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A STUDY ON THE DETERMINATION OF GENOTYPIC VARIATION FOR SEED YIELD AND ITS UTILIZATION THROUGH SELECTION IN DURUM WHEAT (*Triticum durum* Desf.) MUTANT POPULATIONS

Tamer KUŞAKSIZ*[1] Şahin DERE[2]

[1] *University of Celal Bayar, Vocational College of Alasehir, 45600-Manisa, Turkey*
[2] *University of Ordu, Faculty of Agriculture, Department of Field Crops, 52200-Ordu, Turkey*
**Corresponding Author: tmr.kusaksiz@bayar.edu.tr*

ABSTRACT

The effect of gamma irradiation on three spring durum wheat cultivars namely Salihli-92, Ege-88 and Gediz-75 were studied. Various doses of gamma irradiation i.e (0-150-300 Gy) were applied to dry seed. The mutated populations were grown at two locations (Bornova and Alasehir) in the 2003-2004 and 2004-2005 growing seasons. A total of 100 single plants were selected from each mutant and control populations in the 2003-2004 growing season. Twenty five percent selection pressure was applied. The progeny rows of the selected mutant plants were grown at two locations in the 2004-2005 growing season. A second stage selection was applied in each progeny population and selected mutant lines were advanced to the micro yield testing. Genetic advance at each stage of selection was estimated for single plant yield, and expected progeny means for plot yield was estimated. In certain mutant populations, heritability and phenotypic standard deviation values, genetic gains were higher than those of control population. The progeny means of the certain mutant populations were also higher when compared to control population.

Keywords: Durum wheat, gamma ray, genetic gain, selection

INTRODUCTION

Wheat is one of the primer crops in regard to its antiquity, acreage, and production in the wold. According to the FAO (2008), Turkey has 8.1 million hectares sowing area and 17.2 million tonnes production of wheat. Wheat production consists of 85 % of bread wheat and 15 % of durum wheat (*T. durum* Desf.) in Turkey (Yazar and Karadogan, 2008).

Breeders have been trying to improve high yielding durum wheat cultivars in order to compete with the bread wheat cultivars in yielding ability (Sakin et al. 2005; Başer et al. 2007; Çağırgan, 2009). Among the different breeding methods, mutagenesis has been used as an important tool to create additional variability for quantitatively inherited traits in different plants.Mutagenesis is considered as an alternative method to increase genetic variability in plant breeding (Camargo et al. 2000). Mutagenesis is often used to correct defects in a cultivar, which has a set of good agronomic characteristics (Sigurbjörnsson 1977). The use of nuclear techniques in plant breeding has been mostly directed for inducing mutations. Since the discovery of x-rays about one hundred years ago, the use of ionizing radiation, such as x-rays, gamma rays and neutrons for inducing variation, has become an established technology. Induced mutations have been used in the improvement of major crops such as wheat (*Triticum spp.*), rice (*Oryza sativa*), barley (*Hordeum vulgare*), cotton (*Gossypium hirsutum*), chickpea (*Cicer arietinum*) which are seed propagated (Ahloowalia and Maluszynski 2001).

Since its establishment, the Joint FAO/IAEA Division of the Nuclear Techniques in Food and Agriculture, Vienna, has sponsored extensive research and development activities in their member states on mutation induction to enhance the genetic diversity in the germplasm of food and industrial crops. These efforts have resulted in the official release to farmers of over 2700 new crop cultivars in approximately 170 species (Lagoda 2008).

In many mutagenic studies, gamma ray and x-rays have been used to induce mutations. The key factor in the irradiation of plant material is the dose, which is the amount of radiation energy absorbed by the material (Ahloowalia and Maluszynski 2001). The purpose of the study was to investigate the effects of a second stage selection on the mutant durum wheat cultivars constructed by induced mutations in terms of yield and to estimate the genetic gains in the M_2 and the M_3 generations.

MATERIALS AND METHODS

Three durum wheat cultivars (Salihli-92, Ege-88, Gediz-75) in Table 1 were chosen for irradiation using gamma rays. Dry seeds, equilibrated at 11 % moisture content, were irradiated at the Nuclear Research and Training Center Saraykoy-Ankara-Turkey, with 0, 150, 300 Gy (Gy = gray (1 Gray= 10 krad)) gamma rays at Cobalt 60 (Co^{60}) source as a physical mutagen (FAO/IAEA,1997).

Irradiated seeds and control seeds were sown with a density of 400 plants per square meter. Sowing was performed by hand on November 25, 2002 at Alasehir, and on November 20 at Bornova. Harvesting was completed in the bulk method by hand in the first week of July at two locations in 2003. The testing procedure was introduced by Yildirim et al. (1987).

Table 1. Three durum wheat cultivars used in the study

Salihli-92	Registered by Aegean Agricultural Research Institute (12.05.1992)
Ege-88	Registered by Aegean Agricultural Research Institute (26.04.1988)
Gediz-75	Registered by Aegean Agricultural Research Institute (13.05.1976)

M_1 plants grown after mutagenic treatments were propagated based on the spike progeny method. The M_2 seeds obtained from each spike were sown to rows. Selection of mutants was carried out in the M_1 and the M_2 generations. M_2 plants showing a difference from the control were considered to be macro mutant types and the plants with desirable phenotypes were harvested individually in the 2003-2004 growing season. The M_3 progeny from the selected M_2 plants, were selected according to micro mutation procedure which is a method of selecting single plants randomly, were grown in the 2004-2005 growing season (Gaul 1964; 1965). The mutants were identified by visual screening for long spike and maturity and were confirmed by measuring for single spike yield and single plant grain yield in the M_2 and M_3 (Bagnara et al. 1973; Sakin et al. 2005). Histograms of grain yield per plant were used to select plants with the highest 25 % grain yield in each population. The selected plants were advanced to the next generation. Mutant types selected in the M_2 generation were grown in a randomized complete block design with two replications in the M_3 generation. Each plot consisted of 20 seeds planted in 1 m long row with 20 cm between rows and 5 cm between plants within a row. The following traits were measured; Plant height (measured from surface of soil to top of the spike (excluding awns)), spike length (measured from beginning of the spike to end of the spike (excluding awns)), grain yield per plant (10 plants harvested from each plot were threshed and weighed and divided by 10), kernel number per spike (determined by carefully counting the seeds on the primary tiller), tiller number per plant (plants was rooted by hand from soil then root of each plants cleaned by water and counted plants that each plant has a fertile spike), thousand kernel weight (estimated as the average of four 100 kernel samples multiplied with 10).

Statistical analysis

The data obtained for measured traits from two years of growing at Bornova and Alasehir were analyzed and combined over years and locations in order to get a better heritability estimate by applying variance components method (Allard 1999). Single plant yields of the selections done in the original populations were analyzed statistically assuming normal distribution and mean standard deviation and the coefficient of variation (C.V.) values were calculated (Steel and Torrie 1980) while the effects of radiation doses and their cultivar response were compared by Duncan‘s new multiple range test. The data were analyzed with ANOVA using MSTAT-C (Freed et al.,1989). Selection Differential is determined by the selection intensity applied to the population and the phenotypic variation present on the population. Genetic advance is the rate of change on a population under selection and difference between parental and progeny mean values. The genetic gains were estimated by following formula; Genetic gain = *H x Sf x I*, where; *H* = heritability in broad sense, *Sf* = Phenotypic standard deviation, *i* = Selection intensity (1.40, 1.755 and 2.064 for 20, 10 per cent and 5 percent selection, respectively) (Falconer and Mackay,1996).

RESULTS AND DISCUSSION

Selection in the base populations

The results of selection applied in the base populations grown at Bornova and Alasehir in the 2003-2004 growing season are shown in Tables 2 and 3.

Salihli-92 had the high selection differential value at 150 Gy dose at both locations (2.06 and 2.23 g). The expected progeny means were in agreement with the actual mean of selected groups at both locations. Mostly, in all mutant durum wheat populations. the 150 Gy dose applications have showed higher means for grain yield per plant as compared to control populations.

Table 2. The estimates of genetic gains and the expected population means of progenies for simple plant yield based on the selection applied at Bornova in the 2003-2004 growing season

Population	Doses	Mean (g) (n=100)	Standard Deviation	Mean of Selected Group(n=25)	Selection Differential (g)	Genetic Gain (g)	Expected Plant Yield (g)
Salihli-92	0	2.82±0.10	0.99	4.00	1.18	0.22	3.04
Salihli-92	150	2.89±0.14	1.40	4.95	2.06	-0.02	2.87
Salihli-92	300	2.45±0.09	0.96	3.66	1.21	0.04	2.49
Ege-88	0	1.82±0.09	1.27	5.19	3.37	-0.33	1.49
Ege-88	150	2.77±0.16	1.68	5.20	2.43	0.10	2.87
Ege-88	300	1.93±0.10	1.00	3.21	1.28	0.07	2.00
Gediz-75	0	2.80±0.09	0.96	3.96	1.16	0.06	2.86
Gediz-75	150	3.01±0.13	1.36	4.89	1.88	-0.24	2.77
Gediz-75	300	2.49±0.10	1.04	3.76	1.27	0.03	2.52

Table 3. The estimates of genetic gains and the expected population means of progenies for simple plant yield based on the selection applied at Alasehir in the 2003-2004 growing season

Population	Doses	Mean (g) (n=100)	Standard Deviation	Mean of Selected Group(n=25)	Selection Differential (g)	Genetic Gain (g)	Expected Plant Yield (g)
Salihli-92	0	2.87±0.10	1.02	4.16	1.29	0.05	2.92
Salihli-92	150	2.95±0.15	1.56	5.18	2.23	0.00	2.95
Salihli-92	300	2.44±0.20	1.93	3.69	1.25	0.04	2.48
Ege-88	0	2.40±0.12	1.22	4.26	1.86	0.01	2.41
Ege-88	150	2.60±0.18	1.86	5.45	2.85	0.02	2.62
Ege-88	300	1.82±0.09	1.96	3.21	1.39	0.05	1.87
Gediz-75	0	2.89±0.08	0.89	3.99	1.10	-0.03	2.86
Gediz-75	150	2.99±0.14	1.47	5.06	2.07	0.04	3.03
Gediz-75	300	2.55±0.10	1.01	3.85	1.30	0.05	2.60

The source of variation created by the method has been beneficial for breeding quantitative traits. In addition, it has been recorded in wheat that negative micro mutations can decrease the means of quantitative traits. (Borojevic and Borojevic 1972; Kusaksiz 1996; Budak and Yildirim 2001; Irfaq and Nawab 2001; Jamil and Khan 2002). Besides, harmful micro mutations that cause lower means of quantitative traits may be overcome during the selection process. Some with certain agreements between the expected single plant yields and the actual means of the selected groups at this location could be accepted as an indicator of positive selection.

Selection in the progeny populations

The mutant populations had higher plot yield means than the control populations (Table 4). For instance, Ege-88 at 150 Gy dose at Bornova and Alasehir locations (190.9 g and 197.2 g) had high means as compared to control populations respectively (175.2 g and 153.7 g). It could be concluded that mutant populations (by a majority 150 Gy dose) had high plot yield as compared to the control cultivars.The higher expected plot yields obtained for mutant populations could be promising.

Therefore, a second stage selection could be applied to the mutant population in order to select mutant lines with high yield and good agronomical traits. Twenty percent of the top yielding progeny rows in each mutant and control population were selected and genetic gain and expected plot yield were estimated. The results of the second stage selections are given in Table 4. The estimates of genetic gain for the mutant progeny populations were higher than those of the control populations. Ege-88 at 300 Gy dose at Bornova location and Salihli-92 at 150 Gy at Alasehir location had higher genetic gains compared to the control population at both locations, respectively (65.68 g and 82.44 g) (Table 4).

Table 4. The means, range, coefficient of variation, phenotypic standard deviations, genetic gain, expected plot yield of the plot/yields for progeny populations grown at Alasehir and Bornova location in the 2004-2005 growing season (n=25 for each population)

Population	Dose	Mean (g)		Range		C.V (%)		Phenotypic Sd. Deviation		Heritability		Genetic Gain (g)		Expected Plot Yield (g)	
		B	A	B	A	B	A	B	A	B	A	B	A	B	A
Salihli-92	0	151.9	151.5	104.0 261.7	103.4 275.6	30.8	28.0	48.13	41.82	0.72	0.99	48.52	57.96	200.41	209.46
	150	177.7	186.5	112.9 356.3	123.5 270.7	32.7	23.3	59.48	43.22	0.99	0.98	82.44	59.30	260.13	245.79
	300	133.3	134.6	100.9 241.2	105.1 184.3	28.5	17.9	37.17	23.60	0.99	0.97	51.52	32.05	184.81	166.64
Ege-88	0	175.2	153.7	117.2 305.6	117.2 344.1	28.6	28.3	48.17	46.01	0.56	0.81	37.77	52.18	212.96	205.87
	150	190.9	197.2	125.5 310.2	135.0 302.3	25.6	23.9	47.90	44.33	0.14	0.99	9.39	61.44	200.28	258.64
	300	118.1	117.4	76.3 235.4	70.9 236.7	38.2	38.8	45.79	47.39	0.99	0.99	63.46	65.68	181.56	183.08
Gediz-75	0	144.9	142.7	103.3 277.3	114.3 251.6	31.3	25.6	45.22	37.00	0.99	0.71	62.67	36.78	207.57	179.47
	150	167.5	183.6	100.5 296.6	118.9 270.3	29.1	25.9	48.14	46.49	0.61	0.99	41.11	64.38	208.61	248.03
	300	136.5	140.6	101.8 267.8	105.4 241.9	31.8	24.6	42.90	33.79	0.88	0.99	52.85	46.83	189.35	187.43

B: Bornova; A: Alasehir

The high genetic gain estimates obtained as a result of the second stage selection for plot yield in the mutant populations indicated positive effects of selection on means. Some researchers indicated that genetic gain obtained by selection compared each generation of the mutant population or line with the best lines selected from control population (Gaul and Hesemann 1966).

Agronomical characteristics of selected mutant lines

The highest yielding mutant genotypes from each population were advanced to the micro yield testing in the breeding program (Table 5)

Those mutant genotypes had better agronomic traits when compared to the control cultivars. The findings indicated that selection done using micro mutant populations has had higher yield than that of control population. In this research, populations are used usually from the 150 Gy doses which increased the frequency of positive changes (Gaul 1965; Gustaffson et al. 1968). Increasing the dose has enhanced the variability and the frequency of the negative effects (Cagirgan and Yildirim 1989).

The results obtained from this study imply the increases of means in the progeny population were higher as compared to control. The similar results have been reported by Allard (1999); Gustafsson et al. (1968). Kusaksiz (1996); Yildirim et al. (2005); Baser et al.(2007). Kusaksiz and Dere (2009). Reported that some control populations also had positive expected genetic gain. Some experts reported that even in pure lines after selection, genetic variation could be detected (Gustafsson et al.1968; Cagirgan and Yildirim,1989). In practical studies mutations followed by selection or interaction with environmental effects can give unexpected results.

Table 5. Means of five certain traits of mutant and control lines selected at Bornova and Alasehir locations in the 2004-2005 growing season

Population	Doses	Location	Plant yield per plant (g)	Kernel number in spike (number)	1000- kernel weight (g)	Plant height (cm)	Spike Length (cm)
Salihli-92	0	Bornova	4.22	48.06	47.88	72.64	8.03
Salihli-92	150	Bornova	**4.93**	49.12	47.66	64.22	8.94
Salihli-92	300	Bornova	3.70	46.86	47.67	62.54	8.30
Salihli-92	0	Alasehir	4.21	48.60	47.78	72.84	8.10
Salihli-92	150	Alasehir	**5.18**	50.34	47.76	62.80	9.10
Salihli-92	300	Alasehir	3.73	42.18	47.66	63.50	7.24
Ege-88	0	Bornova	4.86	47.10	47.24	75.62	7.52
Ege-88	150	Bornova	**5.30**	47.10	47.16	72.92	7.76
Ege-88	300	Bornova	3.28	49.38	46.66	57.86	7.28
Ege-88	0	Alasehir	4.27	46.50	46.58	73.02	7.24
Ege-88	150	Alasehir	**5.47**	47.34	46.59	69.08	7.76
Ege-88	300	Alasehir	3.26	49.44	46.88	57.38	7.28
Gediz-75	0	Bornova	4.02	48.42	43.40	77.98	7.98
Gediz-75	150	Bornova	**4.65**	49.44	43.56	65.62	8.52
Gediz-75	300	Bornova	3.79	43.98	43.55	60.27	7.20
Gediz-75	0	Alasehir	3.96	49.29	42.88	73.28	8.26
Gediz-75	150	Alasehir	**5.10**	49.32	42.89	64.98	8.42
Gediz-75	300	Alasehir	3.90	41.46	43.02	63.76	7.20

CONCLUSIONS

Selection applied for high individual plant yield in the base population and selection applied for high plot yield in the progeny population resulted in certain mutant lines with improved agronomical and quality characteristics. Therefore, it may be concluded that mutation breeding in durum wheat would be successful if suitable techniques in constructing the base population and in the base and offspring populations are used. The favorable gamma rays dose in the study was found to be 150 Gy, which may avoid detrimental side effects on the fitness characters.

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