STUDY SOME FACTORS AFFECTING A MECHANICAL COATING OF MAIZE SEEDS.

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ABSTRACT

The aim of this research is to study some factors affecting the mechanical coating of maize seeds. The studied factors are coating temperature of 30, 40, 50, 60, and 70 C^o, coating speeds of 20, 28, and 36 rpm, coating times of 15, 20, 30, 40, 50. And 60 minute, batch masses of 0.5, 1, 1.5, 2 and 2.5 kg, and coating materials of clay, "Fe + Zn" and "Fe + Zn + Arsan". The main results in this study can be summarized in the following points:

* *The maximum germinations maize seeds were 89.5, 99.6 and 89.7 % for coating-unit speed of 28 rpm, coating time of 15 minute, coating temperature of 30 C^o with their different coating treatments coating with "Fe + Zn", "Fe + Zn + Arsan" and clay respectively. Meanwhile, the minimum maize seed germinations of 22.5, 37.8 and 14.7 % were obtain at coating-unit speed of 36 rpm, coating time of 60 minute, coating temperature of 70 C^o and coating with the same coating mechanicals respectively.*
* *The maximum machine capacity of maize seeds coated was 9.2 kg/h was obtained using seeds-batch mass of 2.5 kg and coating-unit speed of 36 rpm. Meanwhile, the minimum machine capacity of maize seeds coated was 0.85 kg/h using seeds-batch mass of 0.5 kg and coating-unit speed of 20 rpm.*
* *The operation and production costs at optimum parameters batch mass of 2.5 kg, coating-unit speed 28 rpm, coating temperature of 30 ^0C, coating time of 15 minutes and coating with "Fe + Zn + Arsan" were 17.02 L. E./h and 1850 L.E./ton.*

INTRODUCTION

Maize *(Zea mays, L.)* one of the important crops worldwide after rice and wheat because of its high grain and forage yield. El-Habbal et al. (1995) proved that coating the maize corn seeds with fertilizer containing Fe, Mn and Zn (2:1:2 by weight) at the rate of 6.5 g/kg seeds gave significant increments in number of spikes/plant,

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grain mass/plant and both grain and straw yields/fed. Seeds vary greatly in size, shape and color.

In many cases, seed size is small or irregular, making singularization and precision placement difficult. In addition, seeds should be protected from a range of pests that attack germination seeds or seedlings. Seed-coating technologies can be employed for two purposes: they can facilitate mechanical sowing to achieve uniformity of plant spacing, and can act as a carrier for plant protectants. So materials can be applied in the target zone with minimal disruption to the soil ecology and environment (Taylor et al., 1998).

Film coating is a method adapted from the pharmaceutical and confectionery industries for uniform application of materials to seeds. The film forming formulation consists of a mixture of polymer, plasticizer and colorants (Halamer, 1998 and Robani, 1994), and formulations are commercially available that are ready-to-use liquids or prepared as dry powders (Ni, 1997). Application of the film-forming mixture results in uniform deposition of material on each seed with little variation among seeds (Halmer, 1998). The formed film may act as a physical barrier, which has been reported to reduce leaching of inhibitors from seed coverings and may restrict oxygen diffusion to the embryo (Duan and Burris, 1997).

A standard pelleting pan has been adapted for application of film-coating polymers, and drying is achieved by applying forced warm air into the coating pan (Taylor and Eckenrode,1993). A small-scale. fluidized bed seed-coating apparatus has been described with controlled air velocity and temperature (Burris et al., 1994). Film coating is routinely performed in vented or perforated pans on a large-scale basis either on a batch or continuos system (Halmer, 1998 and Robani, 1994).

Film coating is versatile as a coating system or a component of a coating system. Colorants as aesthetic appeal to seeds, serve to color-code different verities and increase the visibility of seeds after sowing. Film-coated seeds have better flow characteristics in the planter (Hill, 1997) due to reduced friction between seeds. Film coating provides an ideal method for the application of chemical and / or biological seed treatments

(Taylor et al. 1990, Taylor et al., 1994 and McGee, 1995). Relatively high loading rates of plant protectants can be applied with film coating. However a spatial separation between the plant protectants and seed surface is not obtained as described for pellet loading. A major impetus for using film coating is to reduce exposure of workers to chemicals from treated seeds.

The cultivated area of the maize corn reached about 65 thousand feddan in 2005 that produces about 388 thousand ton per year (Agricultural Statistics Economic Affair Sector, 2006).

Rehm (2003) found that coating the soybean seeds with iron increased the yield from 2.1 to 11.7 bu/acre compared with the seeds without iron applied.Yehia (2008) concluded that the optimum conditions of coating machine were: coating-unit speed of 28 rpm, coating temperature of 40 C^o, heat exposure time 30 min, Arabic-gum temperature and concentration 50 – 110 C^o and 25 – 75 %, and grain-batch mass 1 – 4 kg. The results obtained at optimum conditions were: germination of coated wheat-grain = 98.1 %, coating-machine performance = 3 – 12 kg/h, mass of 1000 coated-grain = 95.7 – 98 g, external and internal friction-angles = 18 – 20.5 and 21 – 23.5 degree, by using fe + Zn coated wheat-seeds: grain emergence = 94.2 %, grain yield = 2186 kg/fed and net profit = 1195 L.E./fed (531 L.E./ton).

Yehia et al. (2010) found that the maximum fennel, caraway, coriander, nigella and guar seeds germination of 98.1, 96, 98, 100 and 100 % were obtained with coating temperature of 40 C^o and coating time of 30 min. Meanwhile, the minimum fennel, caraway, coriander, nigella and guar seeds germination of 63.38, 61.43, 66.3, 67.76 and 70.2 % were obtained with coating temperature of 70 C^o and coating time of 70 min.

Abd-Al Fattah et al. (2015) and Abd-Al Fattah. (2016) designed the coating machine which used in this paper. It was found that the highest germination of 100, 98.5, 97.5 and 99.5 were obtained at 28 rpm coating speed, 30 C^o coating temperature and 15 minute coating time for onion, pepper, tomato and cotton seeds respectively.

The objective of this paper is to study the factors affecting the mechanical coating of maize seeds such as coating temperature and duration, coating unit speed, concentrate and temperature of Arabic gum and seed quantity inside coating unit on seed germination and machine productivity. In addition, study includes the effect of maize seeds coating with some trace elements of "Fe + Zn" and fungicide of "Arsan 50" on germination percent and crop productivity.

MATERIALS AND METHODS

Coating machine:

The coating machine used in this study was designed by Abd-Al Fattah et al. (2015).Views and photograph of the coating machine are shown in Figs. (1) and (2). The main specifications of this machine are: total height 60 cm, width 50 cm, depth 40 cm, and total mass 18 kg. The main coating machine parts are as follows:

(1) Frame: made of steel sheet with thickness of 2 mm, height of 50 cm, width of 40 cm and depth of 50 cm.

(2) Coating pan or unit: made of copper sheet with thickness of 3 mm. The coating pan has an elliptical shape with diameter of 35 cm, depth of 35 cm and with feeding opening of 22 cm diameter.

(3) Coating-unit shaft: The coating-unit shaft is made of steel with diameter of 20 mm and length of 100 mm. The first edge of coating-unit shaft welded with a flange. The flange of 100 mm diameter is connected with the coating unit by 4 bolts of 10 mm diameter. The second edge of coating-unit shaft has a cut with 30 mm length. The cut-shaft part was interfered with the same slot in a ring welded inside the flange of the coating pan. The ring height is 30 mm.

(4) Hot-air dryer: The hot-air dryer consists of case, electric motor, fan, and heater. The hot-air dryer is attached with coating-machine frame by two hinged links to enter and exit it inside or outside the coating pan.

(5) Two hinged-links: Two hinged links connect the hot-air dryer with coating-machine frame. The two hinged links are used to enter and exit the air dryer inside or outside the coating pan and adjust the distance between seeds and hot-air dryer head.

(6) Power unit: Power unit consists of DC-motor, transformers, bridge, switches and electric cables.

Seed variety: "Giza 132 white" was used in the experimental tests.

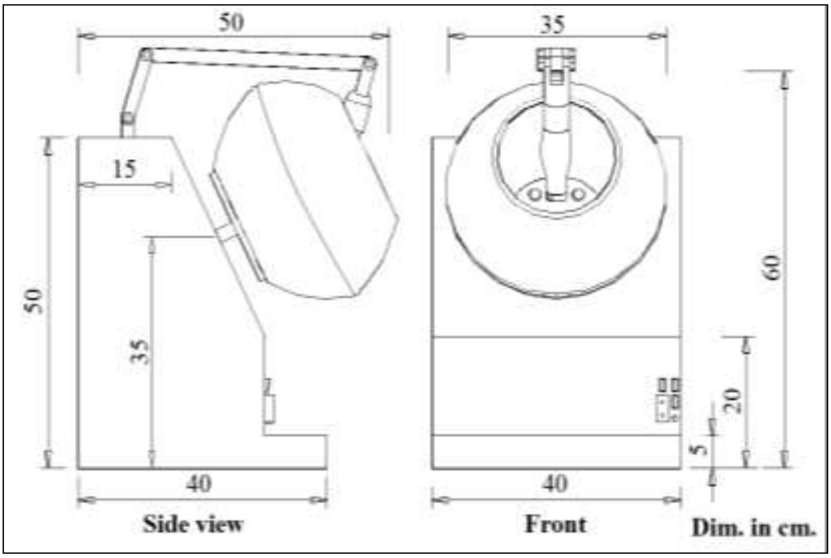

Fig. 1: Views of a seed-coating machine Abd-Al Fattah et al. (2015).

Fig. 2: Photograph of the seed-coating machine Abd-Al Fattah et al. (2015).

Tested parameters:

(1) Coating temperature of 30, 40, 50, 60 and 70 C^o were tested at different coating speeds, times and materials at maize seed batch mass of 2.5 kg.

(2) Coating-unit speeds of 20, 28, and 36 rpm were tested at different coating temperature, time and materials at constant maize seed batch mass of 2.5 kg.

(3) Coating times of 15, 20, 30, 40, 50, and 60 minutes were tested at different coating temperature, speed, and materials at constant maize seed batch mass of 2.5 kg.

(4) Coating materials: clay, “Fe + Zn” and “Fe + Zn + Arsan”were tested at different coating temperature, speed and times at constant maize seed batch mass of 2.5 kg.

(5) Seed-batch mass of 0.5, 1, 1.5, 2, and 2.5, kg were tested at different coating unit speed to measure machine capacity at optimum coating temperature, time, and speed.

<u>Coating steps*:*</u>

(1) Each chemical powder: fertilizer “Fe and Zn” and fungicide “Arsan 50” flour powder was mixed with wheat in the ratio of 5 g/kg

(2) The wheat flour powder of 0.5 kg was spread inside the rotated coating pan (unit) which was heated by hot-air dryer. The temperature of coating pan and seeds was controlled by heat-control button and the distance between seeds and heat source.

(3) The maize seeds batch was spread inside the rotating coating pan.

(4) Arabic-gum solution with 75 cm^3 volume was spread on the seeds inside coating pan.

(5) The seeds were agitated by hand to distribute the Arabic gum.

(6) The mixture of chemicals and wheat flour powder of about 70 g was spread directly after then.

(7) The seeds were agitated by hand to distribute the mixture powder to add it as a layer around the seeds.

(8) The steps from 4 to 7 were repeated until finishing the entourage (first) layer. The entourage layer needs 1 : 2 mixture powder grain ratio.

(9) The seeds exit from coating pan and were spread in the air to dry.

(10) The dried coated-seeds were put inside coating pan.

(11) The steps from 4 to 7 were repeated until finishing the jacket layer. The jacket layer needs 0.3 : 1 wheat-flour powder seed ratio.

(12) The seeds exit from coating pan and were spread in the air to dry.

The field experiments: Field experiments were carried out under roof by hydroponic system in Shandawell Research Station, Sohag Governorate during two successive seasons of 2017/2018 and 2018/2019. The planting area was 100 m^2. The maize seeds were planted in foam bins with 1000 eyes to produce the seedlings after about 10 -12 days. Then, each the maize corn seedling was put in plastic bags which contains peat moss. Then, the seedlings in plastic bags were put inside pipes of hydroponic system. The number of pipes is 20 with diameter of 10 cm. Each tube has upper holes with diameter of 5 cm and hole spacing of 15 cm. The picking of the maize corn fruits was done after period of 50 – 60 days from planting. The picking was done each 10 days.

Estimating the machine capacity: Seed-coating machine capacity calculated by using the following equation:

$$P_m = W / T \quad \text{………………...….. (1)}$$

Where

P_m = Machine capacity, kg/h, W = Mass of coated seeds, kg and T = Coating time, h.

Solubility in soil: In the present study, solubility in soil was determined as the weight of the film that is dissolved after incorporating coated-seeds in soil at a gives time period. A circular film sample was cut from each film, dried at 100 ± 2°C for 24 h in a laboratory oven, and weighed to determine the initial dry weight. The solubility in soil of the different composite films was measured by incorporating coated-seeds in soils with moister contents of 10, 20, 40, 60, 80 and 100 % and incorporated times of 6, 12, 18, 24 and 30 h. After that period, the remaining pieces of film were taken out and dried at 100 ± 2°C until constant weight (final dry weight). The percentage of the total soluble matter "TSM" of the films was calculated using the following equation: This test for each type of film are carried out in three replicates and average as reported by (Gontard et al., 1994).

$$TSM, \% = \frac{\text{Initial dry weight} - \text{Final dry weight}}{\text{Initial dry weight}} \times 100 \quad \text{….. (2)}$$

The yield: The crop yields were evaluated by taking 4 samples (1 m^2 area) randomly selected from each plot. The plants were collected manually and then weighed.

(3) Power requirement and specific energy.

The power requirement of DC motor was calculated according to Kurt, (1979) using the following equation:

$$P = I \times V \qquad \text{.....................} (3)$$

Where:

P = Power requirement for the seed-coating machine in W,

I = Line current strength in amperes,

V = Potential difference (Voltage) being equal to 6, 9 and 12 V,

The Specific energy was calculated by using the following equation:

$$\text{Specific energy, kW. h/ton} = \frac{\text{Power, kW}}{\text{Machine capacity, ton/h}} \qquad \text{............} (4)$$

Estimating the costs of using the machine: Cost of operation was calculated according to Awady (1978), as follow:

$$C = p/h\ (1/a + i + t/2 + r) + (Ec * Ep) + m/144 \qquad \text{...................} (5)$$

Where: C = hourly cost, p = price of machine, h = yearly working hours, a = life expectancy of the machine, i = interest rate/year, t = taxes, r = overheads and indirect cost ratio, Ec = Electricity consumption kW.h/h, Ep = Electricity price L.E/kW.h, "144" are estimated monthly working hours. Notice that all units have to be consistent to result in L.E/h.

$$\text{Production cost} = \frac{\text{Operation cost, LE./h.}}{\text{Machine capacity, ton/h.}} \qquad \text{......................} (6)$$

RESULTS AND DISCUSSION

Effect of coating temperature, time and speed, by "Fe + Zn", "Fe + Zn + Arsan" and clay on germination of the maize seeds at seed batch mass of 2.5 kg.

Fig. 5 shows the effect of coating temperature, time, speed and material ("Fe, Zn and Arsan" and clay) on maize seed germination.

The maximum maize seed germinations of 89.5, 99.6 and 89.7 % were obtained by using coating-unit speed of 28 rpm, coating time of 15 minute, coating temperature of 30 C^o and coating with "Fe + Zn", "Fe + Zn + Arsan" and clay respectively and at constant seed batch mass of 2.5 kg. Meanwhile, minimum maize seed germinations were 22.5, 37.8 and

14.7 % obtained by using coating-unit speed of 36 rpm, coating time of 60 minute, coating temperature of 70 C^{o} and coating with "Fe + Zn", "Fe + Zn + Arsan" and clay respectively and at constant seed batch mass of 2.5 kg.

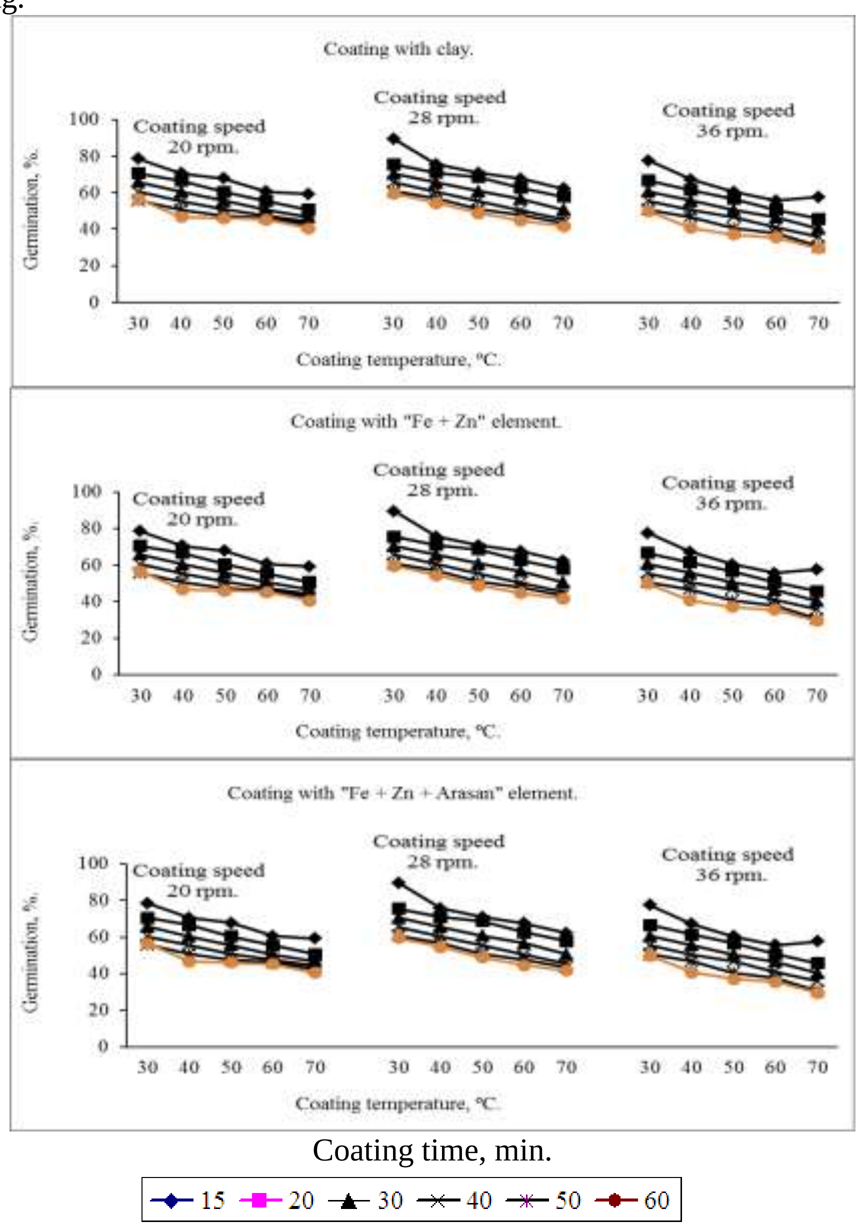

Fig. 5: Effect of coating temperature and time, by "Fe + Zn", "Fe + Zn + Arsan" and clay on the maize seeds germination and at constant seed batch mass of 2.5 kg.

The germination of the maize corn-seeds without coating was 32.5 %.

By increasing coating speed from 20 to 28 rpm maize seed germinations increased by 54.7, 50.7 and 66.6 % for coating with “Fe + Zn”, “Fe + Zn + Arsan” and clay respectively. Meanwhile, by increasing coating speed from 28 to 36 rpm, maize seed germinations decreased by 66.9, 56.2 and 73.4%.

By increasing coating time from 15 to 60 minute the maize seed germinations decreased by 31.8, 30.8 and 40.6 % for coating with “Fe + Zn”, “Fe + Zn + Arsan” and clay respectively.

By increasing coating temperature from 30 to 70 ^{0}C the maize seed germinations decreased by 61.9 – 41.6, 79.8 – 61.2 and 65.0 – 46.8 % for coating with “Fe + Zn”, “Fe + Zn + Arsan” and clay respectively.

Seed germination increase by coating with “Fe + Zn + Arsan” may be due to feeding seed-embryo by “Fe + Zn” and fungicide protection by “Arsan” through seed-germination period.

Increasing germination using seed heat-treatment at 30 ^{0}C may be due to activate seed embryo and accelerating seed germination. Seed witting by Arabic gum and heating by hot air through seed-coating process is similar to “vernalization” phenomenon which encourages germination and plant flowering.

Decreasing seed-germination at coating-temperature range of 50 - 70 ^{0}C and coating time 70 – 60 minutes is due to death of some embryo seeds.

Effect of coating-unit speed and seed-batch mass on coated-seeds machine capacity.

Fig. 6 shows effect of coating-unit speed and seed-batch mass on machine capacity of coated the maize corn-seeds.

The machine capacity of coated the maize corn-seeds increased by 194 % by increasing coating-unit speed from 28 to 36 rpm. Meanwhile, the machine capacity of coated the maize corn-seeds increased by 600 % by increasing seeds-batch mass from 1 to 5 kg.

The maximum machine capacity of coated the maize corn-seeds of 9.2 kg/h was obtained using seeds-batch mass of 2.5 kg and coating-unit speed of 36 rpm. Meanwhile, the minimum machine capacity of coated the maize corn-seeds of 0.85 kg/h was obtained using seeds-batch mass of 0.5 kg and coating-unit speed of 20 rpm.

Decreasing machine capacity of coated the maize corn-seeds at coating-unit speed of 20 rpm is due to increased un-coated seeds after coating process. Meanwhile, increasing machine capacity by increasing coating-unit speed may be due to decreasing the coating time.

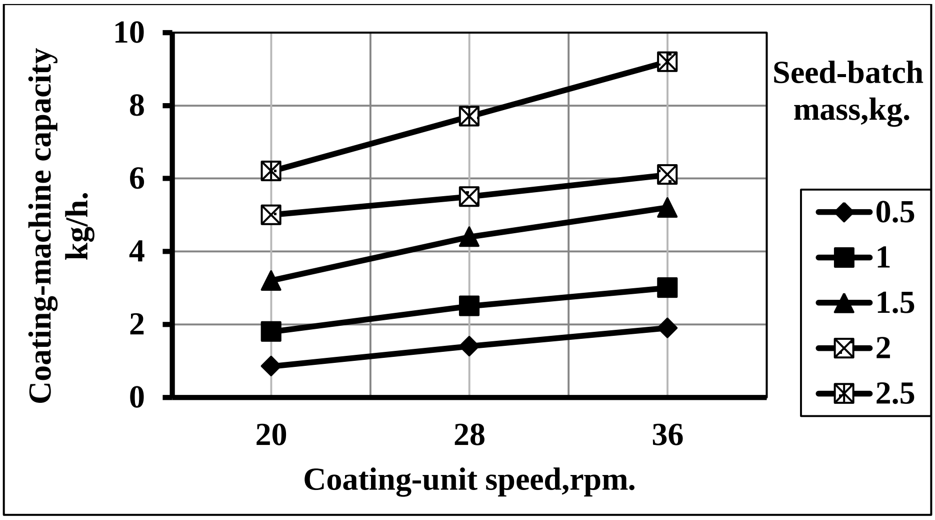

Fig. 6: Effect of coating-unit speed and maize seed batch mass on coated-seeds machine capacity.

Physical and mechanical properties of the maize corn seeds before and after coating at optimum parameters.

Tables 3 and 4 show physical and mechanical properties of the maize seeds before and after coating at optimum parameters of batch mass of 2.5 kg, coating-unit speed of 28 rpm, coating temperature of 30 ^{0}C, coating time of 15 minutes and coating with “Fe + Zn + Arsan”.

Tables 3 shows that averages of mass of 1000 kernel before and after coating are 12 and 44.5 g respectively. Averages of seed length, width and thickness before coating were “3.15, 1.51 and 2.7 mm” and after coating were 4.63, 2.57 and 3.86 respectively. Average of bulk and real densities before coating were 483 and 420 kg/m^3 and after coating are 520 and 509 kg/m^3 respectively. Averages of the maize corn seed volume before and after coating were 6.22 and 24.09 mm^3. Averages of projected area of the maize corn seeds before and after coating were 3.73 and 9.34 mm^2 respectively.

Table 3: Physical properties of the maize corn-seeds before and after coating at optimum parameters of batch mass of 5 kg, coating-unit speed of 28 rpm, coating temperature of 30 ^{0}C, coating time of 15 minutes and coating with “Fe + Zn + Arsan”.

Properties	Before coating				After coating			
	Max.	Min.	Av.	C. V.	Max.	Min.	Av.	C. V.
The mass of 1000 kernel	15.0	9.5	12.0	0.22	44.8	44.0	44.5	8.9
Real density, kg/ m³	428	414	420	0.02	544	499	509	0.04
Bulk density, kg/ m³	493	477	483	0.16	540	510	520	0.02
Dimensions: Length, mm. Width, mm Thickness, mm	 3.99 1.76 2.88	 2.90 1.11 2.30	 3.15 1.51 2.70	 0.17 0.21 0.10	 4.83 3.88 4.20	 4.22 3.55 4.11	 4.63 2.57 3.86	 0.06 0.06 0.01
Volume, mm^3	10.6	3.87	6.22	0.62	41.21	32.23	24.09	0.18
Projected area, mm^2	5.51	2.52	3.73	0.40	14.71	11.76	9.34	0.15

Max: maximum, Min.: minimum, Av.: average and C. V.: coefficient of variation.

Table 4 shows that maximum friction-angle with glass, wood and stainless steel before coating are 16.69, 22.29, 17.22, 27.92 and 19.29 degree respectively and after coating are 21.3, 25.64, 20.3, 30.54, 24.22 and 19.79 degree. Averages of angle of repose before and after coating are 33.8 and 38.8 respectively. Meanwhile, the maximum repose-angles before and after coating are 19.3 and 24.9 degree respectively.

Effect of soil moisture-content, soluble time on coating-film solubility in soil.

Fig. 7 shows the effect of soil moisture-content, soluble time on solubility of coating films for the maize corn-seeds.

The maximum solubility of coated films for the maize corn-seeds of 96 % was obtained using soluble time of 30 h and soil moisture-content of

100 %. Meanwhile, the minimum solubility of coated films for the maize corn-seeds of 15 % was obtained using soluble time 6 h and soil moisture-content of 10 %.

Table 4: Mechanical properties of the maize corn-seeds before and after coating at optimum parameters of batch mass of 5 kg, coating-unit speed of 28 rpm, coating temperature of 30 ^{0}C, coating time of 15 minutes and coating with "Fe + Zn + Arsan".

Properties	Before coating			After coating		
	Max.	Min.	Av.	Max.	Min.	Av.
Angle of repose	19.3	17.8	18.5	25.4	24.3	24.9
Friction angle:						
- Glass	16.69	11.30	14.03	21.30	17.22	19.29
- Wood	22.29	16.17	18.26	25.64	21.80	23.74
- Stainless steel	17.22	11.85	15.64	20.30	16.17	17.74
- Copper	27.92	17.74	24.22	30.54	25.17	28.81
- Galv. iron-sheet	21.80	17.74	19.29	24.22	22.78	23.74
- Iron sheet	19.29	16.69	17.74	19.79	18.26	18.77

Max: maximum, Min.: minimum, Av.: average .and Galv.: Galvanized.

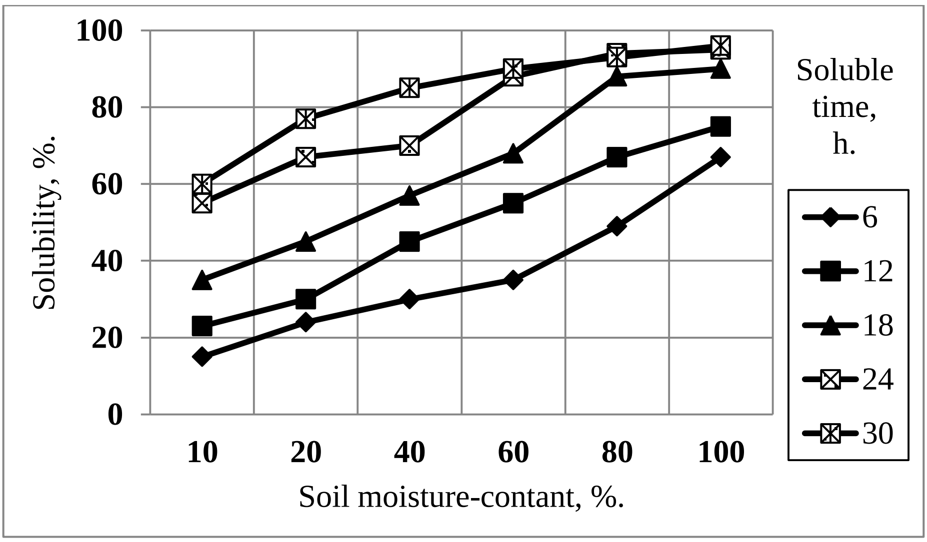

Fig. 7: Effect of soil moisture-content, soluble time on coating-film solubility of maize seeds.

Effect of coating unit speed on power requirement and specific energy.

Figs. 8 and 9 show the effect of coating-unit speed and maize seedbatch mass on power requirement and specific energy.

The maximum power and specific energy of 31.2 W and 18.3 kW.h/ton was obtained at coating-unit speed of 20 rpm and seed batch-mass of 0.5 kg. Meanwhile, the minimum power and specific energy of 15.6 W and 1.7 kW.h/ton was obtained at coating-unit speed of 36 rpm seed batch-mass of 2.5 kg.

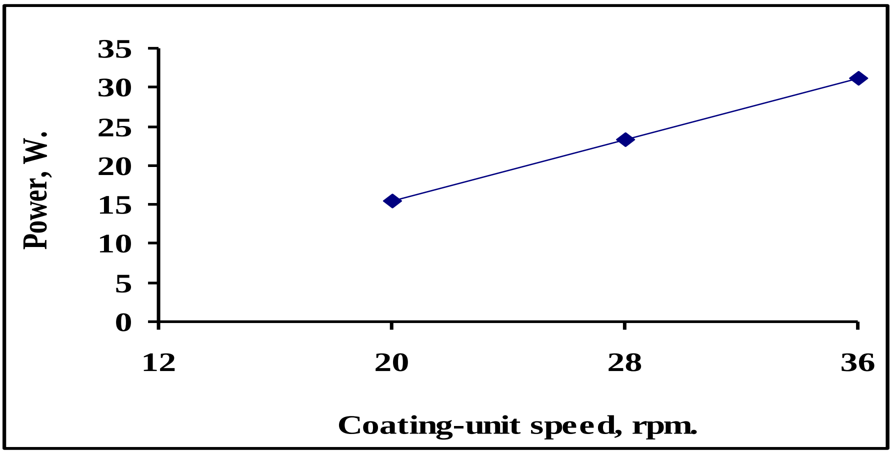

Fig. 8: Effect of coating-unit speed and the maize seed batch mass on power requirement.

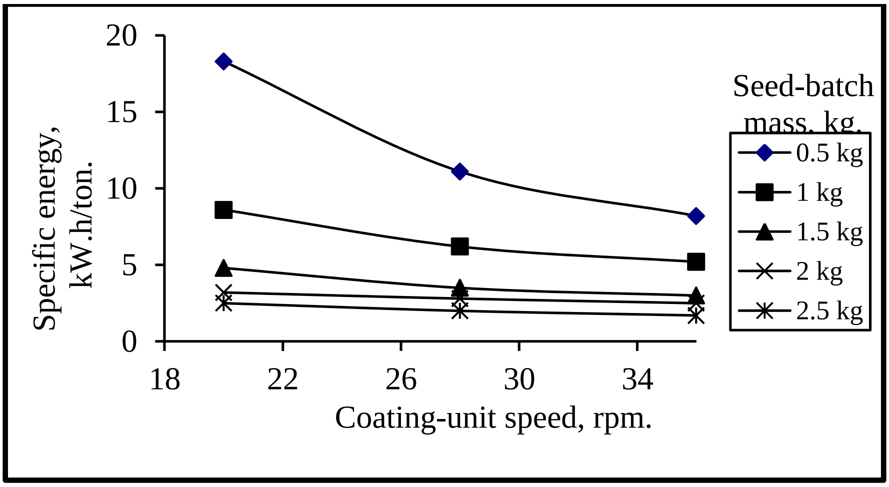

Fig. 9: Effect of coating-unit speed and maize seed batch mass on specific energy.

Effect of seed-coating treatment on the maize seed yield.

Fig. 10 shows that the maximum the maize seed yield of 99.6 kg/m^2 was obtained by using seeds coated by “Fe + Zn + Arsan”. Meanwhile, the minimum the maize corn-fruit yield of 60.5 kg/fed was obtained by using untreated seeds.

Increasing the maize seed yield by coating with “Fe + Zn + Arsan” compared with coating with “Fe + Zn” is due to increasing the health of seedlings because of fungicide presence in coating materials.

Cost of using the seed coating machine.

Table 5 shows individual parameters Awady equation and operation and production costs of using the seed coating-machine.

Table 5: The components of Awady equation.

p, L.E.	h, h	a, year	i	T	r	Ec, kW.h/h	Ep, L.E.	m, L.E
4000	4000	10	0.15	0.10	0.03	0.016 – 0.031	0.80	2400

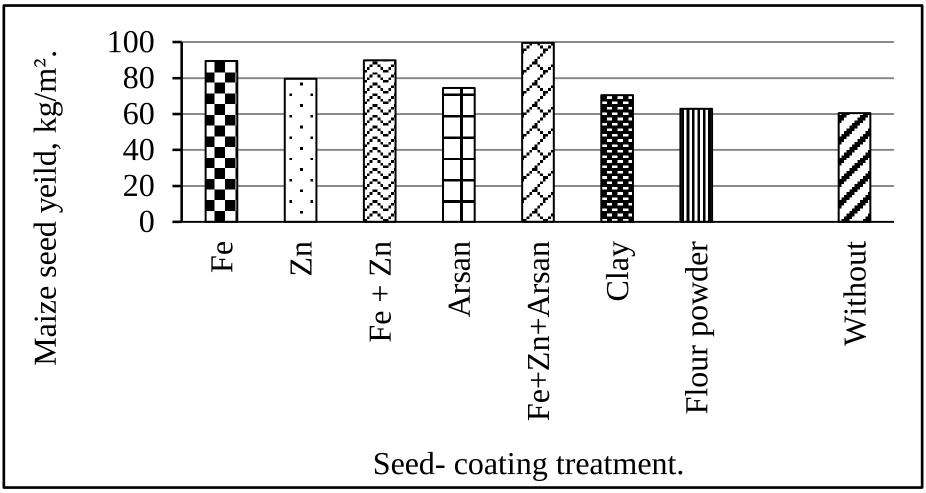

Fig. 8: Effect of seed coating by trace element, clay, flour powder and without coating on maize seed yield.

C = 4000 / 4000{(1 / 10) + 0.15 + (0.10 / 2) + 0.03} + (0.031 * 0.80) + (2400 / 144)
= 17.02 L.E./h.

The operation and production costs of coating machine at optimum parameters (batch mass of 2.5 kg, coating-unit speed of 28 rpm, coating temperature of 30 ^{0}C, coating time of 15 minutes and coating with “Fe + Zn + Arsan”) were 17.02 L. E./h and 1850 L.E./ton.

The production cost of the maize seeds by using coated seeds with “Fe + Zn + Arsan” was about 1.8 L. E./kg. Meanwhile, the production cost of the maize seeds by using the traditional seedlings was about 9.5 L. E./kg.

CONCLUSION

The optimum conditions of coating machine were: coating-unit speed of 28 rpm, coating temperature of 30 C^o, coating time 15 min, coating with “Fe + Zn + Arsan” and seed-batch mass 2.5 kg. The results obtained at optimum conditions of the maize corn were: seed germination of 95.2 %, coating-machine capacity = 9.2 kg/h, specific energy = 18.3 kW.h/ton seeds coated and costs of 17.02 L. E./h and 1850 L.E./ton.

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الملخص العربي

دراسة بعض العوامل المؤثرة على التغليف الميكانيكي لبذور الذرة الشامية

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يهدف هذا البحث إلى دراسة بعض العوامل المؤثرة على التغليف الميكانيكي لبذور الذرة الشامية. وكانت عوامل الدراسة كالتالى: ثلاث سرعات لغرفة التغليف (٢٠، ٢٨ و ٣٦ لفة/د)، خمس كميات وجبة (٠,٥، ١، ١,٥، ٢ و ٢,٥ كج)، خمس درجات حرارة (٣٠، ٤٠، ٥٠، ٦٠ و ٧٠ درجة سيليزية) ، خمس أزمنة تغليف (١٥، ٢٠، ٣٠، ٤٥ و ٦٠ دقيقة)، تغليف البذور بمواد ("الحديد +الزنك"، "حديد + زنك + أرسان"، طين و دقيق).

وكانت أهم النتائج المتحصل عليها كالتالى:

(١) نسبة الإنبات: وجد أن أعلى نسبة إنبات لحبوب الذرة الشامية ٩٩,٦ % بتغليف بالهواء الساخن بحديد وزنك وأراسان "٥٠ %" عند استخدام درجة حرارة تغليف ٣٠°م، زمن تغليف ١٥ دقيقة وسرعة ٢٨ لفة / دقيقة . بينما وجد أن أقل نسبة إنبات لبذور الذرة الشامية ١٤,٧ % بدون تغليف عند استخدام درجة حرارة تغليف ٧٠°م، زمن تغليف ٦٠ دقيقة وسرعة ٣٦ لفة/دقيقة.

(٢) معدل أداء آلة التغليف: تم الحصول على أعلى معدل أداء لآلة التغليف ٩,٢ كج/س عند استخدام الآلة على سرعة تغليف ٣٦ لفة/د، وكمية وجبة الحبوب ٢,٥ كج. بينما تم الحصول على أقل معدل أداء لآلة التغليف ٠,٨٥ كج/س عند استخدام الآلة على سرعة تغليف ٢٠ لفة/د، وكمية وجبة الحبوب ٠,٥ كج.

(٣) الإنتاجية: تم الحصول على أعلى إنتاجية بذور الذرة الشاميه (٩٩,٦ كج/م^{٢}) عند استخدام بذور الذرة الشامية المغلفة بالحديد + الزنك + أرسان فى الزراعة، كما تم الحصول على أقل إنتاجية (٦٠,٥ كج/م^{٢}) عند استخدام الحبوب غير المغلفة

(٤) معدل الإذابة: وجد ان أعلى معدل إذابة كان ٩٦ % عند زمن إذابة ٣٠ ساعة ونسبة رطوبة ١٠٠%، بينما كان اقل معدل إذابة كان ١٥% على زمن ٦ ونسبة رطوبة ١٠%.

(٥) تكاليف تشغيل الآلة: كانت التكاليف المتحصل عليها عند أنسب ظروف (سرعة ٢٨ لفة/د، كمية وجبة ٢,٥ كج، درجة حرارة ٣٠°م، زمن تغليف ١٥ دقيقة، مادة تغليف "حديد + زنك + أرسان" هى ١٧,٠٢جنيه/ساعة أو ١٨٥٠ جنيه/طن بذور مغلفة.

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