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# Devlopment and Evaluation of Modified Solar Photovoltaic Powered Paddy Winnower

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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***Original Research Article***

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## ABSTRACT

A solar photovoltaic (SPV) powered paddy winnower was developed and evaluated at CAET, BSKKV, Dapoli. In order to eliminate the operational problems and difficulties, it was proposed to modify the existing SPV power operated paddy winnower, for better and improved performance. The existing SPV operated paddy winnower was tested to find the operational difficulties, and the physical properties of different paddy verities i.e., Ratnagiri-1, Ratnagiri-6, karjat-3. Including the terminal velocity, angle of repose, bulk density. It was found that improving several parameters can eliminate the operational difficulties from the existing SPV operated paddy winnower. The necessary modifications were incorporated in a modified SPV operated paddy winnower. The modified SPV operated paddy winnower was tested for Ratnagari-1 Variety of paddy and its improved performances were reported.

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*Keywords: Paddy winnower; blower; cleaning efficiency; SPV operated paddy winnower.*

## 1. INTRODUCTION

The agricultural production system is the main source of livelihood for one third of population of an India [1]. Paddy rice (*Oryza sativa-Asian rice*) is an important crop amongst all food grains. As one of the three most important grain crops, maize, rice, wheat, that helps to fulfil food needs all across the world. Three quarters of total world population consumes rice as staple food. Rice is the staple food for 65 % of the population in India. Global rice production more than tripled between 1961 and 2010 with compound growth rate of 2.24 % per year (2.21% in Rice Producing Asia). India is the world's second largest producer and consumer next to China. In India, rice cover area was 42949.80 thousand hectares against total geographical area of 163.46 million hectares with production of 112905.50 thousand tones and productivity was 2585 kg/ha (India agristat). Maharashtra has 1446.60 lakh ha land under rice cultivation with rice production of about 2660.50 lakh tons and productivity was 1839 kg/ha for the year 2017-18 (Dept. of agriculture Gov. of Maharashtra). In Konkan region, it is grown on 0.50 million hectares with the production of 1.14 million tons per year and productivity is 2768 kg/ha.

Cleaning and winnowing is one of the important processes done in preparing rice as food [2]. There are several post-harvest operations carried out on paddy. The most important goals of post-harvest handling are keeping the product fresh, to avoid losses and slow down undesirable chemical changes, and avoiding physical damage such as bruising and to delay spoilage [3-6]. It has been reported that about 9 per cent of paddy is lost due to use of old and outdated methods of drying and milling, improper and unscientific methods of storage, transport and handling [7-11]. It has been estimated that total post-harvest losses of paddy at producers level was about 2.71 per cent of total production. To minimise post-harvest losses, precautions should be taken to follow proper post-harvest practises. It includes timely harvest at optimum moisture percentage, use of proper method of harvesting; avoid excessive drying, fast drying and rewetting of grains, and ensure drying of wet grain after harvest. The losses in threshing and winnowing can be avoided using better mechanical methods [12-16].

In the post-harvesting process of the paddy threshing contributes 12 % cost of production. Presently hold on type paddy thresher in some areas of Konkan region are widely use which do not have cleaning facility. Hence, winnowing operation is necessary after manual or hold on type threshing [17-22]. Cleaning and winnowing is one of the important post-harvest processes for preparing paddy as food. It involves the removal of unwanted material like chaff, straws, weeds soil particle and other debris from the grain. Winnowing helps to improve grain storability, reduces dockage during milling, gives good quality milled rice and improves the milling output. It also reduces insects, pests and disease infestation [23-26].

Winnowing may use an agriculture method developed by ancient cultures for separating grain from foreign material like chaff, straw, husk. It involve simple process like throwing the mixture into the air so that the wind blows away the lighter chaff, while the heavier grains fall back down for recovery. There are different techniques used which include a shaped basket shaken to raise the chaff, a winnowing fan, winnowing fork or shovel. These methods are time consuming, uncomfortable and laborious. Labours get tired within a short period of time and this operation completely depends on wind conditions.

The winnower may be hand operated or power operated. Hand operated winnower require two persons for operation, one for operating the fan and another one for feeding the grain to winnower [27-30]. Effectiveness of separation of winnower may be very low in case of hand operated winnowing due to non-uniform speed of the blower as it was operated manually [31-37]. Power operated winnower has the higher effectiveness of separation due to uniform blower speed, but requires electrical power to run the blower. In many rural locations of developing countries, grid-connected electricity and supplies of other non-renewable sources of energy are either unavailable and unreliable or too expensive.

The available solar energy in tropical countries like India can be efficiently utilize to provide the source power supply for the post-harvest operations like paddy winnowing. In such conditions, solar photovoltaic powered paddy winnower is useful in areas with no utility lines. Photovoltaic systems are often less expensive and require less maintenance and operating cost than conventional electrical powers [38-41].

## 2. METHODOLOGY

The development and evaluation were conducted at Energy park, College of Agricultural Engineering and Technology, Dapoli, using three varieties of paddy i.e. Ratnagiri-1, Ratnagiri-6, Karjat-3.

**Operational difficulties in the existing SPV powered paddy winnower:** Under no load field-testing operational difficulties found were as follows:

- Irregular inflow of feed from hopper.
- Irregular outflow from outlet 1 and outlet 2.
- Absence of hooks on outlet for hanging of gunny bag.
- Variable blower speed and air velocity with solar intensity.
- Absence of auxiliary power in case of low solar intensity.

### 2.1 Modifications to Existing SPV Powered Paddy Winnower for Improved Performance

- **For regulating inflow of feed from hopper:**

The inside surface of the hopper was polished after paint was removed. The existing two side central feed control plates were replaced with a single sliding type feed control plate with an inclination angle equal to hoppers slant angle. Four springs was provided each at the four corners of the hopper and two vibration motors fixed to vibrate the hopper to give smooth and continuous flow of paddy grains.

- **For regulating outflow from outlet 1 and outlet 2:**

The painted outlet 1 and outlet 2 were creating hurdle in smooth outflow; to facilitate smooth outflow, the paint was scrapped off from the outlet surface.

- **For hanging of gunny bag at outlet:**

Three hooks were attached to outlet 1 and outlet 2 for hanging of gunny bags to collect grains.

- **To regulate blower speed and air velocity because of solar intensity fluctuation:**

To keep the blower speed constant there was need to have a constant supply voltage to the blower motor. To achieve this objective, a 12 V 7.2 Ah battery was provided with maximum power point (MPP) tracking charge controller. DC to DC step up booster was incorporated to increase the voltage supply to the blower, A DC motor speed regulator was provided to control the blower speed and air velocity suitable for different varieties of paddy.

- **To provide uninterrupted power in case of low solar intensity:**

Battery backup of 12 V 7.2 Ah was provided to facilitate uninterrupted winnowing operations in case of low solar intensity.

These necessary modifications required for smooth working and making trouble free operations of winnower was incorporated in the existing solar photovoltaic paddy winnower.

### 2.2 Performance of the Modified solar Photovoltaic Powered Paddy Winnower

The modified SPV operated paddy winnower was equipped with 7.2Ah maintenance free sealed lead acid battery. The battery was charged by the solar photovoltaic panel with the help of the MTTP charge controller. The charge controller gives the load output voltage of 12.6 V. In order to increase the blower speed, the voltage needs to step up: hence, a step-up booster module was added. To regulate the speed of fan blower in order to accommodate winnowing of different varieties of paddy, a DC motor speed controller module was provided. Two vibration DC motors were also connected parallel to the 12 V load output of the charge controller.

### 2.3 Technical Specifications of the Modified Solar Photovoltaic Powered Paddy Winnower

- Solar Photovoltaic Panel: Power – 80 W, Voltage – 12V, Size – 83 cm×45 cm
- D.C Motor Power – 18 W Voltage – 12 Volt
- Centrifugal Blower RPM - 2800
- Hopper Capacity – 10 Kg Size = 40×40×20 (G. I. Sheet)
- DC Motor Speed controller 12Volt 4 amp.
- Battery 7.2 Ah, 12 V
- Solar Charge Controller 12 V/24 V
- Vibrating D.C motors Voltage 12 V

- DC to DC voltage booster 150 W, 6 A, 10-32 V to 12-35 V
- Switch 1 no. On/Off
- Caster wheel 4 nos.
- Frame (Height = 100 cm, Length = 70 cm, Width = 40 cm) Mild steel.

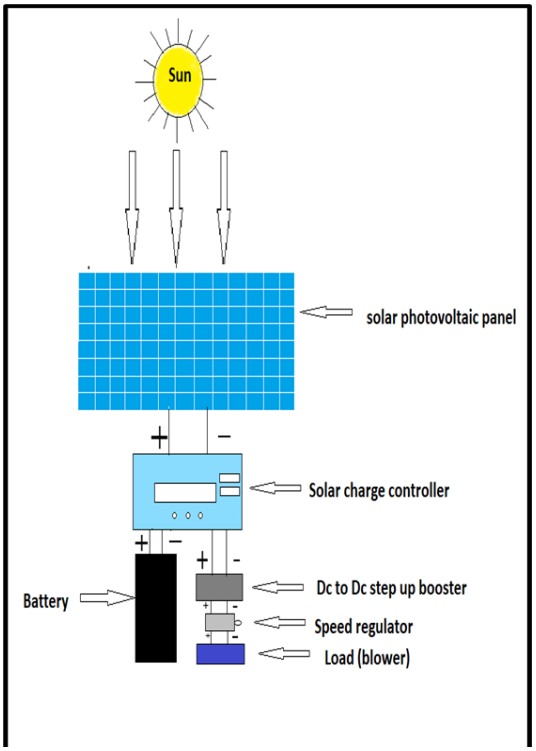


**Fig. 1. Block diagram of electrical system of the modified SPV powered winnower**

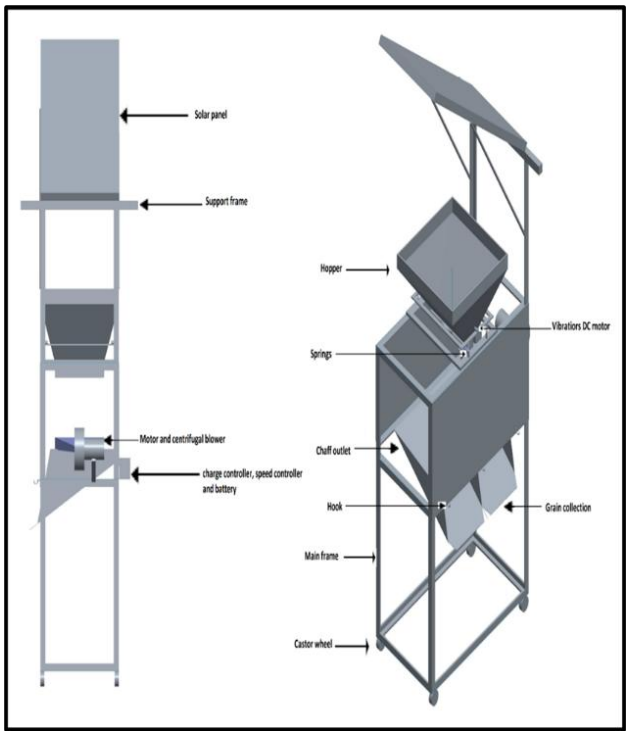


**Fig. 2. Diagram of the modified SPV powered winnower**

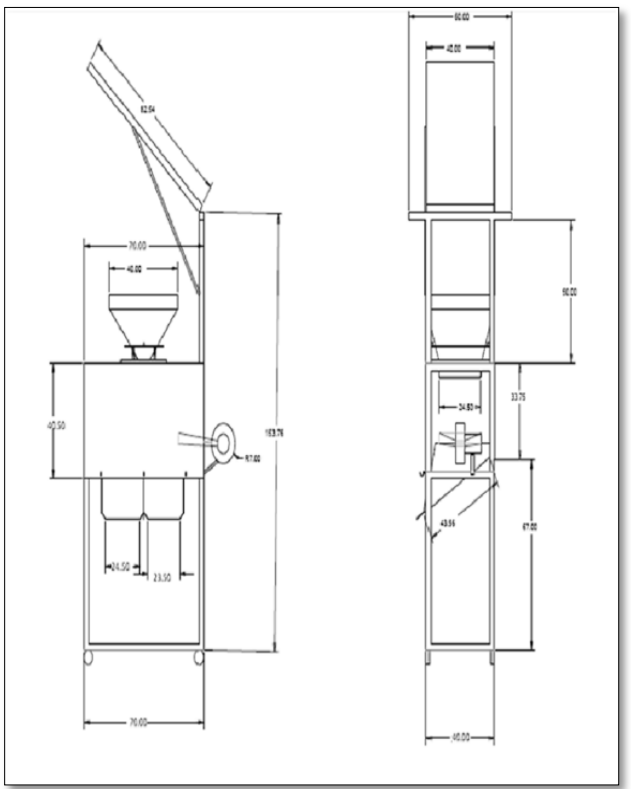

**Fig. 3. Sketch of the modified SPV powered winnower**

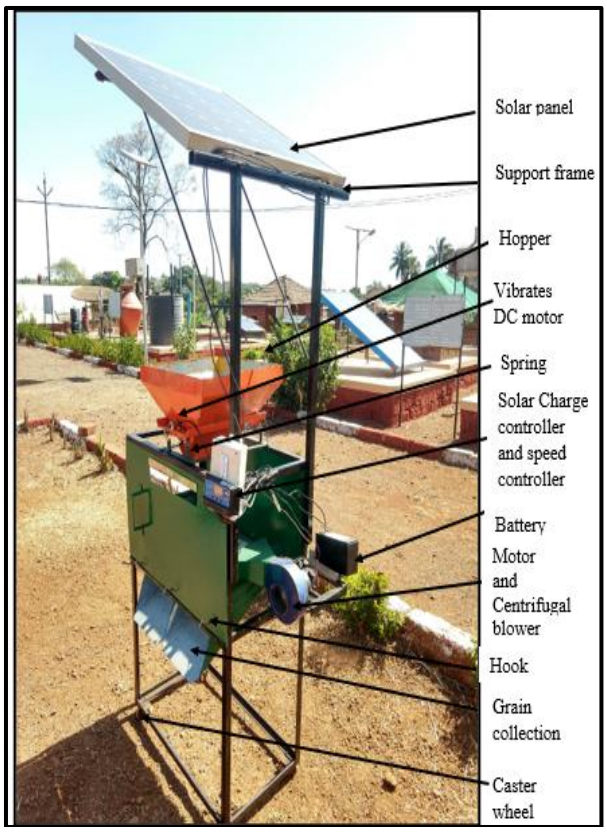


**Fig. 4. Photo of the Modified SPV powered winnower**

## 3. RESULTS AND DISCUSSION

The field testing of the modified SPV operated paddy winnower was conducted at Energy Park, Department of Electrical and other Energy sources, CAET, DBSKKV, Dapoli. The different operating parameters were recorded as per RNAM test code for field testing of winnower. The results obtained are given on the basis of cleaning efficiency, output capacity, percentage of blown grain and power consumption.

Parameter details of the SPV operated paddy winnower evaluated are as follow.

| |
|---|
| Name of crop - Paddy |
| Variety of crop – Ratnagiri-1 |
| Grain ratio - 0.896 |
| Operating time - 15 min |
| Moisture content (w.b) -11.76% |
| Grain input – 30 kg |

The filler trials of Sthe PV operated winnower were conducted at different positions of feed plate. It was observed that if the 100% feed plate was opened, the feed rate was found to be very high, which is beyond the capacity of the blower. Hence, the modified SPV operated winnower was evaluated only at constant feed rate of 120 kg/h.

### 3.1 No Load Tests of Modified SPV Paddy Winnower Include

#### 3.1.1 Effect of solar intensity on blower speed

It was observed that, solar intensity does not affect the blower speed; the blower speed in the modified winnower remains steady around 2800 rpm because the battery provided a steady voltage supply to the blower. The maximum solar intensity (542.3 W/m$^2$) was achieved at 13:00 h of the day.

#### 3.1.2 Effect solar intensity on air velocity

Variation of solar intensity and air velocity with respect to time at different distances from blower. It was observed that the air velocity also remains steady with respect to time, the solar radiation varied with the time of the day. The maximum velocity of air through at 10 cm, 20 cm, 30 cm from blower was found to be 8.73 m/s, 7.43m/s, 5.40m/s, respectively.

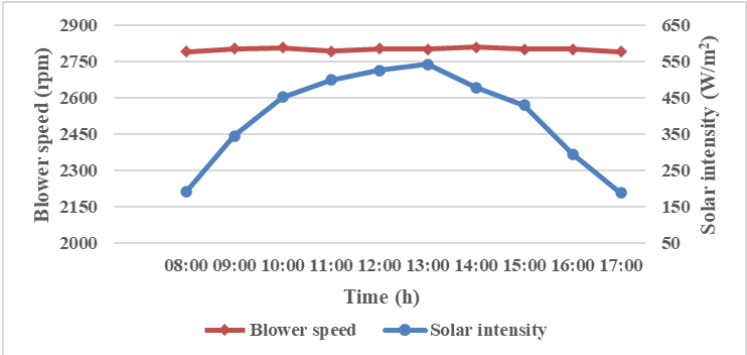


**Fig. 5. Variation of blower speed with respect to time and solar intensity**

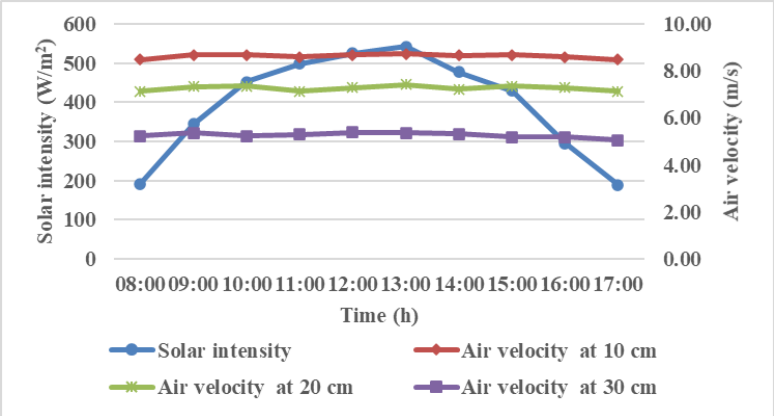


**Fig. 6. Effect of solar intensity on air velocity**

### 3.2 Field Testing of Modified SPV Operated Paddy Winnower

The cleaning efficiency and output capacity at outlet 1 with respect to time reveal that the cleaning efficiency during the day was almost constant. The maximum cleaning efficiency was found to be 95.5 per cent and the minimum cleaning efficiency92 per cent. Maximum output capacity of outlet-1 found to be 40.82 kg/h. and minimum found to be 40.6 kg/h.

The cleaning efficiency and output capacity at outlet 2 with respect to time reveal that the cleaning efficiency during the day was also almost constant. The maximum cleaning efficiency was found to be 94 per cent and the minimum cleaning efficiency 90 per cent. Maximum output capacity of outlet-2 ws found to be 78.6 kg/h. and the minimum 78.1 kg/h.

### 3.3 Variation of Percentage of Blown Grain with Respect to Time at 20 cm Distance from Blower

It was observed that, the percentage of blown grain from blower was nearly constant. The percentage of blown grain ranged from 0.1% to 0.12%. The variation power consumption with respect to time of operation was also studied.

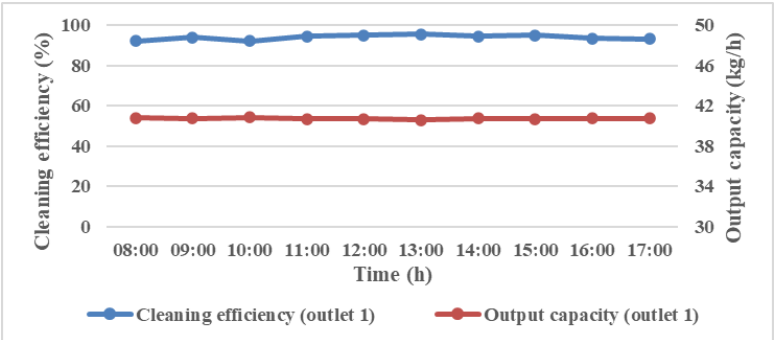


**Fig. 7. Cleaning efficiency and output capacity at outlet 1**

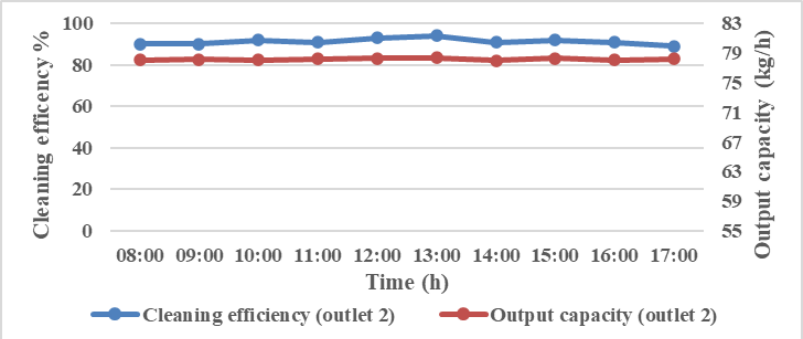


**Fig. 8. Cleaning efficiency and output capacity at outlet 2**

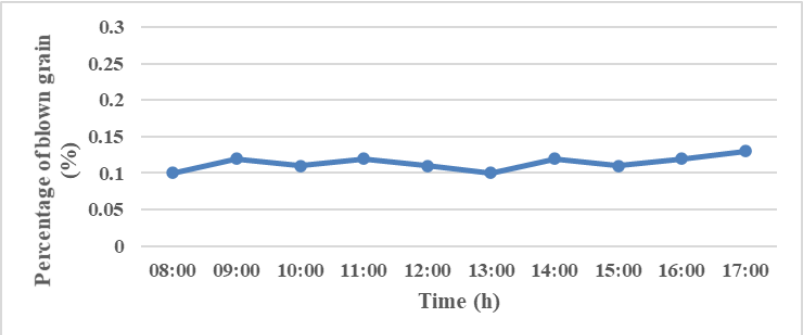


**Fig. 9. Variation of the percentage of blown grain with time**

## 4. CONCLUSION

As expected, the installation of a battery to provide a constant voltage supply has removed most of the irregular operational difficulties in the unmodified SPV operated paddy winnower.

As blower speed and distance of hopper can be controlled, the modified SPV operated paddy winnower is suitable for winnowing of various paddy varieties.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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