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PHENOTYPIC, GENOTYPIC VARIANCE, HERITABILITY AND EXPECTED GENETIC ADVANCE OF YIELD AND ITS COMPONENTS IN F_3 AND F_4 GENERATIONS OF SOME FLAX HYBRIDS.

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ABSTRACT

The breeding materials used in this study were 48 families of flax derived from four crosses along with their four parents (P_1=Giza7, P_2=Giza8, P_3=S.2419/1, and P_4=S.148/6/1) as well as a bulk of each cross in F_3 and F_4 generations. These genotypes were grown in RCBD with three replicates at Etay El-Baroud exp. Sta., El-Beheira Governorate through the two successive seasons (2000/2001 and 2001/2002). The present study aimed to compare the improvement resulting from application of independent culling levels selection method with the bulk hybrid for straw and seed yields in early segregating generations of flax hybrids. The results obtained could be summarized as follows:

1- The results indicated that the possibility of using number of basal branches, technical length and plant height as selection criteria for improving straw yield per plant. In the meantime these traits gave low discrepancy between PCV and GCV values with high heritability as well as high genetic advance (GA%).

2- The cross, P_1xP_2 showed high heritability (h^2) associated with high genetic advance (GA%) as well as narrow range between PCV and GCV for the three components of straw yield (plant height, technical length and number of basal branches), whereas the cross, P_3xP_4 gave similar results for only two components of straw yield (plant height and technical length) in both F_3 and F_4 generations. Therefore, these two crosses may be recommended for isolating superior pure lines for these traits in later generations.

3-The crosses P_1xP_3 and P_2xP_3 showed for all seed components high heritability and high genetic advance which indicated that it is due to additive gene effects. Particularly, the cross P_2xP_3 may be recommended for isolating superior pure lines for seed yield and its components in later generations.

4- The use of independent culling level selection (ICL) method in most cases, was more efficient in improving straw yield through selection for the two important components of straw yield viz., plant height and technical length than bulk hybrid and so, number of capsules per plant and1000-seed weight could be used as selection criteria to improve seed yield per plant.

5- Straw yield showed significant positive correlation with each of plant height, technical length, number of capsules per plant and seed yield per plant of the cross P_1xP_2. Seed yield exhibited significant positive correlation with number of capsules per plant in all crosses in both generations and 1000-seed weight in F_4 only. However, number of capsules per plant showed significant and negative correlation with both of 1000-seed weight and number of seeds per capsule in both generation of the cross P_3xP_4. Also, 1000-seed yield and number of seeds per capsule exhibited significant and negative correlation in two crosses, P_1xP_2 and P_1xP_3.

Keywords: Flax, independent culling levels selection, segregating generations, correlation.

INTRODUCTION

Plant breeders are continuously searching for more effective methods of selection in early breeding generations in order to obtain superior genotypes from a population with a minimum input of labor and time. The major target of flax breeders is to produce high yielding varieties for each of straw, seed yields and good quality of both fiber and oil.

Successful pure - line breeding in self- pollinated plants, like flax (*Linum usitatissimum* L.) by using pedigree selection method requires superior segregating populations from which homozygous lines could be selected. The major disadvantage of this method is the difficulty to identify high yielding lines in early generations (Salas and Friedt, 1995). For this reason, breeders may delay selection until lines are approaching homzygousity and when sufficient seed is available to carry out preliminary field test.

Hoffman (1961), defined pedigree and bulk population breeding as the most useful methods for flax. Momtaz *et al.,* (1977) found that number of capsules per plant seems to be the simplest character for any flax breeder if selection is for high seed yield. Mourad (1983) found that independent culling levels selection (ICL) for straw yield and its components gave seed and straw yields which did not differ significantly from selection indices or even from some mean of seed or straw yield obtained by individual trait selection based on breeding value per plant for yield and yield components in each of three flax crosses. Therefore, independent culling levels selection (ICL) for straw yield and its components was recommended to improve both seed and straw yields, due to its simplicity.

The present investigation aimed to study the magnitude of variability, heritability estimates and expected genetic advance under selection for straw, seed yields/plant and their components in some hybrids of flax. These parameters were used to compare the improvement resulting from application of independent culling levels selection method with the bulk hybrid for straw and seed yields in early segregating generations of flax hybrids.

MATERIALS AND METHODS

The four flax crosses (Giza7 x Giza8, Giza7 x S.2419/1, Giza8 x S.2419/1 and S.2419/1 x S.148/6/1) which showed consistent superiority for integrating yield and stability in both F_1 and F_2 generations (Abo-Kaied 1999) were used as a potential breeding material in F_3 and F_4 generations.

In 1999/2000 season, a part of the F_1 seed bulk of the four crosses were grown at Giza Res. Sta. of Agric Res. Center in order to evaluate their F_2 progenies. At harvest, 240 guarded plants were taken from each cross to study straw and seed yields per plant as well as their components characters. The remained F_2 plants of each cross were harvested in bulk. Selection was practiced within each of the four F_2 progenies using plant height, technical length, number of capsules per plant and 1000-seed weight as selection criteria with 5% selection intensity.

In the method of "Independent Culling Levels", a certain level of merit was stablished for each trait, and all individuals below that level are discarded regardless of the superiority or inferiority of their other traits, Hazel and Lush (1942). The level of merit for each individual trait was estimated as the mean of that trait plus one standard deviation. The levels of merit for different traits in F_2 and F_3 generations of the four flax crosses under study were as follows:

Table1: Minimum levels of selection for the different traits by ICL method in F_2 and F_3 generations of four flax crosses.

Cross	Plant height (cm)		Technical length (cm)		No. Capsules per plant		1000 - seed weight (g)	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
C1	116.5	118.0	82.5	83.5	51.0	56.0	10.34	10.44
C2	117.0	120.5	82.0	85.0	48.0	50.0	9.92	9.94
C3	93.5	90.5	60.0	70.0	43.0	45.0	10.56	10.31
C4	109.0	111.0	73.5	76.0	49.0	48.0	10.15	10.45

In 2000/2001 season, 48 F_3 families along with the four parents of the original crosses as well as F_3 bulk of each cross, were grown in Randomized Complete Block Design (RCBD) with three replicates at Etay El-Baroud Exp.Sta., El-Beheira Governorate. Each block contained 56 entries.

A plot consisted of 3 rows for each F_3 line, 3 rows for each parent and 3 rows for bulk of each cross. Rows were 3 m long and 20 cm apart. Spacing within row was 5 cm. Selection was practiced within F_3 families of each cross in the same way as that followed in F_2.

In 2001/2002 season, 48 F_4 families along with the four parents as well as F_4 bulk of each cross were grown in RCBD with 3 replication at Etay El-Baroud Exp.Sta. Plot size, row length and spacing between and within rows were the same as F_3 generation. The normal recommended agronomic practices for flax cultivation were applied in both generations.

Recorded data:

At harvest, 60,60 and 20 F_3 or F_4 plants from ICL selection procedures, F_3 or F_4 bulk crosses and parents, respectively were sampled to measure straw yield per plant, plant height, technical length, number of basal branches per plant, seed yield per plant, number of capsules per plant, 1000-seed weight and number of seeds per capsule.

Biometrical analysis:

Data were subjected to regular analysis of variance of RCBD according to Snedecor and Cochran (1980). The expected genetic advance

from selection (GA) in both F_3 and F_4 generations was calculated for each trait according to Allard (1960) using the following formula:
$GA= K \sigma ph. h^2$ where:
K is the selection differential at 5% intensity =2.06, σph is the square root of the phenotypic variance (standard deviation) and h^2 is the heritability in broad sense, (σ^2g/σ^2ph) for the character being evaluated. The phenotypic (PCV) and genotypic (GCV) coefficient of variation for families in each generation was computed as (σph x 100)/ū and (σg x 100)/ū, where σph is the square root of the phenotypic variance of families, σg is square root of genotypic variance of families and ū is the general mean of families. Phenotypic correlation coefficients among all possible pairs of studied traits were computed by using the data of 48 families selected by ICL method from four crosses (C_1:C_4) in F_3 and F_4 generations.

RESULTS AND DISCUSSION

Straw yield and its components:

Results of the analysis of variance showed that mean squares due to entries (families selected by ICL method, four bulk crosses and four check parents) in F_3 and F_4 generations were significant for straw yield per plant and its two components viz., plant height and technical length as presented in Table2. This indicated that these entries showed reasonable degree of variability for these traits. However, mean square for basal branches per plant was significant for most entries except bulk $C_4(P_3xP_4)$ and P_3(S.2419/1) in both generations as well as P_4(S.148/6/1) in F_3 only, indicating low genetic variability among these entries for this trait.

Data in Table 4 shown that the mean performances of F_3 and F_4 families belonged four crosses by using independent culling levels selection (ICL) were higher than means of check parents and also were higher than bulk cross for straw yield and its components except number of seeds per capsule. These results indicated that the amount of improvement occurred by using this method of selection.

The range of entry means (Table4) showed wide variation either for each cross under selection or bulk cross for all studied characters in both generations. This indicated the presence of superior individual lines in each cross and bulk cross in the breeding material.

Variability for each entry, estimated by PCV and GCV, reached maximum values for number of basal branches followed by straw yield per plant, technical length and plant height in both F_3 and F_4 progenies of bulk crosses (bulk C_1 to bulk C_4). The high values of GCV were also reflected in the values of observed ranges for these traits, indicating that it is possible to achieve further improvement by selection. The observed narrow range between PCV and GCV, which gave almost similar values for the four crosses under selection by ICL method (C_1 to C_4) followed by the four check parents (P_1 to P_4) was mainly due to genetic differences as evidenced for high broad sense heritability for all studied traits in both F_3 and F_4 generations. These results indicated the possibility of using these yield traits in selection index with give more weight for number of basal branches and technical length for improving straw yield per plant. Also, these results reflect the importance of selection for these traits which gave high heritability estimates. This conclusion may be supported by evidences that yield components traits are genetically controlled, Abo-Kaied (1992) and El-Hariri *et al.* (2002a). On the contrary, wide range were observed between PCV and GCV with moderate or low broad sense heritability of the four bulk crosses for all studied traits in F_3 and F_4 generations. These results are in harmony with that reported by Mourad (1983) for plant height, Abo-Kaied (1992) for both plant height and technical length and El-Hariri *et al.,*(2002a) for straw yield per plant.

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According to Burton (1952) the genotypic coefficient of variability together with heritability estimate would give the best indication of the amount genetic advance to be expected from selection. Data in Table (4) showed that $C_2(P_1xP_3)$ followed by $C_4(P_3xP_4)$ for straw yield per plant, $C_1(P_1xP_2)$ for plant height, followed by $C_4(P_3xP_4)$ for technical length as well as the four crosses for number of basal branches per plant gave low discrepancy between PCV and GCV values with high heritability as well as high genetic advance (GA%) expressed as percentage of the general mean. In general, $C_1(P_1xP_2)$ for all three components of straw yield and $C_4(P_3xP_4)$ for two components (plant height and technical length) showed high heritability (h^2) coupled with high genetic advance (GA%) as well as narrow range between PCV and GCV in both F_3 and F_4 generations. Because of narrow range between PCV and GCV, with high heritability and high genetic advance of these crosses for these traits, the high selection gain may be attributed to a high degree of additive gene effects. Therefore, these crosses (C_1 and C_4) may be recommended for isolating superior pure lines for these traits in later generations. The association between high heritability and high genetic advance was already reported for straw yield (Abo-Kaied, 1992) and for both plant height and technical length (El-Hariri *et al.*, 2002b). Finally, the use of independent culling level selection (ICL) method in most cases, were more efficient in improving straw yield through using the two important components of straw yield viz., plant height and technical length than bulk hybrid. This result was in agreement with Mourad (1983).

Seed yield and its components:

Analysis of variance (Table3) showed significant differences among F_3 and F_4 entries for seed yield/plant and its components, viz., number of capsules per plant, 1000-seed weight and number of seeds per capsule for all entries except the bulk of $C_3(P_2xP_3)$ in both F_3 and F_4 generations.

Data in Table (5) showed that the bulk of $C_3(P_2xP_3)$ followed by P_2(Giza8), bulk of $C_4(P_3xP_4)$, $C_1(P_1xP_2)$ and $C_4(P_3xP_4)$ gave high mean performances for both seed yield per plant and number of capsules per plant in both F_3 and F_4 generations. However, the bulk of $C_4(P_3xP_4)$ followed by bulk of $C_3(P_2xP_3)$ and $C_3(P_2xP_3)$ exhibited highly means for both 1000-seed weight and number of seeds per capsule.

The range of entry means (Table5) revealed wide variation for the bulk of the four crosses followed by ICL method of selection and check parents for seed yield and its components in both generations. These results indicated the presence of superior individual lines in the bulk of crosses than the other entries for all studied traits. Therefore, effective selection in bulk crosses could be practiced on individual plant basis during next generations for seed yield and its components.

Estimates of phenotypic (PCV) and genotypic (GCV) coefficient of variability, heritability (h^2) as well as genetic advance (GA%) for seed yield and its components are presented in Table (5).

The highest values with wide range between PCV and GCV estimates were recorded for the bulk of crosses followed by ICL method and four parental genotypes for all studied characters.

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High coefficient of variation for these characters is indicative of high magnitude of variability present in these materials for seed yield/plant and its components.High heritability values and high GA% with almost similar estimates of PCV and GCV in both F_3 and F_4 generations were observed in $C_1(P_1xP_2)$ and $C_3(P_2xP_3)$ for seed yield per plant. On the contrary, wide range between PCV and GCV with moderate or low broad sense heritability could be observed for the four bulk crosses for the same trait. These results are in harmony with that reported by El-Hariri *et al.,*2002b. Although, selection by ICL method in $C_2(P_1xP_3)$ followed by $C_3(P_2xP_3)$ and $C_1(P_1xP_2)$ for number of capsules per plant, C_1,C_2 and C_3 for 1000-seed weight and C_3 followed by C_2 for number of seeds per capsule showed low discrepancy between PCV values with high heritability as well as high genetic advance (GA%). These results, indicated that a high selection gain may be attributed to a high degree of additive gene effects, hence these crosses, for these characters, are likely to respond to direct selection. On the other hand, number of seeds per capsule and in most cases in both F_3 and F_4 generations exhibited low heritability values, indicating that selection for this trait on individual plant basis would not be effective. The two crosses, $C_1(P_1xP_2)$ and $C_3(P_2xP_3)$ gave high heritability, high GA% with narrow range between PCV and GCV values for seed yield and its two important components viz., number of capsules per plant and 1000-seed weight as well as $C_2(P_1xP_2)$ and $C_3(P_2xP_3)$ for all seed yield components. On the other hand, expected genetic advance (GA%) in $C_4(P_3xP_4)$ for number of capsules per plant, 1000-seed weight and number of seeds per capsule was comparatively low, however, these three characters for this cross (C_4) had high heritability estimates. Thus, it appears that the expression of these characters for this cross is controlled by non-additive gene effect. The crosses like $C_2(P_1xP_3)$ and $C_3(P_2xP_3)$ for all seed components have shown a high heritability and high genetic advance which indicated that most probably the heritability is due to additive gene effects (Pause,1957). The present results are in partial agreement with those reported by Yadava and Dalal (1971) and Mourad *et al.* (1987). Generally, the cross $C_3(P_2xP_3)$ may be recommended for isolating superior pure lines for seed yield and its components in later generations.

It evident from Table (5) that application of independent culling levels selection (ICL) method using, number of capsules per plant and 1000-seed weight was more efficient in improving seed yield. This result was in agreement with that obtained by Mourad (1983). He arbitrated that, the ICL method for straw yield and its components were recommended to improve both seed and straw yields.

Correlation studies:

Phenotypic correlation coefficient among eight characters (straw, seed yields and their components) by using the data of 48 families derived from four crosses (C_1:C_4) in F_3 and F_4 generations are shown in Table (6). Significant and positive correlations were obtained for straw yield and number of capsules per plant in F_3 and F_4 generations of the two crosses C_1 and C_2. Straw yield was significant positively correlated with plant height for $C_1(P_1xP_2)$ in F_4 only.

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Also, straw yield exhibited significant and positive correlation with technical length for all crosses except $C_2(P_1xP_3)$ in F_3 generation only, thus maximization of straw yield may be obtained by selection for plant height and technical length specially in $C_1(P_1xP_2)$. Also, correlation between straw yield and seed yield per plant in both generations of the cross $C_1(P_1xP_2)$ was significant and positive. Similar results were reported by Momtaz (1965), Younan (1974), Mourad (1983) and Sabh (1989) reported highly significant positive correlation between straw yield and seed yield. Therefore, the cross $C_1(P_1xP_2)$ may be recommended for isolating superior pure lines for straw and seed yields.

Seed yield exhibited significant positive correlation with number of capsules per plant in both generations for all crosses. Whereas, this trait showed positive correlation with 1000-seed weight in F_4 only. These results indicated that capsule number per plant and 1000-seed weight are main components for seed yield per plant. These results are in harmony with that reported by Mourad (1983) and Abo-Kaied (1992). However, number of capsules per plant showed significant and negative correlation with both of 1000-seed weight and number of seeds per capsule in both generation of the cross $C_4(P_3xP_4)$. Also, 1000-seed yield and number of seeds per capsule exhibited significant and negative correlation in two crosses, C_1 and C_2.These results are in harmony with that reported by Kumar and Chauhan (1979).

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معامل التباين الظاهري والوراثي ودرجة التوريث والتحسين الوراثي المتوقع للمحصول ومكوناته في الجيلين الثالث والرابع لبعض هجن الكتان

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أجريت هذه الدراسة بمحطة البحوث الزراعية بايتاي البارود– البحيرة، علي عدد 48عائلة منتخبة بطريقة الانتخاب المستقل للصفات علي مستويات من نسل أربعة هجن كتان ناتجة من التهجين بين أربعة آباء (1=جيزة7، 2=جيزة8، 3=س1/2419، 4=س1/6/148) بالإضافة إلى إجمالي كل هجين من الهجن السابقة (2x1، 3x1 ، 3x2 ، 4x3) وذلك في تصميم قطاعات كاملة العشوائية ذات الثلاثة مكررات في الجيلين الثالث والرابع خلال موسمي 2001/2000، 2002/2001 وذلك بهدف مقارنة التحسين الناتج عن استعمال طريقة الانتخاب المستقل للصفات علي مستويات مع إجمالي كل هجين علي محصولي القش والبذرة ومكوناتهما وذلك باستخدام عدد من المقاييس الوراثية المختلفة. وتتلخص أهم النتائج فيما يلي.

1- تشير النتائج إلى إمكانية استخدام صفات عدد الأفرع القاعدية/نبات والطول الكلي والطول الفعال كعوامل انتخاب في تحسين صفة محصول القش/نبات حيث أن هذه الصفات أعطت أقل فرق بين معاملي التباين الظاهري والوراثي وأعلي درجة توريث بالإضافة إلى أعلي نسبة تحسين وراثي متوقع من الانتخاب في كلا الجيلين.
2- أظهر الهجين جيزة7x س 1/2419 ، جيزة8 x س 1/2419 أعلي درجة توريث مع أعلي نسبة تحسين وراثي وأقل فرق بين معاملي التباين الظاهري والوراثي في كلا من الجيلين الثالث والرابع لصفات الطول الكلي والطول الفعال وعدد الأفرع القاعدية

وكذلك الهجين جيزة8 x س 1/2419 لصفات الطول الكلي والطول الفعال ، لذلك فمن المتوقع أن يعطيا هذين الهجينين انعزالات متجاوزة الحدود في الأجيال المتقدمة لهذه الصفات.

3- أظهرا الهجينين جيزة7x س 1/2419 ، جيزة8 x س 1/2419 أعلي درجة توريث وأعلي درجة تحسين وراثي متوقع من الانتخاب لصفات مكونات البذرة (عدد الكبسولات/نبات، وزن الآلف بذرة، عدد البذور بالكبسولة) - ودرجة التوريث العالية هذه محتمل أن يكون راجع للتأثير المضيف للجينات لهذه الصفات لذلك يتوقع أن يعطيا هذين الهجينين أنعزالات متجاوزة الحدود في الأجيال المتقدمة لهذه الصفات.

4- وبصفة عامة تشير النتائج إلى أن استخدام طريقة الانتخاب المستقل للصفات علي مستويات في معظم الحالات كانت أكثر فعالية في تحسين محصول القش من خلال الانتخاب لصفتي الطول الكلي والطول الفعال ، ولتحسين محصول البذرة من خلال الانتخاب لصفتي عدد الكبسولات/نبات ووزن الألف بذرة 0

5- تشير دراسة الارتباط الظاهري بين الصفات تحت الدراسة إلى أن هناك ارتباط موجب ومعنوي بين صفة محصول القش وكلا من الطول الكلي والطول الفعال وعدد الكبسولات/نبات ومحصول البذور وذلك في الهجين جيزة7x جيزة8 كذلك كان هناك ارتباط موجب ومعنوي بين محصول البذور وكلا من عدد الكبسولات في كل الهجن الأربعة تحت الدراسة في كلا الجيلين الثالث والرابع، بينما كان هناك ارتباط سالب ومعنوي بين عدد الكبسولات/نبات مع كلا من وزن 1000 بذرة وعدد البذور بالكبسولة في كل من الهجينين جيزة7x جيزة8 ، جيزة7 x س 1/2419 .