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Performance evaluation of cattle dung based automatic pot making machine

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Abstract
In this study an appropriate automatic pot making machine suitable for use in rural community was selected for its performance evaluation. The performance of the machine was evaluated for making pots by using cattle dung as a base material and different agriculture residues such as rice husk, rice straw, saw dust and coco peat which were mixed with dung. The properties like shattering index, water absorption capacity and moisture content after drying of produced pots were determined for different treatments. Each treatment comprises mixture of selected agriculture residue and cattle dung. Rice starch and soil was used as a binding material for making pots with biomass. Results revealed that physical properties of the pot were significantly affected by the binder level. Rice starch has a best binding quality for pot making. Rice is a source of starch that is organic, bland gel, white in colour and as a gel smooth in texture and creamy consistency. The study indicated that pots having more cattle dung content i.e. 15:03:02 ratio, in which cattle dung have 15, soil have 03 and other agriculture residues have 02 parts on weight basis. These pots made using above said ratio of raw material gave better results for shattering index and resistance to water penetration. The study concluded that pots produced from mixture of cattle dung and agriculture residues at different proportion could be serving as many ways cattle dung cake and logs alternative source of energy for domestic cooking. The performance of the machine was based on the capacity of developed machine was determined in terms of time required to prepare one pot and number of pots prepared in one hour for each treatment. Results obtained showed that average time required to prepare one pot was 1 min 34 sec. The testing and evaluation of prepared pots as per treatment, after drying was carried out to see the different parameters like shattering index, water absorption capacity, drying time, pot size and shape. The average shattering index of produced pots was 87.4%. The average water absorption capacity of pots produced by using cattle dung as a base material and other agricultural wastes was obtained as 1.26%. Mean values of moisture content of produced pots after drying was 12.21%.

Keywords: Pot, cattle dung, cattle dung powder, rice straw, rice husk, saw dust, coco peat, lime, rice starch

Introduction

In India, 66.46% of the population reportedly resides in rural areas, where over 15–20% of families are landless and about 83% of the landholders belong to the category of small and marginal farmers (Fasake and Dashora, 2020) [4]. Livestock, being a key source of supplementary income and livelihood, especially for small landholders and the landless rural poor, play an important role in the rural economy of the country. The total livestock the population is approximately 600 million, where the cow and buffalo contribute 35.94% and 20.45% of the total population respectively and the supply of raw material (dung) is substantial. At the same time, the livestock sector plays a strategic role in improving the economic, environmental and socio-cultural of any nation (20th Livestock Census). Cow dung in India is also used as a co-product in agriculture such as manure, biofertiliser, biopesticides, pest repellent and as a source of energy (Dhama *et al.* 2005) [3]. As per ayurveda, it can also act as a purifier for all the wastes in the nature (Randhwa and Khullar, 2011). Cow dung is the major source of biogas or gobar gas production in India. The total population of female cows in India is 190.90 million out of which 151 million are indigenous whilst 39 million are crossbreed (Livestock Census 2012). Cow dung generated from 3–5 cattle/day can run a simple 8–10 m^3 biogas plant which is able to produce 1.5–2 m^3 biogas per day which is sufficient for the family 6–8 persons, can cook meal for 2 or 3 times or may light two lamps for 3 h or run a refrigerator for all day and can also operate a 3-kW motor generator for 1 h (Werner *et al.* 1989) [13]. Cattle dung manure has been used since ancient times as anorganic fertilizer in agriculture. Being rich in micronutrients.

It also contains 24 different minerals like nitrogen, potassium, along with trace amount of sulphur, iron, magnesium, copper, cobalt and manganese. The indigenous Indian cow also contain higher amount of calcium, phosphorus, zinc and copper than the cross-breed cow (Garg and Mudgal 2007; Randhawa and Kullar, 2011) [5, 8]. It is suitable to be used for all types of crops. The strict laws on waste management on reduction of environment pollution and in general addressing the decrease of the manmade pollution are some of the reasons that have led to the different natural product making. This paper aims to another much more beneficial feature of cattle dung through its modern use by making pot, there are different type of product is made such as – cattle dung cake, mosquito repellent, dhupbatti, hawan samagri, pot etc.

In this way, pot can be made using many waste agriculture residues such as rice husk, rice straw, saw dust, coco peat and lime. Cattle dung pot was produced by mixing different agriculture residues at different rate to observe the nutritional value, changes of nutrient characteristics among different treatments and the effects of pot on the growth performance of plants. Which are bio-degrable, healthy environment, better soil condition and better for cost management. This will increase the usefulness of organic and natural materials along with the pure environment. These agriculture residues will make a good quality pot. In the automatic machine, the pot will be ready in less time and in more numbers. Whose binding quality and water absorption capacity will be high, which will be helpful in the growth of the plant and will increase the fertility of the soil. Therefore, a pot based on cattle dung was made, which allows the tree to grow naturally and clean environment. At the same time this will enable to get uniform shape, size and quality of pots. This type of machine can also facilitate to get different sizes of the pot by changing mold or die in a single machine.

Methodology

Collection of raw material for pot making

This study was conducted at Swami Vivekananda College of Agricultural Engineering and Technology and Research Station Raipur in the year of 2021-2022. Cattle dung and other agricultural residues rice husk, rice straw, coco peat, lime powder, saw dust, rice starch and cattle dung powder were used in this study. Fresh cattle dung was collected from dairy farm of SV CAET, IGKV Raipur and other raw materials were purchased from local market of Raipur. The fresh, one day old and two days old cattle dung as a base material was mixed with other raw materials as per treatment for pot making. The details of raw materials are discussed in following sub sections.

Table 1: Raw material for pot making

S. No.	Types of materials	Raw materials
i	Base material	Cattle dung and cattle dung powder
ii	Binding material	Rice starch
iii	Agriculture residues	Rice husk, rice straw, saw dust, coco peat.
iv	Other materials	Soil, lime

As discussed earlier, cattle dung as a base material, 5 different agricultural residues like rice husk, rice straw, saw dust, coco peat; cattle dung powder, lime powder, soil and rice starch as a binding material were selected for pot making. In total 11 treatments were designed by using above said items and presented in Table no. 2.

For preparation of mixture as per treatment a container is used and all the raw materials were mixed in container after weighing as per decided ratio by hand. This mixed material is put into the die of pot making machine by hand for making pots.

Table 2: Treatments details

S. No.	Treatments	Composition	Ratio
1	P1	Cattle dung+Soil+Rice husk	15:03:02
2	P2	Cattle dung+Soil+Rice straw	15:03:02
3	P3	Cattle dung+Soil+Saw dust	15:03:02
4	P4	Cattle dung+Soil+Cocopeat	15:03:02
5	P5	Cattle dung+Soil+Lime powder	15:03:02
6	P6	Cattle dung powder+Soil+Rice husk+Rice starch	15:03:02
7	P7	Cattle dung powder+Soil+Rice straw+Rice starch	15:03:02
8	P8	Cattle dung powder+Soil+Saw dust+Rice starch	15:03:02
9	P9	Cattle dung powder+Soil+Cocopeat+Rice starch	15:03:02
10	P10	Cattle dung powder+Soil+Lime powder+Rice starch	15:03:02
11	P11	Cattle dung	1

Testing of cattle dung based pot making machine and produce pot

Cattle dung based pot making machine was tested and evaluated as per standard methodology for making pots by using different mixture of raw materials. Machine was tested for its pot making capacity i.e. time taken to make one pot and no. of pots per hour, damage percentage, shape deformation etc. Further, prepared pots were tested for its drying time, shattering index, water absorption capacity, size of prepared pots. Cost economics was also estimated. The pots made from machine are shown in Fig. 1, 2, 3 and 4.

Fig 1: Cattle dung pot before and after sun drying

Machine capacity

The machine capacity of the pot making machine was estimated by observing time take to prepare one pot. This time includes grabbing of mixture of raw material from container, feeding into the die, compression time, preparation of pot and its removal from die block. The observation for making pot was recorded in terms of time taken to prepare one pot and no. of pots prepared per hour.

Moisture content

The initial and final weight of sample was determined Moisture content throughout this study was measured by drying the sample at 105 ^{0}C for approximately 24 h. Wet basis moisture is most commonly used for describing moisture changes during drying. When a sample loses moisture, the change in the wet basis moisture is linearly related to the weight loss of sample. The initial moisture content of whole material was determined by using the standard hot air oven method using the following formula (Sahay and Singh, 2005).

$$MC\ (\%) = \frac{Wi - Wf}{Wi} \times 100$$

Where,

MC = Moisture Content, (%)

W_i = Initial weight of sample, (g)

W_f = Final weight of sample, (g)

Shattering index

The life of prepared pot is depending on its storage type and use condition. However, the durability of prepared pot was determined in accordance with the shattering index. The samples of prepared pot were dropped repeatedly from a specific height of one meter in to the solid base. The distinct particle of the pot

retained was used as an index of pot breakability. The percentage weight loss of pot was expressed as a percentage of the initial mass of the material remaining on the solid base, while the shattering index was obtained by subtracting the percentage weight loss from 100 (Gorpade, 2006 and Sengar *et al.*, 2012)

$$\text{Percentage weight loss} = \frac{\text{Initial weight brfore shattering} - \text{Final weight after shattering}}{\text{Initial weight of shattering}} \times 100$$

Shattering index (%) = 100 – percentage weight loss

Water absorption capacity (WBC)

A prepared pot sample was placed in container filled with water for whole submerging of pot and left it for 2 days as shown in figure 5.

Fig 2: Pot is submersing in water for two days

After soaking in water for 2 days and draining excess water through filter paper, the saturated sample was weighed again (Ws). The amount of water retained by sample was calculated as the water absorption capacity. The water absorption capacity (g water/g dry material) is details by using as following formula (EL – Sayed G. Khater, 2014) [7].

$$WBC = \frac{(Ws - Wi) + (MC \times Wi)}{(1 - MC \times Wi)}$$

Where

Wi = Initial weight of sample, (g)

Ws = Final weight of sample, (g)

MC = Initial moisture content of sample, (%)

Fig 3: Dry pot hold in water for 2 days

Observation recorded

The machine while performing test the observation has been noted and different performance parameters has been calculated. The performance parameters are calculated as the method described below

Capacity of machine

The mixture materials feed in die to get pot with compressive force by power transmitted of power screw. The capacity of machine to calculate how much time to get the one pot. Then calculate the capacity of machine for per pot per hour. Hence, the capacity of the machine was calculated by the formula as given below (Sonboier, 2018) [9]

$$C = \frac{w}{t}$$

Where

C = Actual capacity (kg/h)

w = Weight of cattle dung collected (kg)

t = Time taken (h)

Strength of pot

The strength of pot to calculate the breaking point that is rapture force of pot. Strength of pot which hardness of materials by which pot was made and binding property of binding material that is rice starch. Cattle dung owns binding material and hardness is very hard after drying. This cattle dung mixture other agricultural residues so his hardness highly increase a lot and pot have a highly hardness and strength.

Cost analysis

Operating cost of machine

Cost of operation was determined by straight line method with two heads such as fixed cost and variable cost. Cost of operation depends on all such as fabrication cost of the machine, maintenance and labor cost. Therefore, the cattle dung based pot making machine operational cost was divided into fixed and variable costs. The operating cost explains how the machine would be affordable and how much it will cost to operate. Operational cost of the machine is the sum of fixed cost and variable cost of the machine. The depreciation, interest on the capital cost, shelter, insurance and taxes were taken under fixed cost and variable costs include fuel, lubrication, repair-maintenance cost and wages of labor.

Cost analysis of pot production

The economic analysis begins with the calculation of working capital cost, investment cost and operational cost that is needed to operate the production process with knowing the price of materials using pot making. The analysis continued by calculating the value of profit, cash flow and economic parameters i.e. net income, gross income, production cost (Suliyanto, 2010) [10]. The cost of operation of power operated pot making machine was constant per hour for all types of raw materials used for pot production, while cost of production of pot was determined different for each biomass due to its purchasing cost.

Result and discussion

Machine performance

The capacity of developed machine was determined in terms of time required to prepare one pot and number of pots prepared in one hour for each treatment, the obtained data of machine performance is presented in Table no. 4.

It was observed from the table that average time required to prepare one pot was 1 min 34 sec, It was found that, by using lime powder and in some case cattle dung powder the production rate was higher may be due to that during compression and removal of prepared pot from the die, friction and sticking of material between the surfaces is low.

Table 3: Machine performance

S No.	Treatments	Time required to make one pot (min.)	No. of pot prepared in one hour
1	P1	1:30	40
2	P2	1:42	42
3	P3	1:30	40
4	P4	1:36	44
5	P5	1:33	45
6	P6	1:30	40
7	P7	1:42	42
8	P8	1:39	43
9	P9	1:35	44
10	P10	1:33	45
11	P11	1:31	40
Average		1:34	42.27

Testing of different pot after drying

The testing and evaluation of prepared pots as per treatment after drying was carried out to see the different parameters like shattering index, water absorption capacity, drying time, pot size and shape.

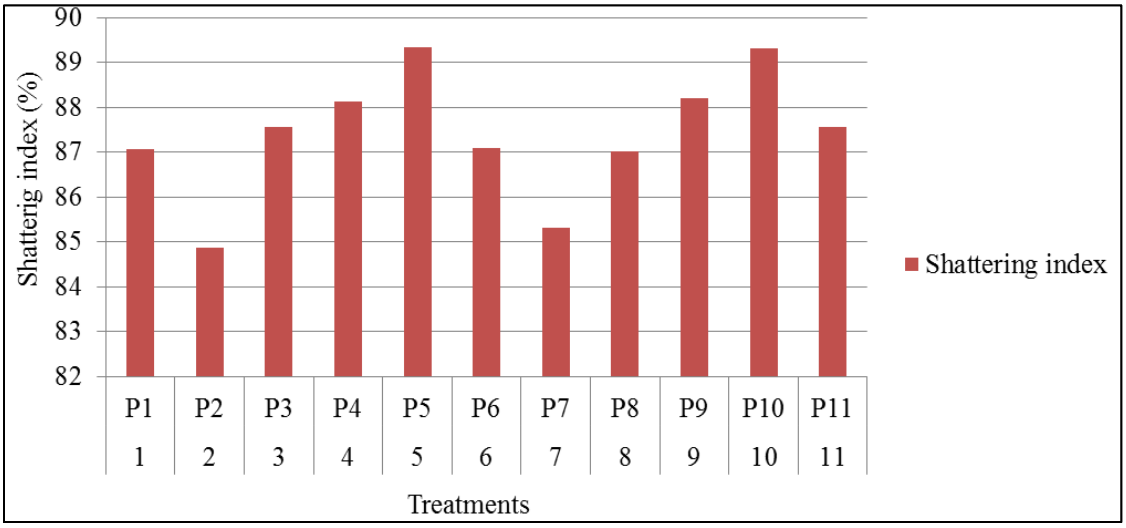

Fig 4: Shattering index of different raw materials pots measured at different height

Table 4: Testing of different pot after drying

Treatments	Average shattering index (%)	Average water absorption capacity (%)	Average moisture content (%)
P1	87.08	1.19	12.56
P2	84.86	1.41	12.77
P3	87.55	1.23	11.67
P4	88.13	1.58	12.89
P5	85.34	1.08	10.45
P6	87.10	1.08	12.34
P7	85.32	1.39	12.45
P8	87.03	1.20	11.98
P9	88.21	1.61	11.67
P10	86.32	1.10	12.55
P11	87.56	1.06	12.99

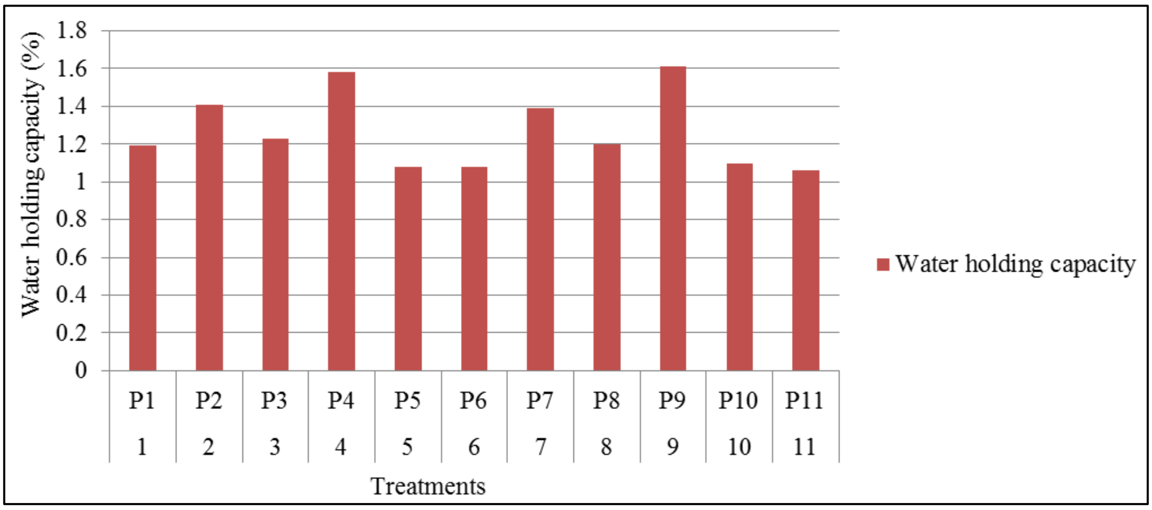

Fig 5: Water absorption capacity of different pots

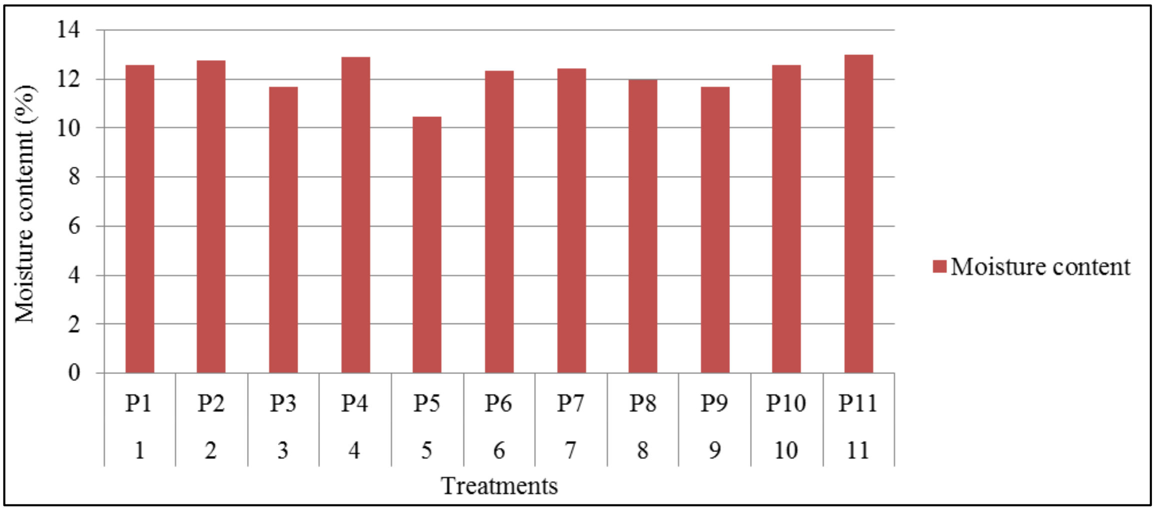

Fig 6: Moisture content after drying of different pot

Shattering index

From the above fig. 4 it was observed that average shattering index of produced pots was 87.4%. The highest shattering index 88.21% was obtained in pots made by cattle dung + soil + coco peat + rice starch (treatment P9). Maximum shattering index was obtained in treatment P9 was obtained may be due to that additional rice starch was mixed in raw materials for better binding. Lowest shattering index was obtained in treatment P2 as 84.86% in which pots were prepared by cattle dung + soil + rice straw.

Water absorption capacity

Water absorption capacity of pots made by using cattle dung + soil + coco peat + rice starch under treatment P9 was found highest as 1.61% while the lowest was observes under treatment P11 as 1.06%. In general average water absorption capacity of pots produced by using cattle dung as a base material and other agricultural wastes was obtained as 1.26%.

Moisture content of pot after sun drying

After making a pot, it was sun dried for two days. It was observed that after drying materials became not bone dried. Little amount of moisture was present in the produced pots. Moisture content of the pots produced as per treatments after sun drying is presented in fig. 6.

Mean values of moisture content of produced pots made with pot making machine and by using mixing of different raw materials was 12.21%. However, maximum moisture content (12.99%) was recorded in treatment P11 in which only cattle dung was used as a raw material to produce pots. Result shows that pots made by only cattle dung required more time for its drying.

Pot size

The size of prepared pot was measured with feet scale, vernier caliper and calipers in terms of its height, thickness and diameters

Fig 7: Pot size

Drying time

The prepared pot was dried in sun at temperature of 25 °C for 48 hours.

Cost analysis for pot production

Table 5: Cost analysis of pot production

Treatments	Cost of production₹/ h	Gross income ₹/ h	Net income ₹/ h	Production cost of one pot ₹	Profit per Pot ₹
P1	134.88	400	265.12	3.37	6.62
P2	130.08	420	269.92	3.09	6.91
P3	134.88	400	265.12	3.37	6.63
P4	348.88	440	91.12	7.92	2.07
P5	166.38	450	283.62	3.69	6.31
P6	165.13	400	234.87	4.12	5.88
P7	161.83	420	258.17	3.85	6.15
P8	172.78	430	257.22	4.01	5.99
P9	382.13	440	57.87	8.68	1.32
P10	200.38	450	249.62	4.45	5.55
P11	64.88	400	335.12	1.62	8.38

Costs for all agriculture residues are different depend on local market prize. The cost of cattle dung is fixed but the costs of different agriculture residues are different. So, different agriculture residues such as rice husk, rice straw, saw dust, coco peat and lime mixed with cattle dung as a base material for making pot. Cost of production by power operated pot making machine was found maximum for the production of pots in treatment P9 as Rs 382.13 per hour and minimum for the P11 as Rs 64.88 per hour. The gross income (Rs/h) found maximum for the P5 and P10 as Rs 450 per hour and minimum for the P1, P3, P6 and P11 as Rs 400 per hour. The net income generated was found maximum for the pot P11 as Rs 335.12 per hour and minimum for the as Rs. 57.87 per hour hence the pot production from P2 using power operated machine was found more profitable compared to other biomass pot.

Conclusion

On the basis of different parameter to evaluate the cattle dung based pot making machine it was observed that pot making machine performed satisfactorily. The capacity of machine was found 40-45 pots per hour. The average cost of making per pot was estimated as Rs. 4.50. Among all the treatments, treatments P9 (cattle dung + soil + coco peat + rice starch) was found best on the basis of cost analysis, shattering index and water absorption capacity.

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