Design and development of power-operated continuous-run potting machine for seedling-nursery

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Received: 18 October 2014; Accepted: 9 January 2015

ABSTRACT

Potting is still a manual operation in plantation, forestry, and 11 other horticultural nurseries in India and the preparation of pot-mixture and filling in polybags are crucial tasks and are time consuming. Therefore, a power-operated continuous-run machine was specially designed, fabricated, and tested to master seedling-nursery management capable of mixing, pulverizing, sieving, and filling of pot ingredients in polybags. The machine is a vertical free-standing unit mounted on four legs and consists of 3-hp motor, feed-hopper, pulverizing chamber with 8-numbers of paddles, sieving compartment operated by a slider-crank mechanism, vending instrumentation, and outlet. Ingredients like soil, sand, granite power, farmyard manure, and compost are fed from the top and the pot-mixture is collected at the bottom. Electronic vending is the novelty of the machine, which permits filling pot-mixture at set quantity at set time-gap. Aggregate analysis, degree of pulverization, and other physical parameters of machine-made mixture are at recommended level as well as on par with manually-made pot-mixture. More proportion (81.8%) of desirable level of aggregate was achieved with machine compared in manual method (79.5%) resulted in improved quality of the mixture for seedling establishment. Bagging through machine worked out 71.4% cost-saving and 80.2% time-saving. The machine is recommended for nursery-holders around the nation since the machine can provide pot-mixture for development of saplings of 30 000 numbers per month in a commercial nursery.

Key words: Bagging machine, Potting machine, Potting media, Propagating medium
avoid contamination in manual handling. Moreover, it is
tedious in the bending posture during the operation with
spade.

By considering the prevailing scenario of pot media
preparation and handling, a power-operated continuous run
potting machine was designed and developed at Central
Institute of Agricultural Engineering, Regional Centre,
Coimbatore, India. The paper deals with the design criteria,
agronomical requirement of pot media handling, fabrication
of the prototype, and performance evaluation including
study of effect of machine potting in germination of the
seedlings.

MATERIALS AND METHODS

This power operated continuous type pot machine is
capable of mixing, pulverizing, sieving, and filling of pot
ingredients in polybags at desired quantity. The unit consists
of 3 hp motor, feed hopper, paddles, sieving tray, and
electronic vending instrumentation. For spices nursery, the
optimized ratio of soil, granite powder, and compost is
2:1:1 (v/v) is used for pot-mixture. Electronic vending is the
novel approach adopted in this machine, which is used for
filling the pot-mixture at set quantity (250, 500, 1000g, etc.)
at set time gap with 90% accuracy which is the acceptable
level in nursery practices. The uniformity of mixing,
aggregate analysis, degree of pulverization, and other related
parameters of machine made pot-mixture were at
recommended level as well as on manually made
pot-mixture. This gender friendly machine is of very aesthetic
and compact design, portable and handy to transport to the
gardens and fields. Any unskilled person can operate
the machine. Two operators are required, and both the operators
can safely and comfortably work with the machine in standing
and sitting position (Gavin et al. 2013). The machine is
shown in Fig 1.

The potting machine operation consisted of various
unit operations, viz mixing cum pulverizing, sieving cum
destoning, stirring, and vending. The mixing cum
pulverizing of pot media fed through feed-hopper was
carried out by eight numbers of paddles attached at central
shaft revolving at 350 rpm. The central shaft was actuated
by a 2.25 kW electric motor (3-phased) through speed
reduction gears (Mangwandi et al. 2010). The feeding throat
controls the smooth flow of the feed. The sieving cum
destining is actuated through slider-crank mechanism
2010, Rong-Fong et al. 2009). String is carried out for
proper flow of end product without getting choked in the
delivery chute. The stirring mechanism is driven from the
prime mover. Vending is carried out through two modes,
viz electronic vending and pedal vending (Feng-Cheng et
al. 2011). The electronic vending is actuated from the
control panel. The electronic vending was instrumented in
such a way that the potting mixture is dispensed in the
polybag to the desired set weight which is controlled by a
load cell and set time gap (Sujin and Sang 2011, Yang and
Evans 2007). Pedal vending unit was also provided to use
it as alternative way in the field condition. This is actuated
by the foot of the operator (Fig 1).

Based on the materials used and labour requirement for
the fabrication of the pot machine, the material cost and
fabrication cost of the unit was calculated. The cost of
operation per hour of the pot machine was worked out using
the procedure recommended by RNAM test codes (Anon.
1995). This cost was compared with the cost of operation
of the same by conventional method. The time and cost saved
by using the pot machine against conventional method was
compared.

RESULTS AND DISCUSSION

Optimization of agronomic parameters
The bulk density and moisture content of soil, sand,
and farm yard manure were measured before and mixing.
Fineness and tilth was determined through sieve analysis.
Angle of repose of the mixture was also determined. The
soil, granite powder, and FYM at the ratio of 2:1:1 (v/v) was
adopted for the design of the machine.

Machine performance
The machine was evaluated in the laboratory condition
and field condition at TNAU Botanic Gardens before
installation at IISR farm. The observations on performance
evaluation of pot machine are furnished in the tables.

Capacity of the machine
The working capacity of the machine was observed by
taking different combinations. There is no significant
difference on capacity of the machine with the combination
of pot media as indicated in the Table and Fig 2.
Particle size distribution

The distribution of particle size determines the quality of the pot-mixture. The results on sieve analysis of both hand-made pot-mixture and machine made pot-mixture are furnished in Table and Fig. It is revealed from the observations of sieve analysis that the particle size distribution of both hand-made pot-mixture and machine made pot-mixture is on par. Hence the machine made pot-mixture is found to be most suitable for seedling establishment (Richards et al. 1986). It is also found that more proportion (81.8%) of desirable level of aggregate was achieved with machine mixture compared in manual method (79.5).

The comparison of basic properties of pot-mixture prepared by manual method and by pot machine was studied.

Table 3  Particle size distribution of pot-mixture

<table>
<thead>
<tr>
<th>Sieve opening (mm)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Weight (g)</td>
<td>%</td>
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<tr>
<td>6.30</td>
<td>346</td>
<td>81.8</td>
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*Soil: granite-powder:FYM, v/v

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<th>Weight set (g)</th>
<th>Machine filling</th>
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<tbody>
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<td></td>
<td>Weight SD</td>
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<tr>
<td></td>
<td>filled (g)</td>
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<tr>
<td>250</td>
<td>243.18 20.1</td>
<td>260.4 26.4</td>
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<tr>
<td>500</td>
<td>514.60 37.2</td>
<td>519.2 40.9</td>
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<tr>
<td>750</td>
<td>741.92 64.7</td>
<td>769.7 86.4</td>
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<tr>
<td>1 000</td>
<td>1 032.9 82.0</td>
<td>1 076.2 93.5</td>
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The physical properties, viz. bulk density, particle density, water holding capacity, and mechanical properties, viz. fine sand content, course-sand content, silt content, and clay content were analyzed. It is found from observations that the physical properties and mechanical properties of the machine made pot-mixture is on par with the hand-made pot-mixture and hence it is concluded that the machine made pot-mixture is suitable of growth of seedlings.

Germination test

A germination study was conducted with the machine made pot-mixture to find out the effect of quality of machine made pot-mixture on seedling growth and root development. The observations showed that seedling growth and root development were on par with the hand-made pot-mixture. Hence it is concluded that there is no adverse effect observed.
with the machine made pot-mixture on the establishment of seedlings.

Cost economics

The machine capacity was 100 kg/h which denotes 1 600 bags of 500-g capacity can be filled in a day of 8 hr by engaging two labourers, while only 300-350 bags were filled in the conventional method. Bagging of 1 000 bags through machine costs ₹ 320 while it is ₹ 1 140 manually which worked out 71.4% cost-saving and 80.2% time-saving through machine-filling. Break-even point for utility of this machine is 63 tonnes/annum and pay-back period is 1.4 year. The machine is recommended for nursery-holders around the nation since the machine can provide pot-mixture for development of saplings of 30 000 numbers per month in a commercial nursery.

(a) The pot machine developed enables easy mixing, pulverizing, and vending the pot-mixture in polybags in a desired quantity. The mixing index, pulverization, and aggregate analysis of the pot-mixture prepared by this machine is meeting out agronomic standards. Ninety per cent accuracy is maintained by the electronic vending unit during dispensing of pot-mixture in polybags. Germination percentage of the planting material and root development with the machine made pot-mixture is on par with manual pot-mixture.

(b) The electronic vending is the novel approach adopted in this machine. This vending unit fills the pot-mixture at set quantity (250g, 500g, 1 000g, etc.) at set timing with 90 per cent accuracy.

(c) The machine is recommended for nursery-holders around the nation since the machine can provide pot-mixture for development of saplings of 30 000 numbers per month in a commercial nursery.

REFERENCES


