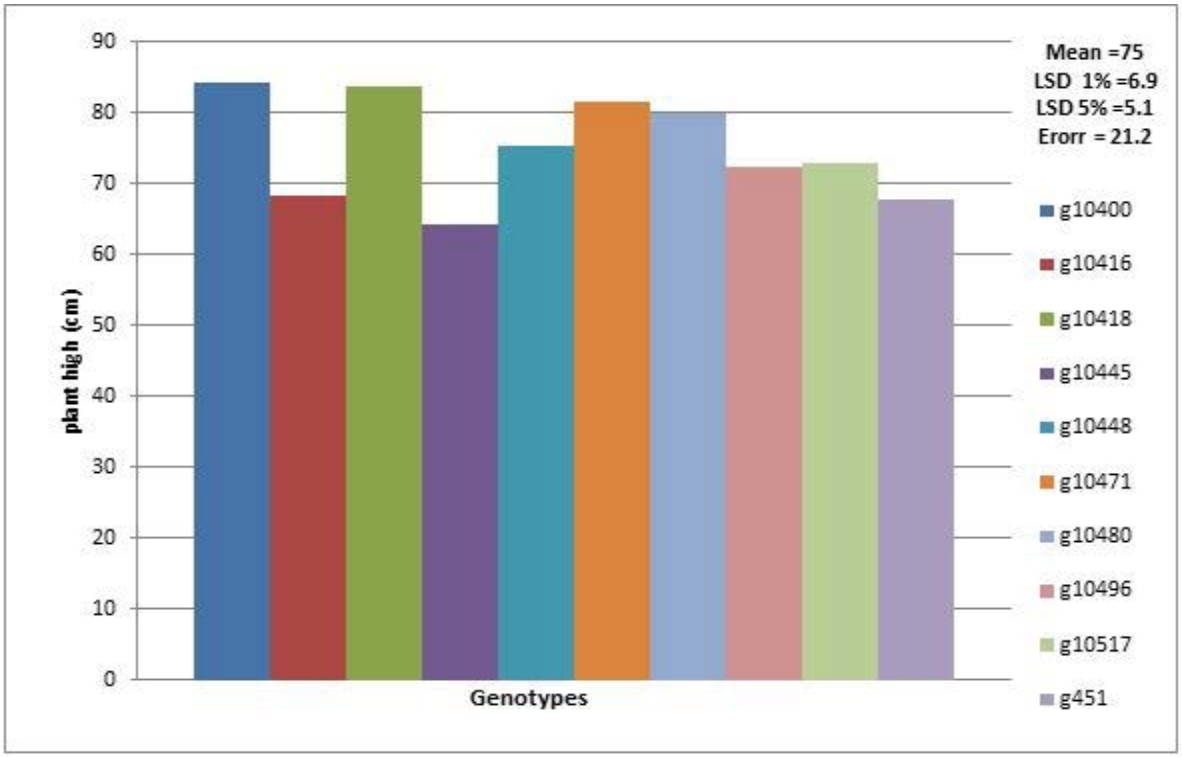

Figure 1: The results of averages explained the greatest value of the lengths (84.4 cm) came from (10400) genotype in compared by the rest of lines. The smallest value (64.4 cm) was obtained by genotype (10445).

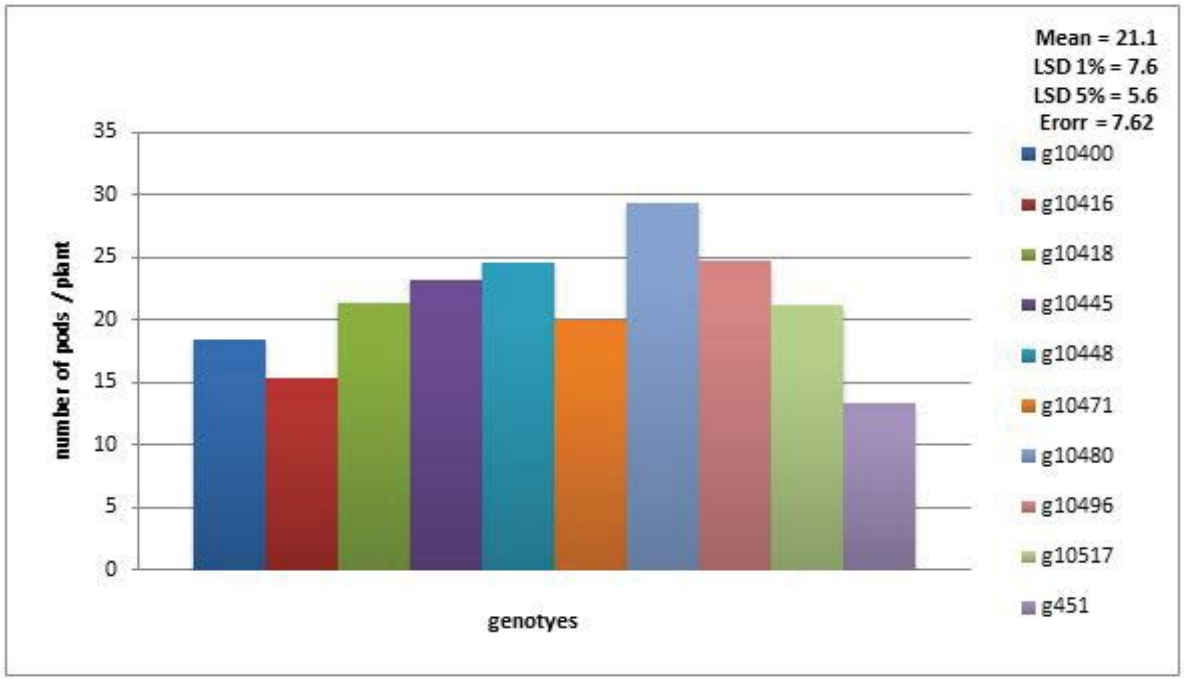

Figure 2: Genotype (10480) was the most containing of pods (29.3 pod), whereas the strain (451) contained the lowest number of pods (13.3).

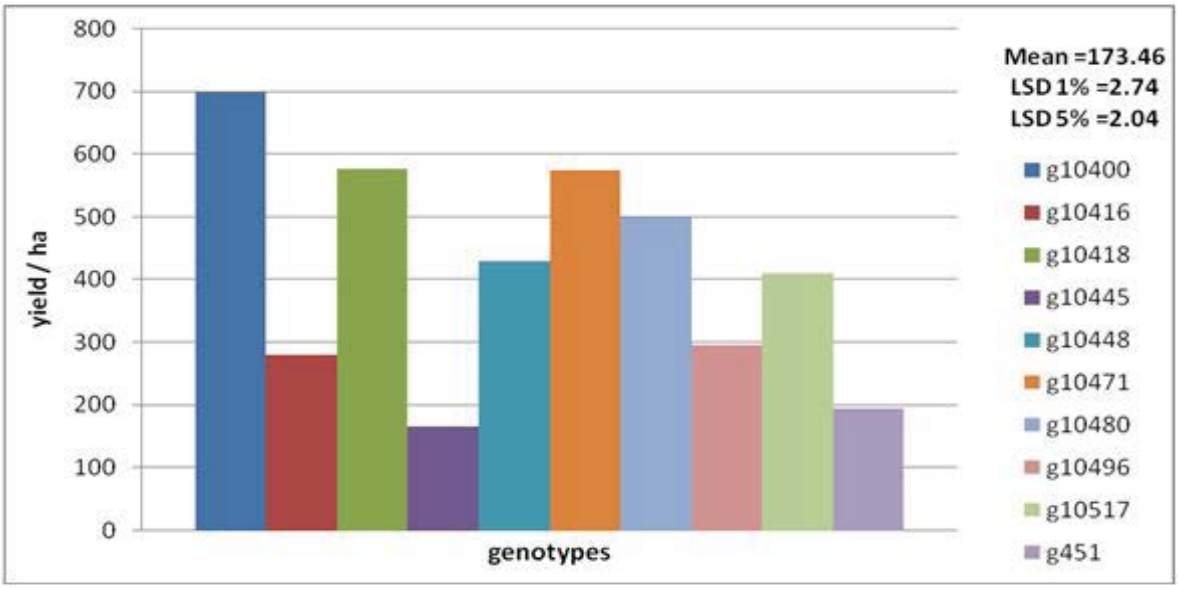

Figure 3: The highest yield was appeared (699.2 kg/ha) in genotype (10400) while strain (451) was the least yield (195.7 kg/ha).

Table 1: Significant differences between the genotypes of pods per plant and plant length.

Source	Replications	Genotypes
Degree of freedom	2	9
pods/plant	0.08, NS	11.11**
Plant high	0.27, NS	9.5**
100 seed weight	0.13, NS	0.71, NS
Yield	3.88**	1.50, NS
NS: Mean non-significant.		
**Mean significant at 1%.		

Table 2: The significant heritability scored for length (0.74) and pods/plant (0.77) traits.

Source	Length	Number of pods
Environmental variation (E)	21.2	7.32
Genetic variation (G)	60.3	25.68
Interaction between (G) & (E)	1278.3	188
Phenotypic variation (P)	81.5	33.3
Heritability (h^2)	0.74*	0.77*

of ridges. In each hole three seeds were planted and the spacing between holes was 10 cm. Irrigation done after ten days, ten times in whole season. In the land of experiment fertile not added at all. In addition, weeding conducted in three stages, start growth, vegetative growth and flowering.

Field experiment performed to determine yield and heritability for ten genotypes of faba bean. The sowing was started in the 4th week of November season 2014-2015.

Data collected and analysis

The genotypes distributed randomly in randomized complete block design divided into three replications and thirty plots (15 m^2). The same number of treatments was exposed to random select for evaluating the yield and heritability. The criteria were plant length (cm), number of pods and weight of hundred grains (kg). Data collected one time after crop mature completed and entered to Microsoft office excel software for analysis of variance (ANOVA).

Heritability for trait was estimated according to the equation:

$$h^2=V_G/V_P \quad (1)$$

Where Vg and Vp are genotypic variance and phenotypic variance, respectively. The genotypic variance, Vg was determined as:

$$V_G=MS^t-MS^e/R \quad (2)$$

Where MS^t, MSe and R, are treatments mean squares, error mean squares and replication, respectively. The following formula was used for phenotypic variance

$$V_p=V_G+MS^e \quad (3)$$

RESULTS

Analysis of variance

The results of the statistical analysis shown there were no significant differences in 100-seed weight and yield, as for the number of pods per plant and plant length there were significant differences between the genotypes (Table 1).

Heritability

The significant heritability scored for length (0.74) and pods/plant (0.77) traits (Table 2).

Plant height

The results of averages explained the greatest value of the lengths (84.4 cm) came from (10400) genotype in compared by the rest of lines. The smallest value (64.4 cm) was obtained by genotype (10445) (Figure 1).

Number of pods

Genotype (10480) was the most containing of pods (29.3 pod), whereas the strain (451) contained the lowest number of pods (13.3) (Figure 2).

Seed yield

The highest yield was appeared (699.2 kg/ha) in genotype (10400) while strain (451) was the least yield (195.7 kg/ha) (Figure 3).

DISCUSSION

In general, the winter season in Sudan is shortened with high temperature [2], which leads to a decrease in the capacity of storage as a source of photosynthesis products. Warming also causes damage or death of plant tissues due to drying of the protoplasm. Environmental factors also influence plant transformation from vegetative growth to fruit growth. Dropping seeds by wind give rise to increase the proportion of crop loss by exposure to the phenomenon of lodging, which causes the increased risk of infection by pests and diseases in the soil. Environmental impacts such as low temperature during flowering period may cause reduced fertility and seed rates compose. It perhaps has influenced the composition of grains where the stage of grain formation and maturity depends on optimal environmental conditions [13]. The crop exposed to excessive amount of water with spacing periods of irrigation probably that effected of nitrogen fixation process, faba bean very sensitive for drowning in any phase of growth may reflected passively on flowering and less of pods.

In the present investigation, the non- significant variance among genotypes shown in yield and 100- seed weight that indicated to genotypes responsive for interaction with environment was negative and significant difference between genotypes appeared in number of pods per plant and plant height indicate to the interaction between genotypes and environment was positive. Phenotypically, individuals come by inbred line show differ, but heritability is absent because of lack the genetic variation. Seed yield is under polygenic control (genes with small indistinguishable effects) due to that inherited with low heritability value. When the heritability is height that means the most of the variation observed in the population caused by variation in genotypes however, low heritability explains their small value of variation in genotypes but it does not mean the additive genetic variance is small [14].

Interaction appears manifestly when genotypes perform differently in various environment so, in various environment interaction observe due to the different performance of genotypes, if environmental diversity is slight for determined trait and interaction is absent, the phenotype of parents is fairly accurate indication of its genotype but, in the case of rising the additive genetic variance which it base of heritability will occupy few value of the total phenotypic variance than previously [15] commonly, the proportion of heritability influenced by genetic material and the expression of genetic compound in environment such as yield. Inheritance of characters will continue on the same path in the event of ensuring the perfect environmental factors [10].

We described the results of heritability (Table 2) which shown significant heritability scored for length (0.74) and pods/plant (0.77) traits. Because of non-significant differences between genotypes in plant height and 100-seed weight we decided not investigated on heritability of them. In the set of previous studies lower heritability found by Ceccarelli [16] in low yielding environments, also the same author [17] reported that lower heritability expected in low input conditions. Abdelmula et al., [18] pointed out the weak heritability in faba bean (*Vicia faba* L.) coming from low yielding environments. When comparing our results with the results of previous studies we found similar results in seed yield and 100 seed weight and variant in the other traits. Results of plant height and number of pods (Table 2) shown the environmental variation (21.2) and (7.32) less than the genetic factor (60.3) and (25.68) so recorded positive h^2 may be attributed to genetic factors and interactions between genotypes and the environment were high.

Toker concluded seed weight least affected trait by environment and followed by days to flowering and maturity also added, number of pods per plant, biological/seed yields and number of stems per plant were the most affected traits by environmental conditions [10]. Muehlbauer and Singh [19] reported seed yield and number of pods per plant are more affected by environment due to low heritability. Toker reported that days to flowering and plant height are less affected by environment owing to medium heritability [20]. This study completely agreed with this finding, we recorded middle heritability in both plant height and number of pods. In summary, hundred seed weight and yield obtained non-significant value may be due to the influence of external factors and less interaction with environment. Otherwise, days of flowering and maturity may be effectiveness on number of pods per plant and plant height given significant value owing less affected by external conditions and the interaction was very high.

Pollination is not only reason for low pod set, other factors are responsible also such as environmental compound and field practices that effect on flowers may triggered pods dropping, for example high temperature concurrently with drought constrains pods set and caused dropping [21]. Insect pollinators like honey bee make balance in yield by avoiding the effect of heat stress on anthers via moving fertile pollen in place of pollen lost by act of hotness weather [7]. The interference of these factors action and the un expectable impacts in plant may controlled in flowering and pod drop, it takes multiple forms for instance competition among pods and young pods with vegetative parts, competition between pods within the same inflorescence and the pressure come from pods in depletion of nutrients detriment other plant parts for example branches formation [22]. In the present investigation, genotype (10480) scored largest amount of pods (Figure 2), that may be due to less affected by environment and positive relationship with genetic factors.

Plant heights basically return to the environment and uptake nutrients elements that contributing for increase the internodes in plant because internodes lead to increase the plant length [23]. This result supports the perfect distribution of nutrients among all parts of the plant, lead to improve growth and other processes.

The capability of plants to distinguish day temperature and night temperature knew as thermoperiodism that reflects the response to flowering, fruiting, and growth [24]. In many species stem elongation governing by the relationship between them for that use environment to take place of chemicals utilized for increase plant length cheaper and safer but that need to understanding temperature and light [25]. Provided studies on the interaction among specific degrees of temperature and determined amount of light for increase stem elongation, the effect of abiotic factors and that impact on variability whence availability or non-availability in plant abiotic factors affected on stimulate or inhibit gibberellin hormone which responsible for growth and elongations in plants [26-28]. Interaction in plant height indicated the integration of the environmental factor with the genetic factor significantly, which led to the expression of this as phenotypic (Table 2). In this present investigation, genotype 10400 represented top value of plant length (Figure 1).

Considering to the weight of seed and its reflection on the seed yield although large seeds reduced total numbers of seeds on pods, that explain number of seeds in genotype (10400) was medium with large seed and increase the 100-seed weight mass videlicet the nutrients were distributed very intensely to this average number of seeds. With this result, a breeding strategy was formed based on increase yields by increasing seed size and weight as well. Illustrated the same idea. Moreover, large seed should be used as parent for the dominant trait of big seed size to increase seed weight [29-32].

In the line of present study, genotype (10400) given highest yield value and greatest value of plant length between lines (Figure 1 and Figure 3) and medium number of pods per plant (Figure 2). Singh reported phenotypic and genotypic correlations between seed yield and number of pods per plant were positive and significant; this result similar to the currently study as previously mentioned and genotype 10400 evidenced that. All these evidences indicated to the selection based on seed per pods increases seed yield. In the currently research, by estimate significant heritability the practicing of selection on the next generations will be very successful.

CONCLUSION

This aspect of the research indicates that inheritance is available in the surrounding conditions rich by organic matter and high yield. Heritability become high when the values of genotypic and phenotypic variances closeness. Large seed size with increase mass weight contributing in yield. Genotype 10400 proved high performance in environment so should be complete the rest of breeding program and released as cultivar.

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