DESIGN AND DEVELOPMENT OF MECHANICALLY POWERED LIGHT WEIGHT MULCHER CUM ZERO- TILL MULTI CROP PLANTER SUITABLE FOR TERRACE FARMING

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Abstract: The North Eastern Region (NER) of India lies between 21.5° to 29.5° N latitude and 85.5° to 97.5° E longitude and comprises of eight states, viz. Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim. For hilly tracts of NER, powered assisted equipment, animal drawn implements and light weight power tiller equipment have shown greater relevance for increasing the mechanization. Keeping in view of above, a self propelled light weight walk behind type mulcher cum multi-crop planter was designed and developed at College of Agricultural Engineering and Post Harvest Technology (Central Agricultural University, Imphal), Ranipool, Gangtok (India) during 2015. The developed planter was tested in the clay loam soil for planting of pea at 32% (wb) soil moisture. The biomass (paddy residue) was 2730.00 kg ha^{-1}. The actual field capacity was 0.043 ha h^{-1} at 1.21 km h^{-1} average operating speed with 89% field efficiency. The seed rate at 155 mm and 350 mm seed and row spacing respectively was 50.67 kg ha^{-1}. The number of seed per meter length was 06 and average deviation of seed from the center line was 25 mm. The missing hills could not be observed.

Keywords: Self-propelled, Biomass, Field capacity, Missing hills

Introduction: The NEH Region has total geographical area of 26.2 million hectares with total cropped area of 5.4 million hectares. The agricultural production system in the region is mostly rain fed, mono-cropped and at subsistence level. Traditionally farming is done by use of hand tools and animal drawn wooden plough, wooden harrows and wooden bamboo/bamboo leveler/planker. The prevalent power sources of North Eastern Hill (NEH) Region of India are human, animal and walk behind small tractors. Therefore, there is need to develop farm machinery matching to available power sources and topography of the NEH for cultivation and to manage the crop residues and weed biomass especially in terrace cultivation under rain-fed condition. For hilly tracts of NEH region, powered assisted hand tools, animal drawn implements and light weight power tiller equipment have shown greater relevance for increasing the mechanization. As the average land holding size getting smaller, the use of bulky and heavy machinery becomes restrictive. For marginal and small farmers, larger machinery may not be economical and viable.

The share of machinery energy through hand tools and animal drawn implements to the total energy input is 25%–30% of total energy input. It therefore, showed the scope for introduction of small and efficient hand tools for the agricultural operations [1]. Results of most of the research studies show that zero/ minimum tillage practices without crop residue yield limited advantage as the rain-water is generally lost as runoff due to rapid soil surface sealing. Therefore, the need is to identify the type and amount of residues for incorporation in the zero and minimum tillage practices to enhance soil health and efficient use of rain-water [2].

The primary focus of developing and promoting conservation agriculture (CA) practices so far has been around the development and adoption of zero-till seed-cum-fertilizer drill for wheat, mostly in the rice-wheat system. Several researchers have concluded that zero-till wheat yields 3 to 5 percent higher than that for the traditional practices [3,4,5].

Although, efforts have been made in developing and promoting machinery for seeding wheat in zero till systems, successful adoption of CA practices would be useful for developing, standardizing and promoting quality machinery aimed at a range of crops and cropping sequences, permanent bed and furrow planting systems, harvesting operations to manage the crop residues and others specially in terrace cultivation under rain-fed conditions. For hilly tracts of NEH region, mechanically powered knapsack type hand tools, animal drawn implements and light weight power tiller operated equipment may have greater relevance for adoption of CA practices. However, ensuring availability of quality equipment with repair and maintenance services would be more important for promotion of site specific CA practices.

In the study on changes in soil physical properties on sites affected by terracing in the Priorat vineyard region of NE Spain, it has been reported that the changes in soil structure and bulk density together with low organic matter content after transformation have significant influence on some of the soil hydrological properties such as water retention capacity, hydraulic conductivity and aggregate stability. Significant differences have been observed for hydraulic conductivity which was lower in newly terraced vineyards.

Therefore, it was attempted to develop light weight self propelled multi crop planter for seeding under mulch condition for CA practices.

Materials and Method:

Theoretical Considerations: The calculations for power requirement, operating speed, seed rate and spacing, required relative speed of shaft, etc. was done to find out required size of different working components. The required engine rating for design of planter was calculated as below.

Cross sectional area of soil to be cut = 1.5 cm (width of cut) × 3 cm (depth of cut) = 4.5 cm^2

Considering the soil resistance as 1.2 kg/cm^2, the required draft = Soil resistance × cross sectional area

=1.2 kg/cm^2 × 4.5 cm^2

= 5.4 kg = 53.00 N

Since there are two disks, the total draft = 2 × 53.00 N = 106.00 N

Estimated weight of the machine = 35 kg = 343.35 N

Pull required = 106.00 + 343.35 = 449.35 N

× 1.5 (factor of safety) = 674.025 N

Power requirement = pull (N) × speed (kmph) Watts

= 674.025 N × 1.5 kmph

= 1011.03 W = 1.01 kW

Considering the transmission efficiency as 40%, the required power rating of the engine will be 1.01 /0.40 = 2.52 kW. The nearest rating of engine available in the market is 3.3 kW. Therefore, a 3.3 kW engine was selected. The size of sprockets on different shafts and diameter of the ground wheel were calculated to match the normal walking speed (1.5 km/h to 2.0 km/h) and required seed spacing by;

Engine rated speed = 7000 rpm

Speed reduction ratio in the gear box = 50:1

Therefore, the speed of the main shaft on gear box = $\frac{1}{50} \times 7000 = 140\ rpm$

Speed of ground wheel;

Number of teeth of sprocket on main shaft was 12 and on ground wheel shaft was 45

Therefore, speed ratio of main shaft and ground wheel shaft N $= \frac{12}{45} = \frac{1}{3.75}$

$= \frac{1}{3.75} \times 140 = 37.33\ rpm$

The forward speed of the ground wheel V=πDN

Where,

D = Diameter of ground wheel = 300 mm

N = Number of revolution of ground wheel

Therefore, V=3.14 × 0.30 m × 37.33

= 35.16 m/min

= 2.1 km/h

Since the planter will not always be operated at rated speed, the actual forward speed will be less than the 2.1 km/h which will be within the normal walking speed (1.5 to 2.0 km/h) of human.

Calculation for seed spacing: The speed ratio of metering shaft to ground wheel was 1:1. In one revolution, the ground wheel will cover *2πr distance.*

= *2×3.14 × 15 cm* = 94.2 cm

Number of cells on the seed plate = 5

Therefore, seed to seed spacing = *94.2/5* = 18.84 cm

The recommended seed spacing is 20 cm. Therefore, the designed seed spacing is matching to recommended spacing. This spacing can be changed by changing the speed ratio between the ground wheel and seed plate shaft for seeding of different seeds.

Constructional Details of Designed Prototype: The 1020 170 mm frame was made up of 25 x 25 3 mm mild steel (MS) angle. and its was bend at 170 mm from the front side and 200 mm from the rear side to attach the wheel shafts through bearings. The size of the handle (1100 mm) was taken based on the ergonomical data of Sikkim. It was made of 20 mm dia steel pipe. Two power driven ground lugged wheels of diameter 300 mm and two support wheels of diameter 200 mm in the front were fitted. The rotary furrow opener was made from MS flat of size 20 x 3 mm and effective diameter was 185 mm. The seed hopper consists of main seed box, secondary seed box, seed plate, metering shaft and adjustable gate. The hopper was made of acrylic sheet of 3.0 mm thickness. A residue chopper blade of 300 mm dia was attached in the front to cut the weeds/crop residue.

Power Transmission: The power of the engine was taken to gear box through centrifugal type clutch. Chain and sprockets and belt and pulley were used for transmitting power from main shaft to other different shafts. The teeth ratio of the sprockets on main shafts and ground wheel shaft was 1:3.75. The power to the seed metering shaft was transmitted from the ground wheel shaft through chain and sprockets in 1:1 ratio. The power was transmitted to the chopper blade through V-belt and pulley from the input shaft of the gear box (before speed reduction as high speed of the blade was required.). The developed prototype is shown in Fig. 1 and its specification is given in Table 1.

Table 1: Specification of the developed zero -till planter

Name of the machine		Light weight No-Till Multi-crop Planter
Type of the machine		Self- propelled, walk behind
Size of the machine (Length X Width X Height), m		1.0 x 0.4 x 0.95
Type of seed for which the planter is designed		Multi crops
Power source		Petrol engine, 3.3 kW, 4-stroke, single cylinder, 360° mounting, recoil start system, 7000 rpm
Furrow opener	Type of furrow opener	Rotary
	No. of furrow openers	2
	Distance between two furrow openers ,mm	300 -450
Metering mechanism		Cell type

Table 2: Field performance of the developed planter

Sl. No.	Parameter	Value
1	Type of field	Terrace
2	Soil type	Clay loam
3	Moisture content(% wb)	32%
4	Bulk density($g/cm^{3)}$	1.496
5	Biomass (paddy stubble), kg/ha	2730
6	Area of the test plot, m^2	67.5
7	Speed of operation, km/h	1.21
8	Average depth of sowing, mm	30
9	Average seed to seed spacing, mm	155.71
10	Row to row spacing, mm	350
11	Number of seeds per meter length	6
12	Deviation of seeds from the center of row line, mm	25
13	Working width of the planter, m	0.35
14	Theoretical field capacity, ha/h	0.048
15	Actual field capacity, ha/h	0.043
16	Field efficiency, %	89
17	Time required to cover one hectare, h	23
18	Fuel consumption, l/ha	5.3
19	Sowing cost, Rs/ha	1860.00

Fig. 1: Field evaluation of developed planter

Fig. 2: Pea crop after 20 days of sowing by the developed planter

Field Evaluation: The developed planter was tested in the field for planting of pea (Fig 1). Observations were taken for time taken to travel marked distance, cover the marked area, average depth of sowing, fuel consumption, soil bulk density before operation, soil moisture content before operation, number of seeds/m furrow length, and side displacement of seed. The crop stands (Fig 2) was observed after 20 days of sowing. The data were analyzed to find out the operating speed, field capacity etc. and are given in Table 2.

Aiming for the need of mechanized agricultural operation especially in the hill based terraces in North-East India; a small scale No-till planter of dimension (1.0 x 0.4 x 0.95 m weighing 32 kg) was developed. The No-till planter functioned reasonably well in field trails. The average operating speed was 1.21 km/h, sowing depth 30 mm, actual field capacity 0.043 ha/h, field efficiency 89%, cost of pea planting Rs 1860/ha.

Acknowledgment: The authors are deeply indebted to authorities of the Central Agricultural University, Imphal (India) for financing the research and providing the research facilities of the College of Agricultural Engineering and Post-Harvest Technology, Ranipool, Gangtok (India).

References:

1. Dr.V.V. Radhakrishnan,Dr. C. Beena ,Dr.P.V. Sindhu, Evaluation of Neelamari Accessions Dr.M.T. Kanakamany, ; Life Sciences International Research Journal , ISSN 2347-8691, Volume 1 Issue 1 (2014): Pg 105-107
2. Yadav, S. N., R. Chandra, Khura, T. K. and Chauhan, N. S. (2013). Energy input-output analysis and mechanization status for cultivation of rice and maize crops in Sikkim. Agricultural Engineering International: CIGR Journal. 15(3) (2013): 108 -116.
3. Maurya, Swapnilkamble, Saraswati Patel, Padma Deshmukh, Isolation and Characterization of Halophilic Anand; Life Sciences International Research Journal , ISSN 2347-8691, Volume 1 Issue 1 (2014): Pg 108-112
4. *Manderia Sushil , Manderia Krishna,* Indices of Water & Soil in Physico-Chemical & Biological Properties At River Kshipra, Ujjain India; Life Sciences International Research Journal , ISSN 2347-8691, Volume 2 Spl Issue (2015): Pg 30-36
5. Olivier, F. C., and A. Singels (2012). The effect of crop residue layers on evapotranspiration, growth and yield of irrigated sugarcane. *African Journals Online* 38(1) (2012) : 77-86.
6. *Abdulwaheed Adeyemi Bello,* Chemical Composition of Sun–Dried Poultry Droppings; Life Sciences International Research Journal , ISSN 2347-8691, Volume 2 Issue 2 (2015): Pg 40-42
7. Thiagalingam, K., N. P. Dalgliesh, N. S. Gould., R. L. McCown., A. L. Cogle., and A. L. Chapman. Comparison of no-tillage and conventional tillage in the development of sustainable farming systems in the semi-arid tropics. *Animal Production Science.* 36(8) (1996): 995-1002.
8. Neelam Yadav, Hetal Parekh, I. R.Gadhvi, A Study on Diversity of Mangrove Associated ; Life Sciences international Research Journal , ISSN 2347-8691, Volume 2 Issue 1 (2015), Pg 372-375
9. Israil, H., M. A. Sufian., E. Haque., S. Justice. (2006). Development of power tiller operated zero tillage planter for small land holders. *Bangladesh Journal of Agricultural Research.* 31(3) (2006):471-484.
10. *Ch. Mukunda Rao, K. Prasada Rao, R. Ankaiah,* Study on Post-Harvest Cane Quality Deterioration in Sugarcane; Life Sciences International Research Journal , ISSN 2347-8691, Volume 2 Spl Issue (2015): Pg 33-35
11. Salil Singh, Dr. S.K. Jain, Aethroderma Multifidum Reported From Soil of Ujjain; Life Sciences international Research Journal , ISSN 2347-8691, Volume 2 Issue 1 (2015), Pg 376-379
12. He, J., Z. Zhiqiang., L. Hongwen., W. Qingjie (2014). Development of small/medium size no-till and minimum-till seeders in Asia: A review. *International Journal of Agricultural and Biological Engineering.* 7(4)(2014): 1-12
13. *Jayashree Pawar, Dileep Kamat, Sheela Kamat,* A Comparative Study of Ozonated and Non-Ozonated Effluents to Screen Novel Paranitrophenol Degraders; Life Sciences International Research Journal , ISSN 2347-8691, Volume 2 Spl Issue (2015): Pg 83-88

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