

Utilization a New Control Feeding System of Wheat Broadcasting

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ABSTRACT

A new feeding system on spreader implement was evaluated for basic performance in the broadcasting mode through pattern testing under operating variables such as tractor forward speed, a group of spring specification and a regular of ball mass of governor under two-transmission system of spreader land wheel. The VICON pendulum spreader modified and prepared to wheat broadcast. It included hopper from fiberglass-reinforced polyester of 200 kg capacity, spreader width from 1-14 meter, hopper width of 1430 mm, filling height of 1020mm; net mass of 130kg and with 3-point linkage category II and power needed of 9kW. The bottom of the hopper exist included two discs. One of them is fixed and the others is moving. The fixed disc have a three holes which look like this in the moving disc adjusted manually before broadcasting operation to obtain a suitable open which gives a needed quantity of seeding and spout that oscillates from side to side in a horizontal plan to distribute seeds or other granular materials. Calibration tests evaluated in a laboratory and field tests carried out under Egyptian conditions. Results showed that, under laboratory tests, the optimum quantity of wheat seeds g/m^2 was 16.3g/m^2 at forward speed 4.5 km/h, the balancing masses of 200 g and the group transmission system of 18 teeth and the spring specification of 18.01 N/cm. The above parameters gives the best results because of their obtained a suitable centrifugal forces and suitable opening gate out area of feeding machine. Under field experiments, the minimum fuel consumption were recorded at ball mass governor of 375g, forward speed of 5.6 km/h, the spring specification of 18.01 N/cm and the transmission system teeth ratio 18 teeth. On the other side, the minimum energy found under ball mass governor of 200g, forward speed of 4.6 km/h, the spring specification of 18.01 N/cm and the transmission system teeth ratio 18 teeth.

INTRODUCTION

Wheat is the most important cereal crop in Egypt; it occupies about 2.75 million feddan with a national average of about 2.28 tons per feddan, producing yearly about 7.17 million tons of grain and 9.6558 million tons of straw (Ministry of agriculture -2016). Therefore, many attempts were carried out to increase the productivity using a news seeding/sowing technology. One of them is broadcasting pre-germinated wheat seeds. Besere (2002) mentioned that traditionally sowing of pre-germinated wheat might be used as a rice planting method. In Egypt, broadcasting pre-germinated wheat seeds with centrifuge machines has begun to increase through the last decade depending on good field leveling and field size.

Broadcasting is the direct distribution of seeds over the soil surface which manually or automatically done (Ismail- 2009). The manual broadcasting is used in smallholdings which based on the existing method of broadcasting process where resulted in difference in seed distribution rate. It also difficult to use in scattering of small seeds which preferred to use the automated broadcasting because of the advantages of doing broadcasting process with moist ground or existing weeds as well as good distribution of seeds on the surface of the earth and the scattering of small-sized seeds that are difficult to manually spreading with wide broadcasting width.

Seeding with centrifuge broadcasting is getting increasing especially at condition of reduce labours and the amount of seeding rate per feddan. It seems that, centrifuge broadcasting of pre- germinated seeds will be used much more in the future, because of its compatibility with the conditions of the Egyptian farmer. Furthermore, this method is also cheap and gives very good result for seeding setting uniformity (Ismail-2015). Ibrahim *et al.* (2008) mentioned that wheat and rice broadcasting carry out manually or by using seeder with desk or by airplanes. Nevertheless, this planting method caused more weeds competition with small emergence plant. On the other side, Peterson (2006) mentioned that broadcast seeding is the

best method for seeding grass and alfalfa mix. Nevertheless, Zewdu and Solomon (2007) stated that the seeds with equivalent diameter between 0.71 to 0.87mm or with thousand-grain mass of 0.257 to 0.421 g or with moisture content range, 5.6 % to 29.6 % WB are the best for seeding by broadcasting methods.

Zewdu (2008) showed that the possibility of using a spinning disc spreader for broadcast the seed, which may be used for replace broadcasting of the seed by hand manually. Under the same trend, Islam and Desa (2010) stated that, in the hand seeding, the seed are usually at random and the crops stand in the field without any rows.

Previous research shows that there is a vital importance to use broadcasting methods. Therefore, field experiments carried out to test and evaluate the effectiveness of developed mechanism needed to ensure about if broadcast spreader is suitable for distribution and covering planted area during the wheat broadcasting under the Egyptian conditions.

MATERIALS AND METHODS

Proposed Prototype

The VICON pendulum spreader with outline dimensions of 1020×1430×1020 mm was modified and prepared to broadcast. It included hopper from fiber glass reinforced polyester of 200 kg capacity, spreader width from 1-14 meter, hopper width of 1430 mm, filling height of 1020mm; net mass of 130kg and with 3-point linkage category II and power needed of 9kW as shown in Fig.1. The bottom of the hopper exist included two discs. One of them is fixed and the others is moving. The fixed disc have a three holes which look like this in the moving disc adjusted manually before broadcasting operation to obtain a suitable open which gives a needed quantity of seeding and spout that oscillates from side to side in a horizontal plan to distribute seeds or other granular materials.

On the base of VICON pendulum spreader, the following modification were added to connect the seed feed rate with speed. The modification included the following:-

- 1- **Land wheel:** Iron ground wheel has a diameter of 52 cm was used to translate the motion to the moveable parts of investigated prototype. It applied with hop and sleeves to easy reassemble and assemble. The gears of transmission unit were connected with wheel shaft.
- 2- **Transmission system:** The transmission system consist of two groups of sprocket gears. The first group consists of two gears and a chain. The first gear has 37 teeth which fixed in the hub of land wheel and the other one has 18 teeth for translating the motion to another similar group of sprocket gear which translate the motion to articulated arms as shown in Fig. 2.
- 3- **The governorate device:** The governor device as shown in Fig. 3 consists of iron plate with rectangle

cross section dimension of 20×10 mm. It formed in frame of rectangular shape with vertical length of 500 mm while the horizontal length was 450 mm. There are two holes in the center of the two vertical sides of the iron plate. In the first hole, a hand length of 170 mm was fixed. In the other hole, a hand of 230 mm was connected.

- 4- **Group of balancing mass:** Three couples of fly balls fixed in the end of articulated arms inside the iron frame. These masses are 200, 280, and 375g.
- 5- **Group of springs:** A group of spring's specification have different of forces per unit deflections (N/cm), which connected to the hand-feeding disc.

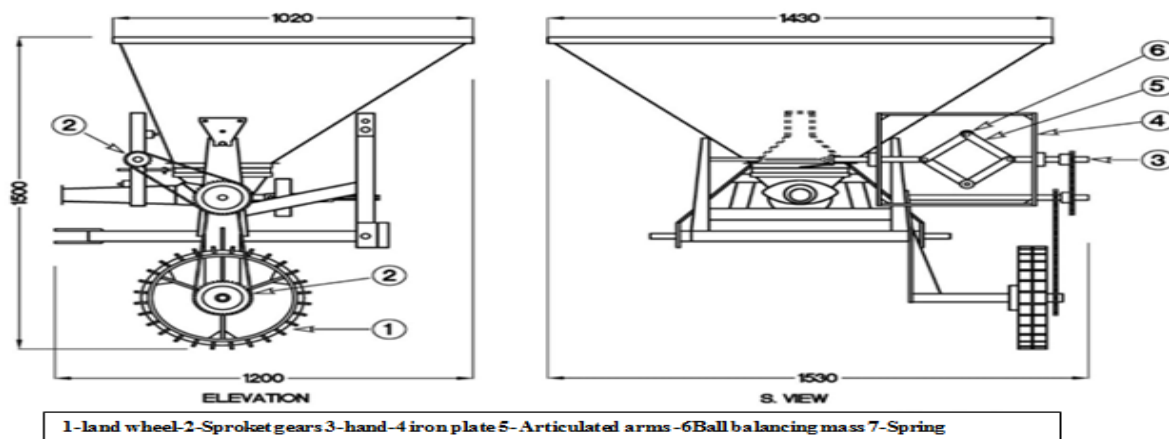


Fig. 1. A schematic of broadcast spreader (after development)



Fig. 2. Developed transmission device of spreader

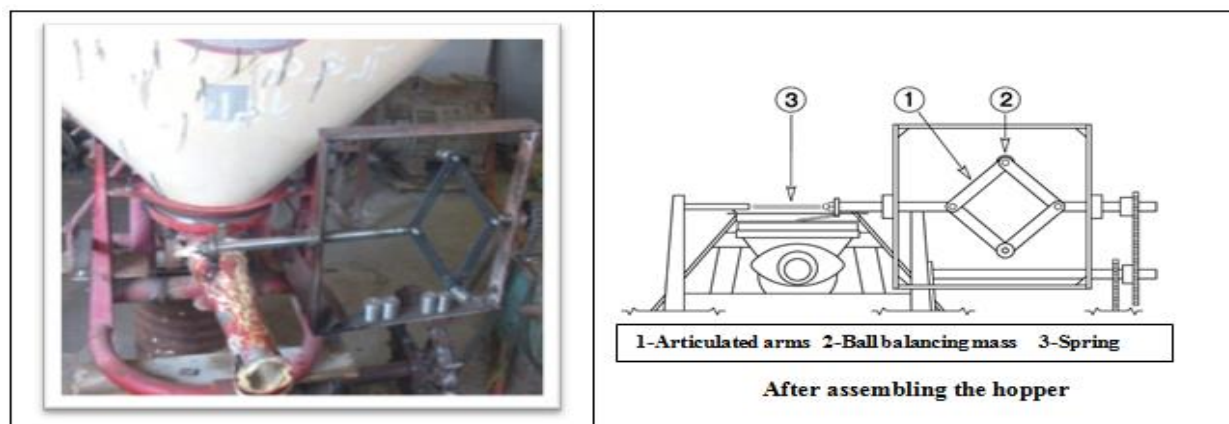


Fig. 3. Governor device of spreader

6- Grain varieties

Wheat seeding with variety of Giza 168 and moisture content of 12.3 % db was used for laboratory tests and field experiments. The main physicochemical properties of grain wheat, mass of grain (55g), bulk density (3.03g/cm³) and percentage of germination (89%) was used in this study were estimated according to (Bernski *et al.*, 1972).

Laboratory calibration, a series of tests were conducted as following:

- The pendulum broadcast spreader was fairly adjusted horizontally and all working parts were checked before carrying out the test.
- Broadcasting width was measured by putting the plastic sheet on a land surface. The spread width value can be obtained by operating the spreader on land surface that represented bare soil and then measuring the width covered which is the lateral distance between spreader centerlines.

Variables Determination

- The machine hopper filled with wheat grains for spreading.
- Plastic sheet placed under the tube for collecting the wheat grains during the test.
- The tractor should have a required speed with the balancing mass of 200 g. Also, number of gears 18 teeth and the different of spring specification for a certain distance.
- Determining the distance for calibration depending on the forward speed and the spread pattern width.
- Determining seed amount collected in the plastic sac for a certain distance by weighing it for each test.
- Each test replicated three times and the mean values were calculated and recorded.
- The obtained data expressed as a percentage of the total grains collected and plotted to show the distribution pattern across the spread width.

Spring calibration

Spring specifications and calibration conducted in the Physic Laboratory, Faculty of Science, and Mansoura University according to Hooke's law. The Young's modulus of spring (E) was found as 207000 mega Pascal and the Poisson ratio of spring (ν) = 0.3.

Spring constant (k)

Calculation of a spring constant using the spring's geometry and shear modulus from principle equation as following:

$$G = \frac{E}{2(1+\nu)} = 79615.38 = 79.61 \text{ Pascal} \dots \dots \dots (1)$$

$$K = \frac{Gd^4}{8n_a D^3} \dots \dots \dots (2)$$

$$D = D_{outer} - d \dots \dots \dots (3)$$

Spring Geometry

$$Coil_{pitch} = \frac{L_{free}}{n_a} \dots \dots \dots (4)$$

$$L_{solid} = n_t d \dots \dots \dots (5)$$

$$F_{max} = K (L_{free} - L_{solid}) \dots \dots \dots (6)$$

Where,

- G = shear modulus of material ν = Poisson ratio of spring
- K = spring constant d = wire diameter
- D = spring diameter D_o = spring outer diameter
- n_a = number of helical spring turns L_f = spring free length
- L_{solid} = spring compacted length E = Young modulus of spring

Field experimental test factors

- 1- Four levels of forward speeds namely; 4.20; 4.58; 5.10 and 5.50 km/h.
- 2- Four spring stiffness with different forces to length were 8.15, 15.8, 16.8 and 18.01 N/m.
- 3- Three different balls masses of 200, 280 and 375 g.
- 4- Two transmission gears include 15 and 18 teeth.

Measurements

Quantity of wheat seeds, gram/m² were measured in the laboratory and number of plant /m² was measured in the field after two weeks from planting date.

Statistical Analysis

The regression analysis and the analysis of variance of experimental factors conducted during analyzing the laboratory and field collected data in this study. Analysis executed with the aid of the computerized statistical procedures of SAS program.

RESULTS AND DISCUSSION

Wheat seeding rate (WSR)

Many factors affecting rate of feeding wheat (WSR) under a new investigated broadcasting prototype (WBP) such as forward speeds of prototype, transmission system of land wheel (LWT), balls mass of governor (BMG) and spring specification of pulling lever of seeds out (SSPL).

Fig. (4) shows the effect of forward speeds of wheat broadcasting prototype (WBP) on wheat seeding rate (WSR, g/m²) under three different balls mass of governor (BMG, g). At tractor forward speed for "WBP" about 4.2km/h and increasing BMG from 200 to 375g increased the average quantity WSR from 15.71 g/m² to 16.16 g/m². These results can be attributed to increasing the balancing mass cause an increasing the centrifugal force which cause increasing position of feeding gate out area.

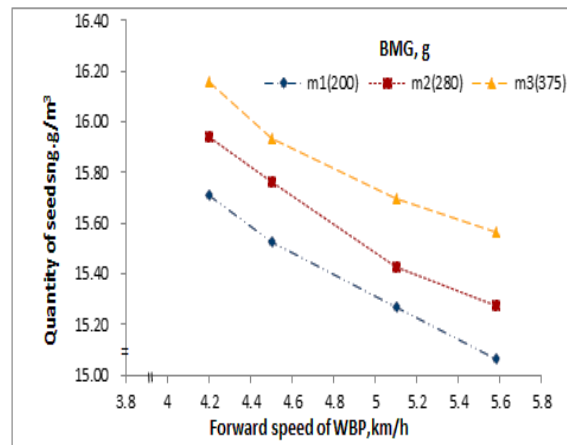


Fig. 4. Wheat seed rate as affecting with forward speeds of WBP and BMG

On the other side, increasing the (WBP) forward speed tends to decrease the quantity of wheat seeds rate (WSR, g/m²) and there was an indirect proportional between of them. For example, increasing the WBP from 4.2 to 5.1 km/h the WSR decreasing by about 0.96; 0.97 and 0.98 time at BMG of 200; 280 and 375g respectively. The maximum of WSR recorded about 16.16 g/m² that found at 4.2 k/h and balls mass of governor of 375g.

While, the minimum of WSR was found at 5.58 km/h and BMG of 200g. Regarding to the theoretical base, increasing the WBP forward speed increasing the revolution number of governor arm that conform to increase the seeds outlet holes and then increasing the amount of seeds and at same times increasing the travel distance. Consequentially, decreasing the WSR (g/m^2). The SAS analysis indicated that the interaction between WBP forward speed and BMG not significant ($Pr = 0.999 > F$). This outcome conformed to Ismail (1994).

The relationship between forward speed for WBP and WSR (g/m^2) under different spring specification of pulling arm “SSPL” illustrates in Fig. (5). The results showed that increasing the tractor forward speed for WBP tends to decrease the WSR at different SSPL. This mean an indirect proportional between them. On the other side, at the tractor forward speed for WBP about 4.2km/h and increasing in the SSPL from 8.15 to 18.01N/m decreasing the average of quantity of WSE from 16.42 to 15.46 g/m^2 . This result due to increases SSPL increasing the control of closing in gate out area on orifice feeding and decreasing the widely it which become at a small position of the gate out area then decreasing the quantity of WSR. The optimum spring specification was the highest one with 18.01N/m. The analysis of variance results indicated that the spring specification had a very high significant effect on the quantity of WSR as which $Pr = 0.0001 < F$ value.

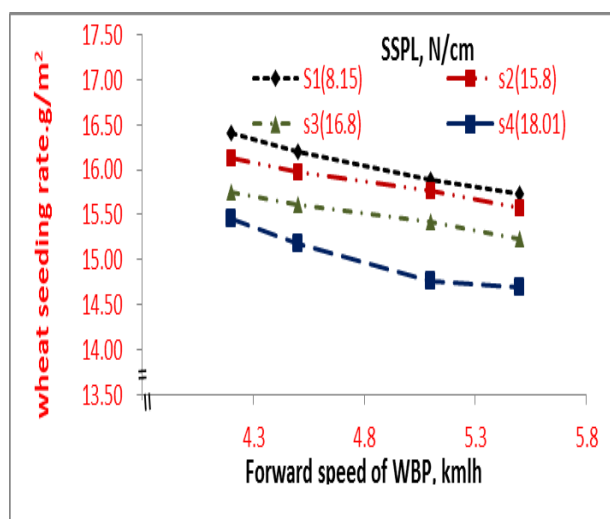


Fig. 5. Wheat seed rate as affecting with forward speeds of WBP and SSPL

The vital and very significant parameter affecting WSR is considered the wheel transmission system or the transmission of articulated arms of (SSPL). From Fig. 6, the data indicated that, increasing forward speeds for WBP decreasing the amount of WSR for all transmission systems. Nevertheless, at lower number of transmission gear of $n=15$ teeth recorded amount of WSR more than that for $n=18$ teeth. For example, at WBP speed of 4.2km/h, the amount of WSR recorded 16.13 and 15.75 g/m^2 . These result can be attributed to increasing the number of teeth ratio lead to decrease the driving of articulated arms and decreasing of centrifugal force and the position of feeding gate out area become a small orifice area then decreasing the amount of wheat seeds, it is clear that the optimum number of gears teeth 18.

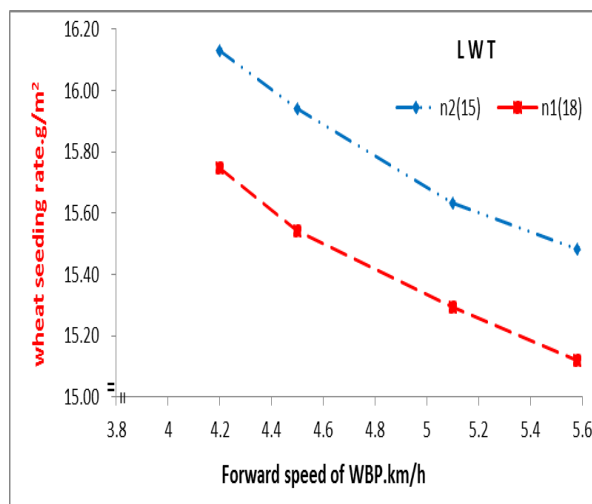


Fig. 6. Wheat seed rate (WSR) as affecting with forward speeds of WBP and LWT

Factors affecting number of wheat seedling per square meter (WSN)

The ball mass of governor (BMG) has a direct proportional with the wheat seedling per square meter. The relationship between forward speed of WBP and wheat seedling number/ m^2 under different ball mass of governor (BMG) are illustrated in Fig. (7). From figure the data indicated that increasing the ball mass (BMG) from 200 to 375g increasing the number of wheat seedling from 265.13 to 277.88 per square meter at constant forward speed of 5.58 km/h with neglected the effect of interaction between LWT and SSPL. These results can be attributed to increasing the balancing masses means increasing ball mass centrifugal force from governorate device that causes the feeding gate out area become more widely and then increasing the number of plant.

The spring specification of pulling lever (SSPL) has an inversely proportional with the wheat seedling per square meter. The relationship between forward speed of WBP and wheat seedling number/ m^2 under different SSPL are illustrated in Fig. (8). As an example, increasing the spring specification of pulling lever (SSPL) from 8.15 to 18.01 N/cm decreased the average number of seedling / m^2 from 293.17 to 275.5 plant/ m^2 respectively at forward speed of WBP 4.2 km/h and neglect the interaction between BMG and LWT. These results can be attributed to increasing the SSPL increased the controlling of close orifice of feeding gate out area, which become narrower then decreasing the feeding rate and NWS.

The transmission system of land wheel (LWT) has an indirect proportional with the WSN. Regarding to data in Fig. 9, as an example, increasing the land wheel transmission system (LWT) from using gear with 15th to using gear with 18th decreasing the average number of wheat seedling/ m^2 from 287.75 to 280.92 seedling/ m^2 . These result can be attributed by increasing the LWT system lead to decreasing the driving of articulated arms which decreasing the centrifugal force values. From the obtained data, it is clear that, the optimum of LWT system is found during using the group of gears that included gear with 18th.

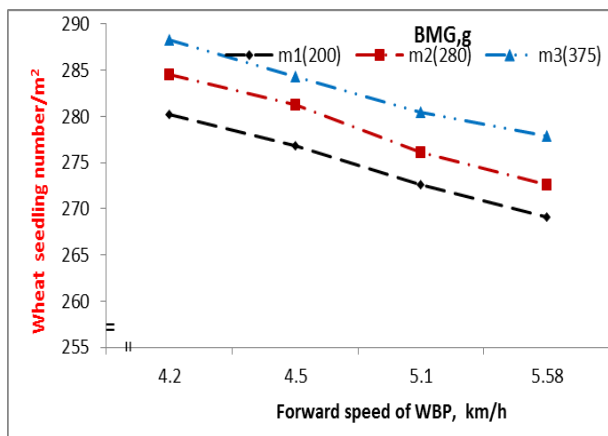


Fig. 7. Effect of forward speed of WBP and BMG on wheat seedling number

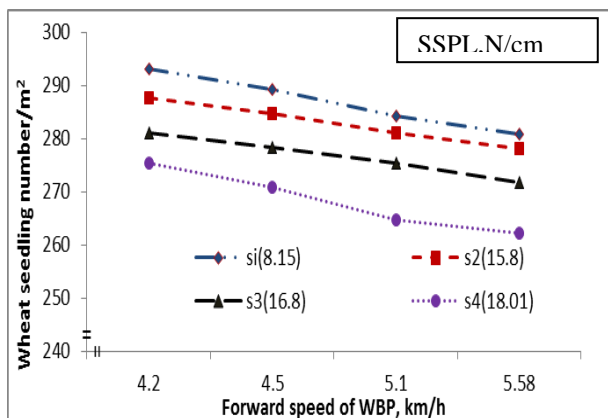


Fig. 8. Effect of forward speed of WBP and SSPL on wheat seedling number

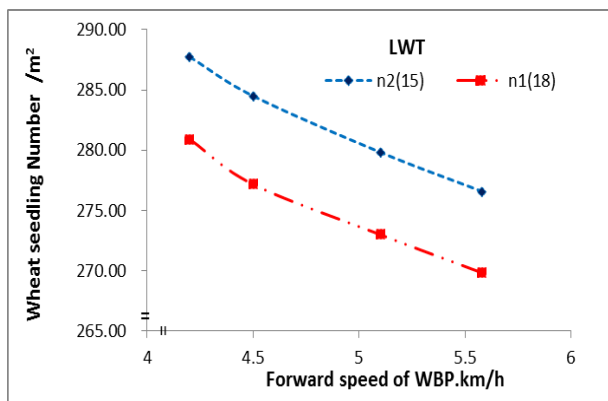


Fig. 9. Effect of forward speed of WBP and LWT on wheat seedling number

In general view, the analysis of variance results show the significant effect of the spreading factors (tractor forward speed, spring specification, balancing mass and the transmission system(teeth ratio) on the number of plant per matter square and the combine forward speed had a very high significant effect on the number of plant/m². These results show the effect of each single factor had very high significant effects on the number of plant per matter square. The analysis of variance results also show the effect of interaction between the spreading factors on the numbers of plant per matter square. In addition, double interaction between each of two factors (forward speed and the spring specification), (the balancing mass and the transmission system) had a very high significant effect on

the number of plant per matter square. However, the double interaction between each of factors (forward speed and balancing mass), (spring specification, forward speed and the transmission system), (spring specification and the transmission system) had a non-significant effect on the number of plant per matter square.

Factors affecting fuel consumption, L/fed

By increasing the ball mass of governor increasing the fuel consumption rate. There was a direct proportional between of them at constant anthers parameters (SSPL, LWT and forward speed of WBP) as shown in Fig. 10. On the other hand, the inverse trend was found during effect the SSPL on fuel consumption. For example, by increasing of the spring specification decreased of fuel consumption (L/fed.) as shown in Fig. 11. While, by increasing the transmission system (LWT) decreased the fuel consumption rate slightly and there was an indirect proportional between of them as shown in Fig. (12).

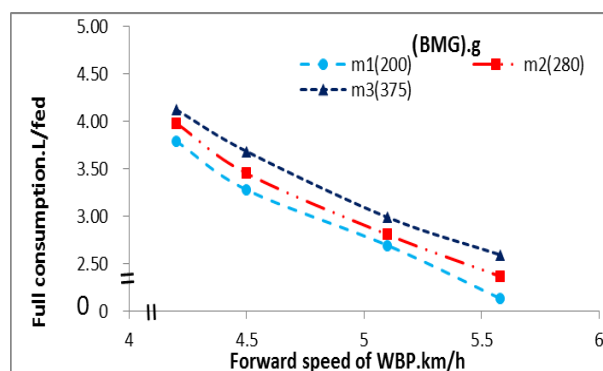


Fig. 10. Effect of BMG on fuel consumption L/fed

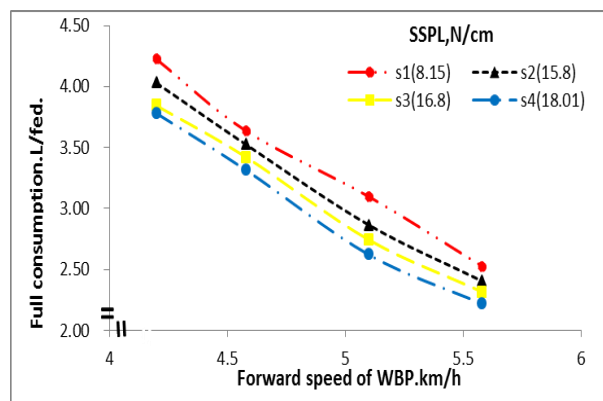


Fig. 11. Effect of SSPL on fuel consumption L/fed

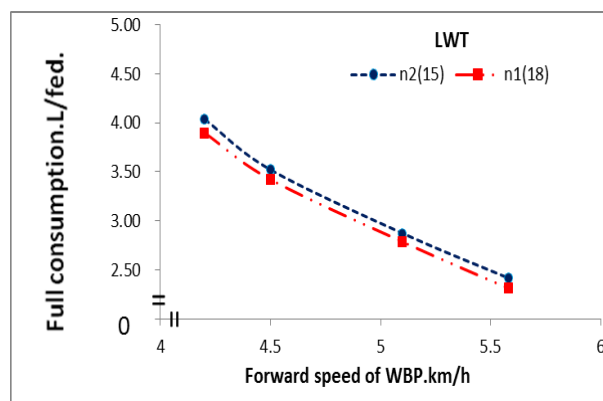


Fig. 12. Effect of LWT on fuel consumption L/fed

For example, increasing of SSPL from 8.15 to 18.01N/cm decreased the average of full consumption rate from 4.22 to 3.78 L/Fed at WBP speed of 4.2km/h; BMG of 200g and LWT at using gear with 18th. In addition, at WBP speed of 4.2km/h; SSPL of 8.15N/cm and LWT at using gear with 18th and by increasing BMG from 200 to 375g, increasing in the average of fuel consumption rate from 3.8 to 4.13 L/fed. While, by increasing the LWT from using gear with 15th to 18 teeth decreased the average of fuel consumption rate from 4.04 to 3.9 L/fed.under constant WBP of 4.2 km/h; SSPL of 8.15 N/cm and BMG of 200g.

Factor affecting energy requirement, kW h/fed

By increasing the ball mass of governor increasing the energy-required rate (kWh/fed). There was a direct proportional between of them at constant anthers parameters (SSPL, LWT and forward speed of WBP) as shown in Fig. 13. On the other hand, the indirect trend was found during effect the SSPL on energy requirement. For example, by increasing of the spring specification decreased of energy requirement (kWh/fed.) as shown in Fig. 14. While, by increasing the transmission system (LWT) decreased the energy requirement slightly and there was an indirect proportional between of them as shown in Fig. (15).

For example, increasing of SSPL from 8.15 to 18.01N/cm decreased the average of full consumption rate from 4.22 to 3.78 L/Fed at WBP speed of 4.2km/h; BMG of 200g and LWT at using gear with 18th. In addition, at WBP speed of 4.2km/h; SSPL of 8.15N/cm and LWT at using gear with 18th and by increasing BMG from 200 to 375g, increasing in the average of fuel consumption rate from 3.8 to 4.13 L/fed. While, by increasing the LWT from using gear with 15th to 18 teeth decreasing the average of fuel consumption rate from 4.04 to 3.9 L/fed under constant each of WBP (4.2 km/h); SSPL (8.15 N/cm) and BMG (200g).

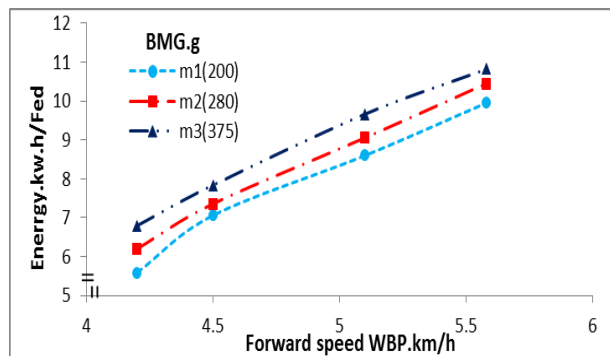


Fig. 13. Effect of BMG on energy consumption kWh/fed

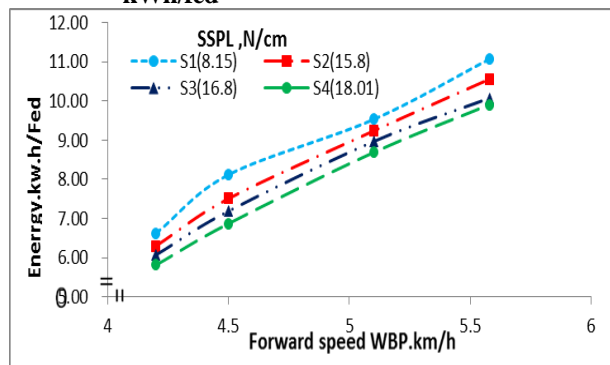


Fig. 14. Effect of SSPL on energy consumption kWh/fed

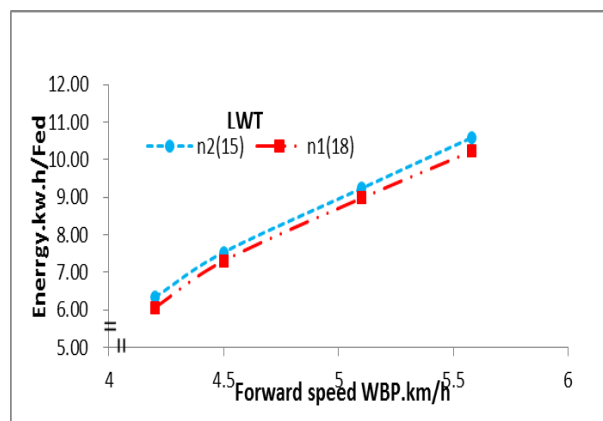


Fig. 15. Effect of LWT on energy consumption kWh/fed

CONCLUSION

The present study involved studying the problems during spreading seeds by mechanical methods under the Egyptian conditions. Preliminary tests were carried out to find out the mechanical defects of the used mechanism and for further improvements to evaluate the best conditions for field tests. Field experiments were carried out to evaluate the effectiveness of developed mechanism during wheat broadcasting.

Under laboratory tests, the optimum quantity of wheat seeds g/m² was 16.3g/m² at forward speed 4.5 km/h, the balancing masses of 200 g and the group transmission system of 18 teeth and the spring specification of 18.01 N/cm. The above parameters gives the best results because of there were obtained a suitable centrifugal forces and suitable opening gate out area of feeding machine.

Under field experiments, the minimum fuel consumption were recorded at ball mass governor of 375g, forward speed of 5.6 km/h, the spring specification of 18.01 N/cm and the transmission system teeth ratio 18 teeth. On the other side, the minimum energy was found under ball mass governor of 200g, forward speed of 4.6 km/h, the spring specification of 18.01 N/cm and the transmission system teeth ratio 18 teeth.

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استخدام نظام تغذية تحكم جديد لنثر القمح

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تم تقييم نظام تغذية جديد على أداء آلة النثر من خلال اختبار النظام تحت متغيرات تشغيل مختلفة مثل السرعة الأمامية للجرار ، ومجموعة من اليايات ومجموعة منتظمة من كتل الاتزان تحت نظامين لنقل الحركة من عجلة الأرض. تم تحديث وتعديل ماكينة نثر البذور البندولية VICON لنثر حبوب القمح. والتي تتكون من قادوس من البولبيستر المقوى بالألياف الزجاجية سعة ٢٠٠ كجم وبعرض تشغيل من ١- ١٤ متر و عرض القادوس ١٤٣٠ ملم وارتفاع الملى ١٠٢٠ مم. بكتلة كلية ١٣٠ كجم والطاقة اللازمة للتشغيل ٩ كيلووات. يوجد أسفل القادوس قرصين. واحد منهم ثابت والآخر يتحرك. يحتوي القرص الثابت على ثلاثة ثقب تشبه مثيلاتها في القرص المتحرك ويتم ضبطه يدوياً قبل عملية النثر للحصول على فتحة مناسبة تعطي كمية كافية من البذور، والصمام يتأرجح من جانب إلى آخر في وضع أفقي لتوزيع البذور أو غيرها من الحبيبات. وقد تمت اختبارات المعايرة معملياً وميدانياً تحت الظروف المصرية. أوضحت النتائج أن الكميات المثلى من بذور القمح بلغت ١٦.٣ ج/م^٢ كانت عند سرعة أمامية ٤.٥ كم/ساعة ، وكتل توازن ٢٠٠ جم ونظام نقل السرعة ١٨ سناً ومواصفات الياي ١٨.٠١ نيوتن/سم. تعطي المعاملات المذكورة أعلاه أفضل النتائج بسبب حصولها على قوى الطرد المركزي المناسبة وفتح فتحة التغذية المناسبة لكمية البذور المطلوبة. في إطار التجارب الحقلية ، تم تسجيل الحد الأدنى من استهلاك الوقود في حاكم مع الكتلة الوزنيه ٣٧٥ جراماً ، وسرعة تقدم ٥.٦ كم / ساعة ، ومواصفات الياي ١٨.٠١ نيوتن/سم ، وعدد أسنان ناقل الحركة ١٨ سناً. على الجانب الآخر ، فإن الحد الأدنى من الطاقة التي تم قياسها كانت تحت كتلة توازن ٢٠٠ جم ، السرعة الأمامية ٤.٦ كم/ساعة ، مواصفات الياي ١٨.٠١ نيوتن/سم وعدد أسنان ١٨ سنة.