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Development and Performance Evaluation of a Tractor Operated Cotton Stalk Shredder Cum Insitu Applicator

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Abstract

Incorporation of cotton stalks into the soil ensures rapid decomposition. The most rapid decomposition occurs when residue is placed 10 cm deep and when stalks are shredded as finely as possible also. The present migration of labour from rural sector to scholastic jobs in urban areas necessitates the need for mechanizing the farming operation of cotton stalk shredding and incorporation in the field. A tractor operated cotton stalk shredder consisting of a shredder assembly, power transmission system with hydraulic motor, hitch frame and hydraulic lift was developed. The shredding unit consisted of main shaft and two swing back type rotary blades. Lifting and lowering of the shredding unit was carried out by the hydraulic lift mounted in the front of the tractor. The power for the shredder was transmitted form the hydraulic motor and reduction gear box. The commercially available rotavator was used as *insitu* applicator for incorporation of shredded cotton stalks Shredding cotton stalks was accomplished by the shredder in front portion of the tractor and incorporation of the shredded cotton stalks into the soil was done by rotary tiller in the rear portion of the tractor. The unit was evaluated for performance. Experiments were conducted with 4 treatments; viz. disc ploughing with the standing cotton stalks, operation of the cotton stalk shredder cum *insitu* applicator at 2.0, 2.5 and 3.0 km h^{-1} to find out the efficient method of cotton stalk shredding and *insitu* application.

Introduction

Cotton has been one of the main sources of India's economic growth and a foreign exchange earner. Cotton is grown commercially over 111 countries through out the world. In India, the major area of cotton is cultivated under rainfed conditions. The area under cotton cultivation in India is about 7.8 million ha with a production potential of 17.0 million bales. Cotton stalk is used as an agricultural waste in large quantities in the cotton growing areas. In India nearly 15 million tonnes of cotton stalks are produced every year (Anonymous, 1999).

There are a lot of stalks left on the field after cotton harvesting. Normally, the plants are removed by either manual pulling or cutting with a sickle up to a height of 50 to 75 mm above the ground surface and burnt later. The above facts necessitate the urgent need for a stalk shredder cum *insitu* applicator.

Review of literature

Sumner et al. (1984) developed a test unit with a pair of counter rotating wheels and pneumatic tires and to determine the effect of operating variables and design elements on the efficiency of cotton plant removal from the soil.

Bansal et al. (1987) designed a stubble collector cum planker. It consisted of a wooden plank fitted with mild steel spikes to an angle iron frame and has a fitting mechanism. Yumak et al. (1990) developed a two-row machine to pull cotton stalks after harvesting cotton. The machine covered an area of 9.2 ha h^{-1} and was 95 % efficient. The broken stalks and plants not pulled were 2 % and 6 %, respectively.

Gangade et al. (2000) conducted a comparative study on different methods of cotton stalk removing and they concluded that the plant removing/uprooting efficiency for the tractor operated uprooter, tractor operated slasher and tractor drawn V blade were 80 %, 100 % and 99 %, respectively. Sheikh El Din Abdel Gadir El Awad (2000) developed a two unit digger for cotton stalk uprooting. The unit of digger consisted of a horizontal cutting edge of 0.4 m length.

Materials and Methods

Development of a Tractor Operated Cotton Stalk Shredder

The shredding of cotton stalks by shredder and incorporation of the shredded cotton stalks into the soil has to be accomplished in a single pass of the tractor. For simultaneous shredding and incorporation of the cotton stalks, it was proposed to mount the shredder in the front portion of the tractor.

A prototype tractor operated cotton stalk shredder with optimized levels of variables of (2 blades, 0 deg rake angle and 12 mm blade thickness) was developed (**Fig. 1**). The functional components of the unit were:

1. Shredder assembly
2. Power transmission system with hydraulic motor
3. Hitch frame
4. Hydraulic lift

Shredder Assembly

The main frame or casing of the cotton stalk shredding unit (110 x 110 mm) was made of 6 mm mild steel plate. The shredding unit consisted of main shaft and the shredding blades. Two number of swing back type rotary blades were hinged to the main drive shaft which were connected with the transmission gear box. The side plates of the main frame or casing attached with the float, 1440 x 220 mm, was made of 3 mm mild steel sheet and 62.5 x 10 mm mild steel flat. Provisions were made to adjust the height of the float according the height of shredding required.

Transmission System

There are three basic methods of transmitting power; electrical, mechanical and fluid power. Most applications actually use a combination of the three methods to obtain the most efficient overall system. Fluid systems can transmit power more economically over greater distances than can mechanical types. Hence, the hydraulic drive was selected as the driving source for shredder. A 1:1.75 speed ratio bevel gear box is mounted On the top of the shredder assembly. A hydraulic motor is fixed for providing drive to the shredder assembly. The drive was obtained from the main output shaft of the hydrometer to the gearbox to get the required rpm of 1200. The drive was transmitted from the gearbox to the main vertical shaft of the shredding unit.

Hitching Frame

Both the sides of the shredding unit was hinged with box like arms made of two 75 × 37.5 × 6.25 mm mild steel channel. The other end of the arms was connected with the chassis of the tractor frame.

Hydraulic Lift

Lifting and lowering of the shredding unit was carried out by the hydraulic cylinder mounted in the front of the tractor.

Incorporation of Shredded Stalks Into the Soil

The organic matter is transformed through the process of decomposition and humification into humus which helps improve the physical, chemical and biological properties of soil. The incorporation of crop residues in soil plays an important role in maintaining soil productivity.

Fig. 1 Tractor operated cotton stalk shredder cum *insitu* applicator

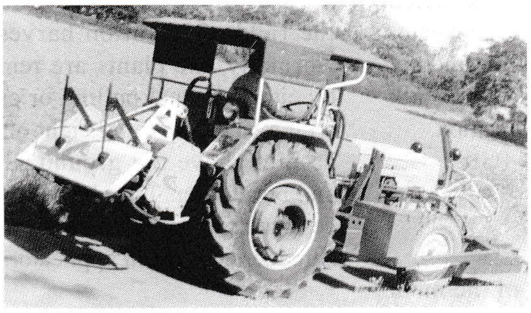

Fig. 2 Operational view of tractor operated cotton stalk shredder cum *insitu* applicator

Insitu Applicator

The rotary cultivator or rotavator is widely considered to be the most important tool as it provides fine degree of pulverization enabling the necessary rapid and intimate mixing of soil. The benefits of the rotavator are (1) effective pulverization of soil for good plant growth; (2) stubble and roots are completely cut and mixed with the soil; and (3) proper ground leveling after the operation. Hence, the tractor operated commercially available rotavator is selected as *insitu* applicator for incorporation of shredded cotton stalks.

Field Performance Evaluation of the Prototype Unit

The developed prototype cotton stalk shredder was mounted on a 59 hp tractor (**Fig. 2**) and evaluated for performance in shredding cotton stalks in the field. The prototype equipment was evaluated at an optimized blade speed with three forward speeds of 2.0, 2.5 and 3.0 km h^{-1}. The prototype was evaluated for performance in terms of shredding efficiency.

Results and Discussion

Field Performance Evaluation of the Prototype Unit

The proto type cotton stalk shredder cum *insitu* applicator was evaluated with optimized parameters in the field at three levels of forward speed; viz. 2.0, 2.5 and 3.0 km h^{-1}.

The shredding efficiency and mean value of cotton stalk length are shown in **Table 1**. Increase in speed from 2.0 to 3.0 km h^{-1} resulted in decreased shredding efficiency from 91.63 to 82.18 % and increased the mean length of shredded cotton stalk by 89.8 %. The operating speed of 2.0 km h^{-1} yielded lowest mean length of cut of shredded cotton stalk of 108 mm and highest shredding efficiency of 91.63 %. Hence forward speed of 2.0 km h^{-1} may be selected as the optimized speed for the cotton stalk shredder cum *insitu* applicator.

The operational view of cotton stalk shredder cum *insitu* applicator is shown in **Fig. 2**.

Conclusions

A front mounted tractor operated prototype cotton stalk shredder (2 blades, 0 deg rake angle and 12 mm blade thickness) has been developed and evaluated for its performance with three forward speeds of 2.0, 2.5 and 3.0 km h^{-1} and optimized for maximum shredding efficiency. A tractor operated (rear mounted) commercially available rotavator was selected as *insitu* applicator for incorporation of shredded cotton stalks. Increase in operating speed from 2.0 to 3.0 km h^{-1} resulted in decreased shredding efficiency from 91.63 to 82.18 %. Increase in operating speed from 2.0 to 3.0 km h^{-1} resulted in increased mean length of shredded cotton stalk from 108 to 205 mm. The actual field capacity of the prototype tractor operated cotton stalk shredder cum *insitu* applicator was 0.24 ha h^{-1}.

Experiments were conducted with 4 treatments viz. disc ploughing with the standing cotton stalks and operation with prototype cotton stalk shredder cum *insitu* applicator with 2.0, 2.5 and 3.0 km h^{-1} forward speed to find the efficient method of cotton stalk shredding and *insitu* application.

Table 1 Shredding efficiency and mean value of shredded cotton stalk length at 3 levels of forward speed

Speed km h^{-1}	Shredding efficiency, %	Mean length of shredded cotton stalk, mm
2	91.63	108
2.5	85.29	188
3	82.18	205

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