PERFORMANCE EVALUATION OF PEARL MILLET THRESHER IN GHANA

S. Atsu¹, G.Y. Obeng² and E. Mensah³

¹,³Department of Agricultural Engineering
²Technology Consultancy Centre
Kwame Nkrumah University of Science and Technology
Kumasi, Ghana.

ABSTRACT

The threshing of millet to obtain clean grain is one of the most tedious operations in small-scale millet processing, particularly in Africa. A prototype millet thresher was developed during the International Development Design Summit (IDDS) 2008 and adapted for the threshing of millet grains in Ghana. Studies were conducted on the effect of millet moisture content on the machine performance and grain quality. Grain quality was evaluated for normal and abnormal germination. The performance of the millet thresher was evaluated for its threshing efficiency and seed loss during threshing. From the study results, threshing efficiency ranged from 87.25% to 89.18% at millet moisture content of 11.84% to 13.48%. The value of seed loss of 1.47% to 3.3% was low due to the relatively high threshing efficiency of the millet thresher. Higher grain germination after threshing was obtained with the millet thresher, and it ranged from 72% to 92%. The threshed millet grains were free from stones and sand.

Keywords: Millet, threshing, clean grain, Ghana.
CHAPTER ONE

INTRODUCTION

1.1 Background

Millet is a staple grain for millions of Ghanaians and their families especially those living in the northern parts of the country. 75% of the pearl millet grown in the northern parts of Ghana is threshed manually, at about 4kg/hour by mortar and pestle or beating (Boateng, 2008). Threshing is the removal of grains from the stalk or panicle. This is usually done either manually or mechanically. Threshing of millet in Ghana and other African countries is done manually by mostly women. It entails beating the millet heads with sticks or clubs repeatedly until almost all the grains are detached from the heads. The beating action may be done either on a mat, canvas or bare ground. In order to ease grain collection after beating, sometimes the heads of millets may be stuffed into bags, prior to beating (Silas, 2001). A faster, affordable threshing device could improve the health and economics of millions of poor families relying on millet for food or sale.

Inefficient processing and traditional primitive techniques of hand threshing are the cause of excessive postharvest grain losses. Much of the pearl millet threshing in rural Africa in countries like Namibia is still done by slow manual pounding that consumes up to 4 hours/day of women’s time, and results in blisters and repetitive stress injuries. For most of the time, the pearl millet is stored threshed, but not winnowed. A family might rent a car to drive over their year’s harvest of millet to thresh it. This cost around US$15 (FAO, 1994). Alternatively, they might pound it by hand in a specially prepared hole. In both cases, the grain gets mixed with grit and dirt. Women separate the grains from the ears with a mortar and pestle, as it is needed for consumption or for marketing purpose. These traditional methods are arduous and slow (10kg per woman-day) (FAO,
Consequently, research has been conducted for some years on how to efficiently mechanize small-scale threshing of millet in rural and peri-urban areas.

Millet grows on a panicle consisting of a stalk, florets, and grain as indicated in figure 1.1. The panicle has complex physical properties. The panicles vary in size over a factor of 2 hence grinding damages the grain, twisting breaks the stalk and rubbing removes florets from stalk. The mechanical threshing of other grains does not raise any special problems - conventional grainthreshers can be used with some modification such as adjustment of cylinder speed, size of the slots in the cleaning screens etc. On the other hand, the dense arrangements of spikelets on the rachis and the shape of the millet ears (especially pearl millet) make mechanical threshing excessively difficult (IDDS, 2008).

![Figure 1.1: A millet panicle consisting of a stalk (B), florets (1&2) and grain.](image)

After being harvested millets may be stacked on the plot. This in-field storage method results in a pre-drying of the millet panicles before threshing, the purpose of which is to separate seeds from panicles. The traditional threshing of millet is generally made by hand: bunches of panicles are beaten against a hard element (e.g. a wooden bar, bamboo table or stone) or with a flail. The outputs ranges between 10g and 30kg of
 grain per man-hour according to the variety of millet and the method applied (CGIAR, 2008). Grain losses amount to 1-2%, or up to 4% when threshing is performed excessively late; some unthreshed grains can also be lost around the threshing area. In many places in the northern parts of Ghana, the grain is pounded in a mortar with pestle (Figure 1.2) or threshed by being trodden underfoot by humans or animals; the output is 30kg to 50kg of grain per man-hour (Eliasu, 2008).

Figure 1.2: Manual pounding of millet in the northern region of Ghana

Figure 1.3: Millet farming community in the Northern regions.
1.2 Problem Statement
The project will evaluate the performance of a manually operated low-cost millet thresher costing US$20 and suitable for local manufacture and sale in Ghana.

1.3 Justification
The performance evaluation of the MIT thresher will produce data that can be used to redesign and adapt the thresher for millet varieties in Ghana. It will also provide data that can potentially be used for producing cost effective and affordable threshers for resource poor farmers in Ghana. The project will help draw the attention of policymakers to the mechanisation of millet threshing in Ghana. It will also provide data that can potentially be used for producing cost-effective and affordable threshers for poor farmers in Ghana.

1.4 Objectives
The objectives of this project were, in summary, to:

1. Determine the threshing efficiency of the millet thresher
2. Determine the millet moisture content suitable for threshing.
3. Determine the percentage seed loss from the millet thresher.
4. Access the percentage germination of threshed millet seeds from the millet thresher.
5. Make recommendations to enhance the development and performance of the millet thresher.
CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Millet is a common name applied to at least five related members of the grass family grown for their edible seeds. Some of the varieties are foxtail millet (*Setaria italica*), pearl or cat-tail millet (*Pennisetum typhoideum*), Japanese barnyard millet (*Echinochloa frumentacea*), ragge or finger millet (*Eleusine coracana*), and koda millet (*Paspalum scrobiculatum*). Proso millet also known as common millet, broom corn millet, hog millet or white millet (*Panicum miliaceum*). Minor millets include: Barnyard millet (*Echinochloa spp.*) Kodo millet (*Paspalum scrobiculatum*) Little millet (*Panicum sumatrense*) Guinea millet (*Brachiaria deflexa* = *Urochloa deflexa*) Browntop millet (*Urochloa ramosa* = *Brachiaria ramosa* = *Panicum ramosum*) (Crawford and Lee, 2003).

Pearl millet is a variety of millet which is a crop for human food. Pearl millet (*Pennisetum glaucum*, or *P. americanum*) is grown widely in the tropics and subtropics in regions of limited rainfall where there is a growing season of 90 to 120 days (BBC News, 2005). In Ghana early-maturing pearl millet is traditionally intercropped with groundnut (*Arachis hypogaea*), sorghum (*Sorghum bicolor*) or late-maturing pearl millet. Pearl millet grain is used in several traditional food preparations: thick porridge called tô, a thin, fermented porridge called koko, and a deep-fried pancake called marsa. The naked seeds are yellowish to whitish in colour and about the size of wheat grain (Appa, et al, 1984).

The thrashing machine, or, in modern spelling, threshing machine (or simply thresher), was a machine first invented by Scottish mechanical engineer Andrew Meikle for use in agriculture. It was invented (c.1784) for the separation of grain from stalks and husks.
For thousands of years, grain was separated by hand with flails, and was very laborious and time consuming. Mechanization of this process took much of the drudgery out of farm labour. (Wikipedia, 2006).

The first millet and sorghum threshers were developed in Africa in the 1960-70s: the Siscoma BS 1000 and the Marot DAK II. Giving relatively high outputs (about 1000kg per hour) they have been intended for village farmers’ groups, cooperatives or private contractors going from village to village to work on big threshing layouts (FAO, 1994). The multipurpose "Bamba" thresher, better suited to rural communities, has a capacity of about 300kg per hour (FAO, 1994). As regards mechanized harvesting at family level, some hand-operated threshers (Champenois) were developed and tested experimentally but they did not prove very successful. From a historical viewpoint, threshing operations were mechanized earlier than harvesting methods, and were studied throughout the 18th century. Two main types of stationary threshing machines have been developed. The machines of Western design are known as 'through-flow' threshers because stalks and ears pass through the machine (FAO, 1994). They consist of a threshing device with pegs, teeth or loops, and (in more complex models) a cleaning-winnowing mechanism based upon shakers, sieves and centrifugal fan (Through-flow Thresher). The capacities of the models from European manufacturers (e.g., Alvan Blanch, Vicon, Borga) or tropical countries (Brazil, India, etc.) range from 500 to 2000kg per hour (Assennato et al., 1994).

In the 1970s, IRRI (International Rice Research Institute) developed an axial flow thresher which has been widely manufactured at local level. Such is the case in Thailand where several thousands of these units have been put into use. They are generally mounted on lorries and belong to contractors working about 500 hours per year. In practice, the costs of machines and services vary from one country to another.
Compared with animal-drawn implements, powered harvesting and threshing machines are difficult to manufacture. Research has been conducted into the design of simplified equipment which can be manufactured locally, e.g. the IRRI and Votex thresher (FAO, 1994).

Theoretically, local manufacturing offers various advantages such as reduced profit margins to retailers and transport costs (100 kits in one container instead of 22 Votex thresher, etc.), but also some drawbacks (quality of construction and employed materials, adverse taxation and customs regulations, etc.). Supplied services are generally paid for about a percentage of the harvested crop: 5 to 10% for threshing and 15 to 20% for combine harvesting (Baker, R. D., 2003).

In Mali, the cost of using the Votex thresher is estimated to be between 3 and 5% of the grain produced. Harvesting is a labour-intensive operation but is less arduous than threshing. Because most of the rural population consider threshing as a particularly tedious operation (especially in the case of millet), grain producers accept the relatively high cost of mechanical threshing (IDRC, 2001).
The 'hold-on' thresher of Japanese design ("Hold on' thresher - Japanese design"), is so-called because the bundles are held by a chain conveyor which carries them and...
presents only the panicles to the threshing cylinder, keeping the straw out. According to the condition of the crop, work rates can range between 300kg and 700kg per hour (Iseki model). The main disadvantage of these machines is their fragility (FAO, 1994).

The pearl millet thresher developed during IDDS 2008 at MIT is an innovative, inexpensive, portable threshing machine developed for small pearl millet farmers and consumers (see Figure 2.3 below). It produces cleaner and healthier grain, faster, safer and cheaper.

Figure 2.3: A prototype of pearl millet thresher developed during IDDS 2008

In developing countries like Ghana, harvesting and threshing operations are traditionally carried out by women. However, in most situations, as these operations become mechanized, they are taken over by men and the role of women is reduced to winnowing and the gleaning of grain scattered during harvesting and threshing. The mechanization of post-harvest operations frequently means the transfer of activities from women to men (Korletey and Eliasu, 2008).
2.2 Threshing methods

The same method, but using a vehicle (tractor or lorry) is also commonly applied. The vehicle is driven in circles over the paddy bunches as these are thrown on to the threshing area (15m to 20m in diameter around the stack). The output is a few hundred kg per hour. This method results in some losses due to the grain being broken or buried in the earth. In Ghana, total losses induced by traditional harvesting and threshing methods are estimated between 5 and 15 % (Silas, 1996). Also other methods include the use of the mortar and pestle.

2.3 Mechanised threshing

More recently, a Dutch company (Votex) has developed a small mobile thresher provided with either one or two threshers (Figure 2.1). The machine has been widely adopted in many rice growing areas. The simple design and work rates of these machines (about 500kg per hour) seem to meet the requirements of rural communities. (FAO, 1994)

2.4 Millet growth in Ghana

Pearl millet varieties namely, PARC MS-1, PARC MS-2, PARC MS-5 PARC MS-6, Ghana White and ICMP 96491 have been proved high yielding dual purpose (grain-cum-fodder) varieties. These varieties are drought resistant. These varieties have been grown in Ghana over the years (Boateng, 2008). Figure 2.4 shows the trend in millet production from 1990 to the year 2007 in Ghana. The data reveal an estimated current production level of about 150, 000 metric tons.
Figure 2.4: Trend in Millet Production from 1990 to 2007 in Ghana.
CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at the Department of Agricultural Engineering at Kwame Nkrumah University of Science and Technology, Kumasi.

3.2 Source and Variety of millet Obtained

Millet grain samples were obtained from farms in the Upper East region of Ghana. Test samples were from the 2008 growing season.

Fig 3.1: Varieties of Millet Identified
3.3 Materials and Method

The millet thresher was developed at the Agricultural Engineering Workshop. A recycled bicycle was use in the development of the thresher. To thresh the millet, a stalk is placed on the rim of the thresher and the pedal rotated anticlockwise due to the fact that, the bicycle which is being used for the threshing has been turned upside down. During the rotation of the rim the millet stalk which is being threshed is also rotated gently in order for the spokes to thresh all the grains on the stalk. The moisture content of the millet before threshing, the spokes clearance and the speed of the rotating rim played important roles in the determination of the efficiency of the thresher. Before threshing the mass of millet stalks to be threshed were weighed using an electronic balance. After threshing, the threshed millet, the chaff and the stalk was weighed.

3.4 Determination of Total Losses

The following relationships were used to calculate the total losses of the thresher.

(a) Percentage of unthreshed seeds =

\[
\frac{100 \times (\text{quantity of unthreshed seeds obtained from all outlet in kg})}{\text{Total grain input in kg}}
\]  

(b) Percentage of cracked and broken seeds =

\[
\frac{100 \times (\text{cracked and broken seeds from specified seed outlet(s) in kg})}{\text{Total seeds received at seed outlet in kg}}
\]  

(c) Percentage of blown seeds =

\[
\frac{100 \times (\text{quantity of clean seed obtained at chaff outlet in kg})}{\text{Total grain input in kg}}
\]  

Total Loss (%) = sum of losses obtained at (a), (b) and (c)
3.5 Determination of efficiencies

(i). Threshing efficiency = 100 - Percentage of unthreshed seeds

3.6 Germination Test

Two pearl millet varieties were used in the determination of the percentage seed germination of the threshed millet from the thresher which will aid in determining the seed quality produced by the millet thresher. 100 seeds were counted from the threshed millet and 10 rows of 10 seeds were planted because the rows make it easier to count seedlings. Seeds were sown at normal seeding depth of 2-3 cm. The seeds were placed on top of the sand or soil and pushed in with a piece of dowel or a pencil and then covered with a little more sand, it was then gently watered or kept moist (not wet) because over-watering will result in fungal growth on the seeds, causing possible seed rot and hence affecting normal germination. Keep moist. Seedlings were counted after 7 to 10 days when the majority of seedlings are up. Late seedlings that germinated were not counted because they were the weak and damaged seeds. Only normal seedlings were counted. Badly diseased, discoloured or distorted seedlings were not counted.

Percentage germination was calculated as;

\[
\text{Percentage germination} = \frac{\text{number of germinated seeds} \times 100}{\text{Total number of seeds planted}}
\]

3.6.1 Paper substrate germination test

In the determination of the viability of the threshed grain, 10 seeds were counted from each variety and the planted in a paper substrate under laboratory conditions at 20°C. The paper substrate was placed in a Petri dish and a water bottle was used to keep the
substrate moist. The seeds were then planted in the paper substrate. It was then covered with another Petri dish. The set up was monitored for 7 days. The germinated seeds were then counted. The number of germinated seeds counted was used to determine the percentage germination. Due to over watering the grey variety was affected by fungal infection hence the inability of the seeds to germinate.

3.7 Determination of moisture content

Seed moisture content is one of the most important factors influencing seed quality and storability, therefore, its estimation during seed quality determination is important. Seed moisture content can be expressed either on wet weight basis or on dry weight basis. In seed testing, it is always expressed on a wet weight basis; the method for its calculation is given later. For the purpose of this experiment, seed moisture content was determined by air oven method or gravimetric method.

In this method, the seed moisture was removed by drying at a specified temperature (103°C) for a specified duration (17h). The moisture content was then expressed as a percentage of the original weight (wet weight basis). The percentage moisture content was then calculated as follows:

Percentage moisture content = \( \frac{\text{Loss in weight}}{\text{Initial weight of seed}} \times 100 \)
CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Results

4.1.1 Moisture Content Determination

Table 4.1: Moisture content determination table

<table>
<thead>
<tr>
<th>Container Identification</th>
<th>Weight of empty container (g)</th>
<th>Weight of sample and container before drying (g)</th>
<th>Weight of sample before drying (g)</th>
<th>Weight of sample and container after drying (g)</th>
<th>Weight loss (g)</th>
<th>% Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>REPLICATE 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YELLOW</td>
<td>32.87</td>
<td>96.69</td>
<td>63.82</td>
<td>88.31</td>
<td>8.38</td>
<td>13.13</td>
</tr>
<tr>
<td>GREY</td>
<td>77.17</td>
<td>148.50</td>
<td>71.3</td>
<td>139.71</td>
<td>8.79</td>
<td>12.33</td>
</tr>
<tr>
<td>STALK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YELLOW</td>
<td>402.38</td>
<td>507.90</td>
<td>105.52</td>
<td>494.53</td>
<td>13.37</td>
<td>12.6</td>
</tr>
<tr>
<td>GREY</td>
<td>57.36</td>
<td>136.04</td>
<td>78.68</td>
<td>126.70</td>
<td>9.34</td>
<td>11.87</td>
</tr>
<tr>
<td>WHITE</td>
<td>26.74</td>
<td>160.03</td>
<td>133.29</td>
<td>144.10</td>
<td>15.93</td>
<td>11.95</td>
</tr>
<tr>
<td>BLK&amp;WHT</td>
<td>25.65</td>
<td>107.13</td>
<td>81.48</td>
<td>97.48</td>
<td>9.65</td>
<td>11.84</td>
</tr>
<tr>
<td>RED</td>
<td>32.39</td>
<td>95.22</td>
<td>62.83</td>
<td>86.75</td>
<td>8.47</td>
<td>13.48</td>
</tr>
<tr>
<td>Container Identification</td>
<td>Weight of empty container (g)</td>
<td>Weight of sample and container (before drying) (g)</td>
<td>Weight of sample before drying (g)</td>
<td>Weight of sample and container after drying (g)</td>
<td>Weight loss (g)</td>
<td>% Moisture</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------------------</td>
<td>-----------------------------------------------------</td>
<td>-----------------------------------</td>
<td>-----------------------------------------------</td>
<td>----------------</td>
<td>-----------</td>
</tr>
<tr>
<td>REPLICATE 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YELLOW</td>
<td>32.87</td>
<td>115.83</td>
<td>82.96</td>
<td>106.57</td>
<td>10.86</td>
<td>13.09</td>
</tr>
<tr>
<td>GREY</td>
<td>26.74</td>
<td>98.32</td>
<td>71.58</td>
<td>88.93</td>
<td>9.39</td>
<td>13.12</td>
</tr>
<tr>
<td>REPLICATE 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YELLOW</td>
<td>89.10</td>
<td>154.15</td>
<td>65.05</td>
<td>145.47</td>
<td>8.68</td>
<td>13.34</td>
</tr>
<tr>
<td>GREY</td>
<td>89.10</td>
<td>149.02</td>
<td>59.92</td>
<td>141.11</td>
<td>7.91</td>
<td>13.20</td>
</tr>
<tr>
<td>REPLICATE 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YELLOW</td>
<td>454.73</td>
<td>482.82</td>
<td>28.09</td>
<td>479.13</td>
<td>3.69</td>
<td>13.14</td>
</tr>
<tr>
<td>GREY</td>
<td>454.73</td>
<td>510.70</td>
<td>55.97</td>
<td>503.27</td>
<td>7.43</td>
<td>13.27</td>
</tr>
</tbody>
</table>

Average moisture content of samples

Yellow variety: \[
\frac{13.13\% + 13.09\% + 13.34\% + 13.14\%}{4} = 13.18\%\]

Grey variety: \[
\frac{12.33\% + 13.12\% + 13.20\% + 13.27\%}{4} = 12.98\%\]
Table 4.2: Weight of Parameters Obtained after Threshing for the Various Varieties

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Yellow Variety</th>
<th>Grey Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of Stalks before threshing (A)</td>
<td>302.86g</td>
<td>492.25g</td>
</tr>
<tr>
<td>Weight of Stalks after threshing (B)</td>
<td>98.20g</td>
<td>103.01g</td>
</tr>
<tr>
<td>Weight of Grain (C = A - B)</td>
<td>204.66g</td>
<td>389.24g</td>
</tr>
<tr>
<td>Weight of empty container (D)</td>
<td>77.18g</td>
<td>77.14g</td>
</tr>
<tr>
<td>Weight of empty container + threshed grains (E)</td>
<td>254.77g</td>
<td>418.74g</td>
</tr>
<tr>
<td>Weight of threshed grain (F = E - D)</td>
<td>177.59g</td>
<td>341.60g</td>
</tr>
<tr>
<td>Weight of unthreshed grain</td>
<td>22.15g</td>
<td>39.56g</td>
</tr>
</tbody>
</table>

Table 4.3: Weight of Parameters Obtained after Winnowing for the Various Varieties

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Yellow Variety</th>
<th>Grey Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of empty container (A)</td>
<td>32.38g</td>
<td>77.14g</td>
</tr>
<tr>
<td>Weight of empty container + chaff (B)</td>
<td>82.31g</td>
<td>108.19g</td>
</tr>
<tr>
<td>Weight of empty container + clean grains (C)</td>
<td>157.13g</td>
<td>387.67g</td>
</tr>
<tr>
<td>Weight of chaff and clean grains (D = B - A)</td>
<td>49.93g</td>
<td>31.05g</td>
</tr>
<tr>
<td>Weight of clean grains (E = C - A)</td>
<td>124.75g</td>
<td>310.53g</td>
</tr>
</tbody>
</table>
Yellow Variety

Percentage of unthreshed seeds = \( \frac{22.15}{204.66} \times 100\% = 10.82\% \)

Percentage of broken or cracked seeds = \( \frac{5.62}{124.72} \times 100\% = 4.51\% \)

Threshing efficiency = 100\% - 10.82\% = 89.18\%

Grey Variety

Percentage of unthreshed = \( \frac{39.56g}{310.53g} \times 100\% = 12.75\% \)

\[ \therefore \text{Threshing efficiency} = 100\% - 12.75\% = 87.25\% \]

Percentage broken seeds = \( \frac{4.56}{310.53} \times 100\% = 1.47\% \)
4.1.2 Germination Test

Total number of seeds planted in the soil = 100

**Yellow Variety**

Table 4.4: Germination test results for yellow variety

<table>
<thead>
<tr>
<th>Sample</th>
<th>Number of seeds germinated</th>
<th>Percentage germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>38</td>
<td>76%</td>
</tr>
<tr>
<td>B</td>
<td>34</td>
<td>68%</td>
</tr>
<tr>
<td>Average % germination</td>
<td></td>
<td>72%</td>
</tr>
</tbody>
</table>

**Grey Variety**

Table 4.5: Germination test results for grey variety

<table>
<thead>
<tr>
<th>Sample</th>
<th>Number of seeds germinated</th>
<th>Percentage germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>47</td>
<td>94%</td>
</tr>
<tr>
<td>B</td>
<td>45</td>
<td>90%</td>
</tr>
<tr>
<td>Average % germination</td>
<td></td>
<td>92%</td>
</tr>
</tbody>
</table>

4.1.3: Paper substrate method

**Grey Variety**

Number of seeds planted in paper substrate = 10

Number of seeds germinated = 8

Therefore percentage germination = 80%
Yellow Variety

Number of seeds planted in paper substrate = 10

Number of seeds germinated = 0

Therefore percentage germination = 0%

4.1.4: Speed Test

Table 4.6: Shows the Various Speed Test and their Efficiency with Time

<table>
<thead>
<tr>
<th>Weight of stalk before threshing</th>
<th>Weight of stalk after threshing</th>
<th>Weight of threshed grains</th>
<th>Speed (rpm)</th>
<th>Time taken to thresh (min)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.87g</td>
<td>10.52</td>
<td>16.35g</td>
<td>75</td>
<td>4</td>
<td>60.8</td>
</tr>
<tr>
<td>44.86g</td>
<td>22.71g</td>
<td>22.5g</td>
<td>110</td>
<td>7.5</td>
<td>50.1</td>
</tr>
<tr>
<td>37.18g</td>
<td>11.66g</td>
<td>25.52g</td>
<td>200</td>
<td>2.4</td>
<td>67.9</td>
</tr>
<tr>
<td>32.63</td>
<td>8.79</td>
<td>23.66g</td>
<td>325</td>
<td>3.59</td>
<td>72.5</td>
</tr>
<tr>
<td>24.33g</td>
<td>8.05g</td>
<td>16.28g</td>
<td>425</td>
<td>1.32</td>
<td>66.9</td>
</tr>
</tbody>
</table>
4.2 Discussion

4.2.1 Performance Evaluation

The millet thresher was installed on level and hard surface. Sufficient quantity of dried two different varieties was taken. The threshing efficiency, percentage total loss and germination were evaluated. During the test period, the speed of the rim was recorded against the time of threshing and the percentage threshing efficiency using a tachometer.

4.2.2 Threshing Efficiency and Moisture Content

The threshing efficiency ranged from 87.25% to 89.18% for the spokes clearance of 6mm to 8mm and 11.84% to 13.48% moisture content for both varieties of the millet. This was obtained at average speed between 200rpm and 325rpm, from table 4.6. The threshing efficiency for a given level of spokes clearance and moisture content increases with increase in rim speed. At given moisture content and rim speed to about 325rpm the efficiency increases and then begins to drop in efficiency to a speed of 400rpm and above. The threshing efficiency increases with increase in spokes clearance between 6mm to 8mm. This is however not the case with increase in rim speed for a given moisture content where the threshing efficiency reduces. This is due to the increased impact on the grains in the stalk resulting in a low ability of the thresher to efficiently thresh the stalks thereby resulting in low threshing efficiency and causing most of the seeds to be lost in the chaff.

4.2.3 Total Loss (%)

The total loss as spilled over and blown-up seeds ranged from a minimum of 3.3% to maximum of 13.1% for the spokes clearance of 6mm to 8mm and moisture content of
11.87% to 13.48% respectively. The total losses were influenced significantly by the rim speed, spokes clearance and moisture content. The total loss was the least at the average rim speed of 200rpm to 325rpm and increased with increase in speed. Generally, the spokes clearance of 6mm caused the minimum total loss at a given moisture and speed. The percentage of cracked or broken seeds observed was minimum between 1.47% and 4.51%.

4.2.4 Germination

The percentage germination of threshed seed was influenced significantly by moisture content, rim speed and spokes clearance. The germination of the threshed seed ranged from 72% to 92% over the range of spokes clearance 6mm to 8mm and 11.84% to 13.48% moisture content.

The percentage germination of the threshed seed reduced with increase in rim speed. The germination of threshed seed at 11.84% moisture content was significantly less at the corresponding levels of speed and spokes clearance compared to germination of seed threshed at 13.13% moisture content. Also, the minimum spokes clearance of 6mm caused the minimum reduction in percentage germination. Increase in cylinder speed causes higher damage while lower spokes clearance reduces the damage. Also the higher the moisture content the more susceptible the seed is to deformation without breakage resulting in injury or viability of seed. Therefore, the observation of reduction in germination with increase in rim speed, moisture content and increase of spokes clearance could be expected. Due to fungal infection on the grey varieties during the paper substrate germination test all the seeds planted did not germinate as compared to the yellow variety.
CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions and Recommendations

The main conclusions and recommendations arising out of the study are as follows:

1. The performance of the millet thresher was high and was affected by the moisture content and the rim speed.

2. The optimum threshing efficiency of 89.18% was obtained using the average speed between 200 rpm and 325 rpm at moisture content of about 13%.

3. The germination of the threshed seeds was high implying that the thresher did not cause internal damage to the seeds.

4. The grains that were produced were free from stones and sand as compared to those threshed in the rural areas.

5. Increase in the number of spikes in the threshing head from 27 to 36 in order to increase the force of impact by the spikes on the material; thus increasing the threshing efficiency.

6. There is the need to design an appropriate threshing chamber to facilitate the collection of threshed grains.

7. There can be viable enterprises manufacturing and selling the millet thresher after it has been continuously perfected and scaled-up as a marketable product.
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