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ENGINEERING AND BIOLOGICAL PROPERTIES OF FABA BEAN SEEDS UNDER DIFFERENT IRRIGATION SYSTEMS

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ABSTRACT

Seeds of faba bean (Giza 461) were submitted from Gene Bank, Agricultural Research Center, Giza and used in this investigation. Faba bean was cultivated under different irrigation systems (subsurface drip, surface drip, center pivot, solid set sprinkler and modified surface irrigation by using gated pipes). Four levels of water amounts were applied to the plants at recommended irrigation intervals of the different irrigation systems used in this investigation. These four amounts were 50, 75, 100 and 125% of the calculated water consumption use (ETc). All plots were harvested manually and the harvested plants were subjected to air drying, then, faba bean pods and seeds were separated manually. From results obtained the seed volume was significantly affected by irrigation system, water requirement and their interaction, whereas, seed volume increased as water requirements increased. Seed volume increased gradually from 647 to 790 mm^3 as water requirements increased from 50% to 125% of ETc. Subsurface drip irrigation system gave the greatest geometry diameter of 9.3 mm. Only water requirement and its interaction with irrigation system showed significant effects on seed sphericity percentage, Values of hectolitre weight varied as affected by irrigation system since modified surface irrigation system gave the greatest value recorded (722 g/L). Higher seed moisture content of seeds were produced under sprinkler and pivot irrigation systems (16.4 and 16.0%) , these high moisture content was due to the high humidity over the plant canopy during the irrigation process. Weight of 1 00 seeds increased significantly by increasing amounts of irrigation water up to 100 % of ETc (60.4 g). Irrigation system had significant effect on the angle of repose. Seed friction coefficient decreased from 0.379 to 0.363 by increasing water requirement from 50% to 125% of ETc. Irrigation system had significant effect on seed germination. , the greatest germination percentage was 94.7% for seeds produced under modified surface irrigation system, while the smallest germination percentage was 89.3% under pivot system. On the other hand, the lowest percentage of vigor was 75.2% under subsurface drip irrigation, while the highest percentage was 82.3% when using pivot irrigation system.

INTRODUCTION

Faba bean is considered to be the most important legume crop in Egypt .The cultivated area of faba bean crop in 1997 amounted to 393,307 feddans according to Agric. Extension Issue, (1998).

A great percentage of the crop production was locally consumed as human food. Seed physical and mechanical properties affecting both seed quality and production must be considered as a good parameters for designing the agricultural machinery such as - planters , harvesters, seed cleaning machines, grading machines, seed drying machines and storage equipments (Harrnond *et al.*, 1962 and Zoerb , 1967).

Static and dynamic coefficients of friction of grain on surfaces of metal and concrete increased by increasing the moisture content of grain but if the moisture content of grain increased than 13%, the friction coefficient were decreased (Stewart *et al.*, 1969). While in certain applications where both seed shape and size affect the process, the relation can be expressed by a single two dimensional system as follows: 1 = f (sh , s) where "I" is an index influenced by both shape "sh" and size "s". In other applications the index may be a function of not only shape and size but also such other parameters as orientation "o", packing "p", firmness "f", ... etc. , as follows : 1 = f (sh , s , o, p, f, ...) (Mobsenin , 1970).

Physical properties such as shape , size , volume , surface area , density , colour , porosity , ...etc. for different grains are important in designing the different systems of threshing , handling, sorting and drying machines , also angle of repose and seed friction characters are important in designing the different shapes of hoppers , grain conveying equipments , storage bins and grain pumping equipments (Chakraverty, 1972).

FAO (1981) classified seeds properties into two groups, (1)- internal properties (varieties - variety purity - viability - germination power and vigour) (2)- External properties (internal purity - volume grading - specific gravity - moisture content).

Practical use of the physical and mechanical properties of plants helps planners to determine the size of machines and develop schemes for technological processes, select more appropriate structural materials and improve the strength of individual subassemblies and parts of agricultural machinery (Buyanov and Voronyuk, 1985). Meanwhile, (Sitkei, 1986) found that shapes of various seeds are generally irregular, and so very great number of measurements data would be needed to describe them accurately. However, practical measurements show that the various shapes may generally be characterized well by specifying purposely selected orthogonal axes. Seeds are usually characterized by their length, width and thickness, these dimensions of agricultural products are not uniform, but scatter around a mean value. Therefore, it is necessary to determine the distribution of individual sizes and the mean size on the basis of this distribution.

Recently, there has been a general recognition of the need to determine the physical and mechanical characteristics of seeds. This is due to many problems that have been caused the developed mechanization and the application of engineering principles to agricultural production, processing, handling and automation.

The properties of these agricultural products must be described in concise engineering terms which an engineer can utilize effectively in the design of specific machine and its operation or in analysis and of the behaviour of the product in handling of the material (El- Raie *et al.* , 1996)

The main objective of this work is to study the effect of different irrigation systems and different amount of water supply on physical, mechanical and biological characteristics and quality of faba bean seed as well.

MATERIALS AND METHODS

Seed material:

Seeds of faba bean (Giza 461) were submitted from Gene Bank, Agricultural Research Center, Giza and used in this investigation. Normal cultivation practices were followed during 1997/1998 and 1998/1999 growing seasons in the Experimental Farm of the Faculty of Agriculture, Ain Shams University at El- Kanater, Kalubia Governorate (loamy clay soil).

Experimental protocol:

Faba bean was cultivated under different irrigation systems are: Surface and subsurface drip irrigation (GR-drip lines, 8lph/m length at 1.0 bar operating pressure), solid set sprinkler irrigation (sprinkler had two nozzles are 3 and 5mm diameter) and 1.5m^3/h discharge at 2.5 bar operating pressure), center pivot sprinkler irrigation(one span with length of 48m and 10m^3/h discharge at 3.0 bar operating pressure), and modified surface irrigation by using gated pipes(The gates were fixed on 6" aluminium pipes and gate discharge of 4.0m^3/h). Four levels of water amounts were applied to the plants at recommended irrigation intervals of the different irrigation systems used in this investigation. These amounts were 50, 75, 100 and 125% of the calculated water consumption use (ETc). Amounts of irrigation water applied to the plants for each irrigation system was calculated according to the available local weather station data at the Central Laboratory Agricultural Climate (CLAC) of Egypt, Ministry of Agriculture and Land Reclamation. These data are presented in Table (1).

Table (1): Total amounts of irrigation water applied (W.A.) and No. of irrigations (I) of the irrigation systems used.

Irrigation systems	50% ETC		75% ETC		100% ETC		125% ETC	
	W.A. m^3/fed	I	W.A. m^3/fed	I	W.A. m^3/fed	I	W.A. m^3/fed	I
Surface drip	460	27	690	27	920	27	1150	27
Subsurface drip	460	27	690	27	920	27	1150	27
Centre pivot	590	19	890	19	1180	19	1480	19
Sprinkler	590	19	890	19	1180	19	1480	19
Gated pipes	520	3	780	4	1040	4	1300	4

All plots were harvested manually at full maturity stage, whereas, the harvested plants were subjected to air drying for a period of 21 days. At the end of drying period, faba bean pods and seeds were separated manually. An amount of 10 kilograms seeds of each treatment were taken to Agronomy Seed Lab. and Agric, Eng. Lab., Faculty of Agriculture, Ain Shams University for proper analysis.

Data recorded:

The following properties were recorded to evaluate the effect of irrigation systems studied:

A- Seed physical properties:

1- Seed dimensions:

The dimensions of fresh faba bean seeds (length "L", width "W" and thickness "T") were measured by slide caliper. The mean dimensions of 300 seeds of each treatment were measured, whereas, the physical properties were calculated according to the following equations

Geometry diameter = $(L.W.T.)^{1/3}$, mm

Seed volume = L.W.T, mm^3

Seed sphericity $=100(L.W.T)^{1/3} / L$, %

2- Seed moisture content:

The moisture content of faba bean seeds was determined by using a seed sample of 20 grams which placed in forced convection oven set at 105'C for 24 hours. Percentage of seed moisture content was calculated.

3- Seed specific weight:

The weight of 100 seeds "W" was measured by electrical balance. The actual volume of seeds "Va" measured by immersing the sample in checked cylinder filled up with water, and the displaced volume of water were recorded. Seed specific weight was figured by applying the following equation:

Specific weight = W/ V_a, gm/cm^3 .

4- Hectolitre weight:

Hectolitre weight was measured by weighing one litre of seeds.

5- Seed porosity:

Seed porosity was calculated by using the following equation:

Porosity = $(V_b - V_a / V_b)$ X 100

Where: "V_b" and "V_a" are bulk and actual volumes of seed samples in cm^3.

6- Float index:

Float index "Fi" is a relation between filling coefficient and seed total surface area. It was calculated using the following equation:

Fi = Total surface area (cm^2) / seed weight (gm)

To calculate seed total surface area, an equation was derived depending on the relation of seed dimensions (geometry diameter) and total surface area as shown in Fig (1), whereas, seed total surface area was estimated from the figured relation. Seed total surface area was divided by seed weight to obtain floating index.

B- Seed mechanical properties:

1 - Static coefficient friction:

The friction coefficient "g" of seed sample (1 009m) was determined by measuring the tangent of the angle "pi" at which the seeds sample starts to slide down the slope on steel surface as shown in Fig (2) . The coefficient of friction was calculated by the following equation:

$\mu = \tan \alpha$

2- Natural angle of repose:

The device is shown in Fig. (3) was used for measuring the dynamic natural angle of repose. Seeds sample placed in a box flows through an aperture in its base, whereby a funnel shaped surface is formed in the box and a conical surface underneath. The angles of this surface are enclosed with horizontal give the dynamic natural angle of repose.

3- Seed hardness:

Seed hardness was determined by using an apparatus which designed and manufactured to measuring the penetration force required to fracture the seed in Agric. Eng. Dept., Fac. of Agric., Ain Sharns Univ. The construction is shown in Fig (4). The following equation was used to calculate the seed hardness.

Seed hardness = registered force reading (N) / contact area (mm^2)

C- Seed biological properties:

I- Germination percentage:

Samples of 100 seeds in four replicates of each treatment were germinated on paper in 12.5 cm Petri dish and incubated at 20^0 C for period of 7days (ISTA, 1996). Germination percentage was calculated as follows:

Germination % = (No. of germinated seeds / total seeds) x 100

2- Vigor percentage:

Sample of 100 seeds in four replicates of each treatment were germinated on paper in 12.5 cm Petri dish and incubated at 10^0C for period of 7days (ISTA, 1996). Germination percentage was calculated as follows:

Vigor, % = (No. of germinated seeds / total seeds) x 100

Statistical analysis:

Collected data were exposed to proper statistical analysis of variance of completely randomized design, then combined analysis was performed, whereas, combined values of both 1997/1998 and 1998/1999 seasons were used for means comparison. LSD at level 5% test was used for comparison between means (Snedecor, 1956).

RESULTS AND DISCUSSION

1-Effect of irrigation system and water requirement on physical properties of seeds:

Data presented in (Table2) indicated that seed dimensions (length width and thickness) did not vary as affected by irrigation system , water requirement and their interaction except effects of irrigation system on seed length which showed significant differences, however, the calculated seed volume showed significant differences as affected by irrigation system , water requirement and their interaction.

Table (2): Effect of irrigation system and water requirement on dimensions, of faba bean seeds(mean of two seasons).

Irrigation systems	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	Seed volume (mm^3)	Geometry diameter (mm)	Sphericity %
Subsurface drip	13.0	9.6	6.6	816	9.3	70.1
Surface drip	12.7	9.5	5.8	731	8.9	70.2
Pivot	12.4	9.5	5.7	667	8.7	70.7
Sprinkler	12.8	9.7	6.4	793	9.2	71.7
Gated pipes	12.1	9.3	6.1	681	8.7	71.9
LSD	0.32	N.S.	N.S.	26.03	0.28	N.S.
Water requirement: W1	1.9	9.2	5.9	647	8.58	72.3
W2	12.5	9.6	6.1	738	9.03	72.3
W3	12.9	9.6	6.2	775	9.08	70.3
W4	13.0	9.5	6.2	790	9.18	68.3
LSD	N.S.	N.S.	N.S.	24.01	0.48	1.63
Irri. sys. X W. req.						
Subsurface drip:W1	12.5	9.4	6.3	740	9.05	72.4
W2	13.0	9.5	6.3	778	9.20	70.6
W3	13.5	9.9	6.5	869	9.54	70.6
W4	12.8	9.5	7.2	876	9.57	66.9
Surface drip :W1	11.9	9.3	5.9	653	8.68	72.9
W2	12.4	9.3	6.1	703	8.90	71.8
W3	13.0	9.6	6.0	749	9.08	69.8
W4	13.6	9.7	5.2	818	9.04	66.4
Pivot : W1	11.8	9.0	6.3	563	8.26	70.0
W2	12.5	9.7	5.7	691	8.84	70.7
W3	12.5	9.9	5.7	705	8.90	71.2
W4	12.6	9.2	6.1	707	8.91	70.7
Sprinkler : W1	12.4	9.4	6.3	734	8.73	70.4
W2	12.8	10.6	6.4	868	9.54	74.5
W3	12.9	9.4	6.6	800	9.30	72.1
W4	13.1	9.3	6.3	768	9.15	69.8
Gated pipes: WI	10.8	9.0	5.6	544	8.17	75.6
W2	11.7	9.1	6.1	649	8.66	74.0
W3	12.7	9.4	6.3	752	8.58	67.6
W4	13.1	9.6	6.2	780	9.21	70.3
LSD	N.S.	N.S.	N.S.	58.50	0.43	3.96

The greatest seed dimensions of13mm length,9.6mm width and 6.6mm thickness (giving volume of 816 mm^3) were obtained when faba bean irrigated using subsurface drip irrigation system, while, the lowest seed dimensions of 12.4 mm length , 9.5 mm width and 5.7 mm thickness (giving volume of 667mm^3) were obtained when using pivot irrigation system. Increasing seed dimensions and volume of seeds produced under subsurface drip irrigation which may be due to the relatively high amount of water in the root zone, less evaporation loss and less nutrients leaching by runoff or deep percolation, and therefore, increasing translocation of metabolises to seeds. On the other hand, it could be noticed that although seed dimensions (length, width and thickness) did not show any significant differences due to the plants, seed volume varied significantly as affected by amount of water applied. Seed volume increased as water requirements increased, whereas, seed volume increased gradually from 647 to 790 mm^3 as water requirements increased from 50% to 125% of the calculated water consumption use (ETc). It is noticed that the greatest seed volume of 876 mm^3 was obtained under subsurface drip irrigation and received the maximum water amount used (125% of ETc). It could be concluded that applied agricultural factors such as irrigation system and water requirement may affect seed dimensions and therefore, seed men should consider variation of seed dimensions and seed volume as well within a seed lot even if it was for a certain propagation degree since different production conditions may affect seed dimensions when separation and grading devices to designed or to be selected for the process.

Irrigation sys.em, water requirement and their interaction had a significant effects on seed geometry diameter , whereas, subsurface drip irrigation system gave the greatest geometry diameter of 9.3 mm, while the values of seed geometry diameter were recorded for seeds produced under pivot and modified irrigation systems (8.7 mm). These results are similar with seed dimensions and volume results since the same attitude of irrigation system effects was found. Therefore, variation of seed geometry diameter may be .due to variation found in seed dimensions of the produced seed of same irrigation treatment. Applied water amounts to faba bean were found to have significant differences on seed geometry diameter, whereas gradual increasing in water amount from 50% of ETC to 125% of ETC caused geometry diameter to be increased gradually from 8.58 to 9.18 mm. The greatest seed geometry diameter (9.57mm) was recorded when seeds produced under subsurface drip irrigation and irrigated with amount of water equal 125% of ETC.

Only water requirement and its interaction with irrigation system showed significant effects on seed sphericity percentage. As seed increased in its dimensions and accordingly the calculated volume, it was found that seed sphericity decreased in turn. Meaning that , increasing seed dimensions and increasing in translocation of metabolises into seed did not cause seed to be rounded , while seeds which recorded the lowest seed dimensions as affected by amount of water (50% of ETC) gave the maximum sphericity % . It could be concluded that, there is a negative correlation between seed volume and sphericity. These findings may provide a great consideration on bases used to design seed separation and grading devices.

Irrigation system and water requirement showed significant effects on hectolitre weight (Table 3), while their interaction did not show any significance. Values of hectolitre weight varied as affected by irrigation system since modified surface irrigation system gave the greatest value recorded (722 g/L), meanwhile, subsurface drip irrigation system gave the lowest hectolitre weight (689 g/L). It is noticeable that these two systems recorded the maximum and minimum sphericity % respectively, which in turn caused pores between seeds to be decreased as sphericity % increased. Consequently, seeds which have high sphericity % and low in between pores within seeds gave highest hectolitre weight since decreasing pores caused number of seeds in the hectolitre device to be increased and vice versa.

On the other hand, seeds of the lowest dimensions and volume which produced under lowest amount of irrigation used (50% of ETC) gave the greatest hectolitre weight (725 g/L). Seed volume has considerable effects on hectolitre weight, meaning, treatments such as increasing irrigation water applied may attributed to increase seed dimensions and consequently increasing total pores between seeds. These circumstances caused hectolitre weight to be decreased.

Seed specific weight, porosity % and float index did not affect by the experimental treatments whereas, statistical analysis of obtained data did not show significance (Table 3). Type of storage polymers in cotyledons, moisture content and filling capacity are factors affecting seed specific weight. Although this investigation showed significant effects of the treatments used on some factors affecting specific weight, consequent effects of these factors did not enforce specific weight to be affected. It would be more understandable if we conclude that experimental treatments did not affect the type of storage polymers in cotyledons which is the most important factor affecting specific weight, and therefore, the experimental treatments did not show any effects on specific weight.

Table (3): Effect of irrigation system and water requirement on some physical properties of faba bean seeds (mean of two seasons).

Irrigation systems	Hectolitre weight (g/l))	Specific weight (g/cm^3)	Porosity (%)	Float index (cm^3/g)	100 seed weight (g)	Moisture Content (%)
Subsurface drip	689	1.24	42.5	8.3	61.5	16.0
Surface drip	708	1.25	42.8	7.5	60.2	15.4
Pivot	717	1.22	45.0	7.2	56.4	16.0
Sprinkler	691	1.25	44.3	8.0	59.6	16.4
Gated pipes	722	1.22	44.0	7.0	56.3	15.7
LSD	17.10	N.S	N.S	N.S	2.94	0.36
Water requirement: W1	725	1.25	43.6	7.3	56.3	15.6
W2	701	1.22	43.2	7.6	58.7	14.6
W3	690	1.24	44.0	7.6	60.4	16.3
W4	704	1.24	44.0	7.8	59.8	16.9
LSD	11.10	N.S	N.S	N.S	1.58	0.22
Irri. sys. X W. req.						
Subsurface drip:W1	694	1.25	43.0	8.0	58.9	15.2
W2	681	1.23	41.0	8.4	59.8	15.7
W3	684	1.23	43.0	8.7	66.3	15.8
W4	698	1.25	43.0	7.9	61.5	17.1
Surface drip :W1	714	1.25	40.0	7.2	56.9	14.3
W2	723	1.25	44.0	7.6	59.3	15.5
W3	698	1.25	43.0	7.3	60.5	15.6
W4	697	1.27	44.0	7.7	63.9	16.1
Pivot : W1	753	1.24	48.0	7.5	54.1	16.7
W2	723	1.22	44.0	6.2	58.2	12.1
W3	660	1.23	45.0	7.7	59.8	17.3
W4	713	1.22	43.0	7.5	53.6	17.7
Sprinkler : W1	712	1.26	44.0	8.1	57.4	16.8
W2	649	1.26	42.0	9.2	59.6	14.1
W3	701	1.26	45.0	6.8	60.2	17.3
W4	701	1.22	46.0	8.0	61.2	17.4
Gated pipes: WI	753	1.24	43.0	5.9	54.3	5.2
W2	733	1.18	45.0	6.4	56.7	15.5
W3	688	1.23	44.0	7.7	55.4	15.6
W4	714	1.25	44.0	8.1	58.6	16.4
LSD	N.S	0.40	N.S	N.S	3.84	0.54

Similarly, porosity did not show significant differences, even when factors such as seed dimensions seed volume and sphericity which affecting porosity showed significant differences.

Meanwhile, variation in seed dimensions had no effects on seed area in a way that affect float index remarkably. It could be concluded that seed specific weight, porosity % and float index are physical properties which did not respond to the experimental factors.

Data presented in (Table 3) showed that irrigation system, water requirement and their interaction had significant effects on 100 seed weight and seed moisture content. Higher seed moisture were of seeds produced under sprinkler and pivot irrigation systems (16.4 and 16.0%), these high moisture content was due to the high humidity over the plant canopy during the irrigation process and therefore, seeds initially contained high moisture content before exposing them to air dry., thus, variation in final seed moisture content was observed revealing that seed produced under high relative humidity contained high moisture content and eventually required longer period of drying than seeds produced under other irrigation systems.

High moisture content did not contribute in 100 seed weight since treatments had high moisture content showed less 100 seed weight, while seeds which showed great volume and dimensions (subsurface drip irrigation) gave the greatest 100 seed weight (61.5g), meaning that seed filling capacity affect 100 seed weight rather than seed moisture content. Weight of 100 seeds significantly increased by increasing amounts of irrigation water up to100 % of ETc (60.4 g), meanwhile the moisture content in faba bean seed increased as water supply increased up to 125 % of ETc (16.9%). Therefore, the greatest 100 seed weight was obtained from seeds produced under subsurface drip irrigation and supplied with 100% of ETc (66.3g). However, the greatest seed moisture content was obtained when seeds produced under pivot irrigation system and supplied with 125% of ETc irrigation water. Seed men pay great consideration to 100 seed weight parameter since this parameter is the most important in determining seed good quality, and seed moisture content as well is important parameter which enable seed men to decide the obligatory of drying process and suitable level of drying which bring seeds to the status to be handled and stored safely.

2-Effect of irrigation system and water requirement on mechanical properties of seeds:

Data presented in (Table 4) only irrigation system had significant effect on the angle of repose, whereas, the greatest value of angle of repose was 23.2^{0} for seeds produced under subsurface drip irrigation system, while the lowest value of angle of repose was 20.4^{0} under modified surface These findings contributed to the great dimensions of seeds produced under subsurface drip irrigation system compared with dimensions of seeds produced under the other irrigation systems. On the other hand, it could be noticed that the water requirement and its interaction with irrigation systems showed no significant effect on angle of repose. The angle of repose of seeds is a parameter plays a significant role when designing handling machine is considered.

Table (4): Effect of irrigation system and water requirement on mechanical and biological properties of faba bean seeds (mean of two seasons).

Irrigation systems	Angle of repose (deg.)	Friction coefficient	Seed hardness (N/mm²)	Germination (%)	Vigor (%)
Subsurface drip	23.2	0.388	61.5	93.3	75.2
Surface drip	22.0	0.379	60.1	92.0	78.4
Pivot	20.6	0.370	56.0	89.3	82.3
Sprinkler	20.9	0.360	59.6	90.7	76.2
Gated pipes	20.4	0.355	56.3	94.7	79.9
LSD	1.73	0.008	N.S.	4.42	6.45
Water requirement: W1	21.2	0.379	62.0	92.7	80.7
W2	21.7	0.374	59.0	84.1	78.8
W3	21.7	0.366	57.6	86.9	76.1
W4	21.0	0.363	56.2	92.0	78.0
LSD	N.S.	0.008	N.S.	N.S.	N.S.
Irri. sys. X W. req.					
Subsurface drip:W1	22.9	0.390	66.4	93.3	81.0
W2	23.8	0.383	61.3	78.7	66.3
W3	23.3	0.390	59.3	85.3	76.3
W4	22.8	0.387	58.9	93.3	77.3
Surface drip : W1	21.3	0.387	63.9	96.0	96.0
W2	23.5	0.383	60.5	86.7	72.3
W3	23.5	0.370	59.3	93.3	69.7
W4	19.8	0.377	56.5	92.0	75.7
Pivot : W1	20.8	0.390	59.9	92.0	73.3
W2	21.1	0.390	56.3	88.0	83.7
W3	20.3	0.344	54.1	78.7	84.7
W4	20.3	0.357	53.7	89.3	87.3
Sprinkler : W1	20.5	0.370	61.2	85.3	73.3
W2	20.6	0.357	60.3	74.0	83.7
W3	20.3	0.370	59.6	84.0	74.3
W4	22.2	0.344	57.4	90.7	73.3
Gated pipes: WI	20.7	0.357	58.6	96.7	80.0
W2	19.4	0.357	56.7	93.3	88.0
W3	21.3	0.357	55.5	93.3	75.3
W4	20.1	0.351	54.3	94.7	76.3
LSD	N.S.	0.020	N.S.	N.S.	7.74

Seed friction coefficient significantly affected by irrigation systems, water requirement and their interaction (Table 4), whereas, the greatest value of friction coefficient was 0.387 under subsurface drip irrigation system, while the lowest value of friction coefficient was 0.355 under modified surface irrigation These findings are due to increase contact area between the seeds and metal surface resulted from increasing seed dimension under subsurface drip irrigation system. On the other hand, seed friction coefficient decreased from 0.379 to 0.363 by increasing water requirement from 50% to 125% of ETc. This is due to increasing seed fill capacity and seed moisture content as well which caused seed to have less shrinks and sprinkles, and therefore, seed friction coefficient was reduced. It was documented previously by Stewart *et al.* 1969 that static and dynamic coefficients of friction of grain increased by increasing seed moisture content of grain up to 13%.

On the other hand, There was not significant effect of irrigation system, water requirement and their interaction on seed hardness. it could be concluded that seed hardness did not affect by investigated treatments.

3-Effect of irrigation system and water requirement on faba bean seed biological properties:

Results presented in (Table 4) showed that only irrigation system had significant effect on seed germination, the greatest germination percentage was 94.7% for seeds produced under modified surface irrigation system followed by subsurface drip irrigation (93.3%) , surface drip (92.0%), sprinkler (90.7%) and finally pivot system (89 3%). It is noticeable that systems which allow no water on plant canopy gave high germination percentage and those of spraying irrigation water over the plant and therefore, allow high humidity around influences where pods formed gave lower germination percentage. This finding seems interesting, however, it is not suggested to answer why such a result happened and it is recommended to propose a further investigation to answer such question. Amount of irrigation water applied and its interaction with irrigation system showed no significant effects on germination percentage.

Although pivot irrigation system showed less germination percentage, it gave the greatest vigour percentage (82.3%), however modified surface irrigation came after with a value of (79.9%) with no significant difference with value obtained with pivot system. Subsurface drip irrigation system produced seeds with low vigour percentage (75.2%) if compared to the other irrigation systems. Therefore, it could be concluded that seed vigor % respond differently than seed germination percentage as affected by the experimental treatments. Irrigation water amounts showed no significant effects on seed vigour percentage, meanwhile, its interaction with irrigation system showed significant effect on vigor percentage. Seeds produced under surface irrigation system and watered with only 50% of ETc showed the greatest seed vigour percentage (96.0%).

CONCULSION

Results of this paper can be summarized as follows:

1-The biggest values of main dimensions of faba bean seeds were 13 mm length and 9.6mm width and 6.6mm thickness when using subsurface drip irrigation system while, the lowest values were 12.4 mm length, 9.5mm width and 5.7mm thickness using pivot irrigation system.

2-Seeds volume increased gradually from 647 to 790mm^3 by increasing the water requirement from 50 to 125% of ETC, but the coefficient of friction decreased from 0.379 to 0.363.

3-The irrigation system had a significant effect on seed sphericity percentage, hectolitre weight, angle of repose and seed germination.

4-The highest moisture content of seeds produced under sprinkler and pivot irrigation systems resulted in high humidity over the plant canopy.

5-Irrigation system had significant effect on seed germination; the greatest germination percentage was 94.7% for seeds produced under modified surface irrigation system followed by subsurface drip irrigation (93.3%)

6-The lowest percentage of vigor was 75.2% using subsurface drip irrigation, while the highest percentage was 82.3% when using pivot irrigation system.

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الخصائص الهندسية والبيولوجية لبذور الفول البلدى تحت نظم الري المختلفة

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بلغت المساحة المنزرعة بمحصول الفول في مصر عام ١٩٩٨ بحوالي ٣٩٣٣٠٧ فدان، حيث يعتبر محصول الفول من أهم المحاصيل البقولية لأنه يستهلك محليا كغذاء للإنسان والحيوان. لذا يهدف هذا البحث إلى دراسة تأثير أربعة نظم للري (السطحي المطور باستخدام الأنابيب المبوبة- الرش المحوري- الرش الثابت- التنقيط السطحي والتحت سطحي) ، وكميات المياه المضافة (٥٠- ٧٥- ١٠٠- ١٢٥% من معدل الاستهلاك المائي)على بعض الصفات الطبيعية والميكانيكية والحيوية للبذور الناتجة تحت هذه النظم لما لها من أهمية كبيرة في عمليات التداول والتصنيع والتخزين .

اجريت هذه التجارب خلال موسمي نمو ١٩٩٧/١٩٩٨ في تربة طمية طينية. وقد أوضحت النتائج أن نظام الري بالتنقيط التحت سطحي حقق أعطي أعلى القيم لأبعاد البذرة حيث بلغت ١٣مم للطول،٩,٦ مم للعرض،٦.٦ مم للسمك بالمقارنة مع نظم الري الأخرى.أما زيادة كميات المياه المضافة من ٥٠ إلى ١٠٠% من معدل الاستهلاك المائي للمحصول أدى إلى زيادة أبعاد البذرة من ١١,٨ إلى ١٢,٩ مم للطول، من ٩,٢ إلى ٩,٦ مم للعرض، من ٥,٩ إلى ٦,٣ مم للسمك. وبناءا على ذلك فان نظام الري بالتنقيط تحت سطحي حقق أعلى القيم في متوسط حجم البذور (٨١٦ جم)،متوسط القطر الهندسي (٩,٣ مم)، وزن ١٠٠ بذرة (٦١,٥ جم)، زاوية التكويم (٢٣,٢)،معامل الاحتكاك بين البذور وسطح المعدن (٠,٣٨٧)، دليل الطفو (٨،٣ سم^{٢} /جم). أما زيادة كميات المياه المضافة من ٥٠ إلى ١٢٥% من معدل الاستهلاك المائي للمحصول أدى إلى زيادة حجم البذرة من٦٤٧ إلى ٧٨٥ مم^{٣} ، من ٨,٥٨ إلى ٩,١٨ مم للقطر الهندسي،وانخفاض كروية البذرة من ٧٢,٣ الى٦٨,٨%. بينما أعطى نظام الري السطحي المطور أعلى قيمة لوزن اللتر الواحد من البذور (٧٢٢ جم). أما نظام الري بالرش فقد أعطى أعلى قيمة للمحتوى الرطوبي (١٧,٢ %)، أما زيادة كميات المياه المضافة من ٥٠ إلى ١٢٥% من معدل الاستهلاك المائي للمحصول أدى إلى زيادة وزن ١٠٠ بذرة من ٥٦,٣ إلى ٦٠,٤ جم، من ٧,٣ إلى ٧,٨ سم^{٢}/جم لمعامل الطفو. وقد تراوحت صلابة البذور بين ٥٦,٠-٦١,٥ نيوتن/ مم^{٢} تحت كل النظم موضع الدراسة، بينما انخفضت صلابة البذور من ٦٢ إلى ٥٦,٢ نيوتن/ مم^{٢} بزيادة كميات المياه المضافة من ٥٠ إلى ١٢٥% من معدل الاستهلاك المائي للمحصول. كما أعطى نظام الري السطحي المطور أعلى نسبة إنبات للبذور (٩٤,٥%) ولكن نظام الري بالرش المحوري حقق أعلى قيمة لقوة نمو البادرة حيث بلغت ٨٢,٣ % بالمقارنة مع النظم الأخرى. أما زيادة كميات المياه المضافة من ٥٠ إلى ١٢٥% من معدل الاستهلاك المائي للمحصول كان غير مؤثر معنويا على كلا من نسبة الإنبات وقوة نمو البادرة.