Journal of Applied Sciences

ISSN 1812-5654

OPEN ACCESS Journal of Applied Sciences

ISSN 1812-5654
DOI: 10.3923/jas.2017.400.406

Research Article
Mechanical Burning Unit for Wheat Stalks Residual after Harvesting

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Abstract

Background and Objective: Wheat stalks residual is the important problem which faces both planting and germination of rice seeds. So, wheat stalks must be burnt before soil tillage. The aim of this study was the development and evaluation of a-unit for burning wheat stalks residual before soil tillage. **Materials and Mathods:** To achieve that aim 3 operating parameters were used in sub-sub plot design, 4 forward speeds (3.19, 3.97, 4.5 and 5.4 km h^{-1}), 3 distance between flame cannon (30, 40 and 50 cm) and 3 flame cannon height from soil (10, 15 and 20 cm) with 3 replicates. The obtained data in this study was analyzed with the statistical analysis software CoStat (version 6.4) in one way completely randomized design. Duncan's multiple range test was used to compare the means at probability level of 0.05. **Results:** The obtained results show that, the maximum burning efficiency and gas consumption were 95.86% and 4.15 (kg fed^{-1}), respectively at forward speed (3.19 km h^{-1}), flame height from soil 10 and 30 cm distance between flame cannon. Fungal population of all genera decreased in the 1st speed and 3rd h after treating compared with control. This study gave good results when use temperature to control soil-borne pathogens. **Conclusion:** It was concluded a simple flame unit fitted on a chisel plow was developed, tested and evaluated. Using the flame to control the pests can reduce the chemical applications that increase environmental pollution. This treatment could be applied to control soil pests once every year.

Key words: Mechanical burning, gas flame, wheat stalks residual, harvesting, soil pests, fungi, speed, sampling time

Received: February 24, 2017 Accepted: June 10, 2017 Published: July 15, 2017

Citation: Mahmoud Ali Awad and Mohamed Ahmed El-Metwally, 2017. Mechanical burning unit for wheat stalks residual after harvesting. J. Applied Sci., 17: 400-406.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The residual of wheat stalks is the important problem which faces both planting and germination of rice seeds. It is for two reasons firstly, wheat stalks not decompose easily and secondly, it is separate between both of soil and rice seeds, which leads to death of seeds.

For that's reasons and before soil tillage wheat stalks must be burn. The burn leads to many effects, (a) Quickly clears the field and is cheap, B) kills weeds, including those resistant to herbicide, (C) Kills slugs and other pests, (D) Can reduce nitrogen tie-up[1].

In many countries, burning agricultural waste continues to be the easiest and least expensive way to reduce or eliminate the volume of combustible materials produced by agricultural activities. Open-air burning is used to eliminate waste from the previous harvest in the quickest manner and to clear fields to prepare them for planting. It is also used to release nutrients for the following growing season and to eliminate mosquitoes and other pests in crop-growing fields. Sometimes-agricultural burning is considered necessary, in order to prevent the spreading of certain pests[1]. Other reasons are economic in nature since the straw left behind from harvesting is burned, costs can be reduced by not using machinery and diesel fuel, as it will not be necessary to incorporate the straw into the soil with a disc plough burning waste after harvest also saves time in preparing the soil for the next planting. However, over the long term, deterioration of plant cover and a diminishing of soil quality are inevitable[1].

Streets *et al.*[2] estimates that farmers burnt 16% of crop residue, at the rate of 116 million metric tons of crop residue. Venkataraman *et al.*[3] observed that in all open burning of crop residue accounted for about 25% of black carbon, organic matter and carbon monoxide emissions, 9-13% of fie particulate matter (P.M 2.5) and carbon dioxide emissions and about 1% of sulphur dioxide emissions.

Farooq *et al.*[4] reported that the open-field burning of crop residue generated from mechanized harvesting of cereal crops. Gupta[5] studied that farmers burnt about 82% of the wheat straw in the field during the period 2001-2005 they attribute the open-field burning of wheat residues to the practice of mechanized harvesting of cereal crops by a combine-harvester. Gupta *et al.*[6] attributes the open field burning of crop residues to using combine harvesters that leave a large amount of loose residue on the field.

Meanwhile, assert that a main constraint in wheat cropping system is the available short time between harvesting and sowing of rice given this short time, farmers find it difficult to utilize the residue and hence opt for burning. The two important organic sources of nutrients were farmyard manure and legumes. Both were almost completely replaced by chemical fertilizers. It is common knowledge that the majority of the rice-growing farmers burn rice-straw, a potential source of nutrients and organic carbon vital for soil health[7].

A combination of driving speed and length of equipment determines the treatment time. The driving speed is usually quite low to achieve sufficient thermal weed control and reduce weed re-growth and thereby the treatment time and costs are increased. Weeds are most susceptible to flame heat when they are 1-2 inches tall or in the 3-5 leaf stage[8]. This technique is effective on small, recently germinated broadleaf weeds. In parks, small 5-gallon propane tanks used to control weeds around tree wells or between cracks[9].

Yusuf *et al.*[10] developed and modified the performance of the air-blast sprayers to burn weeds in fields and around fruit trees. They observed that the modified flame device using to burn weeds in fields at the operating forward speed was 1.6 km h^{-1}, air-blast speed of 83 m sec^{-1} and nozzle diameter was 1.0 mm showed a long effective flame length was 92 cm, weeds burning rate directly after treatments was 95% and burning weeds rate after 8 h was 100%.

El-Danasory[11] tested a flame weeded at different forward speeds, angle and height of burner under various conditions of growing weeds. The highest efficiency of the flame weeded was obtain at a height of flame that ranged from 3-6 cm and an angle from 0-20 degrees. Smith[12] recommended that a suitable flame angle should be at 30-40° with horizontal. Ibrahim *et al.*[13] developed, tested and evaluated a simple flame unit fitted on the frame of a chisel plow for burning all pests in their different phases and preserve the environment. The effect of flame unit parameters (tractor speed, space between beams and flaming depth) were studied. They showed that the highest effect on weeds and all nematodes were died at 0.25 m space between beams, 0.05 m flaming depth and the forward speed of (1.54 km h^{-1}).

Matthews[14] showed that there are several ways to use temperature to control soil borne pathogens. The most common and effective way is raising the temperature to or above the thermal death point of the organisms. In a soil medium this is accomplished by steam heat (free-flowing or under pressure), by electrical heat by burning combustible material on the soil surface or by solar radiation. When the pathogen is present in or on a seed, tuber, bulb, or rhizome, it is sometimes possible to raise the temperature of the propagate organ sufficiently hot. Eradication of the pathogen is, thus, accomplished.

Therefore, the aim of this study was concerned with the development and evaluated a-unit for burning wheat stalks residual after harvesting wheat crop.

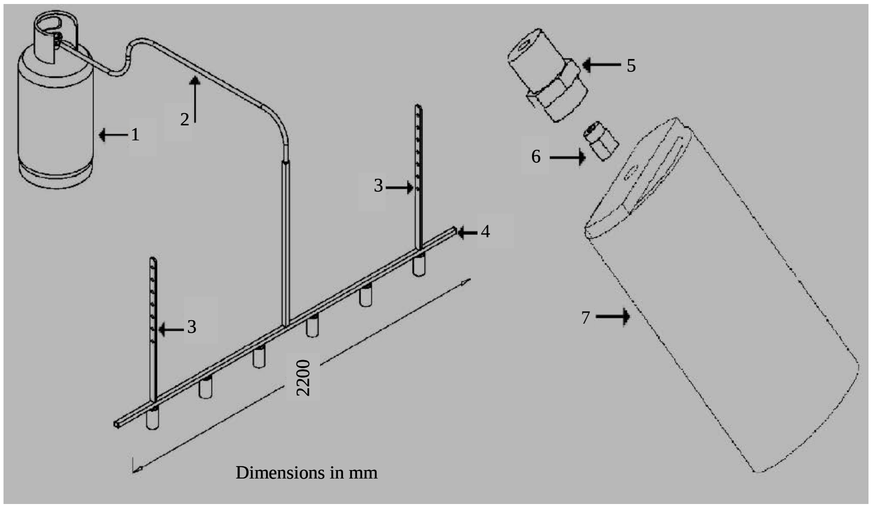

Fig. 1: Flame device, 1-Gas tank 2-Gas trunk 3-Fixing points 4-Square tube (2×2 cm), 5-Adjusting unit 6-Gas nozzle 7-Flame cannons

Fig. 2: Using the developed flame device in the field

MATERIALS AND METHODS

Cheap clear the field and increasing soil elements to improve germination of rice seeds were the main goals of the percent study. These goals could be illustrated through development, using and evaluate a flame device for burning wheat stalks residual after harvesting wheat crop. So this study carried out in local farm at El-Snbellaween district, Dakahlia Governorate after harvesting wheat crop.

Implements specifications: The developed flame device, tractor and chisel plow, were used in this study and its specifications as the following.

Developed flame device: The developed flame device Consists of square tube (2×2 cm) with length of 220 cm that tube closed ends and connected with gas tank from mid of above face by gas trunk but a flame cannon with nozzles of (1 mm) diameters according to Yusuf *et al.*[10] fixed on the bottom face of the square tube as shown in Fig. 1. that device fixed on the rear frame of the chisel plow with angle of 35° with horizontal according to Smith[12].

Source of power: The universal tractor model of 47.8 kW (65 hp.) was used in this study as shown in Fig. 2.

Chisel plow: Drawn chisel plow with 7 shares was used in this study to give safety limit between tractor rear tire and the flame cannons.

Digital scales: The gas tank was fixed on the digital scales during all treatments to determine the gas consumption for every treatment (g).

Soil properties: Soil samples were taken from soil layers (0-10 and 10-20 cm) to determine the soil texture. The results of mechanical analysis indicated that the average amounts of soil fractions (%) were 35 clay, 43 silt and 19.13, 2.87 fine and coarse sand, respectively. Thus, the soil texture was classified as a silty loam type.

Experimental design: To achieve the aim of this study, an experiment having an area about 2.5 feddan was established as a split-split plot in 3 replicates. This area was divided into 4 main plots involved 4 forward speeds of 3.19, 3.97, 4.5 and 5.4 km h^{-1}, 3 distance between flame cannon 30, 40 and 50 cm in sub plots and 3 flame cannon height from soil of 10, 15 and 20 cm in sub sub plots.

Measurements

Fuel consumption: The fuel consumption was determined by measuring the volume of consumed fuel during the operation time for each treatment and calculated in L h^{-1}. It was measured by completely filling the fuel tank then before each end treatment refilling the fuel tank using a scaled container.

Burning wheat stalks residual (%): By the end of burnt treatments a wooden frame (1×1 m) was used a number of non-burning wheat stalks residual counted from randomizing setting per each treatment. After collect the number of non-burning wheat stalks residual in the wooden frame, it can calculate the burning wheat stalks residual percentages from the Eq. 1[5]:

$$Ur = \frac{T_r\text{-}N_r}{T_r} \times 100 \qquad (1)$$

where,

U_r = Burning wheat stalks residual (%)
T_r = The total stalks number before burning per the unit area
N_r = Non- burning wheat stalks number per the unit area

Gas consumption: By the end of every treatment the reading (Kg) of the digital scales was used and by divided it on the treatment area (feddan) the gas consumption can determined (Kg/feddan).

Isolation from soil: Soil suspension of 1:10, 1:100 until 1:1000 dilutions with water are mixed in Petri dishes with a known quantity of PDA supplemented with 50 ppm of streptomycin sulphate and 33 ppm of Rose Bengal, held in liquid state at 45°C. Identification of pure culture of each fungal pathogen was carried out through Dep. of Plant Pathology, Faculty of Agriculture at Mansoura University according to El-Morsy[16]. Stock culture of each fungal pathogen was kept on PDA slant for further studies.

Statistical analysis: The obtained data in this study was analyzed with the statistical analysis software CoStat (version 6.4)[17]. For laboratory experiments, completely randomized design was used, while the randomized blocks design was applied in pots experiments. Duncan's multiple range test[18] was used to compare the means at probability level of 0.05.

RESULTS AND DISCUSSION

The obtained results of the present study could be divided into 3 subsequent divisions. The first division is to inspect and evaluate the function performances of the developed a flame device as affected by different operating parameters. The second is to determine the effect of different operating parameters on the soil pests.

Fuel consumption: The fuel which was consumed during the burning treatments was determined as shown in Fig. 3.

It can be seen that increasing operating travel speed gave a sensible increment rates in fuel consumption rates (L h^{-1}). For example, the fuel consumption increased from 4.29-5.27 (L h^{-1}) as the travel speed increased from 3.19-5.4 (km h^{-1}) by increment of 18.59%. Also from the Fig. 3 and from the analyzed data there is not a significant effect for both interface distance between flame cannon (cm) and flame height from soil (cm) on fuel consumption. For example, increasing the distance between flame cannons from 30, 40 and 50 cm th e fuel consumption was 4.6, 4.7 and

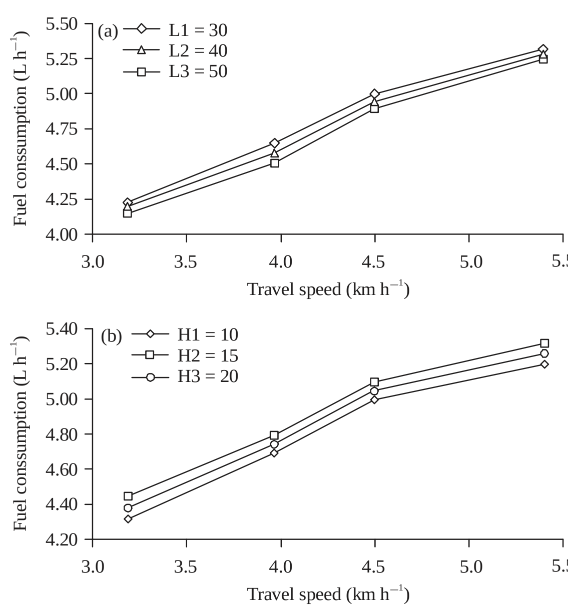

Fig. 3(a-b): Fuel consumption as affected by travel speed (km h^{-1}), flame height from soil (cm) and interfaces distance between flame cannon (cm)

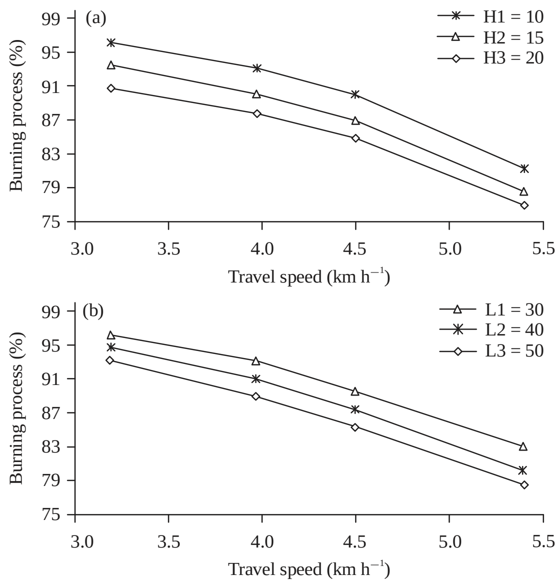

Fig. 4(a-b): Burning process as affected by travel speed (km h^{-1}), flame height from soil (cm) and distance between flame cannon (cm)

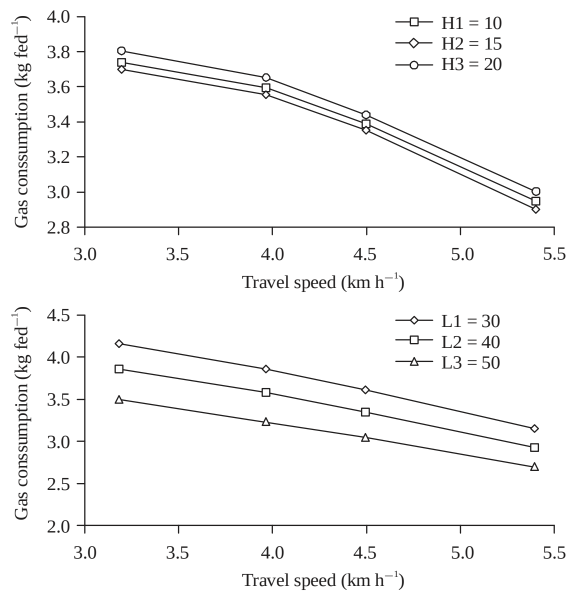

Fig. 5(a-b): Gas consumption (kg fed^{-1}) as affected by travel speed (km h^{-1}), flame height from soil (cm) and distance between flame cannon (cm)

4.76 (L h^{-1}) while increasing the flame height from 10, 15 and 20 cm the fuel consumption was 4.81, 4.86 and 4.92 (L h^{-1}) as shown in Fig. 1.

Burning wheat stalks residual (%): The effect of different traveling speed, flame height from soil and interfaces distance between flame cannon on burning wheat stalks are shown in Fig. 4.

The results are illustrated in Fig. 4 show that the burning process efficiency of the developed device decreased with a higher rate as the forward speed increased from 3.19-5.4 (km h^{-1}). For example, increasing forward speed by 1.7% the burning process efficiency decreased by 14.56% that by reason decreasing the time of residual to face flame. Also from the fig it easily noticed that increasing the flame height from 10, 15 and 20 cm the burning process efficiency decreased by 5% that maybe to decreasing the force of the flame to burn the residual. While increasing the distance between flame cannon from 30-50 cm the burning process efficiency decreased from 89.94-86.17% by decrement of 3.84% that by reason decreasing the number flame cannon by 33%.

Data also denoted that the maximum obtained burning efficiency value was 95.86% at forward speed (3.19 km h^{-1}), flame height from soil (10 cm) and (30 cm) distance between flame cannon.

Gas consumption (kg fed^{-1}): The effect of different traveling speed, flame height from soil and interfaces distance between flame cannon on gas consumption (kg fed^{-1}) are shown in Fig. 5.

The gas consumption decreased with a higher rate as the forward speed increased from 3.19-5.4 (km h^{-1}). For example, increasing forward speed by 1.7% the gas consumption decreased by 22.37% that by reason decreasing the consumption time. But increasing the flame height from 10, 15 and 20 cm was not significant effect on the gas consumption. While increasing the distance between flame cannon from 30-50 cm the gas consumption decreased from 3.7-3.1 (kg fed^{-1}) by decrement of 16.2% that by reason decreasing the number flame cannon by 33% Fig. 5.

Also, the maximum obtained gas consumption value was 4.15 (kg fed^{-1}) at forward speed (3.19 km h^{-1}) and (30 cm) distance between flame cannon while the lowest value was 2.7 (kg fed^{-1}) at forward speed (5.4 km h^{-1}) and (50 cm) distance between flame cannon[5,6,10,13].

Isolation from soil: Mycological survey of soil samples showed that 11 species of 9 principal genera of filamentous fungi as shown in Table 1. These genera were *Alternaria, Aspergillus*, *Cephalosporium*, *Fusarium*, *Penicillium*, *Rhizoctonia*, *Rhizopus*, *Verticillium* and *Trichoderma*. Fungal population of all genera decreased in the 1st speed and

Table 1: Frequency (%) of soil-borne fungal population after using burning unit for wheat stalks residual after harvesting

Treatments			*Alternaria* spp.	*A. niger*	*A. flavus*	*Cephalosporium* spp.	*Penicillium* spp.	*Fusarium solani*	*F. oxysporum*	*F. monliforme*	*Rhizoctonia solani*	*Rhizopuss* spp.	*Trichoderma* spp.	Verticillium spp.
Before	Control		40.08^{a}*	32.23^{a}	41.51^{a}	3.96^{a}	26.37^{a}	8.19^{a}	11.94^{a}	2.96^{a}	6.12^{a}	30.98^{a}	8.91^{a}	4.79^{a}
	Speed	1	7.16^{d}	5.76^{e}	7.42^{e}	0.71^{e}	4.71^{e}	1.47^{e}	2.13^{e}	0.53^{e}	1.09	5.54^{d}	1.60^{e}	0.85^{e}
		2	7.72^{d}	6.21^{d}	8.00^{d}	0.76^{d}	5.08^{d}	1.58^{d}	2.30^{d}	0.57^{d}	1.18	5.97^{d}	1.72^{d}	0.92^{d}
		3	16.70^{c}	13.43^{c}	17.30^{c}	1.65^{c}	10.99^{c}	3.41^{c}	4.97^{c}	1.23^{c}	2.55	12.91^{c}	3.71^{c}	2.00^{c}
		4	26.41^{b}	21.24^{b}	27.35^{b}	2.61^{b}	17.38^{b}	5.40^{b}	7.87^{b}	1.95^{b}	4.03	20.42^{b}	5.87^{b}	3.16^{b}
After	Sampling	0	27.35^{b}	21.99^{b}	28.32^{b}	2.70^{b}	17.99^{b}	5.59^{b}	8.14^{b}	2.02^{b}	4.17^{b}	21.14^{b}	6.08^{b}	3.27^{b}
	Time	1	18.02^{c}	14.49^{c}	18.66^{c}	1.78^{c}	11.86^{c}	3.68^{c}	5.37^{c}	1.33^{c}	2.75^{c}	13.93^{c}	4.01^{c}	2.15^{c}
		2	11.39^{d}	9.16^{d}	11.80^{d}	0.00^{d}	7.50^{d}	2.33^{d}	3.39^{d}	0.84^{d}	1.74^{d}	8.81^{d}	2.53^{d}	1.36^{d}
		3	5.27^{e}	4.24^{e}	5.46^{e}	0.00^{d}	3.47^{e}	1.08^{e}	1.57^{e}	0.39^{e}	0.80^{e}	4.07^{e}	1.17^{e}	0.63^{e}

*Means within a column followed by the same letter(s) is not significantly different according to Duncan's multiple range test ($p = 0.05$)

3rd h after treating compared with control. This study gave a good results when use temperature to control soil-borne pathogens. The most common and effective way is raising the temperature to or above the thermal death point of the organisms. In a soil medium this is accomplished by steam heat (free-flowing or under pressure), by electrical heat by burning combustible material on the soil surface or by solar radiation. When the pathogen is present in or on a seed, tuber, bulb, or rhizome, it is sometimes possible to raise the temperature of the propagate organ sufficiently hot. Eradication of the pathogen is, thus, accomplished[14].

CONCLUSION

This study concluded that the maximum burning efficiency and gas consumption were 95.86% and 4.15 (kg fed^{-1}), respectively at forward speed (3.19 km h^{-1}), flame height from soil 10 and 30 cm distance between flame cannon. A simple flame unit fitted on a chisel plow was developed, tested and evaluated. Using the ame to control of pests can reduce the chemical applications that increase environmental pollution. This treatment could be applied to control soil pests once every year.

SIGNIFICANCE STATEMENTS

This study explains the utilizing of gas ame for disposing the plant residues and controlling of pests. This study will help the researcher to uncover the critical area of disposal of plant residues which caused environmental pollution that many researchers were not able to explore. Thus, this study represents a new theory for the reduction of the pesticide applications that increase environmental pollution.

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