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FACTORS AFFECTING THE DESIGN OF COATING MACHINE FOR CROP SEEDS

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ABSTRACT

The aim of this research is to design and study the factors affecting of the design coating machine for crop seeds. The designed machine was constructed and tested at a private workshop in Sharkia Governorate to coat wheat grains. The coating machine consists of frame, rotating pan (seed coating unit) , gear box, flame source, and electric motor. The main results in this study can be summarized in the following points:

** The maximum wheat-grain germination of 98.1 % was obtained with coating temperature of 40 C^o and coating time of 30 min. Meanwhile, the minimum wheat-grain germination of 38.3 % was obtained with coating temperature of 70 C^o and coating time of 60 min*

** The coated wheat-grain productivity increased 166 % by increasing coating-unit speed from 13 to 36 rpm. Meanwhile, the coated wheat-grain productivity increased 400 % by increasing grain-batch mass from 1 to 5 kg.*

** The maximum mass of 1000 coated wheat-grains of 98 g was obtained by using coating speed range of 13 – 28 rpm and grain-batch mass range of 1 – 4 kg. Meanwhile, the minimum mass of 1000 coated wheat-grains of 93.6 g was obtained by using coating speed of 36 rpm and grain-batch mass of 5 kg.*

** The maximum wheat-grain productivity of 2186 kg/fed was obtained by using grains coated by Fe + Zn. Meanwhile, the minimum wheat-grain emergence of 1950 kg/fed was obtained by using untreated grains*

** The total production costs and net profits by using Fe + Zn trace elements were 1417 L.E./fed (629 L.E./ton) and 1195 L.E./fed (531 L.E./ton) respectively.*

INTRODUCTION

Seed 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.

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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). The introduction of a continuous process vented-drum coating machine by Coating Machinery Systems (Huxely, Iowa) has expanded the use of film coating. This equipment is capable of continous application of various polmyer systems and components, while providing drying capacity to prevent the seed from hydrating. Capacities vary from 100 to 10 000 kg/h depending on seed type, and target weight gain.

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 and Harman, 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.

Wheat is one of the most important cereal crops in Egypt. The major difficulty to attain self-sufficiency in wheat production is to acquire high and continuous increase in production. Therefore, raising wheat production through increasing the productivity per unit area together with expanding the cultivated area in reclaimed lands is the most important national target

The cultivated area of wheat reached about 2.34 million feddan in 2005 that produces about 6.25 million ton of grains per year (Agricultural Statistics Economic Affair Sector, 2006). However, the local consumption in the same year surpassed 12 million tons. The productivity in reclaimed land decreases 25 - 40% comparing to old lands

El-Habbal et al. (1995) proved that coating wheat grains with fertilizer containing Fe, Mn and Zn (2:1:2 by weight) at the rate of 6.5 g/kg grains gave significant increments in number of spikes/plant, grain mass/plant and both grain and straw yields/fed.

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.

The objective of this paper is to study the factors affecting the design of seed-coating machine such as coating temperature and duration, coating unit speed, concentrate and temperature of Arabic gum and seed quantity inside coating unit. In addition,, study the effect of grain-wheat coating with some trace elements (Fe, Zn, and Fe + Zn) on wheat-crop productivity.

MATERIALS AND METHODS

The designed coating machine: The designed coating machine was constructed and tested at a private shop in Sharkeia Gov. The views and photograph of the coating machine are shown in figs. 1 and 2. The main specifications of this machine are: total height 120 cm, width 56.5 cm, depth 104 cm, and total mass 80 kg. The main coating machine parts are as follows:

(1) Frame: made of steal angle with dimensions of 4 x 4 x 0.4 cm, height of 76.5 cm, width of 43 cm and depth of 80 cm.

(2) Feeding pan or unit: has a cylindrical shape made of stainless steal with diameter of 55 cm, depth of 36 cm and with feeding opening with 37 cm diameter and 5 cm height.

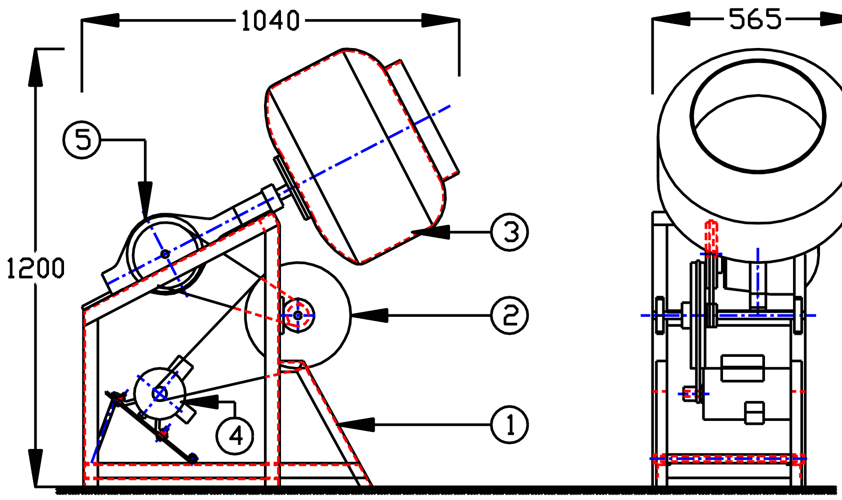


Fig. 1: Sketch of the coating machine.
(1) frame, (2) idler pulley, (3) coating unit, (4) motor and (5) gear box.

Fig. 2: Photograph of the coating machine.

(3) Gear box: with 8.5:1 speed ratio which transmits the motion to feeding unit by countershaft.

(4) Electric motor and power transmission: Electric motor of 1 hp (0.675 kW) and 1400 rpm and four pulleys with 3.8, 25, 6.3 and 19 diameters and belts.

Fertilization rate: was 5.4 g trace element/kg seeds.

Fertilizer wheat-grain ratio: of 5g/kg was used.

Arabic gum solution: with 0.25, 50 and 75 % concentration was used.

Grain batches: of 2, 4, 6, 8 and 10 kg were used.

Coating-unit speeds: of 13, 20, 28 and 36 rpm were used.

Coating steps:

(1) The fertilizer (Fe, Zn and Fe+Zn) was mixed with wheat flour powder 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 heater flame. The temperature of coating pan and grains was controlled by flame intensity.

(3) The wheat grains batch was spread inside the rotating coating pan.

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

(5) The grains was agitated by hand to distribute the Arabic gum.

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

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

(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 grains exit from coating pan and spread in the air to dry.

(10) The dried coated-grain was 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 grain ratio.

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

The field experiments: were carried out in sandy soil at El-Ismalia Research Station, Ismalia Governorate in year of 2005. The following machines were used in the experiment field.

Seed-bed preparation, land leveling and planting implements: Mounted chisel plow with seven shanks arranged in two rows (*El-Behira Co*) was used in two passes with depths of 15-20 cm followed by disc harrow (4 groups with 28 discs, each 50 cm in diameter) with depth of 15 cm and tractor with power of 80 hp (60 kW). A hydraulic leveling scraper width of 180 cm (*El-Behira Co.*) and seed drill (Sulky type) with 21 row and 12 cm row spacing were used for land leveling and grain planting.

Grain variety: Wheat grains variety of Sakha 93 (سخا 93) with germination percent of about 99 % was used.

The yield: The grain yields were evaluated by taking 4 samples (1 m^2 area) randomly selected from each plot. The plants were harvested and threshed by hand and then weighed.

Estimating the costs of using the machines: Cost of operation was calculated according to the equation given by Awady (1978), in the following form:

$$C = p/h\ (1/a + i + t/2 + r) + (Ec * Ep) + m/144,$$

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.

RESULTS AND DISCUSSION

Effect of coating temperature and time on grain germination of wheat

Fig. 3 shows that the wheat-grain germination decreased by 4.3 – 38.4 % by increasing coating temperature from 40 to 70 C^o. Meanwhile, the wheat-grain germination decreased by 37.1 – 59.5 % by increasing coating time from 30 to 60 min.

The maximum wheat-grain germination of 98.1 % was obtained with coating temperature of 40 C^o and coating time of 30 min. Meanwhile, the minimum wheat-grain germination of 38.3 % was obtained with coating temperature of 70 C^o and coating time of 60 min.

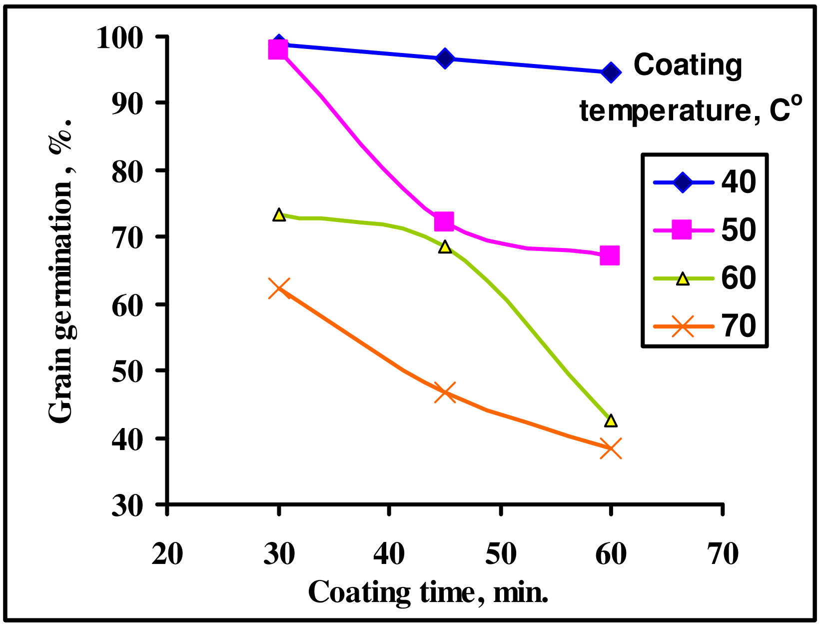


Fig. 3: Effect of coating temperature and time on wheat-grain germination.

Effect of Arabic-gum solution temperature and concentration on grain germination of wheat.

It is noticed from practical experiments that the optimum Arabic-gum solution temperature ranged between 50 to 110 C^o and concentration ranged between 25 to 76 % which gave the optimum grain germination (98.91 – 98.86 %, coating efficiency of 100 %.

Effect of coating unit speed and grain-batch mass on coated-grains production rate (machine performance-rate).

Fig. 4 shows that the coated wheat-grain production rate (machine performance-rate) increased by 166 % by increasing coating-unit speed from 13 to 36 rpm. Meanwhile, the coated wheat-grain production rate increased by 400 % by increasing grain-batch mass from 1 to 5 kg.

The maximum coated wheat-grain production rate of 10 kg/h was obtained using grain-batch mass of 5 kg and coating-unit speed of 36 rpm. Meanwhile, the minimum coated wheat-grain production rate of 0.75 kg/h was obtained using grain-batch mass of 1 kg and coating-unit speed of 13 rpm.

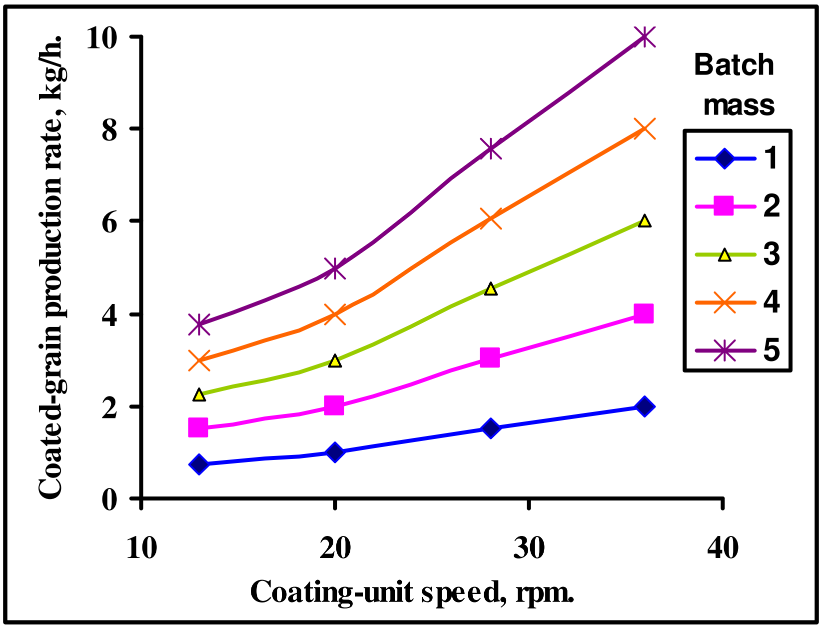


Fig. 4: Effect of coating-unit speed and wheat-grain batch mass on coated-grain production rate (machine performance-rate).

Effect of coating unit speed and grain-batch mass on 1000 coated-grains mass.

Table 1 shows that the maximum mass of 1000 coated wheat-grains of 98 g was obtained by using coating speed range of 13 – 28 rpm and grain-batch mass range of 1 - 4 kg. Meanwhile, the minimum mass of 1000 coated wheat-grains of 93.6 g was obtained by using coating speed of 36 rpm and grain-batch mass of 5 kg. The decreasing of mass of 1000 coated wheat-grain is due to increasing internal friction between grains and accordingly increasing the coating material losses.

Effect of coating unit speed and grain-batch mass on external and internal friction.

Table 2 shows that the maximum external friction-angle between coated wheat-grains and steel sheet of 24 degree and internal angle (between coated grains) of 27 degree were obtained by using coating speed of 36 rpm and grain-batch mass of 5 kg. Meanwhile, the minimum external and internal friction-angles of 18 - 19 and 21 degree respectively were obtained by using coating speed range of 13 - 28 rpm and grain-batch mass range of 1 - 3 kg.

Table 1: Effect of coating-unit speed and grain-batch mass on 1000 coated wheat-grains mass.

Coating-unit speed, rpm	1000 coated-grains mass, g.				
	Grain-batch mass, kg.				
	1	2	3	4	5
13	98.0	98.0	98.0	95.7	94.6
20	98.0	98.0	98.0	95.6	94.5
28	98.0	97.9	97.9	95.7	94.5
36	96.2	95.7	95.7	94.1	93.6

Table 2: Effect of coating-unit speed and grain-batch mass on external friction-angle between coated wheat-grains and steel sheet and internal friction between coated-grains.

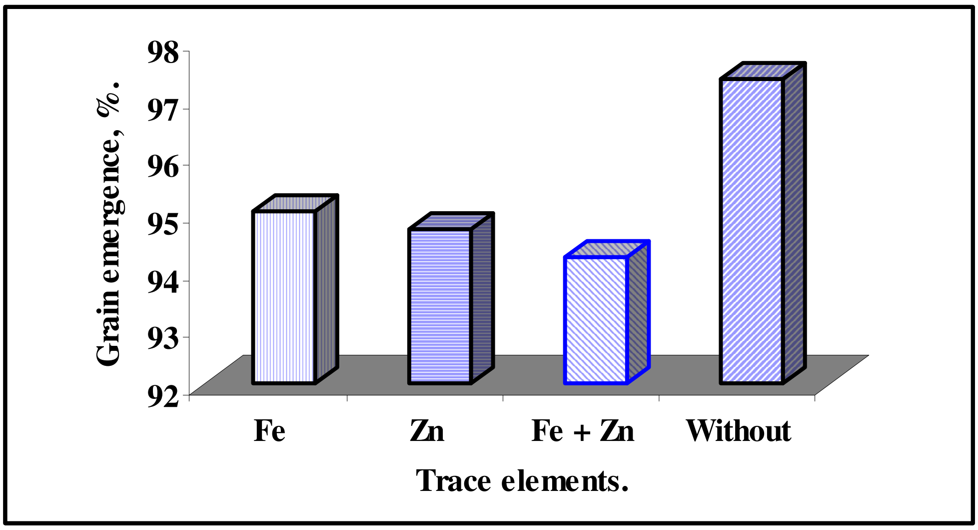
Coating speed, rpm	External friction-angle, degree					Internal friction-angle, degree				
	Grain-batch mass, kg.					Grain-batch mass, kg.				
	1	2	3	4	5	1	2	3	4	5
13	18.0	18.0	19.0	20.0	22.0	21.0	21.0	22.0	23.0	25.0
20	18.0	18.0	19.0	20.0	22.0	21.0	21.0	22.0	23.0	25.0
28	18.0	18.0	19.0	20.5	22.0	21.0	21.0	22.0	23.5	25.0
36	22.0	22.0	22.5	22.5	24.0	25.0	25.0	25.5	25.5	27.0

Effect of grain coating by trace element on grain emergence.

Fig. 5 shows the maximum grain emergence of wheat of 97.3 % was obtained by using untreated grains. Meanwhile, the minimum wheat-grain emergence of 94.2 % was obtained by using grains coated by Fe+Zn .

Effect of grain coating by trace elements on grain yield.

Fig. 5 shows the maximum wheat-grain yield of 2186 kg/fed was obtained by using grains coated by Fe + Zn. Meanwhile, the minimum wheat-grain yield of 1950 kg/fed was obtained by using untreated grains.



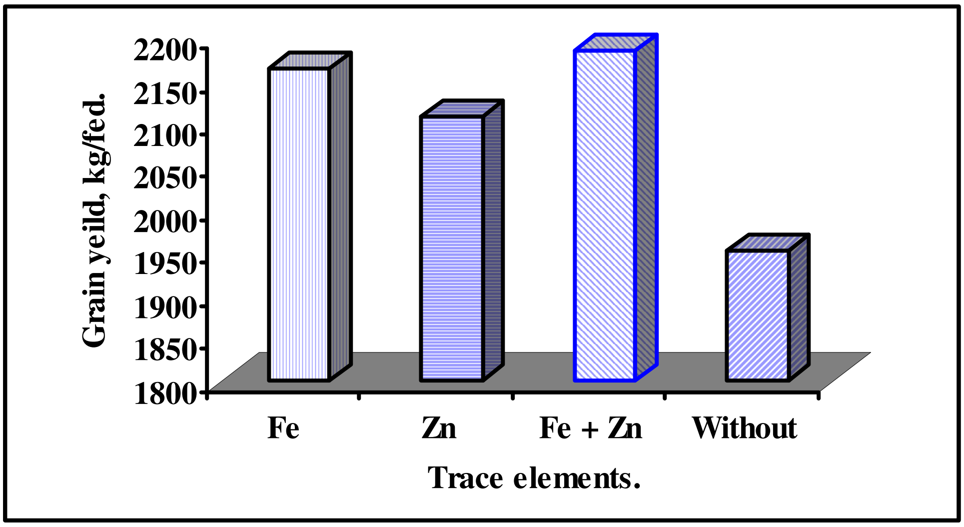


Fig. 5: Effect of grain coating by trace element on grain emergence and yield.

Total production costs and net profit.

Table 3: shows that the total production costs and net profits by using Fe + Zn trace elements were 1417 L.E./fed (629 L.E./ton) and 1195 L.E./fed (531 L.E./ton) respectively. Meanwhile, the operation cost of the designed machine was 19 L.E./fed (2180 L.E./ton).

Table 3: Effect of grain coating by using Fe + Zn total production cost and net profit of wheat crop.

	Costs, LE/fed
Land preparation	90
Seeds	100
Mechanical drilling	12
Fertilizers	846
Coating	19
Herbicides	50
Pumping	100
Harvesting	200
Total costs: L.E./fed L.E./ton	1417 629
Net profit: L.E./fed L.E./ton	1195 531

CONCLUSION

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-grains: grain emergence = 94.2 %, grain yield = 2186 kg/fed and net profit = 1195 L.E./fed (531 L.E./ton).

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الملخص العربي

عوامل مؤثرة فى تصميم آلة لتغليف بذور المحاصيل

د. إبراهيم يحيى*

يهدف هذا البحث إلى تصميم آلة لتغليف بذور المحاصيل، مع دراسة العوامل المؤثرة على تصميمها وأدائها. وتتكون الآلة من إطار، وحدة تغليف دوارة، صندوق تروس، محرك ومجموعة نقل حركة. وتم الحصول على النتائج التالية:

(1) **نسبة الإنبات:** وجد أن أعلى نسبة إنبات لحبوب القمح 98.1 % عند استخدام درجة حرارة تغليف 40 ^{0} م، زمن تغليف 30 دقيقة. بينما وجد أن أقل نسبة إنبات لحبوب القمح 38.3 % عند استخدام درجة حرارة تغليف 70 ^{0} م، زمن تغليف 60 دقيقة.

(2) **معدل أداء آلة التغليف:** تم الحصول على أعلى معدل أداء لآلة التغليف 10 كج/س عند استخدام الآلة على سرعة تغليف 36 لفة/د، وكمية وجبة الحبوب 5 كج. بينما تم الحصول على أقل معدل أداء لآلة التغليف 0.75 كج/س عند استخدام الآلة على سرعة تغليف 13 لفة/د، وكمية وجبة الحبوب 1 كج.

(3) **كتلة الألف حبة بعد التغليف:** تم الحصول على أعلى كتلة ألف حبة 98 ج عند استخدام الآلة على سرعة تغليف 13 - 28 لفة/د، وكمية وجبة الحبوب 1 - 4 كج. بينما تم الحصول على أقل كتلة ألف حبة 93.6 ج عند استخدام الآلة على سرعة تغليف 36 لفة/د، وكمية وجبة الحبوب 5 كج.

(4) **معامل الاحتكاك الخارجى (بين الحبوب والصاج) والداخلى (بين الحبوب المغلفة وبعضها):** تم الحصول على أقل معامل احتكاك خارجى 18 - 19 درجة، وأقل معامل احتكاك داخلى 21 درجة عند استخدام الآلة على سرعة تغليف 13 - 28 لفة/د، وكمية وجبة الحبوب 1 - 3 كج. بينما تم الحصول أعلى معامل احتكاك خارجى 24 درجة، وأقل معامل احتكاك داخلى 27 درجة عند استخدام الآلة على سرعة تغليف 36 لفة/د، وكمية وجبة الحبوب 5 كج.

(5) **الإنتاجية:** تم الحصول على أعلى إنتاجية حبوب قمح (2186 كج/فدان) عند استخدام حبوب القمح المغلفة بالحديد + الزنك فى الزراعة، كما تم الحصول على أقل إنتاجية (1950 كج/فدان) عند استخدام الحبوب غير المغلفة.

(6) **صافى العائد:** تم الحصول على أعلى عائد (1195 جنيه/فدان أو 531 جنيه/طن) عند استخدام الحبوب المغلفة بالحديد + الزنك فى الزراعة.

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