A novel tractor operated grass seed harvester developed in India

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Abstract

The demand of green and dry fodder in India is estimated to increase to 1170 and 650 m tonne whereas availability is expected to be at 411.3 and 488 m tonne in 2025, respectively, depicting deficit of about 64.9% green fodder and 24.9% dry fodder (Vision 2030, ICAR - IGFRI, Jhansi, 2011). In forages, availability of quality seed is only 25-30% in cultivated fodder and less than 10 % in range grasses and legumes (Vision 2050, IGFRI). Prices paid for grass seeds of native species vary from Rs.5,000 to 6,500 per kg for clean, un-haired seeds due to excessive use of manual labour in seed collection and removing hairy portion. In order to increase the capacity of collection of grass seeds from standing crop, A tractor operated grass seed harvester was developed under a collaborative research project of Indian Council of Agricultural Research two Institutes viz. Indian Grassland and Fodder Research Institute and Central Institute of Agricultural Engineering, keeping in view the requirements of common grasses used as feed material in Indian context. This grass seed harvester was made using nylon brushes arranged in specific fashion on a rotating cylinder and a winding reel in front of rotating cylinder to collect grass seed from the grasses standing in the fields, where tractor can operate. The specific features of this machine were variable speed of rotating cylinder brush, helical arrangement of brushes on the cylinder to carry the detached seed in to the seed box, variable height of operation and front mounting of the machine on tractor. This machine was tested for seed collection in *Pennisetum pedicellatum* (Dinanath grass), *Cenchrus cilliaris* (Anjan grass) and *Megathyrsus maximum* (Guinea grass). Seed collection capacity of the machine was 4.24 to 7.12 kg/h in Dinanath grass during 2nd operation, 2.10 to 3.56 kg/h in Anjan grass and 1.61 to 3.56 kg/h in Guinea grass at the full maturity of the grass seeds in two passes of the machine in to and fro direction. The field capacity of seed collection operation ranged from 0.21 to 0.47 ha/h for the grasses in which it was operated.

Introduction

Agriculture is the main occupation in India that gives livelihood and profession to more than 70% of the population in India (Anon. 2018). Livestock rearing is an integral part of the agriculture in various farming systems. India is the largest milk producing country in the world with 187.7 million tonne milk production in 2018-19 (Anon. 2020). The demand of green and dry fodder in India is expected to increase to 1170 and 650 m tonne whereas availability is expected to be at 411.3 and 488 m tonne in 2025, respectively, depicting deficit of about 64.9% green fodder and 24.9% dry fodder (Vision 2030, ICAR - IGFRI, Jhansi, 2011). Arable agriculture contributes as a major fodder resource in the form of crop residues which are extensively fed to the animals. Cultivation of forage crops is restricted to irrigated areas and land rich farmers. Sale of green fodder through retail outlets is a common practice. Cultivation of perennial grasses such as Napier and NapierXBajra (*Pennisetum*) hybrid is coming up in considerable way. The area cultivated for fodder amounts to 4% of the total cultivable area being about 8.3 m ha.

Forage crops in general and range grasses and legumes in particular are shy seed producers. In forages, availability of quality seed is only 25-30% in cultivated fodder and less than 10 % in range grasses and legumes (Vision 2050, ICAR - IGFRI, Jhansi, 2015). Prices paid for seeds of native plants vary from Rs.5000 to 6500 per kg due to excessive use of manual labour in collection and defluffing of seed. Manual seed collection involves picking of grass seed manually. Hand picking is full of drudgery and seed yield are low in this method. Therefore, a tractor operated grass seed harvester was developed for harvesting grasses like Dinanath, Cenchrus and Guinea.

Materials and Methods

Morphological properties of selected grasses used as feed material were studied (Trivedi, 2010) and ranking was assigned according to its utility in feeding and need to harvest by grass seed harvester. *Pennisetum pedicellatum* (Dinanath grass) was given as rank 1 for collection of grass seed using tractor operated grass seed harvester.

Prototype

Tractor operated grass seed harvester was made to fit in front of tractor. The height of operation and rotational speed of seed collection cylinder were controlled by hydraulic levers near the driver's seat. A rotary cylinder having brushes arranged in definite fashion was made as seed collection mechanism. A winding reel was made in front of the rotating cylinder to press the crop against the brush to increase the seed detachment. The seed detached by the rotary cylinder was carried by the flow of the wind to the seed collection box behind the rotary cylinder. Table 1 shows the specifications of tractor operated grass seed harvester.

Table 1 Specifications of tractor operated grass seed harvester

Item	Attribute
Power Source	Tractor, 25.8 kW
Position of the seed collection mechanism	In front of tractor
Controls of the harvesting mechanism	From driver's seat
Seed harvesting mechanism	Rotating cylinder and brush
Rotary motion of brush	Hydraulically controlled from tractor seat
Type of brush	Nylon bristle 75 micron thickness
Direction of rotary motion	Upward and downward
Rotary speed of cylinder, rpm	Variable from 50 to 400
Height of operation, mm	Variable from 300 – 1500
Swath of operation, mm	1800

Tractor operated grass seed harvester was operated in standing grass crops Dinanath and Cenchrus. Due to non-synchronous maturity of grass seeds in Dinanath, seed collection was done two times i) at the time when seed started maturing and ii) 20 to 22 days after first operation. In each operation, the machine was operated twice on the same path in to and fro direction. In other grasses the seed collection was done one time at the time of full maturity. The seed collection was done at different rotating drum speed of the brush, reel speeds and forward speed of the machine. Before operation, the seed available in unit area was measured in weight. Seed left in the crop after operation of the machine was measured from the similar area and thus seed collected from unit area was taken at a particular rotational speed and forward speed of the machine. This determined seed collection efficiency of the machine. Trash coming in the box was also measured in weight and it was calculated as the percentage of the seed weight collected in a particular operation. Seed collection capacity of the machine was determined by weighing the seed collected in the box in 5 minutes of operation at a particular rotational speed of seed collection cylinder and forward speed of the machine. These parameters were seen against the reel index of the seed harvesting machine. Seed collected from unit area, matured seed left in crop in unit area, seed collection efficiency (weight wise), trash coming in the box (weight wise) was seen in respect of the reel index. Reel index is defined as

$$i = r \,.\, \omega \,/\, v \qquad \ldots(1)$$

Where,

$$r = radius\ of\ reel, m$$
$$\omega = rotational\ speed\ of\ the\ reel, rad/s$$
$$v = forward\ speed\ of\ the\ machine, m/s$$

During the operation, the engine speed of tractor was set at 1800 rpm with variation of ±3 % and harvesting cylinder brush was operated at different rotational speed. The variation in rotational speed of harvesting cylinder was ±6 % while operation. The radius of the winding reel including brushes was 225 mm. The machine was operated at three forward speed of the tractor being as 2.07, 3.11 and 4.56 km/h in L1, L2 and L3 gears, respectively. The harvesting brush cylinder was operated in upward rotational direction such that the reel was pressing the crop against the brush while operation.

Results and Discussions

Tractor operated grass seed harvester was operated for first time in Dinanath grass when the seed started maturing. The height of operation was kept at 600 mm. The height of operation was taken as the height of the central point of the harvesting brush cylinder from the ground level. Engine speed of tractor was set at 1800 rpm and operation was conducted on 100, 150 and 200 rpm of harvesting brush cylinder as narrated in methodology. Table 2 shows the relation in forward speed of operation, km/h; Speed of rotation of brush, rpm; Speed of rotation of winding reel, rpm ; Reel index; Seed collected from unit area, g; Matured seed left in crop in unit area, g; Collection Efficiency, % (Weight wise); Seed collected in the box in 5 minutes of operation, kg; Trash collected in the box in 5 minutes of operation, kg; Seed collection capacity in the box,

kg/h; Trash coming in the box, % (weight wise) and Effective field capacity, ha/h of the grass seed harvester in first operation in Dinanath crop.

Table 2 Relation of different parameters versus reel index while 1st set of operation in Dinanath grass

Forward speed of operation of tractor	Rotational speed of harvesting brush cylinder	Rotational speed of winding reel	Reel index	Seed collected from unit area of 1 m^2	Matured seed left in unit area of 1 m^2	Collection Efficiency(Weight wise)	Seed collected in the box in 5 minutes of operation	Seed collection capacity in the box	Trash coming in the box (weight wise)	Effective field capacity
km/h	rpm ±6 %	rpm ±6 %		g	g	%	kg	kg/h	%	ha/h
2.07	100	50	2.05	8.4	4.7	64	0.0519	0.623	1.1	0.24
2.07	150	75	3.07	8.6	7.9	52	0.0746	0.895	1.2	0.22
2.07	200	100	4.10	9.2	13.2	41	0.129	1.548	3.2	0.25
3.11	100	50	1.36	8.4	3.3	72	0.1029	1.235	1.2	0.31
3.11	150	75	2.05	12.4	4.8	72	0.2489	2.987	1.1	0.35
3.11	200	100	2.73	12.6	4	76	0.2621	3.145	2.56	0.34
4.56	100	50	0.93	11.4	4	74	0.2047	2.456	3.9	0.4
4.56	150	75	1.40	10.4	3.5	75	0.2586	3.103	5.4	0.41
4.56	200	100	1.86	12.1	5.4	69	0.2603	3.124	6.3	0.43

Fig. 4 shows the relation between reel index and seed collection from unit area, seed left in crop in unit area and trash collected during operation (weight wise). It shows that as the reel index is increasing, the seed collection from unit area is decreasing and seed left in the crop is increasing exponentially and the trash coming in the seed collection box is decreasing slightly. In this case it is beneficial to operate the machine in lower reel index range from 1 to 2. Fig. 5 shows the relation of seed collection capacity and effective field capacity in respect of forward speed of the machine which show that both are increasing with forward speed.

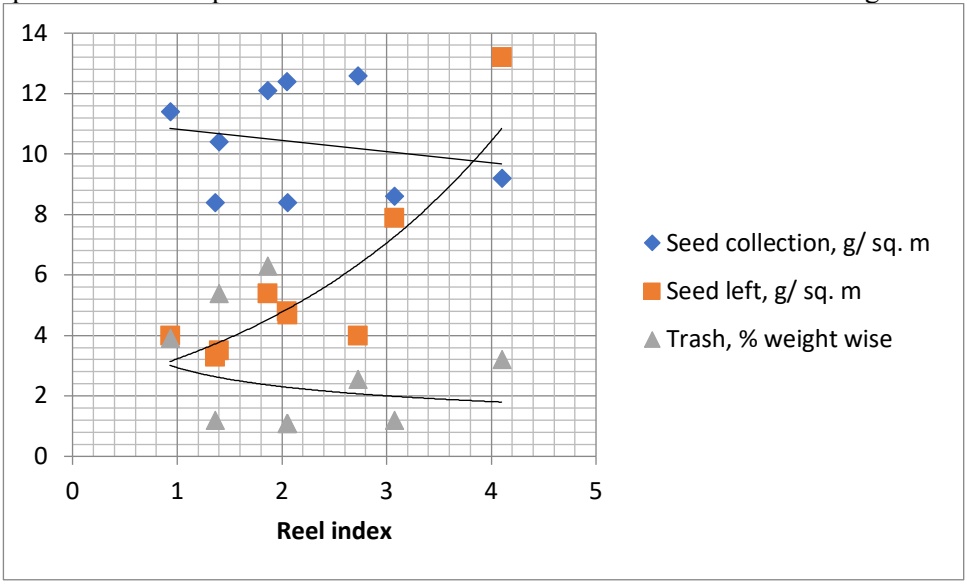

Fig. 4 Relation between reel index and seed collected from unit rea, seed left in the crop in unit area and trash coming in seed collection box during 1st operation of grass seed harvester in Dinanath grass

Stationary operation

In case when the crop is already harvested and kept for drying this machine can be operated while the tractor is in standing condition. This was called as stationary operation of grass seed harvester. In this case the harvesting brush cylinder is given rotary motion and the crop is fed manually to the cylinder so that it touches the rotating brush and the stocks of the crop remain in hands of operator. In case of Dinanath grass seed the harvesting capacity was from 6 to 7 kg per hour when two men used to feed the crop against the

rotating harvesting cylinder. Due to manual feeding of the crop against the cylinder the seed shattering was to the extent of 600 to 700 g per hour that did not go into the seed collection box and shattered outside. This was collected manually from the ground.

Conclusion

A novel tractor operated grass seed harvester was developed that had the seed collection capacity of 4.24 to 7.12 and 2.1 to 3.56 kg/h for Dinanath and Anjan grass, respectively at the full ripening stage of the crop. The field capacity of machine varied from 0.21 to 0.47 ha/h depending upon the forward speed of operation. The height of operation of grass seed harvester was variable from 300 to 1500 mm above ground level and rotary speed of seed collection brush cylinder was variable from 50 to 400 rpm. The height of operation and variable speed of rotary brush cylinder addressed the collection of seeds from different grass crops.

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