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PERFORMANCE EVALUATION OF A SELF PROPELLED SMALL EQUIPEMENT IN POULTRY MANURE COLLECTION

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ABSTRACT: This study was conducted through two successive years 2004 and 2005 including fifteen poultry farms at two villages, Shobra El-Enab and Kafr Abo El-Zagazig, Sharkia Governorate .The main objectives of the present study aimed to evaluate a small multi purpose self propelled equipment (MPSPE) in poultry manure collection and optimize its performance parameters. From the obtained results, it can be concluded that: The proper collecting efficiency was obtained under collecting speed of 3.2 km/h and average width of 1 m. Both of equipment and worker productivity increased with percentages of 1979, 2783, 3556 and 4174 under operating speeds of 1.5, 2.3, 3.2 and 4.0 km/h respectively compared with traditional methods. Increasing the scraping width or increasing the operating speed led to decrease in energy requirements per unit farm.

Key words: Poultry farms, poultry manure, manure scrapers.

INTRODUCTION

During the last twenty years great number of poultry farms had been widely spread in Egypt. The data obtained from the Ministry of Agriculture in 2001 indicated that, there are about 24000 poultry farms for meat production, having an average area of 500 m^2 per each (farm capacity = 5000 chickens) the main problems facing the poultry producer, are:

1) Watering, 2) feeding 3) stirring the poultry waste during the period of breeding, and 4) collecting and transporting of the Poultry manure out of the farm. All previous operations are of high

costs, energy and time consuming specially when it is carried out by the traditional methods. The required time under wet dung condition is more than that required under dry dung condition Joshi et *al*. (1982).

Kellerby and Smith (1977) constructed a manure harvester, which incorporated the functions of pulverizing, loading, transporting and unloading. It was towed by a medium sized tractor and powered hydraulically. In tests on wood paste and beef feedlot manure, power requirements were less than 10 kW to load material 5 cm deep at forward speed of 1 to 2 km/h approximately 40 m^3/h were loaded.

James *et al*. (1980) reported that surface finish of the floor, with its associated effect on footing, is important for animal safety and ability to move freely and easily. Concrete is the usual floor material in most new confinement structures because of its cost and durability. A rough screed or broom finish is common to provide sufficient footing.

MWPS (1993) described scraping systems as means of mechanical removing manure, and used to push manure through collection gutters and alleys similar to flush systems.

Quisenberry(1998) determined that the average litter depth in his poultry house was 4.0 inches. The moisture content of the litter, based on Clemson University Agricultural Service Laboratory results, was 24%. The poultry house floor measures 40 x 500 ft.

Don *et al*. (1999) mentioned that poultry producers select manure-handling system based on factors as location. The size, type and use of their cropland, number of birds, and type of housing.

Joe (2003) showed the importance in use of litter on the floor, whether the floor is dirt, sand, and wood or concrete, some material on the floor is a necessity for either broilers or laying hens. He added that the conventional poultry industry uses rice hulls and pine shavings for litter.

In view the above effort has been made to test and develop a suitable multi purpose self-propelled small equipment (MPSPE) used in poultry farms to suit poultry manure collection.

The main objectives of the present study are:

Developing a small multi purpose self-propelled equipment to suit poultry manure collection. Optimizing some operating parameters of the developed equipment. Estimating the power and energy requirements.

Comparison between using developed equipment and traditional methods of poultry manure collection. The traditional methods of collecting poultry manure, cleaning poultry farm and transporting manure were carried out.

MATERIALS AND METHODS

This study was conducted through two successive years 2004 and 2005 including fifteen meat poultry farms at two villages, Shobra El-Enab and Kafr Abo El-Zagazig, Sharkia governorate . Each experimental farm covered an average area of 500 m^2 (10 x 50m). The experimental work and data collection were carried out with using the locally–made hoe, wide–edge shovel, traditional buckets, small pulled cart ($1m^3$) by a donkey, small trailer ($1m^3$) in rear attachment. The multi-purpose self propelled equipment (MPSPE) were investigated in Fig. 1. The main equipment (MPSPE) having the following specification: Model: Lambordini Made in: Italy Engine Type: Diesel air cooling, one cylinder Power at rated speed: 14 (hp) 10.3kW Gear box: 3 forward speeds + 1 reverse Overall height: 94.7 cm Overall length: 179.4 cm Overall width: 82.5 cm Mass: 113 kg Number of wheels: 2 Wheels size: 14 x 63 cm.

The MPSPE is drive by one operator with the help of two handles. Border scraper was designed and manufactured for poultry litter collection .The fabricated scraper is hitched with the self-propelled equipment as a rear scraper. The border scraper blade in Fig. 2 is a sheet of galvanized iron (1 mm thick) with height of 60 cm and variable widths of 80, 100 and 120 cm by holes and nuts the blade strengthed with iron bars and angles and having lateral borders to keep the manure during collection operation.

Measurements and Calculations

Poultry manure

The following physical properties of manure were measured:

i) Thickness.

ii) Swelling factor.

iii) Specific weight.

iv) Moisture content.

v) Total volume and weight.

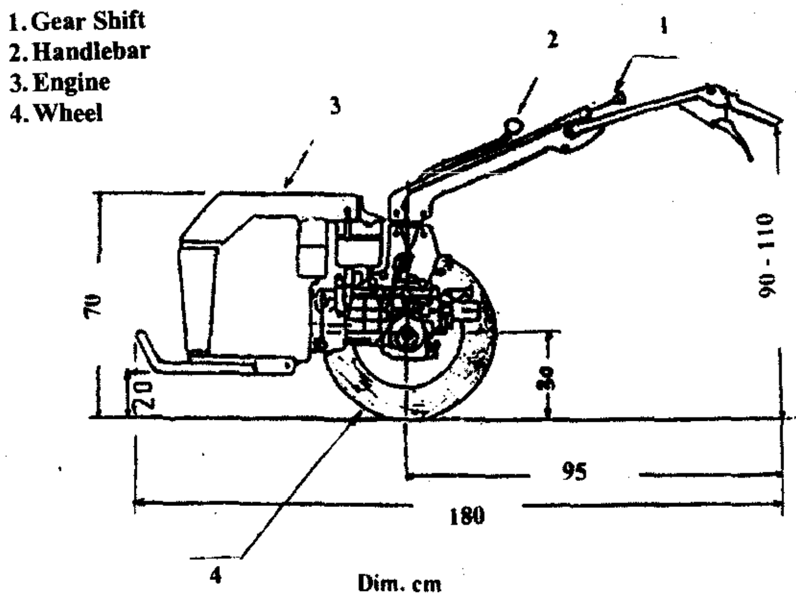

Fig. 1: Schematic diagram of the MPSPE

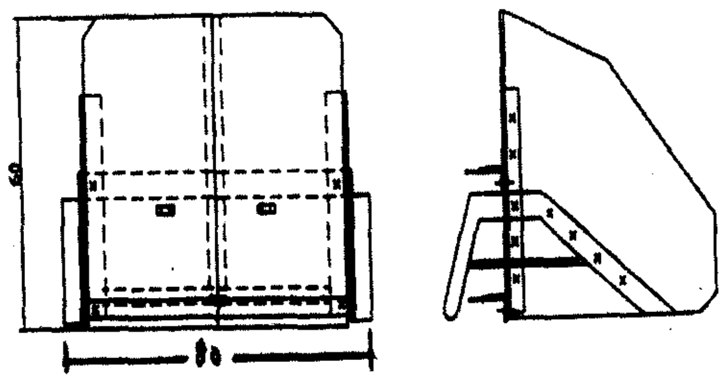

Fig. 2: Two geometric views of border scraper

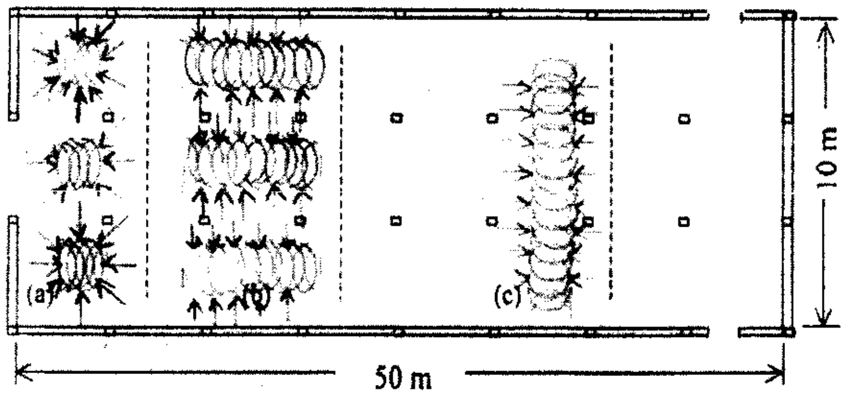

Fig. 3: Section plan of poultry farm and the sequence of poultry manure collecting using different methods. (a & b) hoe and shovel and (c) MPSPE

Slippage Determination

The slippage values were determined with its ratio on some operative speeds with the scraper used.

$$S\ \% = (Lo - L_l / L_o) \times 100$$

Where:

L_o = Distance without load, m (equivalent 5 rev.) , m

L_l = Distance with load (m) (equivalent 5 rev.)

Manure collecting, floor cleaning and transporting operations

The following measurements and calculation were taken:

i) Forward collecting speed (4 speeds were carried out), ii) pushing force and power, iii) effective working stroke, iv) operation time and working efficiency, v) fuel consumption, vi) Power and energy requirements and vii) total cost.

Colleting time and collecting efficiency

In farm unit (500 m^2) estimating collecting theoretical time according operating speed and scraping width. Also the actual collecting times are measured using stopwatch.

Collecting efficiency (%) = Theoretical time / Actual time

Pushing force and power

A hydraulic dynamometer between a small tractor and the (MSPSE) was used to measure the pushing force. The pushing power was calculated using the following equation:

$$PP = \frac{(PF)(OS)}{3.6} \quad ,kW$$

Where:

PP = Pushing power, kW,

OS = Operating speed, km/h and

PF = Pushing force, kN

Fuel consumption

Fuel consumption was determined by measuring the quantity of fuel required during each operation to refill the fuel tank after working period. A graduated glass cylinder was used to measure the added quantity of fuel.

Power and energy requirements

Power calculated according to the following formula Georing, 1992 :

$P = H.W_f.\zeta_{th} / 3600$, kW

$W_f = Q_f \rho_f$

Where

W_f = Fuel consumption rate, kg/h,

ζ_{th} = Engine Thermal Efficiency (0.25)

P = Fuel equivalent power, kW,

H = Gross heating value of fuel = 45434 kJ/kg of fuel ≈ 45000 kJ/kg of fuel,

Q_f = Fuel consumption rate, L/h

P_f = Fuel density, kg/L

Energy calculated according to the following formula:

$E = PT_{act} / 60$, kJ

Where

T_{act} = Total actual collecting time, min

Estimating the total costs of all operations

All operations (collecting, cleaning and transporting) are compared with the traditional methods considering time and costs. The cost of using the developed equipment in comparing to manually traditional methods was determined according to: Man = 3.0 LE/h, Girl = 2.0 LE/h. Small cart = 6 LE/day or 1 LE/h, Small trailer = 6 LE/day, the developed equipment = 10 LE/h and operator of MSMPE wage = 4LE/h.

RESULTS AND DISCUSSION

The obtained results will be discussed under the following items:

Poultry Manure Properties

Table 1 shows the physical properties of the poultry manure such as thickness, swelling factor total mass and moisture content. These parameters are highly in winter than in summer. This may be due to the length of breeding cycle which is about 60 days in winter and not more than 50 days in summer and also due to the additional litter in winter season.

The Effect of Scraping Width (SW) and Operating Speed (OS) on Equipment Slippage (S)

From results and Fig. 4 for border scraper. Data show that increasing scraping width from 0.8 to 1.2 m tends to increase the equipment slippage at different operating speeds. Also results indicate that increasing operating speed from 2.3 to 3.2 tends to increase slippage percentage at different scraping widths by a slightly increase. As a conclusion, it is preferred to use the medium width of 1.0 m with an average collecting speed of about 2.5 km/h. This combination will give equipment slippage less than 15-20%. In general, the use of a higher speed with a small working width will achieve the same results as using a lower speed with a bigger working width as it will be clear later.

The Effect of Scraping Width (SW) and Operating Speed (OS) on Collecting Time (T_{th} & T_{act}) and Collecting Efficiency (η_{col})

The results in Fig. 5 and 6 indicate that, the use of border scraper reduce the operation time compared with the traditional collecting method. For example when SW = 1.0 m, the collecting time reduces to 0.05, 0.036, 0.028, 0.024 of traditional operating time (480 min) under the used four speeds of 1.5, 2.3, 3.2, 4 km/h respectively. On the other hand it increases the equipment and worker productivity by percentages of 1979, 2783, 3556 and 4174% under the used four operating speeds. By increasing the operating speed, the collecting time and collecting efficiency are decreased but the actual productivity increased compared with the traditional collecting method. In general as a conclusion, it is preferred to use collecting speed of about 2.5 km/h with the average width of 1.0 m to obtain medium collecting efficiency, high productivity and accepted slippage (about 15-20 %) at the same time.

Table 1: Poultry manure properties. (Collected from farm area of about 500 m^2)

Breeding season	Thick -ness, Cm	Swelling Factor	Specific weight, Kg/m^3	Moisture Content, %	Total Volume, m^3	Total Weight, Mg
Summer	3.8	1.10	401	24.8	20.90	08.38
Winter	4.4	1.20	429	27.2	24.90	10.86
Average	4.1	1.15	415	26.0	22.88	09.62

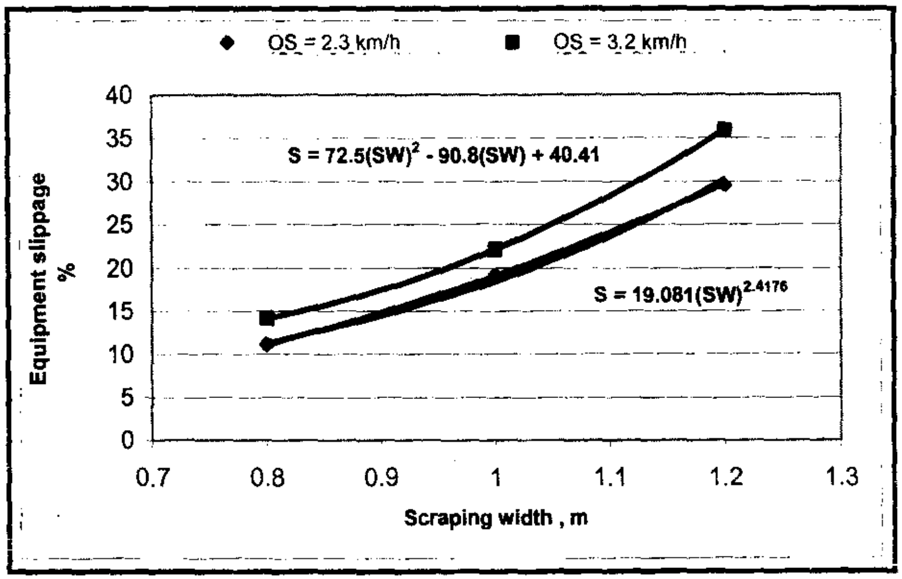

Fig. 4: The effect of scraping width (SW) and operating speed (OS) on equipment slippage (S)

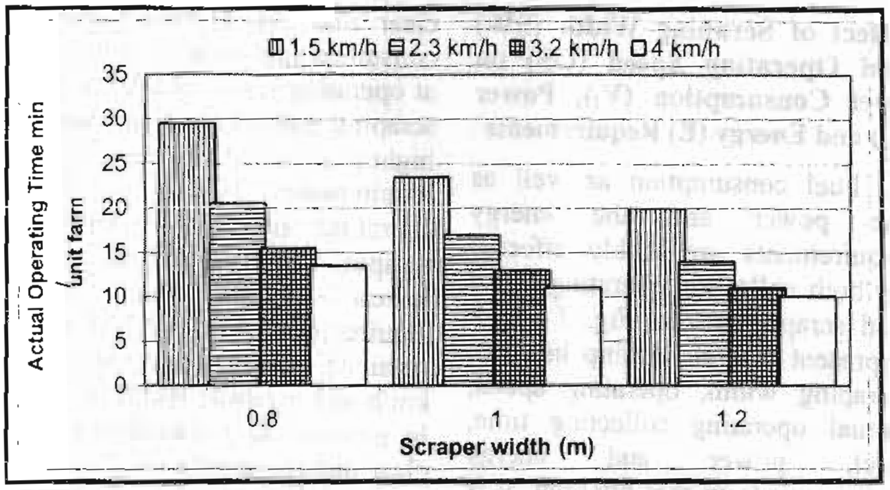

Fig. 5: Relationship between scraping width (SW), operating speed (OS), and actual operating time

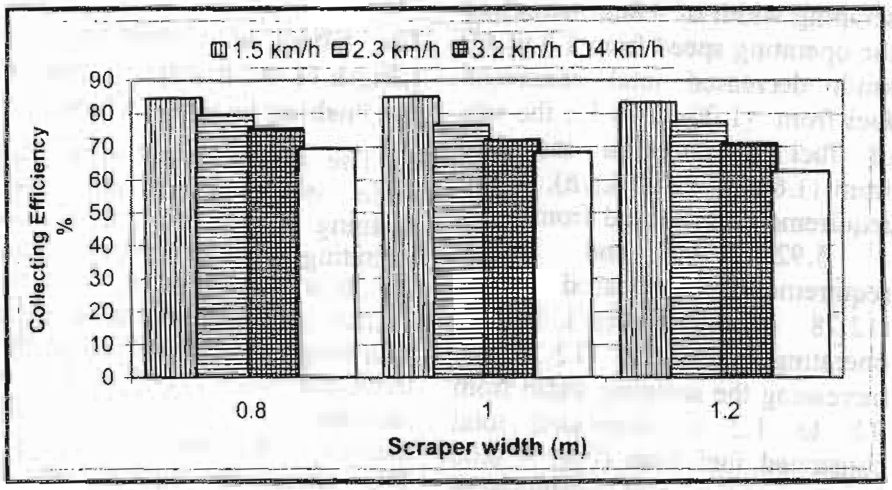

Fig. 6: Relationship between scraping width (SW), operating speed (OS) and collecting efficiency (η_{col})

Effect of Scraping Width (SW) and Operating Speed (OS) on Fuel Consumption (V_f), Power (P) and Energy (E) Requirements

Fuel consumption as well as the power and the energy requirements are highly affected by both collecting operating speed and scraping width. Fig. 7 and 8 represent the relationship between scraping width, operating speed, actual operating collecting time, fuel, power and energy requirements in rear hitching. It is clear that increasing the scraping width or increasing the operating speed increased the power requirements while decreased the energy requirements. Using scraping width of 0.8m, increasing the operating speed from 1.5 to 4.0 km/h decreased total consumed fuel from (1.00– 0.75 L), the rate of fuel consumption increased from (1.688 – 2.767 kg/h), power requirements increased from (1.61 – 5.92 kW) and energy requirements decreased from (12.78 – 9.59 kJ/m^2). Using operating speed of 3.2 km/h, increasing the scraping width from 0.8 to 1.2 m decreased total consumed fuel from (0.80 – 0.60 L), the rate of fuel consumption increased from (2.570 - 2.716 kg/h), power requirements increased from (5.49 – 5.81 kW) and energy requirements decreased from (10.21 – 7.52 kJ/m^2). It is clear that the highest values of consumed fuel volume was 0.75 L at operating speed of 1.5 km/h and scraping width of 0.8 m. Also the highest values of power requirements was 5.86 kW at operating speed of 4.0 km/h and scraping width of 1.2 m, but the lowest values of energy requirements (7.03 kJ/m^2) was obtained at operating speed of 4.0 km/h and scraping width of 1.2 m. In general, as a conclusion, it is clear that the lowest values of fuel, power and energy were obtained at operating speed of 4.0 km/h. It is recommended the speed of about 3.0 km/h where medium power and energy requirements and equipment slippage less than 20 %.

The Effect of Collection Path-Length of the Border Scraper on the Pushing Force and Power

The measurement of pushing force was carried out under scraping width of 1.0 m and operating speed of 3.0 km/h. From Fig. 9 it is clear that, there is a positive relation between operating path-length and required pushing force and power. This is due to the increase of the accumulated manure in the front of the scraper. The maximum capacity of the scraper is observed at the end of 10 to 12 m stroke. So it is necessary to heap the collected litter to be loaded and transported out from the farm.

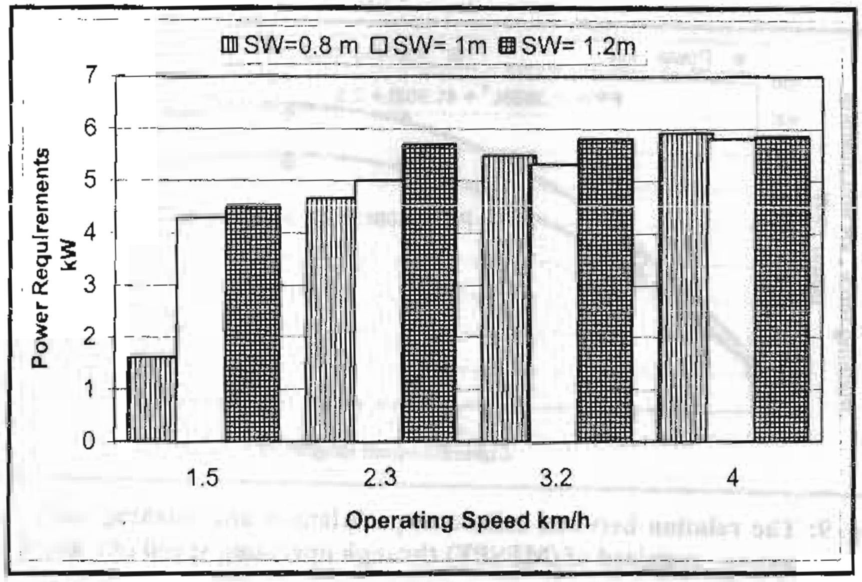

Fig. 7: Relationship between scraping width (SW), operating speed (OS) and power requirements (P)

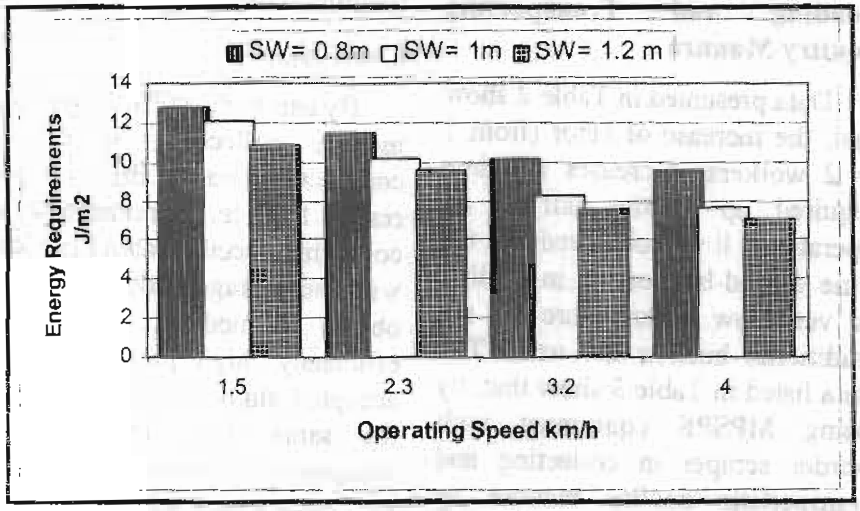

Fig. 8: Relationship between scraping width (SW), operating speed (OS) and energy requirements (E)

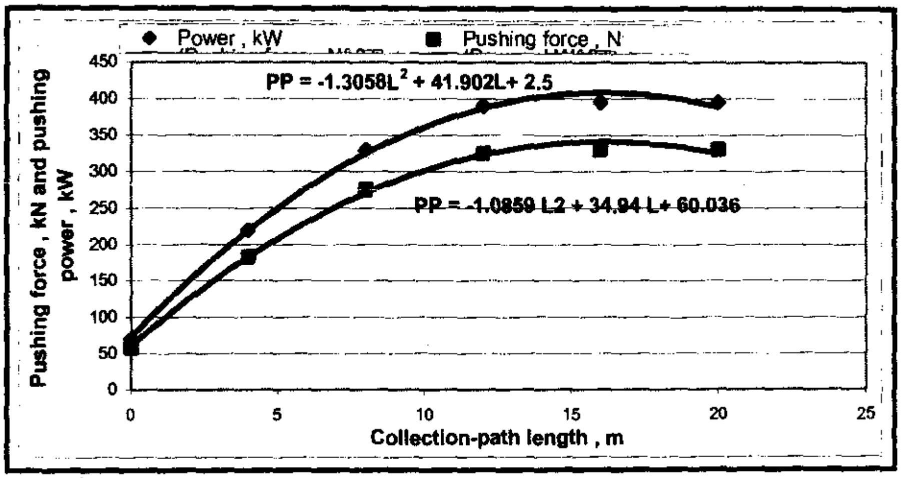

Fig. 9: The relation between collection path length and pushing force and power required of (MPSPE) through operating speed of 3 km/h

Comparative Study on Different Methods Used in Collecting, Loading and Transporting Poultry Manure

Data presented in Table 2 show that, the increase of labor (from 1 to 2 workers) decreases the time required up to the half in all operations. It was observed that the time wasted by workers in loading is very low when more of the traditional buckets are used. The data listed in Table 3 show that, by using MPSPE equipment with border scraper in collecting and transporting poultry manure by (small pulled cart or small trailer hitched with MPSPE) reduces the operation time and total costs by (-1.7, 70.8), (33.3, 83.3)% respectively compared to the traditional method.

Conclusion

By using the MPSPE in poultry manure collection, it can be concluded from the obtained results that: It is preferred to use collecting speed of about 3.2 km/h with the average width of 1.0 m to obtain medium collecting efficiency, high productivity and accepted slippage (about 20 %) at the same time. Increasing the equipment and worker productivity by percentages of 1979, 2783, 3556 and 4174 % under the used four operating speeds and decreasing the time required for

Table 2: Factors affecting the collection, loading and transportation of poultry manure

Operations	Equipment	No. of equipment	No. of buckets	No. of man	No. of girl	Time h	Costs LE
Manure collecting	Hoe	1	-	1	-	8	24
		2	-	2	-	4	24
	Shovel	1	-	1	-	6	18
		2	-	2	-	3	18
	MPSPE	1	-	1	-	0.5	7.0
Loading, trans. using buckets	Hoe	1	4	1	3	4	36
		2	6	2	5	1.75	28
	Shovel	1	4	1	3	3.5	31.5
		2	6	2	5	1.5	24.0
Loading, trans. using Small cart or trailer	Hoe	1	1	1	-	3.0	12.0
		2	2	2	-	1.5	12.0
	Shovel	1	1	1	-	3.0	12.0
		2	2	2	-	1.5	12.0
	MPSPE	1	1	1	-	3.0	54.0
		1	2	2	-	1.5	33.0
		1	3	3	-	1.0	26.0

Table 3: Comparison between different methods of collecting, loading and transporting poultry manure

Methods	Man	Girl	Total costs, LE	Total time, h	Dec., % cost	Dec., % time
Trad. Method,	1	3	60	12	-	-
Hoe & buckets	2	5	52	5.75	13.3	52.1
Trad. Method,	1	3	49.5	9.5	17.5	20.8
Shovel & buckets	2	5	42.0	4.5	30.0	62.5
MPSPE, shovel & Buckets	1	3	38.5	4	35.8	66.7
	2	5	31.0	2	48.3	83.3
Hoe & small cart	1	-	36	11.0	40	08.3
	2	-	36	5.5	40	54.2
Shovel & small cart	1	-	36	9.0	40	25.0
	2	-	36	4.5	40	62.5
MPSPE & small trailer	1	-	61.0	3.5	-1.7	70.8
	2	-	40.0	2.0	33.3	83.3
	3	-	33.0	1.5	45.0	87.5

manure collection by the same above percentages. Increasing the scraping width or increasing the operating speed increased the power requirements while decreased the energy requirements. The lowest value of energy was obtained at operating speed of 4.0 km/h. The maximum capacity of the scraper is observed at the end of 10 to 12 m stroke. So it is necessary to heap the collected litter to be loaded and transported out from the farm. By using small pulled cart or small trailer hitched with MPSPE reduces the total operation time (collecting, loading and transporting time) and total costs by 33.3 and 70.8% compared to the traditional method.

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تقييم أداء معدة صغيرة ذاتـيـة الحركة فى تجميع فضلات الدواجن

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تعتبر مشكلة الأيدى العاملة المتخصصة وارتفاع اجور العمال من أهم المشاكل التى تواجه الإنتاج الزراعى بصفة عامة وإنتاج الدواجن بصفة خاصة والذى يمثل شـق كبيـر حالياً فى إنتاج البروتين الحيوانى فى السنوات الأخيرة. ومن أهـم العمليـات الضـرورية لتربية الدواجن هى عملية السقى – التغذية – التخلص من الفضلات فى نهاية دورة التربية والتى تتطلب من ٥٠ إلى ٦٠ يوماً . وهذه العمليات فى مجموعهـا تتطلـب وقتـاً كبيـراً ومجهوداً عالياً وتكاليف مرتفعة إذا تمت بالطرق التقليدية المتبعة حالياً خاصة فى المزارع الأهلية لذلك:

الغرض من هذه الدراسة

١– تصميم وتصنيع واختبار قصابية تعمل مع معدة ذاتية الحركة صغيرة توجه بالعامل وهو يتحرك خلفها لتقوم بتجميع الفضلات فى نهاية دورات تربية الدواجن.

٢– تقييم الطرق المختلفة للتخلص من الفضلات بالتجميع والنقل خارج المزرعة من ناحية الوقت والتكاليف والطاقة المستهلكة.

٣– تحديد أنسب ظروف تشغيل من حيث السرعة وعرض مشوار التجميع والكفاءة، خاصة صممت القصابية ليمكن استعمالها بعرض تشغيل ٠,٨ ، ١,٠ ، ١,٢ متـر ومـع ٤ سرعات هى ١,٥، ٢,٣ ، ٣,٢ ، ٤,٠ كم/ساعة وتم قياس زمن التجميـع وحسـاب كفاءة التجميع والإنتاجية والتكاليف مع استخدام الآلة و بالمقارنة بالطرق التقليدية.

أهم النتائج والتوصيات

استخدام المعدة ذاتية الحركة (MPSPE) ومعهـا القصـابية المصـممة لتجميـع الفضلات وبالمقارنة بالطرق التقليدية اتضح مايلى:

- زادت إنتاجية المعدة والعامل عن الطريقة التقليدية للتجميع بنسب ١٩٧٩، ٢٧٨٣ ، ٣٥٥٦ ، ٤١٧٤ % مع السرعات ١,٥، ٢,٣ ، ٣,٢ ، ٤,٠ كم/ساعة على الترتيب كما قل زمن التجميع للمخلفات باستخدام المعدة بنفس النسب المذكورة.
- أوضحت النتائج ان سرعة تجميع حوالى ٣ كم/ساعة مع عرض تشغيل ١,٠ متر تعطى أعلى كفاءة تجميع متوسطة وإنتاجية عالية وفى نفس الوقت انزلاق للمعدة فى حدود ٢٠ %.
- فى حالة زيادة السرعة أو زيادة عرض التجميع تزيد القدرة اللازمة للتشغيل بينما تقل الطاقة المستهلكة، وكانت أقل قيم للوقود المستهلك عند أعلى سرعة وهى ٤ كم/ساعة مما انعكس على كلا من القدرة والطاقة.
- وجد أن أنسب طول لمشوار التجميع والتى عنده تمتلىء القصابية يتراوح من ١٠ إلى ١٢ مترا طبقا لكثافة الفضلات.
- أتضح أن استخدام عربة مجرورة بواسطة الدواب يقلل الزمن الكلى اللازم للتجميع والنقل خارج المزرعة بنسبة ٣٣,٣ % بينما استخدام مقطورة صغيرة مع المعدة يخفض الزمن بنسبة حوالى ٧٠ %.
- توصى الدراسة بأنسب ظروف تشغيل باستخدام المعدة مع القصابية على سرعة ٣ كم/ساعة وعرض التشغيل ١,٠ متر ومقطورة صغيرة سعة ١ متر مكعب على أن تكون أرضية المزرعة مستوية تماماً وفتحة باب المزرعة لا تقل عن ١,٢ متر.