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EFFECT OF IRRIGATION INTERVALS, POTASSIUM FERTILIZER RATES AND STORAGE PERIOD ON SORGHUM (*Sorghum bicolor L. Mench*) SEED VIABILITY AND ITS SEEDLING VIGOR.

El-Emam, A. A. M.; I. F. Mersal and M. I. El-Abady
Seed Tech. Res. Sec. Field Crops Res. Institute, A.R.C.

ABSTRACT

Storage studies were carried out at seed Technology Unit Lab. Mansoura, Dakahlia during November 2005 till April 2008 on sorghum (*Sorghum bicolor L. Mench*) seed produced from field experiment which was conducted at the Experimental farm of El-Serw Agriculture Research Station, Dakahlia Governorate in 2005 and 2006 seasons, to study the effect of three irrigation intervals i. e. 14, 21 and 28 days, three potassium fertilizer i. e. 0, 24 and 48 Kg K_2O/fed and four storage periods i. e. 0, 6, 12 and 18 months on germination percentage, seed viability and seedling vigor .

The results revealed that prolong irrigation intervals and storage period reduced germinability (as measured by germination percentage, germination after aging, first count, germination index, germination energy and germination rate) and seedling vigor (seedling length, seedling dry weight and its vigor index), meanwhile, increased mean germination time. Increasing potassium fertilizer rates improved seed viability and seedling vigor traits, on the contrast, decreased mean germination time. High significant effect for the interaction between storage period x irrigation intervals, storage periods x potassium fertilizer rates and irrigation intervals x potassium fertilizer rates were obtained for all studied traits.

The results suggested that sowing grain sorghum (c.v. Dorado) under limited irrigation conditions and fertilized with 48 Kg K_2O/fed plays a prominent role in increasing seed quality under impact of storage periods.

INTRODUCTION

The need for increased food production in Egypt requires the continued development of new agricultural lands which mostly suffer from limited irrigation water. Development of such land is rarely possible without irrigation water regime. Suitable fertilization proved helpful in mitigation the adverse effects of water stress and decreases the deterioration of the resultant seed during storage. The choice of plant materials which posses high efficacy of water utilization or high adaptability for saving water would be great advantage in this context. Such adaptation remains effective until stress conditions are sever or prolonged (Saxena, 1985). Grain sorghum crop (*Sorghum bicolor L. Monech*) is one of the worlds leading cereal crops, providing food, feed, fiber, fuel and chemical/ biofuels feed- stock across a range of environments and production systems. Sorghum plant has an extensive root system and its drought tolerance makes it suitable for limited irrigation conditions. The environment experienced by the mother plant before seed maturity can have large effects on the germination of seed produced

(Roach and Wulff, 1987). Water deficit was reported to reduce rate and percentage of germination, seedling shoot and root (Sajjan *et al.*, 2004 and Wondimu-Bayu *et al.*, 2005). El Hawary *et al.* (2008) found that prolonged irrigation intervals decreased seed quality traits, for both germination percentage and rate, plumule length, radical length, seedling dry weight and seed germination after aging.

Status of minerals in plant nutrition was stated to play a critical role in increasing plant resistance to drought stress (Marschner, 1995). One of the mineral nutrients is potassium which has an important effect for increasing plant tolerance to water stress and activates the enzyme system. Increased potassium during the late stages of maturation increased the germinability of sorghum seed (Arnold *et al.*, 1995). El Hawary *et al.* (2008) recorded that increasing potassium fertilizer rate up to 48 Kg K_2O/fed increased seed viability and seedling vigor compared with the unfertilized with potassium.

Seeds are living organisms, and the shelf life of the seed is affected by previous plant life cycle and factors as soil nutrition which accumulated in high amounts (during the development of the seed) to be used later during germination (Gokce, 2006) such compositions of seeds appear to play an important role in determining the general storability behavior of seeds (Vijay *et al.*, 2009).

During storage, seed viability was reduced because of mold growth, heating, damage aging and greater insect damage, (FAO, 1983). Prolonging the storage period of sorghum seed showed a reduction in viability (Patil and Jarhad, 1987). Rao *et al.* (1993) recorded that germination percentage of sorghum seed decreased with increased storage period. Poonam-Singh, *et al.* (2004) found that shoot length, root length and seedling dry weight of sorghum gradually decreased with an advance in storage period. Organic matter content of grain sorghum did not change in 7-9 storage months, but it decreased from 97.8 to 91.9% over a 17- months period (Mashilla Dejene *et al.*, 2006). Seed viability is affected by many factors among them storage method and period (Mashilla Deijene *et. al.*, 2006).

El Hawary *et al.* (2008) studied the interaction between irrigation intervals and potassium fertilizer rates, they found that at the highest water stress (irrigation every 28 days), application potassium at the rate of 48 Kg K_2O/ fed gave the highest values of seed quality.

The aim of this study was to investigate the effect of different irrigation intervals, potassium fertilizer rates and stored periods on seed viability and seedling vigor of grain sorghum (*Sorghum bicolor* L. Mench).

MATERIALS AND METHODS

Storage studies were carried out at seed Technology Unit Lab. Mansoura, Dakahlia during November 2005 till April 2008 on seed produced from field experiment which was conducted at the Experimental farm of El-Serw Agriculture Research Station, Dakahlia Governorate in 2005 and 2006 seasons, to study the effect of three irrigation intervals i. e. 14, 21 and 28 days, three potassium fertilizer i. e. 0, 24 and 48 Kg K_2O/fed. and four storage periods i. e. 0, 6, 12 and 18 months on germination percentage, seed viability and seedling vigor .

Samples of grain sorghum (c.v. Dorado) for field experiment were obtained from Sorghum Crops Research Program at field Crop Research Institute, Agriculture Research Center, Giza, Egypt. Field experiment was laid out in a split plot design with three replications. Irrigation treatments were allocated in the main plots and the sub plots were assigned to potassium fertilizer rates. The area of each sub plot was 10.5 m^2 (6 ridges 50 cm apart and 3.5 m long). All agriculture practices were performed as recommended by Ministry of Agriculture and Land Reclamation.

Three irrigation treatments applied, irrigation every 14 (control), 21 and 28 days throughout the growing season. The irrigation treatments started 35 days after sowing. Three potassium fertilizer rates, i.e. 0, 24 and 48 Kg K_2O /fed were applied in the form of potassium sulphate (48% K_2O). Potassium fertilizer was applied at 35 days after sowing date. After harvest, sample of each treatment was sieved, cleaned from husk and dust, then seed moisture content determined according to (ISTA, 1985), it ranged between 12.5 to 13.6% before stored in cloth bags. Four storage periods, i.e. 0, 6, 12 and 18 months were applied under laboratory conditions to determine seed technology characters.

Sorghum seed samples of each storage period were undergo to various laboratory testes for evaluating seed quality traits. These include the following:

Germination percentage and accelerated aging test (Germination after seed aging) were performed according to International Seed Testing Association (ISTA, 1985) and defined as the total number of normal seedlings after 10 days.

First count was performed according to International Seed Testing Association (ISTA, 1985).

Germination rate defined according to Bartlett (1937).

$$\textbf{Germination rate} = \frac{a + (a + b) + (a + b + c) + \dots\dots\dots + (a + b + c + m)}{n\,(a + b + c + \dots\dots\dots\dots + m)}$$

Where (a, b and m) number of seedlings emerged at the first count, second count and final count and (n) is the number of counts.

Germination index and Mean germination time were performed according to Alvarado and Bradford (1987).

$$\textbf{Germination index} = \frac{N_1 + N_2 + N_3 + N_4}{Ti}$$

N_1, N_2, N_3 and N_4 = First, second, third and four counts, respectively
Ti = Count time.

$$\textbf{Mean germination time} = \frac{(N_1 \times T_1) + (N_2 \times T_2) + (N_3 \times T_3) + (N_1 \times T_4)}{N_1 + N_2 + N_3 + N_4}$$

N_1,N_2,N_3 and N_4 = First, second, third and four counts, respectively.
T_1, T_2, T_3 and T_4 = Time of first, second, third and four counts, respectively)
Seedling vigor index = S D W X G. P.
S. D. W = Seedling dry weight.
G. P. = Germination percentage.
Germination energy defined according Ruan *et al.* (2002).

$$\textbf{Germination energy} = \frac{N_1 + N_2}{M} \times 100$$

N_1, and N_2 = First and second counts
M = Total number of seeds planted

At the final count, ten normal seedlings from each replicate were taken randomly to measure seedling length (plumule + radical length cm), after then, the seedlings were dried in hot-air oven at 85 ^{0}C for 12 hours to obtain the seedling dry weight (g) according to Krishnasamy and Seshu (1990).

Collected data for each season were statistically analyzed by the technique of analysis of variance and the least significant differences (L.S.D.) of treatments (Gomez and Gomez, 1984). Bartlett test was done to the homogeneity of error variances. The test was insignificant for all traits except germination percentage and germination after aging, thus the data of both years were combined for all traits except these traits only

RESULTS AND DISCUSSION

Data in Table 1 show that the effect of irrigation intervals, potassium fertilizer rates and storage periods on studied traits. Significantly effected were noticed for the irrigation intervals on seed viability and seedling vigor. Germination percentage and germination after aging reached its highest means (87, 87 and 78, 79%) in the first and second seasons, respectively, at 14 days irrigation intervals. Meanwhile these means reduced to (83, 82 and 70, 71%) in the first and second seasons, respectively, with increasing irrigation intervals to 28 days. The same trend was obtained for first count, germination rate, germination energy, germination index, seedling length, seedling dry weight and seedling vigor index. On contrast, mean germination time increased from 3.5 to 4.3 days with increasing irrigation intervals from 14 to 28 days. Drought produce smaller seed size contain less starch reserves which potentially reduced germination capacity and less seedling vigor (Nigel and Jan, 2000). These results are in agreement with those reported by Sajjan *et al.* (2004), Wondimu-Bayu *et al.* (2005) and El Hawary *et al.* (2008). They found that prolonging irrigation intervals decreased seed quality traits, as well as germination percentage and rate, plumule length, radical length, seedling dry weight and germination after aging of the produced sorghum seed in both seasons.

Significant effects were found fore the potassium fertilizer rates on the studied traits in Table 1. The highest means values of germination percentage (87 %) and germination after aging (76 %) were obtained from treating with potassium fertilizer rate up to 48 Kg K_2O/fed. On the other side, the lowest means (83, 83% and 71, 73%) were obtained from potassium fertilizer rates at 0 Kg K_2O/fed in the first and second seasons, respectively. The same trends were recorded for first count, germination rate, germination energy, germination index, seedling length, seedling dry weight and seedling vigor index. On the other hand, mean germination time decreased from (4.1 to 3.7 days) under potassium fertilizer rates 0 to 48 Kg K_2O/ fed. The increase in seed quality characters might be attributed to the increase of dry matter accumulation and potassium stored in seeds. While potassium fertilizer had important role in potassium activation of enzymes in plant tissues. Increasing dry matter in seeds by enzymes enhancing germination rate and seedling growth, hence, the quality of seed increased by potassium fertilization. Similar results were reported by other investigators among them Patil and Jarhad (1987), Arnold *et al.* (1995) and El Hawary *et al.* (2008).

Table 1: Effect of irrigation intervals, potassium fertilizer rates and storage Periods on sorghum seed viability and seedling vigor traits.

Characters / Treatments	Germination %		Germination after aging %		First count %	Germination rate	Germination energy	Germination index	Mean germination time (day)	Seedling length (cm)	Seedling dry weight (g)	Seedling vigour index
	2005	2006	2005	2006								
A- Irrigation intervals												
14 days	87	87	78	79	81	0.556	44.9	27.2	3.5	21.5	0.231	20.3
21 days	85	85	74	74	79	0.543	29.8	22.9	3.9	17.2	0.208	17.9
28 days	83	82	70	71	76	0.495	13.6	17.0	4.3	14.7	0.183	15.3
LSD at 5%	0.24	0.21	0.64	0.05	0.25	0.002	0.57	0.20	0.02	0.11	0.002	0.14
B- Potassium fertilizer rates												
0 kg	83	83	71	73	77	0.514	21.7	20.5	4.1	16.7	0.187	15.7
24 kg	85	85	75	75	79	0.534	30.0	22.4	3.9	18.0	0.208	17.9
48 kg	87	87	76	76	81	0.546	36.7	24.1	3.7	18.8	0.227	20.0
LSD at 5%	0.42	0.22	0.29	0.16	0.17	0.002	0.49	0.12	0.02	0.11	0.001	0.12
C- Storage period												
0 month	93	93	84	85	86	0.597	40.4	27.0	3.6	22.5	0.232	21.6
6 month	91	91	79	80	84	0.578	34.7	24.5	3.7	19.5	0.220	20.0
12 month	86	86	72	73	78	0.525	26.1	21.5	4.0	15.7	0.204	17.6
18 month	70	70	60	61	67	0.425	16.6	16.3	4.3	13.6	0.173	12.2
LSD at 5%	0.38	0.18	0.44	0.26	0.29	0.003	0.65	0.24	0.03	0.12	0.002	0.16

They found that increasing potassium during the late stages of maturation increased the germinability of sorghum seed, also increasing potassium fertilizer rate up to 48 Kg K_2O/fed increased seed viability and seedling vigor as compared with non- potassium fertilizer. Umar (2006) recorded that increase of concentration of K^+ in leave which plays a vital role in increasing water stress resistance and stabilizing yield in the sorghum.

Table 1 also shows that the effect of storage periods on studied traits were significant. Germination percentage significantly reduced with increasing storage period from 0 to 18 months. The highest means (93 and 93%) was obtained at the first storage period. On the other side, the lowest mean (70 and 70%) was obtained after 18 months from storage in the first and second seasons, respectively.

The same trend was obtained for germination after aging (84, 85 and 60, 61%), first count, germination rate, germination energy and germination index in the first and second seasons, respectively. On contrast, the minimum range of mean germination time (3.6 days) was obtained at the first storage period while the maximum range of mean germination time (4.3 days) was obtained after 18 months from storage. The tallest seedling length (22.5 cm) were obtained at the first storage period while, the shortest length (13.6 cm) of seedling length were recorded after 18 months from storage. As a result of that seedling dry weight and seedling vigor index had the same trends. The reduction in seed viability and seedlings vigor traits might be due to increasing storage periods, sorghum seeds might be infested with stored pests (insects and fungi) or might be due to, the increase of some organic compounds consumption during respiration process with increasing storage periods. Similar results were reported by Bekheit *et al.* (1983), Rao *et al.* (1993), Poonam-Singh *et al.* (2004) and Govender and Kritzinger (2008). They found that seed viability and seedling vigour of sorghum gradually decreased with an advance in storage period.

The data presented in Table 2 revealed high significant effect for the interaction between storage periods and irrigation intervals on all studied traits. Germination percentage and germination after aging produced its highest means (94%) and (87% and 88%) at 14 days irrigation intervals initially after treatment. Meanwhile, it reduced to (67% and 66%) and (56% and 57%) after storage with 18 months at 28 days irrigation intervals in the first and second seasons, respectively. The same trend was noticed for the first count, germination rate, germination energy and germination index on contrast, mean germination time reached its earlier time 3.2 days at 14 days irrigation intervals at the first storage period and its lately time 4.9 days at 28 days irrigation intervals after 18 months from storage. seedling length, seedling dry weight and seedling vigor index produced their highest means at 14 days irrigation intervals at the first storage period meanwhile, these traits produced their lowest means after 18 months of storage at the high irrigation intervals 28 days. The reduction in seed viability or seedlings vigor with increasing the storage period might be due to increasing insect infestation or from the increase of some organic compounds consumption during respiration process. These results are similar with those reported by Girish *et al.* (1976).

Table 2: Effect of the interaction between storage periods and irrigation intervals on sorghum seed viability and seedling vigor traits.

Treatments: Storage period	Treatments: Irrigation intervals	Germination % 2005	Germination % 2006	Germination after aging % 2005	Germination after aging % 2006	First count %	Germination rate	Germination energy	Germination index	Mean germination time (day)	Seedling length (cm)	Seedling dry weight (g)	Seedling vigour index
0	14 days	94	94	87	88	88	0.906	58.7	33.2	3.2	24.1	0.256	24.1
	21 days	92	93	85	84	86	0.599	38.8	26.6	3.6	23.5	0. 236	21.9
	28 days	92	92	80	81	85	0.583	23.8	21.1	4.0	19.8	0. 205	18.8
6	14 days	92	93	83	84	86	0.590	53.8	29.8	3.3	23.2	0.244	22.6
	21 days	91	91	80	80	84	0.579	33.3	25.0	3.8	19.3	0.220	20.1
	28 days	89	89	76	77	82	0.565	16.8	18.8	4.1	15.9	0.194	17.3
12	14 days	89	89	77	78	81	0.570	42.2	26.1	3.5	21.1	0.231	20.5
	21 days	86	86	71	71	78	0.554	27.2	22.9	4.0	13.9	0.205	17.7
	28 days	83	83	68	69	77	0.450	8.8	15.7	4.4	12.1	0.177	14.8
18	14 days	73	73	65	65	71	0.453	25.0	19.6	3.9	17.5	0.194	14.2
	21 days	70	71	60	61	69	0.440	19.7	16.9	4.3	12.3	0.170	12.0
	28 days	67	66	56	57	62	0.382	5.0	12.3	4.7	10.9	0.154	10.2
LSD at 5%		0.81	0.42	0.63	0.24	0.50	0.004	1.13	0.41	0.04	0.21	0.003	0.28

Data in Table 3 showed high significant effects for the interaction between storage period and potassium fertilizer rates. The highest mean values of germination percentage and germination after aging (95 and 95%) and (87 and 86%), respectively, were obtained from treated plants with potassium fertilizer at the rate of 48 Kg K_2O/fed at the first storage period. Meanwhile, the lowest means of these traits (68 and 68%) and (59 and 60%) were recorded after storage with 18 months and potassium fertilizer rate with 0 Kg K_2O/fed. The same trends were noticed for the first count, germination rate, germination energy and germination index, seedling length, seedling dry weight and seedling vigor index. On the other hand, mean germination time was increased from 3.4 days at the first storage period under fertilized with 48 Kg K_2O to 4.5 days at 0 Kg K_2O after 18 months from storage. The increase in quality characters might be attributed to the increase of dry matter accumulation and potassium stored in seeds. While potassium fertilizer had important role in potassium activation of enzymes in plant tissues. Increasing matter in seeds by enzymes enhancing germination rate and seedling growth hence, the quality of seed increased by potassium fertilization (Arnold *et al.*, 1995).

Table 3: Effect of the interaction between storage periods and potassium fertilizer rates on sorghum seed viability and seedling vigor traits.

Storage periods	potassium fertilizer	Germination % 2005	Germination % 2006	Germination after aging % 2005	Germination after aging % 2006	First count %	Germination rate	Germination energy	Germination index	Mean germination time (day)	Seedling length (cm)	Seedling dry weight (g)	Seedling vigour index
0	0 Kg	90	91	80	83	84	0.581	31.6	24.6	3.8	21.4	0.212	19.2
	24 Kg	93	93	85	85	87	0.595	42.3	27.3	3.6	22.6	0.232	21.6
	48 Kg	95	95	87	86	89	0.614	47.4	28.9	3.4	23.3	0.253	24.0
6	0 Kg	88	89	77	78	82	0.564	27.0	22.5	4.0	18.5	0.199	17.6
	24 Kg	91	91	80	81	84	0.579	35.3	24.7	3.7	19.6	0.221	20.2
	48 Kg	93	93	81	82	86	0.590	41.7	26.4	3.5	20.3	0.239	22.2
12	0 Kg	84	84	69	70	77	0.506	20.8	20.0	4.1	14.5	0.181	15.3
	24 Kg	86	86	73	74	78	0.533	24.7	21.5	4.0	15.9	0.205	17.7
	48 Kg	88	87	74	75	80	0.536	32.7	23.1	3.9	16.7	0.227	19.9
18	0 Kg	68	68	59	60	65	0.403	7.2	14.8	4.5	12.3	0.156	10.7
	24 Kg	70	70	61	61	68	0.430	17.7	16.3	4.2	13.5	0.173	12.1
	48 Kg	72	71	62	62	69	0.442	24.8	17.8	4.1	15.0	0.191	13.4
LSD at 5%		0.79	0.41	0.56	0.29	0.33	0.004	0.97	0.12	0.03	0.19	0.003	0.25

The data concerned the effect of the interaction between irrigation intervals and potassium fertilizer rates are recorded in Table 4. High significant effects were noticed on all studied traits.

Table 4: Effect of the interaction between irrigation intervals and potassium fertilizer rates on sorghum seed viability and seedling vigor traits.

Irrigation intervals	Potassium fertilizer rates	Germination % 2005	Germination % 2006	Germination after aging % 2005	Germination after aging % 2006	First count %	Germination rate	Germination energy	Germination index	Mean germination time (day)	Seedling length (cm)	Seedling dry weight (g)	Seedling vaguer index
14 days	0 Kg	84	85	75	76	80	0.542	33.3	24.3	3.8	20.3	0.209	17.8
	24 Kg	87	87	79	79	81	0.557	46.0	27.3	3.4	21.6	0.229	20.2
	48 Kg	89	89	80	81	83	0.567	55.4	29.8	3.2	22.4	0.255	23.0
21 days	0 Kg	83	83	71	74	76	0.524	22.9	21.7	4.1	16.0	0.194	16.3
	24 Kg	85	86	75	74	79	0.548	29.6	22.7	3.9	17.1	0.208	17.9
	48 Kg	87	87	76	75	81	0.557	36.8	24.1	3.8	18.5	0.222	19.5
28 days	0 Kg	81	81	67	68	74	0.475	8.8	15.4	4.5	13.8	0.158	12.9
	24 Kg	83	83	71	72	77	0.498	14.4	17.2	4.3	14.9	0.186	15.6
	48 Kg	84	84	72	73	78	0.542	17.8	18.3	4.2	15.4	0.204	17.4
LSD at 5%		0.69	0.35	0.49	0.25	0.29	0.003	0.84	0.22	0.03	0.17	0.002	0.21

At the lowest irrigation intervals (14 days), germination percentage, germination after aging, seed viability and seedling vigor traits had the highest means values under the three potassium fertilizer rates (0, 24 and 48 Kg K_2O). ON contrast, the lowest mean values of these traits were recorded at irrigation intervals 28 days at potassium fertilizer rates 0 Kg K_2O. Also mean germination time was increased gradually with increasing irrigation intervals from 14 to 28 days especially with potassium fertilizer rate at 0 Kg K_2O. These results suggested that increasing potassium rate alleviated the inhibitor effect of seed viability and seedling vigor of grain sorghum. These results are in agreement with those of El Hawary *et al.* (2008).

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تأثير فترات الري ومعدلات التسميد البوتاسي و مدة التخزين على حيوية البـذور وقوة البادرات في الذرة الرفيعة

أحمد عبد اللطيف محمد الإمام ، إبراهيم فتحي مرسال و مجدي إبراهيم العبادي
قسم بحوث تكنولوجيا البذور - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية

تم إجراء تجربه معمليه بوحدة بحوث تكنولوجيا البذور بالمنصورة خلال الفترة من أكتوبر ٢٠٠٥ حتى نهاية ابريل ٢٠٠٨ علي البذور الناتجة من تجربة حقلية أقيمـت بمحطـة البحـوث الزراعية بالسرو موسمي ٢٠٠٥/٢٠٠٦ وذلك بهدف دراسة تأثير فتـرات الـري (١٤، ٢١و ٢٨ يوم) ، التسميد البوتاسي (بدون إضافة ، ٢٤ و ٤٨ كجم بو٢أ / فدان) ومدة التخزين (صـفر، ٦، ١٢و ١٨ شهر) على حيوية وقوة بادرات بذور الذرة الرفيعة صنف دورادو .

أوضحت النتائج:-

زيادة فترة التخزين وفترات الري أدت إلى نقص كل من الحيوية (تم قياسـها بالنـسبة المئوية للإنبات وإختبار الشيخوخة والعد الأول ومعدل الانبات و طاقة الإنبات ودليل الإنبات) وقوة البادرات (تم قياسها بطول الريشة والجذير والوزن الجاف للبادرة ودليل قوة الانبات). بينمـا أدت زيادة فترة التخزين وفترات الري الى زيادة متوسط زمن الإنبات. كما أدي زيادة معدلات التسميد البوتاسي الي زيادة الحيوية (تم قياسها بالنسبة المئوية للإنبات وإختبار الـشيخوخة والعـد الأول ومعدل الانبات و طاقة الإنبات ودليل الإنبات) وقوة البادرات (تم قياسها بطول الريـشة والجـذير والوزن الجاف للبادرة ودليل قوة الانبات). في حين أدت زيادة معدلات التسميد البوتاسي الى نقص متوسط زمن الإنبات. كان التفاعل معنويا بين عوامل الدراسة وكل الصفات المدروسة.

وتوصي الدراسة بإمكانية ري محصول الذرة الرفيعة (صنف دورادو) علي فترات متباعدة (كل ٢٨ يوم) والتسميد البوتاسي بمعدل (٤٨ كجم بو ٢ أ / فدان) للحصول علـي بـذور عاليـة الحيوية والجودة لمدة ١٢ شهر من التخزين.

قام بتحكيم البحث

أ.د / محسن عبد العزيز بدوي	كلية الزراعة – جامعة المنصورة
أ.د / محمود إبراهيم العميري	مركز البحوث الزراعية