Title of the Thesis: Design and Development of a Fully Automatic Paddy Seedling Mat Preparing Machine
Name: Mr. Vinod Choudhary
Roll No: 18AG91R11
Supervisor: Dr. Rajendra Machavaram

Abstract

Paddy (*Oryza sativa L.*) is an important cereal crop and staple food for India's people. The average land holding size of Indian farmers would be mere 0.68 ha in 2020 and would be further decreased to a low of 0.32 ha in 2030. The paddy productivity is lesser in India due to the decreasing land holding size and the lack of mechanization. The transplanting of paddy seedlings is still followed by traditional methods which is labour intensive and requires 250-350 man hours per hectare. The traditional paddy nursery raising methods are tedious and produces weak paddy seedlings that reduce the final yield of the paddy due to higher mortality. The raising mat type nursery in frames or in fields is complicated, labour intensive, and not followed properly by farmers. The available automatic and semi-automatic mat preparation machines have limitations such as lower capacity, increased feed material wastage, higher power requirements, and non-uniformity of the feed material with the desired materials. A fully automatic paddy seedling mat preparing machine (FAPSMPM) was designed and developed with automatic tray feeding, base soil filling, paddy seed filling, top soil filling, leveling, compaction, watering and tray stacking for precisely metering the soil and seed, automatically filling in a single pass into the tray. Process optimization was performed by Inscribed Central Composite Design in Response Surface Methodology for the developed metring units and watering unit. Depth of base soil, quantity of paddy seed, depth of top soil, amount of water spray requirement and coefficient of base soil, paddy seed, top soil and water spray distribution uniformity were taken as response for the optimization. The responses of the machine at its optimal parameter operation were found to be 17.03 mm as depth of base soil, 143.83 g/tray as quantity of paddy seed, 3.98 mm as depth of top soil, 94.48% as coefficient of base soil distribution uniformity, 97.45% as coefficient of paddy seed distribution uniformity, 92.33% as coefficient of top soil distribution uniformity, 1.35 L/tray as amount of water spray requirement and 93.5% as coefficient of water spray uniformity of the machine. Soil organic growing media for mat-type paddy seedling cultivation is considered the best option in the country for its capacity to help proficient and concentrated paddy plant production rapidly and uniformly. The physiochemical properties provided valuable insights for optimizing soil organic growing media composition to enhance the nutrient availability and plant growth. The paddy seedling biometric growth characteristics were found to be superior with soil-organic fertilizer mix treatment (TC_7) containing 50% vermicompost, 30% farmyard manure and 20% soil, filled as base soil (17.5 mm depth) and top soil (4 mm depth) in trays by the developed machine. A maximum paddy seed germination of 94.00±2.38%, paddy seedling height of 17.90±1.88 cm, root shoot ratio of 0.89±0.016, seedling vigour index of 1682.60±122.58, biomass production of 0.484±0.0011 g, and dry matter production of 0.0425±0.0031 g were observed with TC_7 treatment. The mat quality parameters of the trays were recorded at 20 DAS (days after sowing) in nursery. The highest mat thickness was observed to be 28.10±0.05 mm in TC_4 treatment, the lowest mat weight per m^2 area was observed to be 22.30±1.56 kg/m^2 in TC_4 treatment, the highest rolling quality of mat with rolling score was found to be 10.00±0.027 in TC_8 treatment, and the maximum mat strength was found to be 54.90±3.82 kg/m^2 in TC_{10} treatment. The performance of a mechanical transplanter was found to be superior for seedling mats prepared with TC_7 treatment. A maximum planted hills per meter run of 7±1, optimum seedlings per hill of 3, minimum number of missing hills of 1 and maximum plant population per m^2 of 116±5 were found during the transplanting operation using the mats prepared with TC_7 treatment by the developed machine. A maximum grain yield (4280±452 kg/ha), highest grain to straw ratio (0.89±0.0320) and maximum harvest index (0.47±0.0210) were achieved in the crop production using TC_7 treatment prepared by FAPSMPM. The benefit-cost ratio was found to be 4.04 for preparing the nursery by the developed machine whereas it was 1.82 by the manual nursery preparation. The cost of the developed fully automatic seedling mat preparing machine is INR 1,40,000 and it can save about INR 79.20 excluding material cost per hectare for paddy nursery preparation compared to the existing semi-automatic mat preparing machine. The developed machine can be operated by a single person, its capacity is 780 trays/h, weight is 125 kg and its total energy consumption is 4.25 kJ/tray. The performance of the developed FAPSMPM was found to be satisfactory and could be used effectively by paddy farmers and nursery growers raising paddy seedlings.