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EVALUATION OF SOME MUTANT LINES OF RICE INDUCED BY GAMMA RADIATION TREATMENT :
1- MEAN PERFORMANCE OF RICE MUTANTS IN M4 GENERATION

El Banna, M. N.*; H. M. F. El-Wakil*; R. A. Ebaid and R.A. Sallam****

*** Faculty of Agriculture Saba Basha, Alex University**

**** Rice Research Section, Field Crops Research Institute, Agricultural Research Center**

ABSTRACT

Grains of eight rice mutants; SC 1, SC 6, RTY 1, RTY 3, HY 14, HYI 17, EH 4 and HYPI 22 were secured from Botany Department Faculty of Agriculture Cairo university. The procedures and the methodology for induction these mutants as well as the original mean performance of such mutants are presented else where; Sabbour, (1989) and Sabbour *etal*. (2002). Grains were sown (M4 generation) at the experimental farm in Itai El-Baroud Agricultural Research Station Behaira Governorate Agricultural Research Center (ARC) in the summer season (2007). The mean performance of such mutants was studied during M4 generation. The most exciting results were as follows:, the selected line SC 1 showed in M4 generation superior agronomic and yield traits. Sc 1 mutant line is not bred truly and it need more generations to reach stability. SC 6 in M4 generation showed considerable number of individuals scored low mean values toward the negative direction and lowering the over all trait mean performance. The rice lines RTY 1 and RTY 3 proved that, the average number of fertile tillers per plant of the selected lines maintained previously recorded mean values of M3 generation in M4. The traits showed significant differences among their progeny that recorded high CV% values as compared with those showed no significant differences. The rice lines HY 14 & HYI 17 showed a true breeding signs and no more breeding generations are required. Rice lines EH 4, showed a considerable reduction in number of days elapsed from date of cultivation till harvest. As, this mutant maintained 86.58 days till heading. Rice mutant line HYPI 22 did not bred truly for the original selected traits (high yield and high protein content) and it still need more generations of selection to reach considerable stability.

INTRODUCTION

Rice is the most remarkable of cultivated crops. It is the stable diet of over half of the world population including countless millions in Asia and Africa who subsist almost eating rice. Moreover Egypt rice is grown in about 1.5 million Fadden (about 0.64 million hectare), (Anonymous 2007) recorded this area because of the limited water resources. In Egypt, further increase in rice production from increased yield per unit area is needed; this can be achieved through varietals improvement and other agricultural means. Improved varieties of self-pollinated crops such as rice have been developed traditionally through selection in segregation progenies or intra varietal hybridization. Rice is an autogiros plant; consequently, the intra-varietal variability is small. Therefore, the seek of an increase in the genetic variability of the starting material should be needed. Since (1934) Incijima used X-rays

and ultraviolet as a tool for induced mutations in rice. Futsuhara (1968) reported the first induced high-yielding rice mutant "Reimei" which was released in Japan as national variety. In Egypt, the effect of ionizing radiation on rice plant and improving rice via mutation breeding using different sources of mutagens were early reported by El-Balall (1967, 1972), El-Keredy and Niwa (1973) and Sabbour (1989).

The present work is further studies that undertaken to continue long term programmer started since 1984 at the Botany Dept. Faculty of Agric., Cairo Univ. aiming to evaluate eight selected rice mutants in M4 generation and assigned the degree of stability for next generations. Stability is commonly predicted as the product of heritability values and selection differential, the latter being the difference between the mean of the selected group and the mean of entire population. Since the genetic advance and other genetic estimates will be discussed later.

MATERIALS AND METHODS

The present investigation was conducted during 2007, in the experimental farm in Itai El-Baroud Agricultural Research Station Behaira Governorate Agricultural Research Center (ARC). Plant materials were the grains of eight rice mutants; SC 1, SC 6, RTY 1, RTY 3, HY 14, HYI 17, EH 4 and HYPI 22 which secured from Botany Department Faculty of Agriculture Cairo university. The procedures and the methodology for induction these mutants as well as the original mean performance of such mutants are presented else where; Sabbour, (1989) and Sabbour *etal*.,(2002).

Field procedures implies raising M4 generation plants in the nursery for about 30 days, Plantation was performed after field preparation and the experiment was arranged in Randomized Complete Block Design (RCBD) with three replicates. Grains of eight rice mutants were laid out in each Block randomly. The studied characters includes; plant height, in cm. flag leaf area index (LAI), number of fertile tillers/hill, panicle length, in cm, panicle weight, in gm, grain + straw yield per plant, grain yield per plant, harvest index, grain index (1000-grain weight, in gm), number of days to heading and number of days to maturity and Protein contents mg/g was conducted according to (AOAC, 1990). Data were subjected to conventional methods of statistical analysis using SAS system (SAS Institute, 1996)

RESULTS AND DISCUSSION

1- Short Culm Mutation

Data represented in Table (1&2) showed the mean performance and the descriptive values of the selected rice line SC 1 and SC 6 in M4 generation. Statistically, most of the studied traits; plant height, number of fertile tillers, grain and straw yield, harvest index, grain index as well as heading and maturity age showed no significant differences within M4 individuals. On the contrary, significant differences detected in case of Flag leaf area. panicle length and weight.

J. Agric. Sci. Mansoura Univ., 34 (2), February, 2009

1-2

It is noticeable that average plant height of the selected plants maintains nearly the same values of M3 generation. Where, M3 mean plant height of the selected line was 81.5 cm and their progenies in M4 showed an average mean of 87.92 cm and the range of the growing plants ranged between 80.5 and 95.34 cm. It is evident that, the selected line SC 1 showed in M4 generation superior agronomic and yield traits. Where the average grains yield per plant as well the harvest index values were 11.7 g and 0.46, respectively. The correspondent values of M3 generation were 10.2 g and 0.48 for average grain yield per plant and harvest index, table (1). With regard to the traits that showed significant differences within its individuals, it is clear that these progenies exhibited a wide range of distribution where, a considerable number of individuals scored low mean values toward the negative direction and lowering the over all trait mean performance. Indicating that such traits are not bred truly and it need more generations to reach stability. Moreover, such traits may affected by the environment. Variability as estimated by Coefficient of variation (CV%) within the selected lines in M4 were mostly smaller as compared with the traits that showed significant differences. It is notably that the mutant line SC 6 that showed 86.07 cm height as compared with its original and selected M3 parents which scored 131.7 cm and 85.53 cm for both the original and the selected M3, respectively. This is indicated that SC 6 line maintained and preserve its deviated characters and bred truly through the M4 generation. Unfortunately this line produced low yield as compared with its parents. So it need more generations of selection to improve this trait. It is obvious that generally traits showed significant differences among their progeny scored high CV% values as compared with those showed no significant differences. Indicating the uniformity within the progenies of both SC1 and SC 6 in M4 generation.

2- Rich tiller and high yield mutation

Data represented in Tables (3&4) showed the mean performance and the descriptive values of the rice lines RTY 1 and RTY 3 (Rich tiller & High yield mutation) in M4 generation. Statistically, most of the studied traits; number of fertile tillers, grain yield per plant height, flag leaf area, panicle length as well as heading and maturity age showed no significant differences found within M4 individuals. On the contrary, significant differences detected of in case of grain and straw yield, harvest index and panicle weight for the line RTY 1 while the line RTY 3 showed significant differences in harvest index, panicle weight and grain index. It is obvious that average number of fertile tillers per plant of the selected plants maintained previously recorded mean values of M3 generation. Since, M3 mean number of fertile tillers per plant of the selected M3 line were 14.82 and 13.75 for RTY 1 and RTY 3, respectively. Their progenies in M4 showed an average of 13.0 and 12.5 the range of tillers number was between 10.0 and 16.0 for RTY 1 and 10.0 to 15.0 for the mutant line RTY 3. However, line RTY 1 showed promising yield traits. As, the average grain yield per plant in M4 generation was 12.18 g comparing with 10. 20 g per plant for the original selected strain. The corresponding values for the line RTY 3 were: 12.31, compared with 10.20 g of the original plants.It is apparent from Table (3&4) that, both grain + straw yield, harvest index and average panicle weight.

3-4

Regarding to the traits that showed significant differences, it is clear that these progenies exhibited wide ranges as a considerable number of individuals scored low mean values toward the negative direction though it lowering the mean performance of such trait. So it could be concluded that these traits; grain + straw yield, plant harvest index and panicle weight are not bred truly. So, more successive generations are required to reach stability for such traits. Moreover, these traits may affected greatly by the environmental factors. The degrees of variability as indicated by CV% values in M4 generation of the studied traits were used as an indicator of the uniformity within the individuals in M4. It is clear that the traits showed significant differences among their progeny that recorded high CV% values as compared with those showed no significant differences.

3- High yield mutations

Data represented in Table (5&6) showed the mean performance and the descriptive values of the rice lines HY 14 & HYI 17 (High yield mutation) in M4 generation. It is obvious that , most of the studied traits; plant height, number of fertile tillers, flag leaf area, grain + straw yield, grain yield per plant height, as well as heading and maturity age showed no significant differences within the individuals of M4. I t is obvious that average grain yield per plant of the selected plants maintained previously recorded mean values of M3 generation. The average grain yield per plant of the original plants was 10.20. However, M3 mean grain yield per plant of the selected M3 line were 12.84 and 13.1 for HY 14 and HYI 17, respectively. Their progenies in M4 showed an average of 12.6 and 12.8. The grain yield range was between 10.8 to 14.4 for HY 14 and 10.77 to 14.83. However, line HY 14 showed promising yield traits. As, the average grain yield per plant in M4 generation was 12.84 g comparing with 13.10 g for the original selected line in M3. It is apparent from Table (5) that, that, significant differences detected in case of harvest index, average panicle length and weight, for HY 14 while the line HYI 17 showed significant differences for protein content, panicle length and panicle weight. These indicated that the two selected lines progenies in M4 exhibited considerable number of individuals scored low mean values toward the negative direction though it lowering the mean of such trait. Moreover, the degrees of variability as indicated by CV% values were almost greater than the other traits which showed no significant differences. So, it could be concluded that these traits; harvest index, panicle length and weight are not bred truly and still need more generation to reach considerable stability.

With regard to the mean performance and the descriptive values of high yield and high protein content mutant (HYI 17) data presented in Table (6) proved that, most of the agronomic traits showed non significant differences indicating high amount of uniformity within its individuals. This uniformity may reflect on the narrow ranges recorded for their descriptive values. This is a good signal that the line HYI 17 showed a true breeding signs and no more breeding generations are required. Moreover, the recorded CV% values of its agronomic traits were considerably of high magnitude concerning their uniformity. In addition the average grain protein contents of this mutant line showed significant differences in M4. These differences indicated that, grain protein content in this mutant line still need more generations of selection.

J. Agric. Sci. Mansoura Univ., 34 (2), February, 2009

5-6

4- Early Heading mutation

Data represented in Table (7) showed the mean performance and the descriptive values of the rice lines EH 4 (Early Heading mutation) in M4 generation. It is clear that , most of the studied traits; plant height, number of fertile tillers, flag leaf area, grain + straw yield, Panicle length, grain index as well as heading and maturity age showed no significant differences within the individuals of M4. On the contrary, significant differences detected in case of grain yield per plant, harvest index and average panicle weight, table, 7. Data proved that the average grain yield per plant of the selected plants maintained previously recorded mean values of M3 generation. Since, M3 mean grain yield per plant of the selected M3 line was 11.8 g as compared with 10.20 g for the original plants. This mutant progeny in M4 showed an average of 11.68 g. As, the average grain yield per plant in M4 generation was 11.68 g comparing with 11.8 g for the selected line in M3. It is apparent from Table (7) that, number of days elapsed from date of cultivation till harvest showed a considerable reduction. Where this mutant maintained the same period elapsed for heading 82.5 days as compared with 96.1 and 77.4 for both the original and M3 selected plants. Moreover, the degrees of variability as indicated by CV% values were almost small. The uniformity within its individuals may reflect on the narrow ranges recorded for heading age descriptive values. So, it could concluded that this mutant bred truly for the original selected trait (heading age) but it still need more generation to reach considerable stability on its other agronomic traits.

5- High yield + high protein contents

Data presented in Table (8) showed the mean performance and the descriptive values for the rice mutant line HYPI 22 (High yield + high protein contents). Statistically this mutant proved that; significant differences were recorded within M4 generation. Crude protein contents mg/g, harvest index as well as average panicle weight per plant showed no homogeneity within its individuals. As protein content was the major selected factor. This mutant in M4 showed sergeants with low protein content and lowering the mutant mean performance in M4 as the average protein content was 9.04 mg/g which proved that this mutant is not stable and retained its original values which was 9.16 mg/g, table(8). The other agronomic traits plant height, number of fertile tillers, flag leaf area, grain + straw yield, panicle length, grain index as well as heading and maturity age showed no significant differences within the individuals of M4. As, the average grain yield per plant in M4 generation was 11.80 g comparing with 12.20 g for the selected line in M3. It is apparent from Table (8) that, grain yield per plant showed considerable reduction in M4 generation. Moreover, the degrees of variability as indicated by CV% values were almost high for both average protein content and grain yield. The inconsistency within the individuals may reflect on the wide ranges recorded for protein content mg/g values. So, it could concluded that this mutant did not bred truly for the original selected traits (high yield and high protein content) and it still need more generations of selection to reach considerable stability.

J. Agric. Sci. Mansoura Univ., 34 (2), February, 2009

7-8

DISCUSSION

Six out of eight mutants under investigation showed relatively high stability during M4 generation. The other two mutations maintained their original characteristics by different extents. These effects in M4 indicated that certain heritable changes took place in M3 and were transmitted to M4. This support the hypothesis put forward by Brock (1970) that random mutation in quantitative traits which are controlled by a large number of genes, with small positive and negative effects, are expected to increase the variances and shift the means away from the direction of previous selection history. This was of particular significance since most of the agronomic important characteristics, were controed in their inheritance by polygenic systems. The same trend of results was recorded in various plants by Abo-Hegazi (1968), Hanna (1969), Hassan (1977), Abo-Hegazi (1980), Harb (1981), Raaft (1984), Nofal (1989) and El-Sgai (1993).

The degree of variability as indicated by C.V. % values for the agronomic and yield traits in M4 generation, showed variable values within the individual for the six stable mutants.This may be a reflection of its higher mean which is used in the calculation of C.V. % in this connection, Scossirol (1970) attributed the increased variability resulting from irradiation to the mutation in minor genes, but Gupta and Virk (1977) attributed it to both additive and non-additive effects. The same results were recorded in different crops by Balint and Sutka (1968), Marwan et al., (1974), Harb (1981), Raaft (1984) and Nofal (1989).

Stability is commonly predicted as the product of heritability values and selection differential, which is the difference between the mean of the selected group and the mean of entire population. Since the selection intensity was minimized most of M4 characters, showed non significant differences within each mutant progeny which composed the M4 population. The most stable characters were; plant height, number of fertile tillers/hill, grain yield per plant, grain weight, , number of days to heading and number of days to maturity. The other studied traits, flag leaf area index (LAI), panicle length, panicle weight, harvest index, grain index, grain + straw yield per plant as well as protein contents showed a relatively low ability to stability. So, these characters may need more extensive selection during the next generation. So, according to the results found in the present study it could be concluded that raising M4 was important to ensure the major characters of these eight promising rice mutations and establishing the base for rising M5 generation.

REFERENCES

Abifarin, A. O. and Rutger, N. J., (1982): Effect of low gamma irradiation exposures on rice seedling development. Enviromental and Expremintal Botany. Vo. 22, No. 3: 285- 291.

Abo-Hegazi, A.M.T. (1968). Useful mutation induced with gomma-rays and their application in breeding of Vicia faba, minor. Ph. D. Thesis, Fac. Of Agric., Zegreb Univ.

Abo-Hegazi, A.M.T. (1980). Seed protein and other characters in M4-generation on chickpea lnd. J. of Genet. And Pl. Breed. 40 (1) 122:126.

AOAC (1990). Official methods of analysis. Association of Official Analytical Chemists. 15th ed. Washington, DC.

Bala M.S. (1967): Developmental genetic studies on some quantitative characters of rice, Oryza sativa. L. Ph.D. Thesis University of Tokyo. Japan. (After Developmental genetic studies on some quantitative characters of rice, Oryza satival L. Alex. J. Agr. Res. 18: 191- 196 (1970).

Balint, A.D.Dudits and J. Sutka (1968): Study of quantitative characters of pea in a mutant population. Novenytermeles 1968, 17: 187- 96. (C.F.Pl. Breed. Abst., 40(3) 5911).

Brock, R.D. (1970). Mutations in quantitatively inherited traits induced by neutron irradiation. Rad. Bot. 10. 209- 230.

Butron, G.W. (1952). Quantitative inheritance in grasses. Proc. 6th international. Grassi. Conger., 1:277-283.

El-Keredy, M. S. and Abd-Alla, S.A., (1976): A study of differences in the radiosensitivity of some rice varieties. Egyptian Journal of Genetics and Cytology 5 (1) 48- 57.

---------- ---------- , S.A., (1978): Effect of gamma irradiatioins and chemical mutagens on two Egyptian rice varieties. Journal Agric. Res., Tanta Univ., 4(1).

---------- ---------- , S.A., and Niwa, M., (1973): Effect of acute and chronic gamma irradiations on the growth and development of M1 rice plants. Egypt. J. Bot., 16:423-436.

Futshare, Y., (1968): Breeding of a new rice variety reimei, by gamma-ray irraditation, Gamma Field Symposia (1968).

Gupta, V.P. and D.S. Virk (1977). Induced variation in segregation homozygous populations of wheat. (C.F.Proc. of 1st National seminar on Genetics and wheat improvement. Ludhiana, February 22- 23, 1977. Oxford and IBH Publishing Co. New Delhi, Bormbay, Calcuta.

Hanna, E.M. (1969). Studies of Co60 gamma radiation on Vicia faba L. M.Sc. Thesis, Fac. of Science Cairo Univ.

Harb, R.K. (1981). Studies on mutations induced by gamma radiation and EMS in two soybean cultivars. Ph.D. Thesis, Fac. Of Agric. Cairo, Univ.

Hassan, F. H. (1977). Mutaiton studies on Vicia faba. M.Sc. Thesis, Fac. Of Agric . Al-Azher Univ.

Ichijima, K., (1934). On the artificial induced mutations and polypolid plants of rice. Occurring in subsequent generation. Proc. Imerial Acadmy 10 pp. 388-91.

Kowyama, Y. Y.; Saitot, M. and Kawase, T., (1987): intervarietal variations in radiosensitivity of dry rice seeds irradiation with sparsely and densely ionizing radiation. Environmental and Experimental Botany, Vol. 27, No. 4, pp. 431-440.

Marwan, M., A.K.A. Okasha and O. El-Gibali (1974). The implication of yield components interaction under different doses of gamma rays in peas. Egypt. J. Bot. 17, (213): 151- 160.

Nofal, F. H. (1989). Effect of gamma irradiation on morphological and reproductive character of two pea cultivars. J. Agric. Sci. Mansoura Univ. 14(2) 599-600, 1989.

Nofal, F. H. and M.A.H. Mohamed (1989). Studies on some pea mutants induced by gamma irradiation. J. Agric. Sci. Mansoura Univ. 14(2): 585- 598.

Raafat, A.R.M. (1984). Mutagenic treatments and selection in chicpea Ph.D. Thesis, Fac. Of Agric. Cairo Univ.

Reddy, G.M. and Rddy, T.P., (1987): Induction of variability at different stages in scented rice. Indian Coop Improvement. 14 (2): 176- 178.

Sabbour, A. M., (1989):Induced variability by radiation in some quantitative characters of Qryza sativa I., and their implication in breeding. Ph.D. Thesis. Dept. of Agric. Botany. Faculty of Agric. Cairo University.

SAS Institute. (1996).SAS/STAT users guied for personal computer: Version 6.12. SAS Inst., Inc., Cary, N.C.

Scossiroli, R. E. (1970). Mutation in characters with continues variation. In manual on Muation Breeding IAEA, Vienna, 1977-183.

Sparrow, A. H., (1965): some cytogentic and morphogentic effects of ionizing radiation on plants. Proc. Conf., Radioactive Isoltopes in Agric. USAEC. TID. 7512, pp. 125-39.

تقييم بعض السلالات الطافرة من الأرز والناتجة من المعاملة بأشعة جاما:
١- متوسط سلوك السلالات المنتخبة خلال الجيل الطافر الرابع

محمد نجيب البنا* ، حسام الدين محمد فتحي الوكيل* ، رجب عبد الغنى عبيد و رضا عبد المقصود سلام ****

*** كلية الزراعة سابا باشا – جامعة الاسكندرية**

**** قسم بحوث الارز-معهد المحا صيل الحقلية-مركز البحوث الزراعية**

اجري هذا البحث لتقييم عدد ثما نية سلالات طافرة من الأرز و ذلك بمحطة بحوث أبتاى البارود – مركز البحوث الزراعية – وزارة الزراعة خلال موسم ٢٠٠٧. وذلك لدراسة الصفات التالية: طول النبات– عدد الأفرع الخصبة – مساحة ورقة العلم – محصول النبات من الحبوب و القش – محصول النبات من الحبوب – معامل المحصول – طول السنبلة الدالية – وزن السنبلة الدالية – وزن الف حبة – عدد الأيام الى التزهير و النضج – نسبة البروتين.

كانت أهم النتائج المتحصل عليها فى الجيل الطافر الرابع كما يلى:

١- الطفرات قصيرة الساق : أظهرت السلالة SC 1 صفات محصولية متفوقة و حافظت على أغلب صفاتها الإنتاجية بينما السلالة SC 6 أظهرت بعض الأفراد المتباينة بين نسلها و كان متوسط نسلها للصفات المنتخبة اقل من أبائها.

٢- الطفرات غزيرة التفريع: أظهرت السلالات RTY 1 و RTY 3 تجانس كبير بين أفراد نسلها كما أن المتوسط العام لهذه السلالات كان مرتفعا نسبيا لكل من صفة عدد الأفرع الخصبة و محصول النبات من الحبوب.

٣- الطفرات عالية المحصول : كل من السلالتين HY 14 و HYI 17 تفوقت فى محصولها عن قيمها الانتخابية كما أن أفرادهما أبدت درجة عالية من التجانس خلال الجيل الطافر الرابع (صادقة التوالد).

٤- الطفرات مبكرة التزهير : السلالة EH 4 حافظت على صفة التبكير فى التزهير بدرجة ملحوظة كما أنها أظهرت صفات محصولية تحتاج الى المزيد من الانتخاب خلال الأجيال التالية.

٥- الطفرات عالية المحصول عالية البروتين : السلالة HYPI 22 فقدت ميزته النسبية فى ارتفاع المحتوى الكلى من لبروتين بالحبوب حيث كان المتوسط العام للسلالة منخفض إلا أنها سجلت صفات محصولية جيدة فيما يتعلق بوزن محصول النبات من الحبوب .

Table (1): Mean performance and the descriptive values of the rice line SC1 (Short Culm) in M4 generation

Descriptive traits /Entry	Original mean values Giza 172	M3 selected mean for deviated characters	Number of M_4 Plants	Mean ± SE	Range	C V %	δ^2	Significance
	M_0	M_3	M_4					
Plant height (cm)	131.7	81.50	180	87.92 ± 0.36	80.5 – 95.34	0.054	23.13	NS
Number of fertile tillers	11.61	11.73	180	10.0 ± 0.90	8.0 –12.0	0.188	24.50	NS
Flag leaf area (cm^2)	31.63	32.74	180	33.82 ± 0.20	26.25 – 41.4	0.479	7.18	*
Grain + straw yield (g)	21.89	21.73	180	21.62 ± 0.28	19.46 – 23.78	0.173	14.06	Ns
Grain Yield (g)	10.20	10.24	180	11.70 ± 0.32	9.94 – 13.46	0.220	18.38	Ns
Harvest index	0.46	0.48	180	0.46 ± 0.01	0.43 – 0.49	0.273	0.016	Ns
Panicle length (cm)	22.7	23.8	180	24.5 ± 0.09	19.4 – 29.6	0.354	1.54	*
Panicle weight (g)	3.42	3.46	180	3.03 ± 0.02	1.83 – 4.23	0.381	0.073	*
Grain index (1000 grain)	23.48	23.56	180	23.55 ± 0.13	21.3 - 25.8	0.074	3.03	Ns
Heading Age (Days)	96.1	99.2	180	95.0 ± 0.44	90.0 – 100.0	0.062	34.69	Ns
Maturity Age (Days)	132.1	136.1	180	134.0 ± 0.62	129.0 – 138.0	0.060	69.06	Ns

Table (2): Mean performance and the descriptive values of the rice line SC 6 (Short culm) in M4 generation

Descriptive traits /Entry	Original mean values Giza 172	M3 selected mean for deviated characters	Number of M_4 Plants	Mean ± SE	Range	C V %	δ^2	Significance
	M_0	M_3	M_4					
Plant height (cm)	131.7	85.53	180	86.07 ± 0.32	82.4 – 89.74	0.045	17.92	Ns
Number of fertile tillers	11.61	10.21	180	10.5 ± 0.13	8.0 – 13.0	0.402	18.97	Ns
Flag leaf area (cm^2)	31.63	30.04	180	31.8 ± 0.18	29.8 – 33.8	0.065	5.56	Ns
Grain + straw yield (g)	21.89	22.5	180	22.35 ± 0.15	19.8 – 24.9	0.143	10.89	Ns
Grain Yield (g)	10.20	10.06	180	10.36 ± 0.02	9.42 – 11.3	0.345	14.19	Ns
Harvest index	0.46	0.48	180	0.47 ± 0. 01	0.45 – 0.49	0.227	0.01	*
Panicle length (cm)	22.7	19.59	180	21.85 ± 0.18	19.1 – 24.6	0.244	1.19	*
Panicle weight (g)	3.42	2.86	180	2.64± 0.07	2.27 – 3.01	0.267	0.06	*
Grain index (1000 grain)	23.48	21.18	180	21.65 ± 0.11	20.7 – 22.6	0.061	2.34	Ns
Heading Age (Days)	96.1	88.9	180	92.0 ± 0. 39	86.0 – 98.0	0.051	26.87	Ns
Maturity Age (Days)	132.1	123.4	180	128.0 ± 0.51	122.0 – 134.0	0.050	53.48	Ns

Table (3): Mean performance and the descriptive values of the rice line RTY 1 (Rich tiller & High yield mutation) in M4 generation

Descriptive traits /Entry	Original mean values Giza 172	M3 selected mean for deviated characters	Number of Plants	Mean ± SE	Range	C V %	δ^2	Significance
	M_0	M_3	M_4					
Plant height (cm)	131.7	102.53	180	98.5 **± 0.51**	93.4 – 103.6	0.070	47.3	Ns
Number of fertile tillers	11.61	14.82	180	13.0 **± 0.34**	10.0 – 16.0	0.379	21.0	Ns
Flag leaf area (cm^2)	31.63	32.04	180	37.17 **± 0.71**	31.4 – 42.94	0.191	88.7	Ns
Grain + straw yield (g)	21.89	24.98	180	22.48 **± 0.21**	21.4 – 24.34	0.117	7.8	*
Grain Yield (g)	10.20	12.46	180	12.18 **± 0.04**	10.7 – 13.66	0.043	0.3	Ns
Harvest index	0.46	0.48	180	0.47 **± 0.06**	0.46 – 0.48	1.559	0.6	*
Panicle length (cm)	22.7	23.6	180	23.05 **± 0.34**	20.8 – 25.3	0.191	21.0	Ns
Panicle weight (g)	3.42	3.81	180	3.2 **± 0.15**	2.4 – 4.0	0.593	4.1	*
Grain index (1000 grain)	23.48	23.37	180	21.53 **± 0.25**	19.6 – 23.46	0.154	11.0	Ns
Heading Age (Days)	96.1	98.9	180	102. 5 **± 0.80**	97.0 – 108.0	0.104	70.3	Ns
Maturity Age (Days)	132.1	127.4	180	133. 0 ± **1. 06**	128.0 – 138.0	0.102	83.5	Ns

Table (4): Mean performance and the descriptive values of the rice line RTY 3 (Rich tiller & High yield mutation in M4 generation

Descriptive traits /Entry	Original mean values Giza 172	M3 selected mean for deviated characters	Number of Plants	Mean ± SE	Range	C V %	δ^2	Significance
	M_0	M_3	M_4					
Plant height (cm)	131.7	101.13	180	94.6 **± 0.62**	89.4 – 99.8	0.087	69.0	Ns
Number of fertile tillers	11.61	13.75	180	12.50 **± 0.49**	10.0 -15.0	0.577	43.1	Ns
Flag leaf area (cm^2)	31.63	34.57	180	38.15 **± 0.31**	34.6 – 41.7	0.083	17.3	Ns
Grain + straw yield (g)	21.89	23.83	180	21.9 **± 0.27**	20.3 – 23.5	0.158	13.1	Ns
Grain Yield (g)	10.20	11.92	180	12.31 **± 0.24**	10.7 – 13.92	0.259	10.3	Ns
Harvest index	0.46	0.48	180	0.48 **± 0.01**	0.47 – 0.49	0.274	0.0	*
Panicle length (cm)	22.7	24.1	180	20.50 **± 0.08**	18.3 – 22.8	0.522	114.9	Ns
Panicle weight (g)	3.42	3.64	180	3.05 **± 0.13**	2.8 – 3.3	0.498	3.0	*
Grain index (1000 grain)	23.48	23.00	180	21.5 **± 0.22**	19.90 – 23.1	0.134	8.7	*
Heading Age (Days)	96.1	102.5	180	104.0 **± 0.53**	97.0 – 111.0	0.068	50.4	Ns
Maturity Age (Days)	132.1	130.4	180	133.0 **± 0.79**	129.0 – 139.0	0.074	72.1	Ns

Table (5) Mean performance and the descriptive values of the rice line HY 14 (High yield mutation) in M4 generation

Descriptive traits /Entry	Original mean values Giza 172	M3 selected mean for deviated characters	Number of Plants	Mean ± SE	Range	C V %	Δ^2	Significance
	M_0	M_3	M_4					
Plant height (cm)	131.7	107.03	180	110.75 ± 0.42	102.5 – 119	0.056	32.26	Ns
Number of fertile tillers	11.61	12.90	180	11.5 ± 0.44	9.0 – 14.0	0.508	34.10	Ns
Flag leaf area (cm^2)	31.63	35.02	180	38.91 ± 0.24	33.12 – 44.7	0.082	9.98	Ns
Grain + straw yield (g)	21.89	25.94	180	22.51 ± 0.33	18.8 – 26.22	0.180	19.62	Ns
Grain Yield (g)	10.20	12.84	180	12.6 ± 0.38	10. 8 – 14.4	0.437	25.50	Ns
Harvest index	0.46	0.49	180	0.48 ± 0.01	0.47 – 0.49	0.284	0.023	*
Panicle length (cm)	22.7	22.9	180	23.26 ± 0.11	19.8 – 26.72	0.056	2.13	*
Panicle weight (g)	3.42	4.04	180	3.79 ± 0.02	2.83 – 4.75	0.084	0.103	*
Grain index (1000 grain)	23.48	23.12	180	23.75 ± 0.15	21.89 – 25.61	0.177	4.20	Ns
Heading Age (Days)	96.1	102.5	180	103.82 ± 0.52	99.0 – 108.0	0.064	43.43	Ns
Maturity Age (Days)	132.1	135.1	180	139.0 ± 0.42	135.0 – 143.0	0.043	31.67	Ns

Table (6): Mean performance and the descriptive values of the rice line HYI 17 in M4 generation

Descriptive traits /Entry	Original mean values Giza 172	M3 selected mean for deviated characters	Number of Plants	Mean ± SE	Range	C V %	δ^2	Signif-icance
	M_0	M_3	M_4					
Crude Protein Content (mg/g)	9.16	11.53	12	10.36 **± 0.05**	9.52 – 11.2	0.014	0.030	*
Plant height (cm)	98.7	85.53	180	88.54 **± 0.41**	80.68 – 96.4	0.062	30.184	NS
Number of fertile tillers	11.99	12.43	180	12.0 **± 0.31**	10.0 – 14.0	0.392	17.256	NS
Flag leaf area (cm^2)	29.10	30.04	180	34.55**± 0.24**	28.7 – 40.4	0.073	10.343	NS
Grain + straw yield (g)	19.93	22.21	180	24.1**± 0.31**	20.7 – 27.5	0.197	17.256	NS
Grain Yield (g)	9.91	13.1	180	12.8 **± 0.27**	10.77 – 14.83	0.368	13.090	NS
Harvest index	0.48	0.49	180	0.47**± 0.06**	0.46 – 0.48	1.748	0.646	NS
Panicle length (cm)	18.30	19.59	180	22.1**± 0.19**	17.3 – 26.9	0.115	6.482	*
Panicle weight (g)	2.83	2.86	180	3.81**± 0.08**	2.87 – 4.75	0.297	1.149	*
Grain index (1000 grain)	21.89	21.18	180	23.08 **± 0.21**	20.3 – 25.86	0.123	7.919	NS
Heading Age (Days)	86.7	88.9	180	93.0 **± 0.32**	89.0 – 97.0	0.048	18.387	NS
Maturity Age (Days)	119.5	123.4	180	128.0 **± 0.34**	122.0 – 134.0	0.035	20.757	NS

Table (7): Mean performance and the descriptive values of the rice line EH 4 (Early Heading mutation) in M4 generation

Descriptive traits /Entry	Original mean values Giza 172	M3 selected mean for deviated characters	Number of Plants	Mean ± SE	Range	C V %	δ^2	Signif-icance
	M_0	M_3	M_4					
Plant height (cm)	131.7	96.83	180	95.19 ± 0.17	89.4 – 100.98	0.048	13.09	Ns
Number of fertile tillers	11.61	11.43	180	9.5 ± 0.11	7.0 – 12.0	0.248	5.82	Ns
Flag leaf area (cm^2)	31.63	31.36	180	29.11 ± 0.37	21.5 – 36.72	0.153	24.58	Ns
Grain + straw yield (g)	21.89	18.22	180	19.76 ± 0.11	17.8 – 21.72	0.057	2.17	Ns
Grain Yield (g)	10.20	11.8	180	11.68 ± 0.02	9.4 – 13.96	0.024	0.07	*
Harvest index	0.46	0.48	180	0.48 ± 0.03	0.47– 0.49	0.851	0.16	*
Panicle length (cm)	22.7	18.26	180	20.18 ± 0.18	18.6 – 21.76	0.109	5.82	Ns
Panicle weight (g)	3.42	2.74	180	2.47 ± 0.08	2.08 – 2.86	0.338	1.15	*
Grain index (1000 grain)	23.48	21.75	180	20.14 ± 0.13	18.18 – 22.10	0.088	3.03	Ns
Heading Age (Days)	96.1	77.4	180	82.5 ± 0.42	76.0– 89.0	0.063	31.67	Ns
Maturity Age (Days)	132.1	106.3	180	112.0 ± 0.56	108.0 – 116.0	0.058	56.31	Ns

Table (8): Mean performance and the descriptive values of the rice line HYPI 22 (High yield + high protein contents) in M4 generation

Descriptive traits /Entry	Original mean IR 1626	M3 selected mean for deviated characters	Number of Plants	Mean ± SE	Range	C V %	δ^2	Signif-icance
	M_0	M_3	M_4					
Crude Protein Content (mg/g)	9.16	11.34	12	9.04 ± 0.03	7.8 – 10.28	0.136	0.16	*
Plant height (cm)	98.7	91.83	180	94.64 ± 0.45	87.3 – 101.9	0.060	36.36	Ns
Number of fertile tillers	11.99	11.43	180	11.5 ± 0.31	9.0 – 14.0	0.358	17.26	Ns
Flag leaf area (cm^2)	29.10	32.26	180	32.71± 0.24	29.52 - 35.9	0.083	10.34	Ns
Grain + straw yield (g)	19.93	22.94	180	23.41± 0.29	21.9 – 24.92	0.160	15.10	Ns
Grain Yield (g)	9.91	12.20	180	11.80± 0.27	9.6 – 14.0	0.310	13.09	Ns
Harvest index	0.48	0.47	180	0.45± 0.03	0.44 – 0.46	0.891	0.16	*
Panicle length (cm)	18.30	22.9	180	23.44± 0.16	21.8 – 25.08	0.081	4.60	NS
Panicle weight (g)	2.83	3.14	180	3.27± 0.07	2.11 – 4.43	0.449	0.88	*
Grain index (1000 grain)	21.89	23.82	180	22.35 ± 0.24	20.1 – 24.6	0.119	10.34	Ns
Heading Age (Days)	86.7	91.6	180	92.73 ± 0.47	87.0-97.0	0.063	39.66	Ns
Maturity Age (Days)	119.5	124.3	180	123.0 ± 0.38	116.0-130.0	0.035	25.93	Ns