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Effects of gamma rays on bread wheat (*Triticum aestivum* L.), cultivar "Bohaine" for its grain yield and other related traits

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ABSTRACT
Bread wheat is one of the cereal crops produced in Sudan. It is most important crop by production and consumption. Improved varieties to wide range of agro-ecologies are more essential to enhance wheat productivity. In this study hundred lines of Bohain derivatives including three checks (Bohaine, imam and Zakia) were evaluated over two consecutive seasons (2016/ 17 and 2017/18) at two locations, vis. Dongola and New Halfa Research Station Farms of the Agricultural Research Corporation (ARC). One Kg seed of Bohaine cultivar was irradiated in sibersdorfe- laboratory- Austria by using seven doses of gamma rays (0, 150, 300, 450, 600, 750 and 900 gray). The objective was to evaluate these mutant lines (M4 and M5) under different conditions for its grain yields and related attributes. High significant differences were found for all the traits studied including yield due to environment effects. The genotype were affected significantly on days to heading, days to maturity, plant height, grains per spike and wheat grain yields. The interaction between genotype and environment were effeced significantly only for days to heading and thousand grain weight due to combined analysis. Grain yield increased in response to application of gamma irradiation with the most of Bohain proginies. Generally, low dose of gamma rays (150 gray) was more efficient because 36 % of 25 selected lines (top yielding) were coming from this dose.
Key words: *wheat, Mutations, Grain yield, gamma radiations*

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تاثير اشعة قاما على القمح الطرى (*Triticum aestivum* L.) الصنف بوهين على الانتاجية ومحدداتها
مدثر جلال عبد الدائم عبد الله
الخلاصة
يعد القمح واحدا من المحاصيل المهمة في السودان من حيث الانتاج والاستهلاك. تحسين الاصناف وتنميتها لتلائم مدى واسع من البيئات الزراعية يعتبر ضروريا لزيادة انتاجية القمح. في هذه الدراسة تم تقييم عدد من السلالات المطفرة المنحدرة من صنف القمح بوهين.تم اختبار م ائ سلالة مطفرة من الصنف بوهين تحتوى كل منهما على ثلاث ة شواهد (بوهين، زكية وامام) خلال الموسمين المتعاقبين 2016 / 17 و 2017 / 18 بمزرعتى البحوث الزراعية بدنقلا وحلفا الجديدة. استخدمت في التجربة سبع جرعات من اشعة قاما (0، 150، 300، 450، 600، 750، و 900 Gray). يعتبر الهدف لهذه الدراسة تقييم للعينات المطفرة تحت ظروف بيئية مختلفة للانتاجية ومتعلقاتها. وجدت اختلافات معنوية لكل الصفات المدروسة متضمنة الانتاجية نتيجة لتاثير البيئات. كما اظهرت النتائج وجود فروقات معنوية لكل عدد الايام حتى الازهار، عدد الايام حتى النضج، طول النبات، عدد الحبوب فى السنبلة وانتاجية القمح نتيجة لتاثير الاصناف. عدد الايام حتى الازهار ووزن الالف حبة فقط تاثرا معنويا نتيجة التفاعل بين الاصناف والبيئة نتيجة للتحليل الجمعى. ذادت الانتاجية نتيجة لتطبيق اشعة قاما لمعظم الخطوط الناتجة من الصنف بوهين. بشكل عام تعتبر الجرعة الاقل هى الاعلى كفاءة فى احداث التباين الايجابى حيث شكلت 36 % نسبة لافضل خمس وعشرون سلالة منتخبة بناء على الانتاجية العالية.

I. Introduction:

Wheat (*Triticum aestivum* L.) is the most important crop among all cereals in the world. It is the versatile cereal food and presented as the stuff of life or king of cereals (Johnson *et al*., 1978). It has the widest distribution and primarily grown for its grains consumed as human food. It ranks first in the world cereal production and it is a staple food of about one third of the world's population (Igtidar *et al*., 2010). Wheat is grown yearly on 215 million hectares. The global amount of wheat produced was over 772 million metric tons in 2020/21 (https://www.statista.com/topics/1668/wheat/).

Wheat is considered as the second most important cereal crop in the Sudan after sorghum and it is consumed and preferred by the majority of the Sudanese. Sudan's population around 42.8 million and their consumption per capita at 65kg (likely to increase), the current national consumption of 2.8 million metric tonnes (MT) in 2019 will soon hit 3.2 million MT in 2020/21. Sudan continues to meet its increased domestic demand through expensive imports and there is big challenge to reduce the gap between production and

consumption (https://www.afdb.org/sites/default/files/2020/10/08/icarda_sudans_bumper_harvest_final.pdf). Induce mutation is one of breeding methods to improve wheat productivity. One of high yielding Sudanese wheat cultivars was subjected to induce mutation in sibersdorfe laboratory in 2013. All muted lines were used on this experiment were derived from Bohaine cultivar which has been released in Sudan in 2006. The objective of this work is study of wheat grain yield across the two contrasting areas in Sudan Dongola (Normal and traditional wheat area) and New Halfa (New wheat expansion and stressed area).

II. Methodology:

The International Atomic Energy Agency (IAEA) supported the development of mutants derived from Sudanese bread wheat cultivar (Bohain). The cultivar was treated with physical mutation (gamma ray) in Seibersdorf laboratory- Austria 2013. Seven doses; 150, 300, 450, 600, 700 and 750 and 900 gray, were used to induce mutations. The M1 to M3 generations were planted in seasons 2013/14 to 2015/16. Depending on the agronomic performance in M3 there are one hundred lines including three checks (Bohaine, Zakia and Imam) have been selected to use on this study (Table 1). The set in (M4 and M5) was planted at the two locations (Dongola and New Halfa) for the two seasons (2016 / 17 and 2017 /18). Dongola Research Station Farm (high terrace) is located near Dongola City Center (Latitude 19◦ - 10◦ N and Longitude 29◦ - 30◦ E). Soil was described as sandy clay loam in texture, deficient in nitrogen and phosphorus as well as low in organic matter. The pH of soil is 7.6 (Izzedin, 1996). Generally the winter growing season was relatively long and cool compared with the other testing site. The second site New Halfa Research Station Farm lies in North East of New Halfa town (Latitude 15◦ N and Longitude 35◦ E). Soil of the New Halfa Research Farm is heavy clay textured soil with clay content less than 60%. The natural fertility of this soil is low to medium according to the status of organic carbon (Kamal, 2006). Alpha lattice design was used with four replications and all cultural practices were applied as the recommended in Agricultural research corporation (ARC) - Sudan.

Table 1: Bohaine derivative lines with their gamma rays treated

Ent No	M1 plant to Progeny row No	Gamma Doses (Gray)	Ent No	M1 plant to Progeny row No	Gamma Doses (Gray)
1	Bohaine	check	26	81	300
2	Zakia	check	27	83	300
3	Imam	check	28	84	300
4	8	150	29	86	300
5	13	150	30	89	300
6	14	150	31	97	450
7	18	150	32	99	450
8	19	150	33	101	450
9	20	150	34	105	450
10	21	150	35	106	450
11	24	150	36	111	450
12	36	150	37	113	450
13	41	150	38	116	450
14	42	150	39	117	450
15	43	150	40	119	450
16	47	150	41	127	450
17	50	150	42	128	450
18	52	150	43	130	450
19	64	300	44	131	450
20	68	300	45	132	450
21	74	300	46	133	450
22	75	300	47	135	450
23	76	300	48	140	450
24	78	300	49	141	450
25	79	600	50	142	450

Table 1 (cont): Bohaine derivative lines with their gamma rays treated

Ent No	M1 plant to Progeny row No	Gamma Doses (Gray)	Ent No	M1 plant to Progeny row No	Gamma Doses (Gray)
51	150	450	76	195	750
52	151	600	77	196	750
53	152	600	78	197	750
54	153	600	79	198	750
55	154	600	80	200	750
56	155	600	81	202	750
57	156	600	82	208	750
58	157	600	83	218	750
59	158	600	84	226	750
60	159	600	85	229	750
61	161	600	86	238	750
62	163	600	87	239	900
63	164	600	88	240	900
64	167	600	89	244	900
65	168	600	90	250	900
66	169	600	91	255	900
67	170	600	92	257	900
68	171	600	93	259	900
69	173	600	94	261	900
70	175	600	95	262	900
71	182	600	96	271	500
72	185	600	97	272	500
73	191	600	98	273	500
74	193	750	99	274	500
75	194	750	100	283	500

III. Results and discussion:

The combined analysis of Bohaine mutant yield trials across the two seasons and the two locations showed highly significant differences for all the traits studied including yields (Table 2). Differences among genotypes were highly significant for days to heading, days to maturity, plant height and grains per spike. Grain yield and thousand grain weight were affected significantly but, spikes per square meter, harvest index and biomass had no significant effect.

The genotype x environment interaction showed significant difference for thousand grain weight and highly significant on days to heading. Other studied characters such grain yield, biomass, harvest index, grains per spike, spikes per square meter, plant height and days to maturity had no significant effects. Our findings in same line with that found by Laghari *et al*., (2012) and Samia *et al*., (2017), who reported that variations in some wheat characters has been occurred due to induced mutations.

2.9 Grain Yield (t/ha):

Grain yield showed highly significant ($P \leq 0.01$) differences in locations, seasons and their combined except in New Halfa season 2017 which showed significant difference at $P \leq 0.05$. Only 25 top yielding lines were selected to present in table (3). The grand mean of top twenty five yielding lines was 4.949 and 3.167 t/ha at Dongola, while in New Halfa was 3.092 and 2.078 t/ha for the two seasons, respectively.

Comparison between the two seasons showed that, grain yield was higher in the first season in the two tested areas. Higher mean grain yield was found at Dongola for both seasons compared to that found in New Halfa, which might refer to suitable wheat condition at north of Sudan.

For combined analysis, all mutant lines were ranking over the three checks. The highest grain yield was obtained by progenies no. 22 (3.670 t/ha), progeny no. 7 (3.549t/ha) and progeny no. 11 (3.539 t/ha). The lowest grain yield was the check Imam (3.008t/ha). Improving wheat characteristics including yields have successfully been developed by mutagenic inductions in same line with that found by Reddy (1999) and Rahman (1987). Mohammed and Abdollah (2011) reported that induced mutation by gamma rays had effects on grain yield, thousand grain weights (TGW) and harvest index of wheat crop. Our findings are in-line with that of grain yield and 1000 grain weight but in contrary with that found on harvest index. Modifying one or two major traits such as TGW may develop and improve well-adapted plant varieties by increasing their productivity (Yusuff *et al*., 2014). Njau *et al.* (2005) found that some mutant lines performed significantly better than the two elite lines in yield performance. Those results clearly demonstrated the usefulness of mutation as a tool of creating variability in wheat crop.

Effects of different dose of gamma rays on wheat grain yield:

The results indicated that the Bohaine derivative lines were affected significantly due mutations happened by gamma rays. Similar result was found by Samia *et al*., (2017), who found that treatments of gamma irradiation caused significant variations in all of the traits studied including yields. Generally, low dose of gamma rays (150 gray) was more efficient because 36 % of top 25 yielding lines wes coming from this dose (Table 4). These findings in same line with that found by Muhammad *et al*., (2003) who concluded that lower dose of 10 kard had beneficial effect on most of the parameters including grain yields.

Table 2: Mean squares for environment, genotype and their interaction of nine characters of 100 Bohaine mutant lines over two locations (Dongola and New Halfa) and seasons (2016/17 and 2017/18).

Trait	Environment (E)	Genotype (G)	G x E
Days to heading	12621.97**	24.76**	5.523**
Days to maturity	16956.07**	11.06**	4.70 ^{ns}
Plant height	13468.97**	165.87**	26.991^{ns}
Spikes / m 2	1321203.8**	4847.33^{ns}	4938.9^{ns}
Grain / spike	11385.08**	62.645**	27.36^{ns}
Thousand grain weight	230.28**	33.72*	27.48*
Harvest index	6406.45**	52.65 ^{ns}	40.23^{ns}
Biomass	969.43**	6.953 ^{ns}	4.41^{ns}
Yields	277451497.5**	1157847.3*	675779.5^{ns}

*, ** significant at 0.05and P 0.01 probability levels, respectively
ns = not significant

Table 3: Rank and means of grain yield (t/ha) for 22 selected Bohaine mutant lines and three checks grown at Dongola and New Halfa, seasons 2016/17 and 2017/18.

	Mean					Rank				
Ent No	Dongola		New Halfa		Combined	Dongola		New Halfa		combined
	2017	2018	2017	2018		2017	2018	2017	2018	
1-Bohaine	4.25	2.77	3.13	1.99	3.035	22	19	13	15	23
2-Zakia	3.98	3.10	2.95	2.011	3.010	24	16	19	14	24
3-Imam	5.10	2.75	3.16	2.034	3.008	13	20	11	13	25
4	5.14	2.67	2.93	1.81	3.138	11	22	21	21	21
5	5.03	3.13	3.25	2.305	3.429	16	15	7	6	9
6	5.44	3.35	3.00	2.192	3.496	7	11	17	9	5
7	5.72	2.66	3.15	2.667	3.549	1	23	12	1	2
8	4.31	3.43	3.18	2.247	3.292	20	7	10	8	15
9	4.33	3.15	2.79	2.453	3.181	19	14	23	4	18

10	4.33	3.42	2.53	2.366	3.162	18	8	25	5	20
11	5.05	3.77	3.07	2.266	3.539	14	2	14	7	3
12	5.25	3.53	2.79	2.11	3.420	9	5	24	11	10
13	5.20	3.64	2.89	2.106	3.459	10	3	22	12	7
14	5.50	3.77	2.98	1.882	3.533	4	1	18	19	4
15	5.64	2.59	3.30	2.149	3.420	2	24	4	10	11
16	5.47	2.96	3.04	1.787	3.314	6	18	15	22	14
17	4.22	3.36	3.22	1.895	3.174	23	9	9	18	19
18	5.57	2.97	3.35	1.957	3.462	3	17	3	17	6
19	5.11	3.17	3.28	1.717	3.319	12	13	6	24	13
20	3.92	3.51	3.24	1.363	3.261	25	6	8	25	16
21	4.99	3.36	2.95	1.735	3.259	17	10	20	23	17
22	5.04	3.61	3.43	2.599	3.670	15	4	1	2	1
23	5.48	3.32	3.03	1.989	3.455	5	12	16	16	8
24	4.26	2.44	3.29	2.476	3.117	21	25	5	3	22
25	5.39	2.74	3.37	1.832	3.33	8	21	2	20	21
Mean	4.949	3.167	3.92	2.078	3.321					
CV %	18.9	23.34	15.64	28.34	27.43					
SE±	0.857	0.66	0.46	0.542	0.875					
Effect	**	*	**	**	*					

*, ** significant at ≤ 0.05and P 0.01 probability levels, respectively

Table 4: Top yielding Bohaine mutant lines with their treated doses.

Ent	Source	Gamma Doses (Gray)
1	Bohaine	0 (Check)
2	Zakia	0 (Check)
3	Imam	0 (Check)
4	13	150
5	19	150
6	20	150
7	24	150
8	36	150
9	41	150
10	47	150
11	50	150
12	52	150
13	64	300
14	68	300
15	74	300
16	76	300
17	81	300
18	83	300
19	84	300
20	97	450

21	101	450
22	105	450
23	106	450
24	127	450
25	141	450

IV. Conclusions:

Mutation breeding considered to be one of the most superior methods or best technique to enhancement of wheat crop. Genetic variability has been found among Bohaine mutant lines for most of the traits studied including yields. Results obtained during this study showed that 22 wheat mutant lines having high grain yield combined with some desirable yield traits. Low dose of gamma rays (150 gray) was more suitable to create novel variations on wheat crop.

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