The Effect of Gamma Rays and Different levels of Nitrogen Fertilizer on the Productivity of Wheat (*Triricum aestivum* L.)

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Received: 07/04/2019 Accepted: 11/05/2019

Abstract

An experiment was conducted at the Soils and Water Research Department, Nuclear Research Center, Atomic Energy Authority, Egypt, in the year 2018, to study the effect of gamma radiation at different doses (zero, 40, 80 and 160 Gy) on growth and yield of wheat fertilized with 0.0, 120 and 240 N kg ha^{-1} as urea fertilizer. The experiment was laid out in randomized complete block design with three replicates. Results revealed that, straw and grains yields were significantly fluctuated between the increase and decrease, furthermore, under 80 Gy gamma rays, the highest value was 15.677 kg $plot^{-1}$, observed at rate of 240 N kg ha^{-1} in addition to 80 Gy. Grains increased compared to all treatments and control. Under gamma rays, the highest values of straw and grains were 9.974 kg $plot^{-1}$ and 15.677 kg $plot^{-1}$ observed rate of 240 kg ha^{-1} plus dose of 40 and 80 Gy radiation respectively. The data indicated that, N uptake by straw and grains, in non-irradiated treatments, were significantly increased with increasing the doses of nitrogen fertilizer levels 100 kg N fed^{-1} and gamma rays dose up to 80 Gy. Furthermore, the highest N uptake of 98.3 g $plot^{-1}$ and 181.1 g $plot^{-1}$ were observed at rate of 240 kg N ha^{-1} in addition to zero Gy, compared to control, whereas, under doses 80 Gy the highest values of N uptake were 120.1 g $plot^{-1}$ and 195 g $plot^{-1}$ which recorded with straw weight and grains yield, respectively.

Key word: Nitrogen fertilizer, Gamma rays, Wheat.

Introduction

Gamma radiations are considered to be most penetrating than other radiations like alpha and beta rays (Kovacs and Keresztes, 2002). These rays produce free radicals in cells when comes in contact with atom or molecule which can damage or modify important components of plant cells depending upon exposure time. Al Salhi *et al.*, (2004), Hameed *et al.,* (2008), and Hamideldin and Hussin, (2014), observed that exposure of seeds to gamma rays influenced protein synthesis, changes in antioxidative system, leaf gas exchange, and enzymatic activity and hormone balance. Exposure of gamma radiations exhibits two types of effect in a biological system. One is direct effect in which electron excitation occurs results in production of secondary oxygen species, while other is indirect effects in which DNA helix affects leads to DNA breakage (Blagojevic, 2015). Several positive mutations have been created in agricultural crops by using gamma irradiations. Crops with improved characteristics have successfully been developed by mutagenic inductions (Inthima, 2014). It encourages above ground vegetative growth, increases the plumpness of the grains and acts as growth regulator, which may govern the utilization of potassium and phosphorus etc. Moreover, its application tends to produce succulence, and a quality particularly desirable in crops used as feed for animals. Misra *et al.*, (1983) concluded from their study that the application of 50 kg N ha^{-1} significantly increased and spike length similarly. Siddique *et al.*, (1983) reported that higher doses of nitrogen increased grain yield significantly compared to control.

The objective of this study is to explore the possibility of increasing forage and grain yield of wheat with different of radiation doses and nitrogen levels.

Material and methods:

A field experiment was carried out at the soil and water Dept., Nuclear Research Center, Atomic Energy Authority, Inshas, Egypt. 30o 24` N latitude, 31o 35` E longitude, while the altitude is 20 m above the sea level. Some physical and chemical properties of the experimental soil sample were shown in Table (1).

Table 1. Some physical and chemical properties of the experimental soil

Mechanical analysis					Soluble mmol/L (in saturation extract)							
					Cations mmol/L				Anions mmol/L			
Coarse sand %	Fine Sand%	Silt %	Clay %	Soil texture	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
64.1	24.4	8.8	2.7	Sand	15.20	4.60	2.17	0.89	0.00	3.40	6.50	12.90

pH 1:25	Organic matter %	HCO_3 %	EC dSm^{-1} 1:5	Available nutrients mg kg^{-1}		
				N(kcl 1:5)	P($NaHCO_3$)	K(NH4-acetate)
8	0.03	1.90	0.28	5	2	0.2

Plant materials: A homogenous lot of wheat seeds, (*Triticum Asetivum* L.), cv. Sakha 69 were obtained from the Crop Institute, Agricultural Research Center, Giza, Egypt.

Gamma irradiation: Dry seeds were exposed to doses of gamma irradiation (zero, 40, 80 and 160 Gy), using gamma – rays which were generated from the cobalt 60 source at Cyclotron Department, Nuclear Research Center, and Atomic Energy Authority, Egypt.

Experiment: The experiment was laid out in randomized complete block design with three replicates in plots measuring 3 x 2.5 m^2 each plot having 6 rows, 30 cm row to row distance. A seed of wheat cultivar sakha 69, was sown and fertilized with Zero N, 120 and 240 kg N ha^{-1} of N as urea fertilizer, N was applied in split doses, half at sowing time and the other at the beginning of flowering stage. A basal dose of P and K was applied according to recommended rate as a source of single super phosphate and potassium sulphate.

The experiment design included 12 treatments, three doses of N applied and three doses of gamma rays irradiation treatments, besides the control, which were as following:

(No Ro) as a control.
(N0 R1) as N0 + 40 Gy
(N0 R2) as N0 + 80 Gy
(N0 R3) as N0 + 160 Gy
(N1 R0) as 120 kg N ha^{-1} + 0 Gy
(N1 R1) as 120 kg N ha $^{-1}$ + 40 GY
(N1 R2) as 120 kg N ha $^{-1}$ + 80 Gy
(N1 R3) as 120 kg N ha $^{-1}$ + 160 Gy
(N2 R0) as 240 kg N ha^{-1} + 0 Gy

(N2 R1) as 240 kg N fed^{-1} + 40 Gy
(N2 R2) as 240 kg N ha^{-1} + 80 Gy
(N2 R3) as 240 kg N ha^{-1} + 160Gy

Plant nitrogen uptake, production of wheat crop, were uprooted at harvest (240 day for wheat) and separated into straw and grain.

Methods of analysis: Chemical and physical analysis of tested soil samples was carried out according to Page *et al., (*1982) and Black (1965).

Statistical analysis:

The analysis of variance for the final data was statistically assayed using the system ANOVA and the values of L.S.D were calculated at 0.05 levels according to (SAS 1987).

Results and Discussion:

Straw spikes yield (kg plot^{-1}):

Data in Table (1) shows that, in general, the straw spikes weight of wheat which was significantly fluctuated between the increase and decrease as affected by application of radiation rates and nitrogen doses. The main effect of N fertilization shows the following rank: 120 kg N ha^{-1}>240 kg N ha^{-1}> Zero N and the overall average of Gamma irradiation doses 80Gy> 40Gy >160Gy> Zero Gy. On the other hand, the highest straw spikes weight (4.029kg plot^{-1}) was observed in the plot which received 120 kg N ha^{-1} plus gamma rays irradiation at dose of 0.0 Gy and followed by spikes yield (4.00 kg plot^{-1}) recorded in plot received 120 kg ha^{-1}plus gamma rays at dose of (40 Gy) as compared to the control (N0 R0) (1.392 kg plot^{-1}), relatively increased by about 189.44 % and 179.89% over control, respectively. Whereas, the lowest straw spikes weight (1.530 kg plot^{-1}) observed in plot received 0.0 (kg N fed^{-1}) plus gamma rays at dose of (80 Gy) as compared to the control (N0 R0) (1.392 kg plot^{-1}), relatively increased by about 9.91% over control. Singh and Datta (2010) pointed out that, gamma irradiation in low doses of 10 rad had beneficial effect on growth and yield of wheat. Singh and Datta (2010), observed that the low doses of gamma irradiation (0.01-0.10) K Gy, improved plant vigor, flag leaf area, total number of tillers, number of ear baring tillers, grain number/spike and grain yield.

Table 1. Straw Spikes weight (kg plot^{-1}) of wheat as affected by gamma Irradiation (Gy) and N – fertilization levels.

N- fertilizer kg ha^{-1}	Gamma irradiation doses (Gy)				
	Zero Gy	40 Gy	80 Gy	160 Gy	mean
Zero N	1.392	1.401	1.53	1.39	1.428
120 kg N ha^{-1}	4.029	4.000	3.399	3.89	3.830
240 kg N ha^{-1}	3.396	3.86	3.896	3.86	3.753
mean	2.939	3.087	2.942	3.047	
LSD $_{0.05}$	N: 071 Gy : 0.69 N*Gy : 0.80				

Straw weight (kg plot$^{-1)}$:

Data in Table (2) demonstrates, straw weight of wheat which was significantly between the increase and decrease as affected by different doses of N fertilizer levels and gamma rays radiation. The highest value of straw weight was 12.974 kg plot^{-1} observed in the plot that received 240 kg N ha^{-1} plus dose of 80 Gy and followed by straw weight of 8.067 kg plot^{-1} in the plot received rate of 50 kg N fed^{-1} plus dose of 80.0 Gy which was higher than the control treatment which recorded 1.017 kg plot^{-1}. Also, data reveals that, the highest straw weight of 3.541 kg plot^{-1} reduced in plot received rate of 100 kg fed^{-1} plus dose of 40 Gy, relatively increased over control, respectively. Studies by Moench (2010) revealed that exposure to low doses led to an increase of the assimilatory pigments content, while at high doses it decreased significantly as compared with non-irradiated ones.

Table 2. Straw weight (kg plot^{-1}) of wheat as affected by gamma rays irradiation (Gy) and N – fertilization levels.

N- fertilizer kg ha^{-1}	Gamma irradiation doses (Gy)				
	Zero Gy	**40 Gy**	**80 Gy**	**160 Gy**	**mean**
Zero N	1.017	1.060	4.313	1.007	1.849
120 kg N ha^{-1}	3.422	3.450	8.067	3.310	4.562
240 kg N ha^{-1}	3.331	3. 341	9.974	3.230	5.512
mean	2.590	2.255	7.451	2.516	
LSD $_{0.05}$	N: 480 Gy : 0.920 N*Gy : 1.430				

Grains yield (kg plot^{-1}):

Data in Table (3) shows that, grains yield of wheat was affected by different doses of N fertilizer levels and gamma rays radiation. On the other hand, the highest grains yield of 12.999 kg plot^{-1} which produced in plot received rate of 240 kg ha^{-1}plus dose of 40 Gy of gamma rays radiation, followed by grains yield of 12.200 kg plot^{-1} which was observed in plot received rate of 120 kg ha^{-1} plus dose of 40 Gy gamma rays radiation, higher than the control treatment which recorded 3.837 kg plot^{-1}, respectively. Rahm Din *et al.,* (2003), used low dose gamma irradiation to improve grain development and yield attributes of wheat, also they affirmed the stimulatory effect of gamma irradiation on flag leaf area. Singh and Datta (2010), ascertained that, gamma irradiation in high doses (30-35 K rad) had reduction effects on growth and yield of wheat. Studies on the effects of gamma-rays from 60Co on wheat had been reported by Melki and Marouani (2009). Marcu *et al.,* (2014), and Farag *et al.,* (2013), indicated that, wheat grains irradiated with low dose (10Gy) of Gamma radiation surpassed the other two irradiation doses (20 and 30 Gy) and the control in each of plant height (cm), spike length (cm), flag leaf area (cm) at heading, number of spikes/m^2, number of spikelets/spike, number of grains/spikelet, grain weight/spike (g), grain weight/spikelet (mg), 1000- grains weight (g) and grain, straw and biological yields/fad. Each increment in nitrogen supply caused significant increase in each above-mentioned yield and yield components studied. Mohammad and Abdollah (2011) showed that grain yield increased in response to application of gamma irradiation, as compared to the non-irradiated crop. 25 and 50 Gy gamma irradiation produced the highest grain protein content. Increasing in gamma irradiation being more than 50 Gy decreased grain protein by about 28% to 67%.

Table 3. Grains yield (kg plot-1) of wheat as affected by gamma irradiation (Gy) and N – fertilization levels.

N- fertilizer kg ha^{-1}	Gamma irradiation doses (Gy)				
	Zero Gy	**40 Gy**	**80 Gy**	**160 Gy**	**mean**
Zero N	3.837	3.840	2.970	2.910	3.389
120 kg N ha^{-1}	10.194	12.220	9.898	9.880	10.548
240 kg N ha^{-1}	10.995	12.999	15.767	13.000	13.190
mean	8.342	9.686	9.545	8.597	
LSD $_{0.05}$	N: 0.480 Gy : 0.920 N*Gy : 1.430				

N – Uptake by straw and grains yield:

Data shows that, the increments in the quantity of N-uptake by straw and grain yield of wheat fertilized - N with gamma rays could be arranged in the following descending order; 80 Gy > 40 Gy > zero Gy > 160 Gy by straw, with grain yield 80 Gy > 40 Gy > 160 Gy > zero Gy. In general, N-uptake by straw and grain yield was significantly increased with increasing the doses of nitrogen fertilizer levels and gamma rays radiation (Tables 4 and 5). Furthermore, under 80 and 40 gamma rays, the highest N uptake by straw and grains yield of 120.1g plot^{-1} and 195g plot^{-1} were produced in plot received rate of 240 kg N ha^{-1} + 80 and 40 Gy, relatively increased by about 55.4% and 61.7% higher than the control which recorded 77.3 g plot^{-1} and 120.6 g plot^{-1}, respectively. Under the highest gamma rays (160 GY), decreased N uptake by straw and grains yield of 73.6g plot $^{-1}$ and 150 g plot^{-1} which observed in plot received zero kg N fed^{-1} + 160 Gy gamma rays radiation, relatively decreased than the control which recorded 77.3 g plot^{-1} and 120.6g plot^{-1}, for straw and grains yield, respectively. Generally, under gamma rays the highest values of N uptake by straw and grains up to 80 Gy and 100kg N fed^{-1}. The response of wheat plants to nitrogen application may be due to the increase of available (N) in soil. These results are in line with those obtained by Gehan *et al.,* (2011). El-Said and Mahdy (2016) demonstrated that straw yield (ton/fed) was observed with adding 60 kg N /fed. The increase in these characters with the increase of nitrogen level might due to the role of nitrogen in activating the growth and yield components. This reflects the important of nitrogen in building up the photosynthetic area of wheat plants and consequently accumulation of more dry matter, which is reflected in grain yield and its components.

Table 4. N – Uptake by grains yield (kg plot^{-1}) of wheat as affected by gamma irradiation (Gy) and N – fertilization levels.

N- fertilizer kg ha^{-1}	Gamma irradiation doses (Gy)				
	Zero Gy	40 Gy	80 Gy	160 Gy	mean
Zero N	120.6	140.1	151.2	150.0	140.5
120 kg N ha^{-1}	179.1	184.6	187.1	173.0	181.0
240 kg N ha^{-1}	181.1	186.5	195.0	180.1	185.7
mean	160.3	170.4	177.8	167.7	
LSD $_{0.05}$	N: 11.02 Gy : 11.30 N*Gy : 14.17				

Table 5. N – Uptake by Straw weight (kg plot^{-1}) of wheat as affected by gamma irradiation (Gy) and N – fertilization levels.

N- fertilizer kg ha^{-1}	Gamma irradiation doses (Gy)				
	Zero Gy	40 Gy	80 Gy	160 Gy	mean
Zero N	77.3	78.1	106.1	73.6	83.8
120 kg N ha^{-1}	99.1	101.2	118.2	96.3	103.7
240 kg N ha^{-1}	98.3	102.2	120.1	97.0	104.4
mean	91.6	93.8	114.8	89.0	
LSD $_{0.05}$	N: 10.20 Gy : 10.33 N*Gy : 13.27				

Conclusion:

The results of the above research showed that under 80 Gy of gamma rays irradiation recorded high productivity with straw and grains yield at different levels of nitrogen fertilizer, while under gamma rays at dose of zero and 80 Gy plus 240 kg N ha^{-1}, the productivity was reduced with the same sequence. Also, nitrogen content in straw and grains took the same trends with or without gamma rays plus different nitrogen fertilizer levels.

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تأثير أشعة غاما وإضافة معدلات مختلفة من التسميد الآزوتي في إنتاجية القمح الطري (*Triricum aestivum* L.)

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تاريخ الاستلام: 2019/04/07 تاريخ القبول: 2019/05/11

الملخص

أجريت تجربة حقلية لدراسة تأثير أشعة جاما عند معدل (صفر 40 و80 و160 جراى) في نمو وإنتاجية القمح المسمّد بمعدلات (صفر، و50 و100 كغ آزوت/ فدان) على صورة سماد يوريا. أضيف السماد على دفعتين الأولى وقت الزراعة، والأخرى عند بدء مرحلة التزهير. أضيف الفوسفور والبوتاسيوم بالمعدل الموصى به في صورة سوبر فوسفات وكبريتات البوتاسيوم. أظهرت نتائج الدراسة في حالة عدم تأثير الإشعاع، تسجيل أعلى إنتاجية لمحصول القش والحبوب، حيث سجلت القيم 3.422، 10.995 كغ/قطعة تجريبية عند معدل سمادي 50 كغ/فدان مقارنة بالشاهد الذي سجل 1.017، 3.837 كغ/قطعة تجريبية على التوالي. في حالة تأثير الإشعاع، سجل أعلى إنتاجية لمحصول القش والحبوب 9.974، 12.999 كغ/قطعة تجريبية عند جرعة إشعاعية 80 جراى + 100 كغ آزوت/فدان مع القش، وعند جرعة إشعاعية 40 جراى + 100 كغ آزوت/فدان مع الحبوب مقارنةً بالشاهد الذى سجل 4.313 ، 3.840 كغ/قطعة تجريبية عند جرعة إشعاعية 40 و80 جراى + صفر معدل سمادي على التوالي. بالنسبة للنتروجين المستفاد منه بالقش والحبوب، في حالة عدم تأثير الإشعاع، سجلت أعلى إنتاجية 99.1، 181.1 غ/قطعة تجريبية عند معدل سمادي 240 كغ/هكتار، بينما في حالة تأثير الإشعاع، سجلت أعلى إنتاجية من القش والحبوب 120.1، 195 غ/قطعة تجريبية كانت عند الجرعة السمادية 80 جراي + 240 كغ آزوت/هكتار، على التوالي.

الكلمات المفتاحية: التسميد الآزوت، أشعة جاما، القمح.