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ORIGINAL ARTICLE

Evaluation of Irrigation intervals and nitrogen fertilizer rates on some seed qualitative characteristics of hybrid corn (*Zea mays* L.) cv. single cross 704

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ABSTRACT
This study was conducted in order to assess the impact of irrigation intervals and different rates of nitrogen fertilizer on seed quality of hybrid corn S.C 704 in Seed and Plant Certification and Registration Institute (SPCRI) in 2013. The field experimental design was split plot based on randomized complete block design with three replications. The irrigation intervals were (7, 9, 11 and 13 days) and the rates of nitrogen fertilizer were (200, 300, 400 and 500 kg/ha). For assessment the impact of deficit irrigation on quality of produced seeds of S.C 704, the germination percent and vigor tests were conducted. Some traits such as final germination percent, seedling fresh weight, and seedling dry weight, radicle length, electrical conductivity and 1000-seeds weight were measured. The results indicated that the deficit irrigation levels had a significant effect on seed germination and vigor in a way that the highest germination percent and vigor were observed at full irrigation treatment (7 days) and the lowest were related to sever stress treatment (13 days). The highest seedling dry weight at optimum irrigation of 7 days interval was observed with 400 kg/ha nitrogen fertilizer, and in stress condition was recorded at 13 days irrigation frequency with 300 kg/ha nitrogen application. The highest amount of electrical conductivity of seeds was related to the highest nitrogen fertilizer application (500 kg/ha) and 13 days of water stress. The highest 1000-seeds weight (mean of 242 gram) was obtained with 400 kg/ha nitrogen application and optimum irrigation of 7 days.
Key words: *irrigation, seed quality, single cross 704, radical emergence.*

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INTRODUCTION

Modern agricultural practice in many countries aims to produce high quality and uniform products with the minimum cost . Fast and uniform seedling establishment is essential to achieve this objective and this requires high quality seeds . Seed quality is affected by several factors and seed germination, vigor and health are all considered as important determinants of seed quality [1]. Seed vigor is an important factor as it affects seedling establishment, crop growth and ultimately seed yield. Each biotic or non-biotic factor that affects seed vigor and germination during seed development has a subsequent affect on production, especially under stress conditions [2]. Seed vigor and germination have a direct influence on yield and seed quality is known to affect seedling emergence [3]. Seed lots with high vigor show higher rates of final emergence compared to seed lots with low vigor [4]. Experiments on wheat seeds with uniform size but different nitrogen concentrations have shown higher amounts of protein content, which may produce vigorous seedlings [5]. Environmental conditions affect seed quality during seed formation and also affect seedling establishment in the next growing season [2].Environmental conditions, especially the nitrogen content in the soil affect seed's nitrogen content and can increase or decrease yield and yield components. Nitrogen plays a key role in seed filling and may increase dry matter due to increased light absorption through the leaves [6]. Nitrogen fertilizer increased seed protein content in wheat , which is a good index for seed quality and vigor as applications of nitrogen fertilizer in wheat resulted in seeds with higher final germination percentages while the time that 50% of seeds germinated and mean germination time significantly decreased [7]. Furthermore, seeds which were produced with fertilizer applications of 120 kg/ha nitrogen had more vigor compared to applications of 0, 60 and 180 kg/ha in an electrical conductivity test. Research has shown that if mother plants undergo high temperature stress.;

physiological disorders can develop in seeds along with delayed germination, a decrease of seedling growth and emergence and low yield in field [8]. Studies on sunflowers indicated that high germination in sunflower can be achieved from an application of 120 kg/ha nitrogen fertilizer [9]. It has been reported that applications of 0, 200, 400 and 600 kg/ha nitrogen fertilizer had no effect on seed vigor and germination percentage. A high level application of nitrogen fertilizer in pea resulted in a decreased yield and low germination rate . Positive effect of nitrogen fertilizer application to the mother plant can be attributed to the effect of delaying the aging of seeds that allows for enough time to obtain the photosynthetic matters that results in more weight and higher quality [10]. Plants wherever they are, they grow and meet by many stresses that these stresses limit their chance of growing and survival [11]. Drought stress is the most common environmental stress that approximately limits production Planting in 25 percent of world agricultural fields [12]. Water deficit can affect oilseed rape yield, but this effect depends on genotype, the stage of development and adaptability of plant to drought. Breeders and farmers aim to get higher seedling establishment in crops, but some biotic and a biotic stresses reduce seedling establishment in field conditions [13]. Understanding of the ecological and evolutionary responses to environmental stresses is necessary in order to predict the viability of natural plant populations and the survival of species in a geographic area [14]. The drought stress is considered as one of the main factors that imposes crops yield. The effects of water deficit depend on several factors such as its intensity, duration, phenological phase of growth and genetic resistance capacity of plants. The water limitation affects plant growth and its productivity. The most typical symptom of water deficiencies in plants is a retarded growth due to inhibition of cell elongation by water limitation [15]. Low water availability in drought stress treatments can enhance the number of dormant seeds and the seed coat properties can explain the differences of the rate and average speed of germination between treatments [16]. In order to reduce resulted stress damage, selection of cultivars that have a good yield under drought stress conditions, is the main goal in improving racing programs. The sensitivity of subject intensifies when the sufficient water exists for beginning germination but growth of the new established young seedling meets the lack of water.

According to the experiments of greenhouse which has been done on Pea, it has been known that this plant during flowering stage and at beginning of the seed filling is sensitive to drought stress. Drought stress in various stages of plant growth has a different influence. This research was performed in order to study the effect of irrigation intervals and different nitrogen rates on mother plant on germination and vigor characteristics of produced seeds of hybrid single cross 704.

MATERIALS AND METHODS

This research was conducted in experimental field and central seed analysis laboratory of seed and plant certification and registration institute in 2013. The mother plants of hybrid corn of single cross 704 were subjected to 4 irrigation frequencies: 7, 9, 11 and 13 days and 4 levels of nitrogen (ammonium nitrate) application: 200, 300, 400 and 500 kg/ha. The produced seeds were tested in central seed quality analysis laboratory of Seed and Plant Certification and Registration Institute (SPCRI). For estimating germination and some related characteristics, the standard germination test was conducted according to International Seed Testing Association [17] rules. 400 seeds (4 replications of 100 seeds) were planted on germination papers and were placed in germination room at 20-30^{o}c for 7 days [18]. Then the initial germination percent (germinated seeds number at 5th days) and final germination percent (the number of germinated seed at 7th days) were determined (ISTA Rules, 2011). The normal and abnormal seedlings were also determined based on international seed tasting association standards. Also the 1000- seeds weight and seedling fresh weight were measured by precise scale and electrical conductivity was estimated by EC meter in µs/cm and radicle length was measured by ruler.

Radicle Emergence Test:

This is a new method for seed vigor assessment which was presented by ISTA in 2012. In this method 8×25 of each seed sample were planted in 2 rows between papers. The papers rolled and were placed in plastic bags or containers and were kept at 20 ^{o}c for 66 +_ 15 hours. Because temperature is the most important variable in this test, continuous control of temperature was necessary. The seedling with distinguished radicle (2mm length) was counted after 66 $^{+}$- 15 hours and the sum of 4 replications was calculated in percent.

The Electrical Conductivity Test:

For estimating seed vigor by electrical conductivity test, first 4 replications of 25 seeds from each treatment were placed in distilled water at 25^{o}c for 24 hours and then the electrical conductivity of a solute which seeds were soaked in was determined by EC meter.

$$EC(\mu s/cm) = \frac{\text{Electrical conductivity rate for each container}(\mu s)}{\text{sample weight}(g)}$$

The statistical analysis was done by MSTAT-C (v.2,1) software. The mean comparison was assessed by Duncan multiple range test.

RESULTS AND DISCUSSION

The statistical analysis of standard germination test, radicle emergence and electrical conductivity tests indicated that all measured traits were affected by interaction of irrigation intervals and different levels of nitrogen

Final germination percent:

The interaction of drought stress and nitrogen fertilizer on final germination percent was significant at 1 percent level of probability (table1). Mean comparison of irrigation ×nitrogen fertilizer interaction specified that the highest germination percent was related to 7 and 9 days irrigation treatments with mean of 100 percent at all levels of nitrogen fertilizer application. It could be suggested that because germination involves enzyme processes, so it could be affected by water stress (table 2). Drought stress in studied treatments caused un-properly availability of mother plant assimilation to seeds. Germination involves several enzyme process as catabolism and anabolism, so germination severely react to drought. It could be declared that confronting of mother plant to drought stress and disorder in photosynthesis resulted in seeds with lower germination percent compared to seeds which were obtained from normal irrigation condition. Bittman [19] that reported the difference in final germination percent of seed could be result of amount of saved matters in endosperm and different seed size of genotypes. The processes which inhibit germination probably involve cell division and no transfer of nutrients. Also, Levitt et al [20] found that subjecting of mother plant to drought stress in maturity stage is a main reason of seeds physiological differences. This physiological disorder was related to delay of germination, reduction of radicle and seedling growth, poor emergence level and low performance of plant in field conditions.

Normal seedling:

The results of variance analysis indicated that normal seedling percent was affected by irrigation intervals and nitrogen application rate and also the interaction of them (table 1). The mean comparison of normal seedlings revealed that 7 days irrigation treatment and all N-fertilizer levels resulted in the highest normal seedlings(table2) .The normal seedlings percent is one of the most important seed quality criteria. Hampton [21] reported that seeds which obtained more fertilizer and water at production stage resulted in increased seedling establishment and also increased yield in comparison with other treatments. Hamidi *et al*. [22] investigated 3 irrigation frequencies of corn in field and laboratory and found that seeds with less irrigation interval produced more normal seed lines (percent) compared to the seeds which were obtained from mother plant with less water application.

Seedling fresh and dry weight:

The effect of drought stress on seedling fresh weight was significant (table 1). Also the effects of nitrogen fertilizer levels and the interaction of drought stress and N-fertilizer on seedling fresh weight and dry weight were significant at1% level of probability (table1). The mean comparisons of seeding fresh weight indicated that the highest seedlings fresh weight and dry weight (9 and 0.88 gram, respectively) were obtained from 9 days irrigation intervals and 500 kg/ha nitrogen fertilizer (table2). The seedling dry weight is an important index of seedling vigor and is used as a criterion for seedling vigor assessment [21]. Carter (1985) declared that the plants which are not subjected to drought stress will produce seeds with higher 1000-seeds weight due to increased metabolic activities and therefore will produce plants with higher fresh weight. It can be concluded that due to water stress on mother plant it will be weakened and will produce the seeds with low vigor compare to the seeds that are resulted of plants with normal irrigation, therefore the drought stress had significant effect on final germination percent. The seeds that are resulted from plants with normal irrigation had more seedling dry weight, perhaps due to un-confronting of mother plant to water stress and also better germination percent of seeds. With increasing of 1000-seeds weight, the endosperm saved matters increase, so more nutrients will be available to embryo and also seedling vigor and seedling dry weight will increase [20].

Seedling length:

The results of seedling length mean comparisons indicated that the highest value (35.83cm) was related to 7 days irrigation interval and 400 kg/ha N-fertilizer. The seedling length is considered as a seedling vigor index and the correlation of seedling length and it's vigor has been distinguished in many plant species, so it is used as a criterion for assessment of seedling growth and vigor [21].

Radicle and shoot lengths are indices of seedling development and seedling vigor. Their variations is analyzed as a seedling vigor index [21] .Also Abdul- Baki and Anderson [23] used the multiply of germination percent initial radicle length and/or initial shoot length as an index for seedling vigor assessment.

Radicle length:

The mean squares results indicated that effects of irrigation intervals, nitrogen rates and the interaction of them were significant on radicle length at 1 percent level of probability (table1).According to mean comparisons the highest radical length (20.89 cm) was related at I_1N_3 (7 days irrigation and 400 kg/ha nitrogen fertilizer and the lowest radicle length (16.88 cm) was related to I4N1 (13 days irrigation and 200 kg/ha nitrogen fertilizer) (table2). Radicle length could be a good criterion for seed emergence ability, because if a seedling cant produce a vigorous root system, it's permanence will reduce significantly [24]. There is a little information about root characteristics, performance and heritability. The main reason is lack of a precise method of measurement and also high error of sampling [20].

Electrical conductivity(EC):

The analysis of variance results showed that the effects of irrigation intervals and different nitrogen fertilizer level on electrical conductivity of produced seeds were significant at 1%level of probability (table1).The mean comparison results indicated that 13days irrigation treatment with 200kg/ha fertilizer had the most amount of electrical conductivity and 200 kg/ha fertilizer with 7 days irrigation intervals had the lowest electrical conductivity .The irrigation intervals of 13 days and 200kg/ha fertilizer caused drought stress on mother plant and finally resulted in EC increasing through cytoplasm membrane disruption and ions leakage to intercellular space and increase of cytoplasm substances concentration and sever reduction of cells water. Hurch, [25] reported that due to drought stress cells membrane of seeds become thin that will cause increase of electrolytes. This experiment is in agreement with above results and a significant difference observed between seed vigor and electrical conductivity, but seed weight is also effective. According to investigation the electrical conductivity could have a significant positive correlation with seedling emergence in field [26].Electrical conductivity test is an index of seed substances leakage. When low vigor seeds are soaked in distilled water, excrete their substances, but excretion is lower in high vigor seeds, so there is a negative correlation between electrical conductivity and seed emergence ability [20]. Robert [27] suggested that the amount of leakage reduces by plant transferring to normal condition and the damage would be recoverable. Pasbanelsan [28] reported that electrolytes leakage from stresses is a reasonable criterion for stress tolerance. It could be suggested that due to stress, cell membrane of seeds becomes thin and will cause more leakage of electrolytes it seems that main detrimental effects of stress are occurred at water uptake stage of seed germination.

Radicle emergence test:

According to analysis of variance it could be concluded that the difference of radicle emergence rate (germinated seeds percent) in radicle emergence test at different irrigation levels was not significant, but different levels of nitrogen fertilizer were significant at 5 % level of probability and the interaction of irrigation intervals and fertilizer was also significant at 1% level of probability (table 2). The most radicle emergence percent in this test was 100% which was related to 300 kg/ha fertilizer application and the lowest (96%) was related to 400 kg/ha fertilizer. The interaction of irrigation intervals and fertilizer levels for radicle emergence rate (or less than 2 mm germinated (was significant at 1% level of probability (table 2). This test was approved in 2012 by ISTA and has no background. Production of sweet corn seeds with different vigor but similar germination ability.

1000 seeds weight:

The irrigation intervals and N-fertilizer rates effects on 1000-seeds weight were significant at 1% level of probability .also, there was a signification difference of drought stress×nitrogen fertilizer interaction on 1000-seeds weight at 1% level of probability (table1).Mean comparison of drought stress and nitrogen rates interaction indicated that seeds obtained from mother plants which received 400 kg/ha N-fertilizer with 9 days irrigation intervals had the highest (242gram) 1000-seeds weight and seeds resulted from plants which subjected to 13 days irrigation intervals and 500 kg/ha nitrogen fertilizer had the lowest 1000-seeds weight. The seeds with higher 1000-seeds weight had high germination ability which seems resulted from more resources of seeds. High 1000-seeds weight causes more germination percent and seedling emergence, then more plants remain until harvest which also increase the yield [29]. Researches about nitrogen effect on germination and seedling growth have indicated different results, but in total larger seeds produce more vigor. The results showed that if a region has adequate water for irrigation, more application of fertilizer could result in higher seed yield and seed quality improvement and in regions subjected to water deficit it's better to reduce nitrogen fertilizer rate application in order to improve seed quality. All results of different irrigation frequencies with application of different nitrogen fertilizer rates are shown in (table2).

Table 1- The Analysis of Variance (Mean squares) of Standard test of Corn 704

Root dry weight	Seedling fresh weight	Root fresh weight	Seedling length	root Length	1000 seed weigh	normal Seedling	Degree free	S.O.V
0.02 **	3.038 **	1.549 **	51.097 **	17.703 **	704.409	266.891 **	3	Irrigation levels
0.003 **	0.577 ns	0.233**	8.648 **	5.076 **	2215.609**	55.891 **	3	nitrogen
0.002 **	0.331**	0.065 **	3.496**	1.747 **	548.014	31.71 **	9	nitrogen× × Irrigation levels
0.001	0.09	0.03	1.597	0.603	1318.965**	6.672	48	Error
7.01	5.01	7.91	4.15	4.40	784.173**	2.99		CV (%)
-Electrical conductivity	**Seedling vigor index weight**	**-Seedling vigor index length**	**Mean daily germination**	**Mean time germination**	**Final germination percent**	**Seedling dry weight**	**Degree free**	**S.O.V**
37.992**	972.731**	1600.235**	1.812**	0.023**	88.708**	0.046 **	3	Irrigation levels
12.328*	157.325 ns	6599.117 ns	1.394 ns	0.02**	68.292**	0.006 ns	3	nitrogen
6.231**	115.162**	5704.724 **	0.19**	0.008**	9.361**	0.005 **	9	nitrogen× × Irrigation levels
0.17	11.284	6319.821	0.135	0.007	6.635	0.001	48	Error
6.74	5.01	4.84	2.89	3.89	2.89	4.65		CV (%)

n.s : Non Significant
*** Significant at 5% levels of probability**
**** Significant at 1% level of probability**

Table 2- Interaction effect if Irrigation Intervals and Nitrogen Fertilizer on Measured traits in Standard test of Corn704

Root dry weight (gr)	Seedling fresh weight (gr)	steam fresh weight (gr)	Root fresh weight (gr)	Seedling length (cm)	steam Length (cm)	root Length (cm)	non normal Seedling	normal Seedling	Nitrogen rate(kg/haa)	Irrigation levels (day)
0.4050 bcd	6.113 bcde	3.815 cd	2.297 bc	30.58 cde	12.88 abc	17.70 cde	1.500 ef	87.25 de	**200**	**7**
0.4100 bc	6.332 bcd	3.985 abcd	2.348 bc	31.60 abcd	13.38 ab	18.23 bcd	1.000 f	88.25 bcde	**300**	
0.4200 abc	6.448 abc	3.720 de	2.727 a	32.90 ab	13.60 ab	19.30 ab	1.000 f	91.50 bc	**400**	
0.4625 a	6.820 a	4.153 a	2.668 a	32.90 ab	13.13 abc	19.77 a	1.000 f	96.00 a	**500**	
0.3700 cdef	6.015 cdef	3.790 cd	2.225 cd	30.94 bcde	13.39 ab	17.55 cdef	2.000 e	87.00 de	**200**	**9**
0.3925 cde	6.172 bcde	3.910 abcd	2.263 bc	31.15abcde	13.30 abc	17.85 cde	1.000 f	88.25 bcde	**300**	
0.4150 abc	6.395 abcd	3.860 bcd	2.535 ab	32.35 abc	13.57 ab	18.77 abc	1.000 f	89.75 bcd	**400**	
0.4475 ab	6.530 ab	4.128 ab	2.403 bc	33.03 a	13.88 a	19.15 ab	1.000 f	91.75 b	**500**	
0.3575 def	5.735 efg	3.820 cd	1.915 efg	29.13 efg	12.40 abcd	16.73 efg	3.250 d	81.50 gh	**200**	**11**
0.3825 cdef	5.940 def	3.800 cd	2.140 cde	29.88 def	12.57 abcd	17.30 def	2.250 e	85.25 efg	**300**	
0.4000 bcd	6.198 bcde	4.033 abc	2.165 cde	30.70 cde	12.80 abc	17.90cde	2.250 e	87.50 cde	**400**	
0.3475 ef	5.382 gh	3.520 ef	1.862 fg	28.50 fgh	12.15 bcd	16.35 fg	6.750 b	81.00 h	**500**	
0.3425 ef	5.285 gh	3.465 ef	1.820 fg	27.73 gh	11.68 cd	16.05 g	4.000 c	81.00 h	**200**	**13**
0.3450 ef	5.560 fgh	3.707 def	1.852 fg	29.25 efg	12.48 abcd	16.78 efg	3.500 cd	83.00 fgh	**300**	
0.3575def	5.950 def	3.983 abcd	1.967 def	29.58defg	12.07 bcd	17.50def	2.250 e	86.00 def	**400**	
0.3375 f	5.110 h	3.445 f	1.665 g	26.88 h	11.18 d	15.70 g	9.000 a	79.25 h	**500**	

Seedling vigor index weight	- Seedling vigor index length	Mean day germination	Mean time germination	Final germination percent	-Electrical conductivity	Seedling dry weight (gr)	1000 seed weigh (gr)	Seedling dry weight (gr)	Nitrogen rate(kg/haa)	Irrigation levels(day)
69.58 def	2668. de	12.68 bcde	2.102 abc	88.75 bcde	4.648 ef	0.7975 bcd	219.6 b-e	0.7975 bcd	200	7
71.46 cde	2789. cd	12.75 bcd	2.235 a	89.25 bcd	4.979 e	0.8100 bc	226.9 bcd	0.8100 bc	300	

75.71 bc	3010. ab	13.22 b	2.173 ab	92.50 b	7.140 b	0.8275 bc	231.7 bc	0.8275 bc	400	
84.74 a	3159. a	13.85 a	2.080 bc	97.00 a	7.737 a	0.8825 a	236.5 ab	0.8825 a	500	
66.10 f	2692. de	12.72 bcde	2.027 c	89.00 bcde	0.1032 h	0.7600 def	205.7 ef	0.7600 def	200	9
69.51 def	2749. cd	12.75 bcd	2.060 bc	89.25 bcd	6.029 c	0.7875 cd	221.7 b-e	0.7875 cd	300	
73.58 bcd	2903. bc	12.97 bc	2.070 bc	90.75 bc	4.921 e	0.8200 bc	249.7 a	0.8200 bc	400	
77.52 b	3030. ab	13.25 b	2.085 bc	92.75 b	6.801 b	0.8450 ab	227.4 bcd	0.8450 ab	500	
59.87gh	2374. fg	12.11 e	2.077 bc	84.75 e	0.1032 h	0.7350 efg	212.6 de	0.7350 efg	200	11
64.35 fg	2548. ef	12.50 cde	2.140 abc	87.50 cde	4.802 ef	0.7550def	235.3 abc	0.7550def	300	
68.23 ef	2686. de	12.82 bc	2.128 abc	89.75 bc	4.193 fg	0.7800 cde	219.3 cde	0.7800 cde	400	
56.01 hi	2306. gh	12.54 cde	2.027 c	87.75 cde	3.800 g	0.6925 gh	179.1 h	0.6925 gh	500	
57.12 hi	2247. gh	12.14 de	2.030 c	85.00 de	5.755 cd	0.7050 gh	194.0 fgh	0.7050 gh	200	13
60.07 gh	2429. fg	12.36 cde	2.130 abc	86.50 cde	5.302 de	0.7225 fg	223.6 bcd	0.7225 fg	300	
65.32 f	2543. ef	12.60 cde	2.027 c	88.25 cde	4.688 ef	0.7600 def	195.8 fg	0.7600 def	400	
52.86 i	2126. h	12.60 cde	2.110 abc	88.25 cde	4.170 fg	0.6675 h	184.7 gh	0.6675 h	500	

Means within the same Colum followed by the same latter are significantly different(0.05) using Duncan, s multiple range test.

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