SEED SIZE, TEMPERATURE, AND WATER POTENTIAL EFFECTS ON GERMINATION AND SEEDLING GROWTH OF TWO WHEAT GENOTYPES.

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE

OF

MASTER OF SCIENCE

IN

PLANT PRODUCTION/CROP PRODUCTION

FACULTY OF GRADUATE STUDIES

UNIVERSITY OF JORDAN

MAY 1997

THIS THESIS WAS SUCCESSFULLY DEFENDED AND APPROVED ON 3, MAY 1997

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DEDICATION

TO MY MOTHER SPIRIT

TO MY FATHER

TO MY WIFE, DAUGHTERS AND SONS

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In greenhouse experiment, germination percentage, root and shoot dry weights were significantly decreased with decreasing seed size and water potential. Hourani-27 produced significantly larger shoot and root dry weights with higher percentage of germination compared to F8.

1.INTRODUCTION

Wheat *(Triticum spp.)* is considered as one of the most important crops. It provides human with a complete diet except for some of the essential amino acids that are found in animal tissues and in some food legumes.

Wheat kernel of wheat contains 60-80% starch; 8-15% protein; 1.5-2% fats; 1.5-2% minerals and vitamins such as the B complex and vitamin E. The by-product of wheat such as straw and bran are main components in animals ration especially during winter (Feldman, 1976).

In addition to its high nutritive value, the low water content, ease of transport and processing and good storage qualities have made this crop the most important stile food for more than 35% of the world's population.

The world production of wheat increased by 21% during the period between 1980 to 1994, while the wheat-planted area decreased by 8% during the same period. Whereas wheat production and area in Jordan have been decreased in the last 15 years. The wheat-planted area decreased by 54% whereas production decreased by 25% during the same period (FAO, 1994).

In Jordan, durum wheat is the most widely grown wheat species ***(Triticum durum L.)***. It mainly grows under dry land conditions. The dry land areas in this region are characterized by a high year to year variation in precipitation and temperature. This means that durum wheat is grown in a high risk area, and the crop yield reduction and failure due to climatic fluctuations are frequent (Nachit and Ketat, 1986).

Wheat production relies upon a number of environmental and cultural parameters. Rapid and uniform stand establishment is basic to vigorous seedling and plant performance.

Under rainfed conditions of arid and semiarid regions, variable temperature and low moisture are often limiting factors during germination.

Large areas in the Middle eastern countries are characterized by low and erratic rain fall during late fall and early winter, the period at which wheat is sown and usually suffer from early moisture stress resulting in a poor stand and early seedling growth problems. Such problems may seriously affect germination and seedling establishment and subsequent winter survival of wheat in these regions.

Seed size is one trait of economic important that affect stand establishment survival and plant performance and can be easily manipulated. The superiority of large seeds compared with small seeds in producing more vigorous and larger plants is generally more pronounced in case of unfavorable environmental conditions in early growth stages (Burris *et al.*, 1973).

Seed size and environment may interact in their effects on the germination and early seedling growth of wheat, yet most studies on the effects of drought stress and temperature on germination and seedling vigor of wheat have been conducted using seeds of uniform size.

There was no report on the combined effects of seed size, temperature and water stress on germination and seedling growth of durum wheat. Therefore, this study was designed to determine the effects of seed size, temperature water potential and their interactions on seed water uptake germination and seedling growth of two durum wheat genotypes under laboratory and greenhouse conditions.

larger plants is generally more pronounced in case of deep planting and unfavorable environmental conditions in early growth stages.

Evans and Bhatt (1977) reported that seed size influenced seedling vigor in five wheat cultivars regardless of seeding depth or harvesting method. Lafond and Baker (1986) indicated that 53% of the variation in seedling vigor was attributed to variation in seed size and protein content. This is in agreement with previously reported results by Ries and Everson (1973) and Evans and Bhatt (1977). Lafond and Baker (1986) concluded that selecting for seedling vigor could be done by selecting for seed size, rate of germination and/or rate of plant development. Also Burris *et al.* (1973) indicated that the largest soybean seeds developed seedling with greater cotyledonary and unifoliat leaf area, height and yielded consequently more than small seeds. On the other hand, the smallest seeds developed seedlings which exhibited higher photosynthetic rates (Burris *et al.*, 1973).

There was no genotype by seed size interaction for both rate of emergence (Bulisani and Warner, 1980; Lafond and Baker, 1986) and shoot dry weight (Evans and Bhatt,1977; Lafond and Baker, 1986) whereas, for genotype their was an increase in seedling vigor with increase in seed size.

Douglas *et al.* (1994) found that seed size and density did not significantly affect main stem leaf number, dry weight, tillers number, seminal roots, number of heads, straw weight and grain yield.

Seed size had no significant effect on water uptake (Lafond and Baker 1986). Also Clarke (1980) compared rates of water uptake in six spring wheat cultivars at 30°C and found that four of them have the same rate of water uptake. Similar results have been reported by Lafond and Baker (1986), whom indicated that cultivar has no effect on rate of water uptake. On the other hand, Butcher and Stenvert (1973) and Stenvert and Kingswood (1976) as cited by Clarke (1980) found that there is differential rates between wheat cultivars for water uptake.

Bulisani and Warner (1980) found that within each seed lot the largest seed had approximately a 2.5 % higher protein percentage than smallest seeds. Lowe *et al.* (1972), Lowe and Ries (1972) and Ayers *et al* . (1976) found that seedling dry weight is positively correlated to seed protein content, small seed, with high protein produced larger seedlings than large seeds with lower protein.

Ching and Rynd (1978) found high protein grains produced seedlings 25% heavier with 25% more total RNA, 30% more DNA, 40% more amino acids, 60% more Ribosmoes, 80% more soluble protein, higher glutamine synthetase and α-amylase, but lower acid phosphatase activities. They reported that the higher polysome content in high protein seeds is responsible for rapid growth and high yield.

Lopez and Grabe (1971) found that the increased in protein contents was located primarily in endosperm, which confirm that the factor responsible for the greater growth, and high protein seeds is in the endosperm. Also they stated that high protein seeds of barley and wheat germinated and developed faster in N-deficient soils. Seed protein had little effect on seedling growth in soil with high concentration of available nitrogen. In contrast, Lowe and Reis (1972) found significant difference in dry matter between seedlings grown from low and high protein seeds, even with abundant N-fertilizer.

Ries *et al.* (1970) and Ries and Everson (1973) found that a significant correlation of both seed protein content and seed size with seedling vigor ranging from 0.68 to 0.87 and from 0.69 to 0.87, respectively. Also they reported that seed size and protein content of both monocotyledonous and dicotyledonous species are positively related to early seedling growth and sometimes to economic yield.

Bulisani and Warner (1979) found that seedling vigor was significantly increased by seed weight and percent protein, they reported that large seeds significantly increased seedling emergence rate index and grain yield.

2.2. Effect of temperature on seed germination and plant growth:

Brar *et al.* (1991) reported that there were major effects of temperature on germination rate and germination percentage, and they indicated that, since temperature had a strong influence on germination, seeding time should be selected to match expected temperature for particular locations. Lafond and Fowler (1989) indicated that the effect of temperature on germination was much larger than moisture potential, this result is different from Lafond and Baker (1986) who reported that seeding should proceed at optimum date regardless of the dry seedbed moisture condition. Also they reported that, as temperature increased, the rate of germination as measured by median germination time decreased. Similar results were found by Livingston and de Jong (1990). Lafond and Baker (1986) reported that, the final germination percentage was not affected by temperature as reported by Ashraf and Abu Shakra (1978). The germination rate increased with increasing temperature, but final germination were highest at intermediate temperature (20-25°C), (Sharma, 1976).

Brar *et al.* (1991) reported that early high germination a cross a large range in temperatures may be beneficial for rapid establishment of the crop in semiarid warm regions where soil moisture in the upper soil surface is available for only a short period. However, in temperate regions, where lower temperature exist, slower germinating species might be more beneficial where the germination periods extends from 5 to 10 days after planting.

Root growth was found to be influenced by temperature. Lower rate of root growth of wheat obtained at lower temperature (3-10°C). It was concluded that a rapidly penetrating and extensive root system is essential for cultivars grown in semi arid areas (Ashraf and Abu-Shakra 1978). A significant difference in water uptake due to temperature was also reported by Lafond and Baker (1986). As temperature increased, rate of water uptake increased as indicated by Lafond and Fowler (1989).

2.3.Effect of water potential on seed germination and plant growth:

Tests for seed germination, usually involve using different osmotic agents as polyethelene glycol (PEG) and mannitol to induce moisture stress and simulate drought conditions during germination in different crops. Thill *et al.*, (1976) ability of wheat to grow and establish stand under limited soil moisture conditions in the field were related to germination and seedling growth in mannitol solution (Helmeric and Pfeifer, 1954; Williams *et al.*, 1967; Ashraf and Abu Shakera, 1978; Thill *et al.*, 1979 and Jaradat, 1979).

In most drought studies, seeds are exposed to germination media for extended period of time. If the solution are not osmostically satiable over time, the germination results could be erroneous and subsequent interpretation misleading. Thill *et al.* (1979) studied the osmotic stability of mannitol solution with time and they concluded that, mannitol solution was effective in simulating drought conditions for germination and seedling growth of several crops, and it is a simple easily repeated test, and the osmotic stability did not change with time.

Brar *et al.* (1991) reported that water potential at planting affected germination rate and final germination. Whereas both total germination and germination rate decreased with decreasing water potential (Younis *et al.* (1963); Sharma (1976); Roundy *et al.* (1985) and Hardegree and Emmerich (1992). Also it has been indicated by Mian and Nafziger (1994); Livingston and de Jong (1990); Lafond and Baker (1986); Somer (1983); Ashraf and Abu Shakra (1978); Sharma (1973); Williams *et al.* (1967); Helmerick and Pfeifer (1954) and Ayers (1951) that increasing osmotic potential more negative levels progressively delayed and reduced germination, but relative germination time of the cultivars were found to be consistent over the different levels of osmotic moisture stress as indicated by lafond and Baker (1986). However, Lafond and Fowler (1989) indicated that water potential had no significant effect on the rate of germination . Also it has been indicated by Ashraf and Abu Shakra (1978) and Hadas and Russo (1974) that total germination was not affected by moisture stress until the critical level was reached. Roundy *et al.* (1985) and Blum *et al.*(1980) reported that germination rate or injury to germination at various water tension differed significantly among cultivars. They stated that, seed of different species may have different critical water potential or hydration levels below which the physical processes of germination are slowed or prevented.

It was observed by Hunter and Erickson (1952) that, in order for the seed to germinate, each species of seed had to attain a specific moisture content. This minimum moisture content was approximately 30.5% for corn; 26.5% for rice; 5% for soybean and 31.0 for sugar beet seeds.

Roundy *et al.* (1985); Blum *et al.* (1980) and Younis *et al.* (1963) found a significant variety moisture tension interaction for both germination and germination rate.

Mian and Nafziger (1994) found that shoot dry weight, root dry weight and number of tillers were decreased with decreasing water potential. Nearly the same result have been found by Gull *et al.*, (1976) who indicated that total stand, coleoptile length, seedling height and root weight were similarly reduced as water potential decreased.

Wright, (1962) reported that soil water stress significantly reduce root weight of panicgrass. The root length reduced with increasing moisture stress tension as indicated by Jaradat (1979) and Hoveland and Buchanan (1973). Radical length varied statistically between species and among different osmotic Roundy *et al.* (1985) and Richards *et al.* (1981) indicated that when wheat is growing predominantly on a limited supply of stored soil and those seeds were discarded at each reading. The seeds were germinated in a vertical incubator and the four replicates blocked vertically to compensate for temperature gradient in the incubator (Lafond and Baker, 1986). The seeds were equilibrated to the desired temperature for approximately 12 hours before starting each experiment.

Statistical Analysis System (SAS) was used for calculation and obtaining Analysis of Variance (ANOVA) Mean Separation using Duncan Multiple Range Test (DMRT).

3.4 Effects of seed size and water potential on germination and plant growth under laboratory conditions:

Water potential of 0, -100, -300, -600 and -900 kPa were created using osmotic solutions of mannitol. The amount of mannitol and water to provide the different atmospheric tensions were calculated by the following formula given by Helmeric and Pfeifer (1954):

Osmotic pressure (P) = $\frac{gRT}{mV}$

Grams mannitol (g) = $\frac{PVm}{RT}$

where V = volume in liters

m = molecular weight of mannitol

R = 0.08205 liter atmospheres per degree per mole

T = absolute temperature

Standard germination papers were soaked in these solutions (distilled water for 0 kPa) for 10 min. Twenty seeds were placed on double layers of germination paper in a single line 3.5 cm from the top of the paper. A third germination paper was placed a top the seeds, and each roll was secured loosely with a piece of string. The roll then placed in an upright position in a plastic container containing osmotic solution of the same strength used to soak the germination paper, the bottom one third of the roll was in the solution. Each of the containers had six such rolls in it representing the two genotypes and three sizes. Five containers, one of each osmotic treatment, were placed in a larger plastic tank (52 × 25 ×18 cm) that contained water at the bottom. The plastic tank was covered with polyethylene to minimize water evaporation and was then placed into a dark germination cabinet under a constant temperature of 24°C. A total of four replications was used for this experiment and all five tanks, each representing a block, were placed in the same growth chamber. The tanks in the growth chamber were rearranged once a day to minimize the effect of any temperature gradient in the germination cabinet. The level of osmotic solution in each plastic container was restored to the previous level by adding distilled water once a day. Germination counts were made 10 days after placing the seed in the germination cabinet

3.5. Effects of seed size and water potential on germination and plant growth under greenhouse conditions:

Seeds of the two genotypes with three sizes were planted in plastic pots (22 cm diameter). The water tension for the soil medium determined using a pressure outflow system as described by Klute (1986). The soil medium was dried and its moisture content was determined. Pots were filled with 5 kilogram dried clay soil. Then lined by plastic film to reduce water evaporation, and weight of each pot was recorded. Required amount of water were added to each pot to create soil matrix potentials of -30, -100, -300, -600 and -900 kPa.

Six hills in each pot, each consisting of five seeds, and representing the three seed sizes and two genotypes were planted in a circular pattern with a distance of 7 cm between adjacent hills. The pots were arranged on a bench in a CRD design with five replications. Each pot is weighed daily and water was added to bring the total weight back to its original status. The pots were rearranged once a day to minimize the effect of any temperature gradient in the greenhouse. Germination counts were made 10 days after planting, and then all but two largest seedlings in each hill were removed. After 28 days of growth the pots were soaked overnight into a large container, and roots were gently washed to remove the soil. Plants were separated into shoots and roots and dry weight for both shoot and root were determined.

4.RESULTS AND DISCUSSION

4.1. Effects of seed size and temperature on seed water uptake of two wheat genotypes:

This experiment was designd to test the effect seed size, temperature and on seed water uptake of two wheat genotypes. The only significant interaction effect was detected after 36 hours soaking period. Therefore, interactive effect will be presented only for 36 hours soaking period and separated effects for other soaking periods will be presented only.

After 36 hours of soaking period, for both genotypes the rate of water uptake (Table 2) by small seed is significantly higher than large one, except for F8 at 20°C. Also the rate of water uptake increased with increasing temperature, except for small seed of F8 at 20°C which is significantly lower than 5 and 10 °C. At low temperatures (5 and 10 °C), The rate of water uptake for F8 was significantly higher than for Hourani-27 at comparable seed size, except for large seed at 5°C, where they were not significantly different. On the other hand, at 20 °C the rate of water uptake was significantly higher for Hourani-27 as compared with F8.

Table (2): Effects of seed size and temperature on the rate of water uptake by seeds of two wheat genotypes.

Genotype	Seed size	Temperature °C		
		5	10	20
	Large	14.43 IJ	15.69 H	20.38 C
Hourani-27	Small	18.05 F	19.81 D	23.95 A
F 8	Large	14.23 J	16.31 G	19.76 D
	small	19.21 E	21.53 B	14.47 I

* Means followed by different letters are significantly different at the 0.05 probability level, according to Duncan's Multiple Range Test (DMRT).

The rate of water uptake (Table 3) by the seed of both genotypes were significantly the same, except after 4 and 36 hours which was higher for F8 and for Hourani-27, respectively.

The rate of water uptake was not significantly affected by seed size at soaking period of 2 hours, Later on the rate of water uptake by small seed was significantly higher than for large seeds. In general, the rate of water uptake increased with increasing temperature.

Table (3): Effects of genotype, seed size and temperature on the rate of water uptake by wheat seeds.

Treatment		Rate of water uptake (g kg^{-1} hr^{-1})						
		0 hours	2 hours	4 hours	8 hours	16 hours	36 hours	48 hours
Genotype	Hourani-27	77.75 A	134.19 B	77.72 B	55.02 A	36.95 A	18.72 A	18.66 A
	F 8	82.35 A	157.50 A	107.22 A	58.04 A	36.04 A	17.56 B	21.90 A
Seed size	Large	74.06 A	144.36 A	79.37 B	52.45 B	33.08 B	16.77 B	16.42 B
	Small	86.04 A	147.33 A	105.58 A	60.62 A	39.97 A	19.50 A	24.14 A
Temperature °C	5	79.99 A	85.26 C	79.12 C	52.96 B	31.60 C	16.48 C	15.12 B
	10	87.17 A	149.44 B	87.60 B	55.92 B	35.15 B	18.29 B	21.58 A
	20	72.99 A	202.83 A	110.70 A	60.72 A	42.73 A	19.64 A	24.14 A

* Means within columns for each treatment followed by different letters are significantly different at $p \leq 0.05$ according to DMRT.

Rate of water uptake were significantly affected by seed size (Table 2, 3). This result disagreed with previous findings of Lafond and Baker (1986). They indicated that seed size had no significant effect on water uptake.

The water uptake as shown in (Table 2, 3) was significantly affected by temperature. This result agreed with findings of reported by Lafond and Baker (1986) and Lafond and Fowler (1989), who indicated the rate of water uptake increased with increasing temperature.

The difference between the two genotype in the rate of water uptake is consistent with previous results reported by Butcher and Stenvert (1973) and Stenvert and kingswood (1976) as cited by Clarke (1980), but differ from that reported by Clarke (1980) and Lafond and Baker (1986). This discrepancy may be due to differences in medium, temperature, or method of expressing moisture content.

4.2. Effects of seed size and temperature on seed germination of two wheat genotypes:

There were no germination at 5°C for one month. However, germination started after 7, 4, 3 and 2 days at 10 , 15, 20 and 30C°, respectively. Therefore, the results for each temperature will be presented only with no comparison between temperatures.

Accumulative germination percentage for large (A_1 and A_2) and medium seeds at 10°C did not significantly differ over time from each other for both genotypes, but the accumulative germination percentage for small seeds of each genotype is significantly lower than the other two seed sizes (Table 4). These results were inconsistant with those results reported by Green *et al.* (1966); Bhatt *et al.* (1979); Lafond and Baker (1986) and livingston and de Jong (1990), who reported that small seeds germinated faster than large seeds of different species but similar size emerged at the same rate.

Table(4): Effect of seed size on seed germination of two wheat genotypes at 10°C.

Treatment		Accumulative germination %					
Genotype	Seed size	After the onset germination (hour)					
		10	20	30	40	50	60
Hourani-27	Large A1	25.0B	57.0B	57.0B	71.5B	78.0B	84.5B
	A2	25.0B	66.0B	66.0B	77.5B	84.5B	89.0B
	Medium	22.5B	64.5B	64.5B	73.5B	79.5B	84.0B
	Small	13.5C	36.0C	38.5C	54.0C	64.5C	74.5C
F8	Large A1	30.0A	80.0A	80.0A	91.0A	94.5A	96.5A
	A2	32.0A	85.0A	85.0A	91.0A	95.5A	97.5A
	Medium	29.5A	78.0A	80.0A	93.5A	96.0A	96.5A
	Small	11.5C	27.5C	27.5D	47.5C	62.5C	76.5C

* Means within columns followed by different letters are significantly different at $p \leq 0.05$ according to DMRT.

Except for small seeds accumulative germination percentage for F8 is significantly higher than that for Hourani-27.This result disagree with previous results reported by Bulisani and Warner (1980) and Lafound and Baker (1986), who indicated that their was no cultivar by seed size interaction for the rate of emergence. The accumulative germination percentage were increased for the first 20 hours, then started to decline gradually.

No significant interaction of seed size and genotype on accumulative germination percentage at 15°C. The separated effect will be presented only. Accumulative germination percentage for both genotypes were significantly the same, except after 4 hours, where germination percentage Hourani-27 is significantly higher as compared with F8 (Table 5).

At 15°C the accumulative germination percentage for the first 12 hours after the onset of germination decrease with decreasing seed size, with no significant difference between A_1 and A_2. Later on, it is significantly higher for large (A_1 and A_2) once compared with medium and small seeds. The variation in accumulative germination percentage due to seed size variation also disagreed with previously reported results, by Green *et al.* (1966); Bhatt *et al.* (1979); Lafond Baker (1986) and Livingston and de Jong (1990), who reported that small seeds germinated faster than large seeds of different species but similar size emerged at the same rate.

Table(5): Effects of seed size and genotype on germination percentage at 15°C.

Treatment	Accumulative germination % After the onset germination (hour)					
Genotype	**4**	**8**	**12**	**16**	**20**	**24**
Hourani-27	14.38A	46.00A	74.13A	91.63A	93.00A	93.00A
F8	13.13B	45.90A	70.25A	88.38A	91.25A	91.25A
Seed size						
Large A1	16.50A	55.75A	82.50A	94.50A	95.75A	95.75A
Large A2	15.50A	53.50A	80.00A	92.75AB	94.00AB	94.00AB
Medium	12.75B	41.50B	69.25B	87.75C	90.25C	90.25C
Small	10.25C	33.00C	57.00C	85.00C	88.50C	88.50C

* Means within columns for each treatment followed by different letters are significantly different at p= ≤ 0.05 according to DMRT.

At 20°C the only significant interaction of seed size and genotype on accumulative germination percentage were detected only for the first 12 hours, while separated effect will presented for the last 12 hours.

At 20°C the accumulative germination percentage (Table 6) for both genotypes tended to decrease significantly with decreasing seed size, with no significant difference between A_1 and A_2. For the first 8 hours the accumulative germination percentage for lage A_1 and A_2 of Hourani-27 was significantly higher than that for F8.

Table (6): Effect of seed size on germination percentage of two wheat genotypes at 20 °C.

Treatment		Accumulative germination %		
		After onset germination (hour)		
Genotype	Seed size	4	8	12
Hourain-27	Large A1	23.0A	74.5A	95.0A
	A2	23.0A	74.0A	95.0A
	Medium	14.0BC	46.5C	71.5BC
	small	10.5D	38.0D	59.0D
F.8	Large A1	15.5B	55.5B	87.5A
	A2	15.5B	55.5B	88.0A
	Medium	12.0CD	44.5C	74.5B
	Small	9.5D	34.5D	65.5CD

* Means within columns followed by different letters are significantly different at $p \leq 0.05$ according to DMRT.

For the last 12 hours there was no significant difference between the two genotypes in the accumulative germination percentage (Table 7). Accumulative germination percentage for large (A_1 and A_2) were significantly higher as compared with medium and small seeds, which are not significantly different from each other.

Large seeds (Table 6, 7) germinated at significantly higher percentage. These results were disagreed with results previously reported by Green *et al.* (1966); Bhatt *et al.* (1979); Lafond Baker (1986) and Livingston and de Jong (1990), who reported that small seeds germinated faster than large seeds of different species but similar size emerged at the same rate.

Table(7): Effects of genotype and seed size on germination percentage of wheat at 20 °C.

Treatment	Accumulative germination % After the onset germination (hour)		
Genotype	**16**	**20**	**24**
Hourani-27	87.75A	89.63A	89.63A
F8	85.88A	88.50A	88.50A
seed size			
Large A1	96.25A	96.75A	96.75A
Large A2	95.00A	96.25A	96.25A
Medium	81.00B	83.25B	83.25B
Small	75.00B	80.00B	80.00B

* Means within columns for each treatment followed by different letters are significantly different at $p \leq 0.05$ according to DMRT.

At 30 °C the only significant interactive of seed size and genotype were detected for the first 8 hours. Therefor the interactive effect will be presented only for the first period and separated effect will presented for 12-24 hours (Table 6).

For both genotypes accumulative germination percentage (Table 8) significantly decrease with decreasing seed size, and it is significantly higher for Hourani-27 as compared with F8.

Table(8): Effects of seed size on germination percentage of two wheat genotypes at 30 °C.

Treatment		Accumulative germination % After onset of germination (hour)	
Genotype	Seed size	4	8
Hourani-27	Large A1	20.0A	67.0A
	A2	20.0A	64.5A
	Medium	13.5C	48.0D
	Small	10.0D	40.0F
F8	Large A1	15.5B	59.0B
	A2	13.0C	53.0C
	Medium	12.0C	44.0E
	Small	9.5D	35.0G

* Means within columns followed by different letters are significantly different at $p \leq 0.05$ according to DMRT.

After 12 hours the accumulative of germination percentage (Table 9) for medium seed were significantly lower than large (A_1 and A_2) but it is significantly higher than small seeds. Later on, accumulative germination percentage for small seeds were significantly lower as compared with other seed sizes, which are significantly in different from each other. Also, it is significantly higher for Hourani-27 as compared with F8.

These results (Table 8 and 9) confirm with previously presented results (Table 4, 5, 6, and 7) for the superiority of large seed over small one by the accumulative germination percentage and for superiority of one genotype over the other.

Table(9): Effects of genotype and seed size on germination percentage of wheat seed at 30 °C.

Treatment	Accumulative germination %			
	After the onset germination (hour)			
Genotype	12	16	20	24
Hourain-27	80.63A	92.75A	96.13A	96.13A
F8	74.88B	86.13B	92.25B	92.25B
Seed size				
Large A1	89.00A	94.50A	97.25A	97.25A
Large A2	86.00A	94.00A	96.25A	96.25A
Medium	74.00B	90.50A	95.50A	95.50A
Small	62.00C	78.75B	87.75B	87.75B

* Means within columns for each treatment followed by different letters are significantly different at $p \leq 0.05$ according to DMRT.

4.3. Effects of seed size and water potential on seed germination and seedling growth under laboratory conditions:

As no significant interactions were detected for germination percentage and root dry weight, main effects are discussed separately.

The percentage of seed germination significantly decreased with decreasing water potential for all treatments (Table 10). These results are in agreement with those results reported by Younis *et al.* (1963); Sharma (1976); Roundy *et al.* (1985); Brar *et al.* (1991) and Hardegree and Emmerich (1993).

The germination percentage significantly decrease with decreasing seed size. These were not constant with those reported by Mian and Nafziger (1994), who reported that seed size did not significantly affected germination percentage. This discrepancy might be due to difference in seed-water contact area, as reported by Hadas and Russo (1974).

The germination percentage varied significantly between the two genotypes. Hourani-27 gave significantly higher germination percentage as compared with F8. This result differed from that reported by Mian and Nafziger (1994), who reported that germination percentage of two genotypes (Howell and Auburn) were similar under growth chamber condition. This discrepancy might be due to genotypic differences.

Root dry weight decrease significantly with decreasing water potential (Table 10). Similar results were reported by Wright (1962); Gull *et al.* (1976) and Mian and Nafziger (1994). Also root dry weight significantly decrease with decreasing seed size. This was in agreement with those results reported by Evans and Bhatt (1977); Bulisani and warner (1980) and Mian and Nafziger (1994). Hourani-27 produced significantly higher root dry weight as compared with F8.

Table(10):Effects of water potential, genotypes and seed size on germination percentage and root dry weight of wheat in the growth chamber conditions.

Treatment	Germination (%)	Root dry weight (g/plant)
Water potential (kPa)		
0.0	94.17A	0.05A
-100	85.21B	0.045B
-300	73.96C	0.037C
-600	60.42D	0.03D
-900	46.25E	0.02E
Genotype:		
Hourani -27	73.75A	0.0375A
F 8	70.25B	0.0361B
Seed size:		
Large	76.125A	0.0418A
Medium	71.500B	0.0368B
Small	68.375C	0.0318C

*Means within columns for each treatment followed by different letters are significantly different at $p \leq 0.05$, according to Duncan's Multiple Range Test DMRT.

Large seeds of Hourani produce significantly higher seminal root number SRN at -100 kPa than at -300, -600 or -900 kPa, but lower (SRN) than at 0.0 kPa (Table 11). Medium seed size of Hourani-27 was not significantly affected by different water potential, whereas small seed produce significantly highest SRN at -600 kPa and lowest at -100 kPa. Large seed of F8 gave significantly largest SRN at 0.0 kPa and lowest at -900 kPa. On the other hand, SRN for medium seed tended to decrease with decreasing water potential, the same can be said for small seeds, where SRN at -100 and -300 kPa significantly larger than at -600 and -900 kPa, but significantly lower than at 0.0 kPa. From these results, it can be concluded that seminal root number decreased with increasing water stress level, which are consistent with those reported by Richards and Passiora (1981).

Large seeds of Hourani-27 gave significantly higher SRN than medium seeds only at 0.0 and -100 kPa, and both seed sizes gave significantly larger SRN than small seeds regardless of water potential level. Also large seeds of F8 produce significantly larger SRN than small seed at water potential ranges from 0.0 to -600 kPa, whereas medium seeds produce higher SRN than small seed at water potential ranged from -300 to -900 kPa.

Hourani-27 tended to produce larger SRN once compared with F8, were large seeds of Hourani-27 gave significantly the largest SRN under -100 kPa, whereas small seeds of F8 gave significantly the lowest SRN under -900 kPa. The variation in root number as a result of seed size and genotype difference was also in agreement with previous reported results by Robertson *et al*. (1979) and Richards *et al*. (1981) who indicated that seed weight is positively correlated with mean root number, but within each ploidy level accessions having similar seed weight, and significantly different mean root numbers were found.

Table (11): Effects of seed size and water potential on seminal root number of two wheat genotypes.

Genotype	Seed Size	Water potential (kPa)				
		0.0	-100	-300	-600	-900
Hourani 27	Large	6.4A	5.50B	5.00C	4.75C	4.600CD
	Medium	5.00C	4.60CD	4.60CD	4.7C	4.55CD
	Small	3.25GHI	3.05I	3.60FG	3.73F	3.50FGH
F8	Large	5.6B	4.650CD	4.80C	4.70C	3.13HI
	Medium	4.65CD	4.20DE	4.20DE	3.80EF	3.50FGH
	Small	4.60CD	3.90EF	3.63FG	3.00I	2.00I

*Means within coulumns followed by different letters are significantly different at the p≤ 0.05 according to DMRT.

Shoot dry weights of both genotypes tended to decrease with decreasing water potential and/or with decreasing seed size, with significantly higher value for large seed of Hourani-27 at 0.0 to -300 kPa, and smaller value for F8 small seeds at -600 and -900 kPa (Table 12). These results agreed with those reported by Evans and Bhatt (1977); Bulisani and Warner (1980) and Mian and Nafziger (1994), who reported larger wheat seeds gave higher shoot dry weight. Also Mian and Nafziger (1994) found shoot dry weight decreased with decreasing water potential. Small seeds of Hourani-27 at 0.0 kPa gave significantly larger shoot dry weight than F8. This result differ from that reported by Evans and Bhatt (1977) and Lafond and Baker (1986), who reported that, there was no cultivar by seed size interaction for shoot dry weight, but for each genotype there was an increase in seedling vigor with each increase in seed size. Also Younis *et al.* (1963) found no significant variety by water tension interaction. This result may obtained due to the fact that, Hourani-27 is a landrace which means there is an intra-population variation, so the response of Hourani-27 under such condition completely differ from that of F8. Also Hourani-27 is known to have longer coleoptile than F8, so it is expected to emerge and grow faster than F8, and consequently to give good stand establishment which means more dry matter due to larger and vigorous plants of Hourani-27 in comparison with the same age of F8 plants. The correlation between coleoptile length and culm length was reported to by high between culm length and coleoptile length by Duwayri (1983), Nachit and Jarrah (1986). Duwayri (1983) reported that the length of coleoptile in wheat is important to maximize yield under semiarid condition. In addition to intra-population variation and longer coleoptile, Hourani-27 have more seminal roots, which help in more water flow into plants which enhanced plant growth of Hourani-27 than F8. This finding may explain the superiority of Hourani-27 dry matter yield over that of F8.

Table(12): Effects of seed size and water potential on shoot dry weight of two wheat genotypes.

Genotype	Seed Size	Water potential (kPa)				
		0.0	-100	-300	-600	-900
Hourani- 27	Large	0.06A	0.06A	0.06A	0.05B	0.04C
	Medium	0.05B	0.05B	0.04C	0.04C	0.03D
	Small	0.03D	0.03D	0.03D	0.02E	0.02E
F8	Large	0.05B	0.05B	0.05B	0.04C	0.03D
	Medium	0.05B	0.04C	0.03D	0.03D	0.03D
	Small	0.04C	0.03D	0.02E	0.01F	0.01F

*Means within columns followed by different letters are significantly different at the $P \leq 0.05$ according to DMRT.

From the previous results (Table 10, 11 and 12), it can be concluded that, plants from larger seeds have superior vigority over plants from small seeds. These findings confirmed the results reported by other researchers (Reis and Everson, (1973), Evans and Bhatt (1977) and Lafond and Baker (1986)). This might be due to higher protein percentage in larger seeds as indicated by Bulisani and Warner (1979), and seedling dry weight were found to be positively correlated to seed protein content as indicated by Lowe *et al.*, (1972), Lowe and Ries (1973) and Ayers *et al.*, (1976).

Plants grown under high water potential showed superior vigority over plants grown under low water potential. This result is also supported by previous findings of Helmenic and Pfiefer (1954), Ashraf and Abu Shakra (1978) and Brown and Tanner (1983).

4.4. Effects of seed size and water potential on seed germination and seedling growth under greenhouse conditions:

This experiment was conducted to study the effect of seed size and water potential on germination and seedling vigority on two genotypes. As no significant interactions were detected, separate effects are presented only.

Germination percentage and root and shoot dry weight (Table 13) were significantly affected by planted genotype, were Hourani-27 produce significantly higher shoot and root dry weight with higher percent of seed germination.

The superiority of Hourani-27 over F8 for the vigority parameters might be due to its larger seed size (Table 1) or might be due to it's ability to acclimate with unfavorable conditions more than F8 as previously discussed for laboratory experiment.

Germination percentage, shoot dry weight, and root dry weight significantly decreased with decreasing seed size. These results confirmed with laboratory experiment. In both experiments, larger seeds gave higher germination percentage and higher seedling vigority as indicated by shoot and root dry weights.

Germination percentage was significantly affected by water potential (Table 13). This result disagreed with previous results reported by Hadas and Russo (1974) and Ashraf and Abu-Shakra (1978). On the other hand, these results were agreed with the findings of Ayers (1951), Helmeric and Pfeifer (1954), Younis *et al.*, (1963), Williams *et al.*, (1967), Sharma (1973, 1976), Ashraf and Abu-Shakra (1978), Somer (1983), Roundy *et al.*, (1985), Lafond and Baker (1986), Livingstone and de Jong (1990), Brar *et al.* (1991) and Mian and Nafziger (1994).

Root dry weight significantly decreased with decreasing water potential, whereas, shoot dry weight was significantly higher at -30 kPa, than other levels of water potential. This was in consistent with previous results reported by Weight (1962); Gull *et al.* (1976), Sivakumar *et al.* (1977) and Mian and Nafziger (1994) who indicated that shoot and root dry weights decreased with decreasing water potential.

Table(13): Effects of water potential, genotype and seed size on germination percentage, root and shoot dry weights of wheat under greenhouse conditions.

Treatment	Germination (%)	Root dry weight (g/plant)	Shoot dry weight (g/plant)
Water potential (kPa)			
-30	76.0 A	0.163 A	0.20 A
-100	68.0 B	0.149 B	0.17 B
-300	66.6 B	0.146 B	0.17 B
-600	59.3 C	0.139 C	0.15 B
-900	46.0 D	0.122 D	0.14 B
Genotype			
Hourani 27	66.13 A	0.152 A	0.18 A
F 8	60.26 B	0.136 B	0.15 B
Seed size			
Large	78.0 A	0.166 A	0.20 A
Medium	61.2 B	0.145 B	0.16 B
Small	50.4 C	0.122 C	0.14 B

* Means within columns for each treatment followed by different letters are significantly different at $P \leq 0.05$ according to DMRT.

5. CONCLUSIONS

1- Early moisture and temperature stresses resulted in poor germination and seriously affected subsequent seedling stand establishment, therefore, great attention should be paid for planting date.

2- Seed germination and early seedling growth was greatly affected by seed size, therefore, planting large uniform seed size is recommended to insure good and uniform stand establishment.

3- Hourain-27 was better than F8 in response to water and temperature stresses in all triats studied, this might explain why Hourani-27 is widely planted by farmers in Jordan.

4- Germination percentage and accumulative germination percentage was not related to the rate of water uptake by the seed.

6. LITERATURE CITED

1. Ashraf, C. and Abu- Shakra, S. 1978. Wheat Seed Germination Under Low Temperature and Moisture Stress. *Agron. J.*, **70:** 135- 139.
2. Ayers, A. 1951. Seed Germination as Affected By Soil Moisture and Salinity. *Agron. J.*, **44:** 82- 84.
3. Ayers, G., Wert, V. and Ries, K. 1976. The Relationship of Protein Fractions and Individual Protein to Seedling Vigor in Wheat. *Ann. Bot.*, **40:** 563- 570.
4. Bhatt, G. 1979. Effect of Simulated Drought on Germination of Wheat Cultivars. *Cereal Research Comm.*, **7:** 123-133.
5. Blum, A., Sinmena, B. and Ziv, O. 1980. An Evaluation of Seed and Seedling Drought Tolerance Screening Tests in Wheat. *Euphytica.*, **29:** 727-736.
6. Boyd, W., Gordon, A. and LaCroix, L. 1971. Seed Size, Germination Resistance and Seedling Vigor in Barley. *Can. J. Plant Sci.*. **51:** 93-99.
7. Brar, G., Gomez, J., McMichael, B., Matches, A. and Taylor, H. 1991. Germination of Twenty Forage Legumes as Influenced By Temperature. *Agron. J.*, **83:** 173-175.
8. Brown, P., and Tanner, C. 1983. Alfalfa Stem and Leaf Growth During Water Stress. *Agron. J.*, **75:** 799-805.
9. Bulisani E., and Warner, R. 1980. Seed Protein and Nitrogen Effects Upon Seedling Vigor in Wheat. *Agron. J.* **72:** 657-662.
10. Burris, J., Edje, O. and Wahab, A. 1973. Effects of Seed Size on Seedling Performance in Soybeans: II. Seedling Growth and Photosynthesis and Field Performance. *Crop Sci.*, **13:** 207-210.
11. Clarke, J. 1980. Measurement of Relative Water Upake Rate of Wheat Seed Using Agar Media. *Can. J. Plant Sci.*, **60:**1035-1038.

12. Ching, T., and Rynd L. 1978. Development and Differences in Embryos of High and Low Protein Wheat Seeds During Germination. *Plant Physiol.*, **62:** 866-870.

13. Douglas, G., Wilkins, D. and Churchill, D. 1994. Tillage, Seed Size and Seed Density Effects on Performance of Soft White Winter Wheat. *Agron J.*, **86:** 707- 711.

14. Duwayri. M. 1983. Selection for Coleoptile Length and Plant Height in Early Generations in Durum Wheat. *Proc. 6th International wheat Genetic symposium*, Kyoto, Japan: 701-707.

15. Evans, L. and Bhatt, G. 1977. Influence of Seed Size, Protein Content and Cultivar on Early Seedling Vigor in Wheat. *Can .J. of Plant Sci.*, **57:** 929- 935.

16. FAO. *Production Year Book*, 1994.

17. Feldman, M. 1976. Wheats, Triticum spp. In: Simmonds, N. (ed.). *Evolution of Crop Plants*. Longman, London. PP.120-128.

18. Gan, Y. and Stobbe, E. 1996. Seedling Vigor and Grain Yield of 'Roblin' Wheat Affected By Seed Size. *Agron. J.*, **88:** 456-460.

19. Green, D., Cavanah, L. and Pinnell, E. 1966. Effect of Seed Moisture Content, Field Weathering, and Combine Cylinder Rate on Soybean Seed Quality. *Crop Sci.*, **6:** 7-10.

20. Gull A., and Allan, R. 1976. Stand Establishment of Wheat Lines Under Different Levels of Water Potential. *Crop Sci.*, **16:** 611-614.

21. Hadas, A. and Russo, D. 1974. Water Uptake By Seeds as Affected By Water Stress, Capillary Conductivity, and Seed-Soil Water Contact. I. Experimental Study. *Agron.J.*, **66:** 643-647.

22. Hardegree, S. and Emmerich, W. 1992. Effect Of Matric- Priming Duration and Priming Water Potential on Germination of Four Grasses. *J. Experimental Botany.*, **43:** 233 - 238.

23. Helmerick, R, and Pefeifer, R. 1954. Differential Varietal Responses of Winter Wheat Germination and Early Growth to Controlled Limited Moisture Conditions. *Agron. J.*, **46:** 560-562.

24. Jaradat, A. 1979. *Comparisons Among Several Wheat Varieties in Relation to Yield, Yield Components, and Root System*. Master Thesis. University of Jordan, Amman, Jordan.

25. Klute, A. 1986. Water retention: Laboratory Methods. In: A. Klute (ed.). *Method of Soil Analysis*. 2nd Edition- Part One. Agron. Monogr.9. ASA and SSSA, Madison, WI., PP. 635-650.

26. Lafond, G., and Baker, R. 1986 a. Effects of Genotype and Seed Size on Rate of Emergence and Seedling Vigor in Nine Spring Wheat Cultivars. *Crop Sci.*, **26:** 341-346.

27. Lafond, G., and Baker, R. 1986. b. Effect of Temperature, Moisture Stress, and Seed Size on Germination of Nine Spring Wheat Cultivars. *Crop Sci.*, **26:** 563-567.

28. Lafond, G. and Fowler, D. 1989. Soil Temperature and Moisture Stress Effects on Kernel Water Uptake and Germination of Winter Wheat. *Agron J.*, **81:** 447- 450.

29. Livingston N., and de Jong, E. 1990. Matric and Osmotic Potential Effects on Seedling Emergence at Different Temperatures. *Agron J.*, **82:** 995-998.

30. Lopez, A., and D. Grabe 1971. Effect of Seed Protein Content on Plant Growth of Barley and Wheat. *Agronomy Abstracts*. ASA, Madison, WI., pp.44.

31. Lowe, L., Ayers, G. and Ries, S. 1972. Relateinship of Seed Protein and Amino Acid Composition to Seedling Vigor and Yield of Wheat. *Agron. J.*, **64:** 608- 611.

32. Lowe, L., and Ries, S. 1973. Effects of Environment on The Relative Between Seed Protein and Seedling Vigor in Wheat. *Can. J. Plant Sci.*, **52:** 157-164.

33. Mian, M., and Nafziger, E. 1994. Seed Size and Water Potential Effects on Germination and Seedling Growth of Winter Wheat. *Crop Sci.*, **34:** 169-171.

34. Mian, M., and E. D. Nafziger. 1992. Seed size effects on emergence, head number, and grain yield of winter wheat. J. Prod. Agric 5: 265-268.

35. Nachit, M. and Ketata, H. 1986. Breeding Strategy for Improving Durum Wheat in Mediterranean Rainfed Areas. *4th international wheat conference*. Rabat. Morocco.

36. Nachit, M. and Jarrah, M. 1986. Association of Some Morphological Character of Durum Wheat Under Mediterranean Dry Land Conditions. *Rachis*, **5:** 33-34.

37. Ries, S. and Everson, E. 1973. Protein Content and Seed Size Relationships With Seedling Vigor of Wheat Cultivars. *Agron. J.*, **65:** 884-886.

38. Ries, S., Moreno, W., Meggitt, Schweizer, J. and Ashkar, A..1976. Wheat Seed Protein Chemical Influence on and Relationships to Subsequent Growth and Yield in Michigan and Mexico. *Agron. J.*, **62:** 746-748.

39. Roundy, B., Young, J. and Evans, R. 1985. Germination of Basin Wild and Tall Wheatgrass in Relation to Osmotic and Matric Potential. *Agron. J.*, **77:** 129-135.

40. Richards, R. and Passioura, J. 1981. Seminal Root Morphology and Water Use of Wheat. I. Environmental Effects. *Crop Sci.*, **21:**249-252.

41. Robertson, B., Waines, J. and Gill, B. 1979. Genetic Variability for Seedling Root Number in Wild and Domesticated Wheats. *Crop Sci.*, **19:** 843-847.

42. Sivakumar, M., Taylor, H. and Shaw, R. 1977 Top and Root Relations of Field - Grown Soybeans. *Agron.J.*, **69:** 470-473.

43. Singh, K.., and Singh, K. 1982. Stress Physiological Studies on Seed Germination and Seedling Growth of Some Wheat Hybrids. *Indian J. Plant Physiol.*, **25:** 180-186.

44. Sharma, M. 1976. Interaction of Water Potential and Temperature Effects on Germination of Three Semi-arid Plant Species. *Agron. J.*, **68:** 390-394.

45. Sharma, M. 1973. Simulation of Drought and It's Effect on Germination of Five Pasture Species. *Agron.J.*, **65:** 982-987.

46. Somers, D., Ullrich, S. and Ramsay, M. 1983. Sunflower Germination Under Simulated Drought Stress. *Agron. J.*, **75:** 570-572.

47. Tadmor, N., Cohen, Y. and Harpaz, Y. 1969. Interactive Effects of Temperature and Osmotic Potential on The Germination of Range Plants. *Crop Sci.*, **9:** 771- 774.

48. Thill, D., Schirman, R. and Appleby, A. 1979. Osmotic Stability of Mannitol and Polyethylene Glycol 20.000 Solutions Used as Seed Germination Media. *Agron. J.*, **71:** 105- 108.

49. Williams, T., Snell, R. and Ellis, J. 1967. Methods of Measuring Drought Tolerance in corn. *Crop Sci.*, **7:** 179-182.

50. Wright. N. 1962. Root Weight and Distribution of Blue Panicgrass, ***panicum antidotale Retz.***, as Affected by Fertilizers, Cutting Height and Soil- Moisture Stress. *Agron. J.*, **54:** 200-202.

51. Younis, M., Stickler, F. and Sorensen, E. 1963. Reactions of Seven Alfalfa Varieties Under Simulated Moisture Stresses in The Seedling Stage. *Agron. J.*, **55:** 177-181.

7. APPENDIX (A)

Appendix(2): Effect of seed size on germination percentage of two wheat genotypes at 15°C.

Treatment		Accumulative germination %					
Genotype	Seed size	After onset germination (hours)					
		4	8	12	16	20	24
Hourani-27	Large A1	18.0A	58.0A	85.0A	95.5A	96.5A	96.5A
	large A2	16.0B	55.50A	81.0AB	94.0AB	95.5AB	95.5AB
	Medium	13.0CD	39.0CD	70.5BC	87.0ABC	89.0CD	89.0CD
	Small	10.5E	31.0D	60.0CD	90.0ABC	91.0ABCD	91.0ABCD
F 8	Large A1	15.0BC	53.5AB	80.0AB	93.0AB	95.0ABC	95.0ABC
	A2	15.0BC	51.5AB	79.0AB	91.5AB	92.5ABCD	92.5ABCD
	Medium	12.5D	44.0BC	68.0BC	83.0C	88.00D	88.00D
	Small	10.0E	35.0CD	54.0D	85.5BC	89.5 BCD	89.5 BCD

* Means followed by different letters are significantly different at p≤ 0.05 according to DMRT.

Appendix(3): Effect of seed size on germination percentage of two wheat genotypes at 20 °C.

Treatment		Accumulative germination%					
Genotype	Seed size	After onset germination (hour)					
		4	8	12	16	20	24
Hourani-27	Large A1	23.0A	74.5A	95.0A	98.0A	99.0A	99.0A
	A2	23.0A	74.0A	95.0A	99.5A	100A	100A
	Medium	14.0B	46.5C	71.5BC	81.0B	83.0BC	83.0BC
	Small	10.5D	38.0D	59.0D	72.5B	76.5C	76.5C
F 8	Large A1	15.5B	55.5B	87.5A	92.0A	93.5AB	93.5AB
	A2	15.54B	55.5B	88.0A	93.0A	93.5AB	93.5AB
	Medium	12.0CD	44.5C	74.5B	81.0B	83.5BC	83.5BC
	Small	9.5D	34.5D	65.5CD	77.5B	83.5BC	83.5BC

* Means followed by different letters are significantly different at p≤ 0.05 according to DMRT.

Appendix(6): Effect of seed size and water potential on dry weight of two wheat genotypes grown under growth chamber conditions.

Genotype	Seed size.	Water potential (kPa)				
		00	-100	-300	-600	-900
Hourani -27	Large	0.060A	0.050B	0.040C	0.030D	0.03D
	Medium	0.05B	0.05B	0.04C	0.03D	0.02E
	Small	0.05B	0.04C	0.03D	0.03D	0.02E
F8	Large	0.05B	0.05B	0.04C	0.04C	0.03D
	Medium	0.05B	0.04C	0.04C	0.03D	0.02E
	Small	0.04C	0.04C	0.03D	0.03D	0.02E

* Means followed by different letters are significantly different at $p \leq 0.05$ according to DMRT.

Appendix(7):Effect of seed size and water potential on germination percentage of two wheat genotypes grown under greenhouse conditions.

Genotype	Seed size.	Water potential (kPa)				
		-30	-100	-300	-600	-900
Hourani -27	Large	100A	84BA	80BCD	72CDE	60EFG
	Medium	76CD	72CDE	72CDE	60EFG	48GHI
	Small	60EFG	60EFG	60EFG	52GH	36IJ
F8	Large	92AB	80CD	76CD	76CD	60EFG
	Medium	68DEF	60EFG	60EFG	56FG	40HIJ
	Small	60EFG	52GH	52GH	40HIJ	32J

* Means followed by different letters are significantly different at $p \leq 0.05$ according to DMRT.

APPENDIX (B)

الملخص

تأثير حجم البذور ودرجات الحرارة والجهد المائي على الإنبات ونمو البادرات لصنفين من القمح

إعداد

حسين علي القاسم

المشرف

الأستاذ الدكتور محمود عايد الدويري

المشرف المشارك

الدكتور عمر الكفاوين

اجريت اربع تجارب مخبرية لقياس تأثير حجم البذور، ودرجة الحرارة، والشد المائي على معدل امتصاص الماء، نسبة الانبات، ونمو البادرات في صنفين من القمح (حوراني-٢٧، ف ٨).

تم قياس معدل امتصاص الماء لحجمين من البذور (الكبيرة والصغيرة) في صنفين من القمح، باستخدام الحاضنات وعلى درجات حراره ٥، ١٠ و ٢٠ مْ .

اظهرت النتائج أن معدل امتصاص الماء يزيد بزيادة درجات الحرارة وتناقص حجم البذور. ولم يكن هناك فروق معنوية بين الصنفين في معدل امتصاص الماء.

تم استخدام الحاضنات لقياس نسبة الانبات في احجام مختلفة لبذور صنفين من القمح أنبتت في الماء المقطر على درجات حرارة مختلفة (٥،١٠،١٥،٢٠،و٣٠مْ) بدأ الانبات بعد ٧، ٤، ٣، و٢ يوم لدرجات حرارة ١٠،١٥،٢٠،و ٣٠مْ على التوالي ، ولم يكن هناك أي انبات ولمدة شهر على درجة حرارة ٥مْ كما اظهرت النتائج تفوقا معنويا للبذور الكبيرة الحجم مقارنة بالبذور الصغيرة الحجم من حيث نسبة الانبات التراكمية.

كما وأظهر الصنف ف ٨ تفوقا معنويا مقارنة بالصنف حوراني-٢٧ في نسبة الانبات على درجة حرارة (١٠مْ) ، في حين انه لم يكن هنالك فرق معنوي بين الصنفين على درجة حرارة (١٥مْ)، ولكن على درجات حرارة (٢٠و٣٠مْ) كانت نسبه انبات الصنف حوراني ٢٧ اكثر منها في الصنف ف٨.