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PERFORMANCE EVALUATION OF TRACTOR OPERATED SIX ROW PLANTER-CUM-FERTILIZER DRILL FOR MILLETS and OTHER CROPS

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ABSTRACT

Millets are the most useful grain crops as they are nutritious and can withstand climate changes.Performance evaluation of tractor operated 6 row planter with fertilizer drill for millet –multi crops (CIAE design) were carried out to determine the field efficiency, effective field capacity and time required to plant during years, 2022-23 and 2023-24. The field capacity of the planter was 0.32 hah^{-1} with field efficiency 53.87 percent. The average depth of sowing was 55 mm. The cost of operation of tractor operated millet planter on finger millet crop was found Rs.2084 ha^{-1} whereas in traditional method it was Rs.8283 ha^{-1}. Thus, there was a saving of amount Rs.6199 ha^{-1}. The performance of the tractor operated 6 row planter with fertilizer drill for millet –multi crops (CIAE design) was found satisfactory and economical and can be adopted for millet and other crops (small grains) planting by small land holding farmers.

Keywords: Finger millet, Field capacity, Field efficiency, Millet planter

INTRODUCTION

Millets are a nutritious, climate change-ready crops with highpotential for yielding higher economic returns in marginal conditions in comparison with other cereals even in case of climate change such asharsh temperature conditions (Sadhukhan and Debangshi, 2023). Millets are important but underutilized crops in tropical and semiarid regions of the world due to their greater resistance to pests and diseases, good adaption to a wide range of environments and good yield of production, can withstand significant levels of salinity, short growing season, resistance to water logging, drought tolerance, requires little inputs during growth and with increasing world population and decreasing water supplies represents important crop for future.(Chandra *et al.*, 2016).

Millet is a collective term referring to several small seeded annual grasses, belonging to the botanical family Poaceae, which are cultivated as grain crops, primarily on marginal lands in dry areas in temperate, subtropical and tropical regions. Millets are known as “Nutrition powerhouses” (Paliwal *et al.,* 2023). Despite having various advantages, total area harvested is declining since a few decades. It may be due to the lower cost of the produce, less area under cultivation and

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lower level of mechanization in all production operations. Millets are mostly cultivated during Kharif season in India. According to data from the Agriculture Ministry, three millet crops namelybajra (3.67%), jowar (2.13%), and ragi (0.48%) accounted for nearly 7.00% of the nation's gross cultivated area about 15.48 mllion hectare in 2018 to 2019.

In India, millets are sown by broadcasting and drilling method by traditional implements. The use of such devices results in non-uniform distribution of seeds which results in excess plant population and uneven spacing. Non-uniformity in seed spacing and plant population results in reduced crop yield. Uniformity of seed spacing is an important factor in designing the seed metering device. Besides the design of metering device, there are other operational parameters that affect the precision distribution of seeds. The seed metering device may not singulate seeds and sometimes results in more spacing between plants and overcrowded plants. Broadcasting and drilling methods hinder in intercultural operations and effective weed control. Harvesting operations become more effective if sowing is done in line rather than broadcasting.

The main reasons for reduction in millet production area are more sowing and transplanting time, high labour requirement, small size plots and low level of mechanization. Research targeting mechanized crop production is greatly inclined to highpowered equipment, not easily affordable by small marginal farmers and mostly suited for large grains crops. Mechanized seeders currently available are used for large-seeded crops and cannot be used for finger millet as their metering mechanisms release large quantities of seed in a furrow, necessitating another tedious exercise of thinning.

Since the manual, hand push and animal driven methods of grain planting result in low seed placement, low spacing efficiencies and severe drudgery for the farmers which limit the size of field that can be planted. The design and production of tractor operated planters have eliminated most of the limitations attached to the manual and animal driven methods.

Since millet grains are small in size, it is very difficult to singulate seeds and obtain uniform spacing in rows without much scattering with commonly used fluted roller metering in seed drills. The fluted roller type device is not suitable for metering small seed like millets in general, kodo and little millet in particular due to smaller size and subjected to mechanical damages. Similarly, commonly used metering devices in the planters such as vertical plate, inclined plate and horizontal plate with cells/cups/slots over the periphery also causes the non-uniformity and seed damage (Nandede *et al.,* 2018).

Nandede *et al.* (2018) developed a manually operated single row millet planter-cum-fertilizer drill and reported that for kodo millet average seed spacing, seed rate and coefficient of uniformity of the planter were 5.90 cm, 4.50 kg ha^{-1} and 0.90, respectively. Nandede *et al.* (2018) and Kumar *et al.* (2018),conducted research on performance testing of planters in major crops.However, the above developed machines have their own advantages and limitations for small and marginal farmers. Therefore, considering the above facts, a study was carried out to evaluate the performance of the multi-crop tractor operated planter for small sized seeds like finger millet.

MATERIAL AND METHODS

Specifications of Tractor operated 6 row planter with fertilizer drill for millet and other crops.

Tractor operated 6 row planter with fertilizer drill for millet (CIAE design) consists

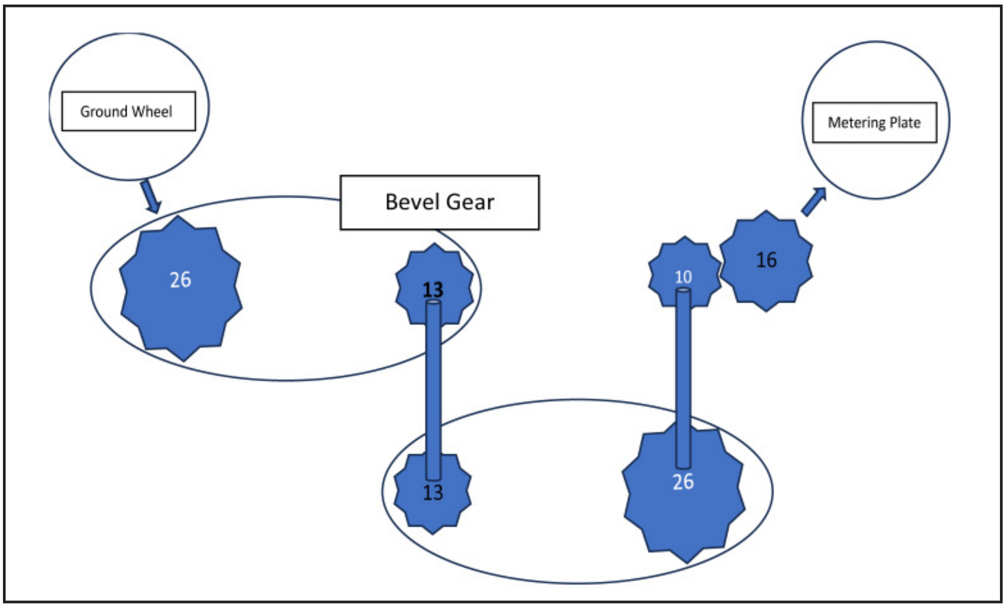


Fig.1. Sprocket setting of Tractor operated 6 row planter with fertilizer drill for millet - multi crops (CIAE design)

of main frame, inclined plate seed metering device, seed hopper, seed tube, fertilizer box, furrow openers and ground drive wheel. Hopper is a storage structure for holding seeds and fertilizers during sowing. Hopper consists of 6 compartments for seeds and fertilizer with 5 kg capacity each. Seed plate has number of holes or cells around its periphery and is exposed to the seed for picking up the seed. Transmission system consists of gear or combination of gear to transmit power from ground wheel to metering disc. It is also used for proper selection of gear ratio for sowing with correct seed rate. It has two ground wheels to provide power through the transmission system to the seed metering plate.Sprocket settings of the planter is as shown in Fig.1.Furrow opener facilitates opening of the furrow in the soil for proper placing of seed. There are six furrow opener of shoe type. Seed tubes are provided at the lower end of the feed cups. They conduct seeds from feed cups to the furrow lines through suitable boots and furrow openers. Main frame is the main supporting structure of seed box, furrow openers and other parts. The specification of tractor operated 6 row planter with fertilizer drill for millet and other crops (CIAE design) is shown in Table 1.

Performance evaluation of the tractor operated 6 row planter with fertilizer drill for millet and other crops.

The planter was tested for its performance in laboratory as well as in the field condition.Before testing the planter in the field, the laboratory testing was carried out. Performance evaluation test of millet planter involved laboratory test to check seed rate and frequency distribution of seed spacing and field performance to evaluate various parameters.

The testing of tractor operated 6 row planter with fertilizer drill for millet and other crops (CIAE design) was carried out for about 2 ha. area at the Research Farm of Birsa Agricultural University, Ranchi (Jharkhand) for 2 years (2022-23 & 2023-24). The experimental field was prepared by using mould board plough followed by secondary

Table 1. Specification of Tractor operated 6 row planter with fertilizer drill for millet and other crops

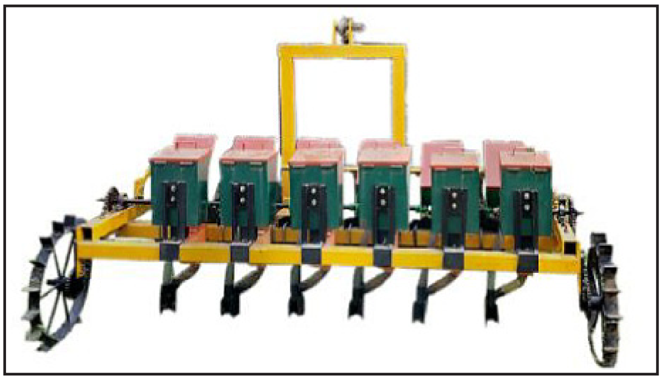
S.No.	Parameter	Specification
1	Power source	33.57kW tractor
2	Overall dimensions	
i	Length (mm)	765
ii	Width (mm)	1800
iii	Height (mm)	1260
iv	Weight (kg)	150
v	Suitability for Crops	Kodo millet, little millet, porso millet, foxtail millet, barnyard millet, finger millet, mustard and jute
3	Furrow openers	Shoetype
(i)	Driver system	Chain and sprocket
(ii)	Transmission ratio (drivewheel axle to metering shaft)	1:2
(iii)	Type of seed and Fertilizer box	inclination angle adjustment system
4	Ground drive wheel	
(i)	Number	One
(ii)	Type	Spiked type
(iii)	Overall diameter (mm)	480
(iv)	Effective diameter (mm)	445
5	Type of hitch	Three point linkage
6	Row to row spacing (mm)	Adjustable
7	Number of rows	6

tillage implements. Field was ploughed twice to obtain a good tilth, destroy weeds, insects and pests; also to mix the crop residues with top soil of the field. The cross ploughing was done by the rotavator. During field operations, different parameters were measured. Systematic view in standing position and during operation of the tractor operated 6 row planter with fertilizer drill for millet crops (CIAE design) is shown in Fig. 2.

During the field study,parameters (seed rate, seed spacing, determination of seed breakage or damage, speed of operation, fuel consumption, actual field capacity, theoretical field capacity, field efficiency, wheel slippage, actual seed to seed spacing, measurement of depth and spacing of seed etc.) were calculated following the Bureau of Indian Standard test code (BIS, 1993).

Economic Analysis

The cost of planter was calculated based on the amount of materials used and the calculated cost incurred in the fabrication. The total cost of the developed power operated rice transplanter was determined by standard procedure guided by Bureau of Indian Standards (BIS, 1979). The cost, time and labour required for the planter were computed.



(a) Tractor operated 6 row planter with fertilizer drill

(b) Sowing and Fertilizer application with Tractor operated 6 row planter with fertilizer drill

Fig.2. Tractor operated 6 row planter with fertilizer drill for millet–multi crops

The life of planter and its use per year were assumed as 10 years and 250 hours, respectively. The fixed cost was calculated by assuming the rates prevailing in the market for mild steels and other materials. The variable cost was worked out by taking the hiring charges prevailing in Jharkhand state for labourers. Cost economics of the planter was compared with traditional method of sowing.

Statistical Analysis

Each experiment was replicated five times. The data sets were processed for analysis of variance as applicable to randomised block design using least significant difference as described by Gomez and Gomez (1984). Treatment means were compared at 5% level of significance. Correlation studies were carried out among the different physical and chemical parameters of soil using Microsoft Excel.

RESULTS AND DISCUSSION

Performance evaluation of Tractor operated 6 row planter with fertilizer drill for milletand other crops

Calibration of planter

For laboratory test, the calibration of planter was done with finger millet seed. The number of holes on metering plate was 42, having a hole diameter of 4 mm, the diameter of ground wheel was 5 cm, spacing between furrow opener were kept 30 cm, it was done manually by adjusting the furrow openers on the main frame. The power transmission to metering mechanism flows according to the sprocket setting as shown in Fig.1 and the transmission ratio was found to be 1.62. Therefore, for the one revolution of ground wheel, metering plate will rotate 1.625 times. The calibration of Tractor operated 6 row planter with fertilizer drill for millet and other crops under laboratory condition is shown in Table 2.

The data obtained from laboratory testing of planter was reported in Table 2. The ground wheel was rotated at constant speed of 1.4 km h^{-1} for 20 revolutions. Seed dropped from each furrow openers were collected and average value was reported. From the Table it was observed that the average seed rate was 16.34 $kgha^{-1}$. The minimum seed rate was 11.01 kg/ha whereas maximum seed rate was 17.76 $kgha^{-1}$. However, the recommended seed rate for manual transplanting is 8kg ha^{-1}. The variation in seed rate could be due to manual error in rotating the ground wheel, non-uniform

Table 2. Laboratory Calibration of Tractor operated 6 row planter with fertilizer drill for millet and other crops

No. of rev	Replication	Time recorded (Minute)	Weight of seed collected from each furrow opener,(g.)						Total seed dropped (g.)	Average seed rate (kg ha^{-1})
			1	2	3	4	5	6		
20	R_1	1.53	10.538	2.500	9.058	12.473	14.038	14.817	63.424	11.01
20	R_2	1:33	14.195	8.432	12.487	30.495	17.044	17.045	99.698	17.31
20	R_3	1:38	13.219	8.047	10.788	30.249	16.556	15.931	94.791	16.46
20	R_4	1:25	13.210	7.501	10.112	30.207	16.223	15.321	92.574	16.07
20	R_5	1:45	12.902	8.082	10.357	28.870	15.909	17.138	93.258	16.19
20	R_6	1:10	12.98	6.243	11.876	28.976	17.594	16.257	93.926	16.31
20	R_7	1:13	13.186	7.358	12.164	31.125	19.024	18.158	101.015	17.54
20	R_8	1:15	11.135	7.053	15.433	30.909	17.151	20.628	102.309	17.76
20	R_9	1:05	9.182	6.254	15.345	30.872	17.553	19.121	98.327	17.07
20	R_{10}	1:09	10.110	8.451	15.168	31.022	18.026	19.145	101.922	17.70
									Average	**16.34**
									Standard Deviation	**0.604**
									CV%	**3.69**

ANOVA

Source	df	Sum of squares	Mean square	F-value	p-value
Replications	9.00	195.025	21.669	3.942	0.00093303*
Treatments.-rows	5.00	2692.977	538.595	97.975	4.9739E-23*
Error(Residual)	45.00	247.377	5.497		
Total sum of squares			3135.379		
Correction factor			14765.640		
T value			2.014		
Standard error difference			1.049		
C.D.			2.112		
Std. dev.(SD)			2.345		
Mean			15.687		
C.V. %			14.946		

Note: SS: Sum of Square; df: degree of freedom; *$p<0.05$: significant. NS: non-significant

seed size, mechanical components error and two or more number of seed picked by inclined plate metering unit. It was also observed that the variation in seed obtained from each seed delivery tube.

The analysis of variance (ANOVA) shows that both replications and treatments had a significant effect on the average seed rate. The effect of replications was statistically significant ($F = 3.942$, $p = 0.00093$), indicating notable variability across different runs. More importantly, the treatment effect was highly significant ($F = 97.975$, $p < 0.00001$), suggesting that different furrow opener rows had a substantial influence on seed distribution. The mean seed rate recorded was 15.687 kg/ha, with a standard deviation of 2.345 and a coefficient of variation (CV) of 14.95%, indicating moderate variability among treatments. The critical difference (CD) at a 5% significance level was calculated as 2.112, suggesting that differences in seed rate greater than this value between treatments are statistically significant. These results confirm that the choice of furrow opener significantly impacts seed delivery uniformity.

Field trial

Testing of planter was conducted in an area of 2 ha.on finger millet crop during years 2022-23 and 2023-24 at the research farm of Birsa Agricultural University, Ranchi, Jharkhand. The seed bed of the field was prepared before hand using cultivator and rotavator prior to experiment date. The speed of operation is affected by the soil condition, draft and the slip produced during operation. The speed of operation was calculated with five replications as discussed above and average speed of operation was found to be 3.30 kmh^{-1}.

The wheel slip is affected by the working depth, soil moisture and tractor speed of operation. The tractive wheel slip and ground wheel slip is shown in Table 3 and Table 4, respectively. The maximum and minimum value of tractive slip was 18.65% and 15.62 %, respectively. Similarly, maximum and minimum value ground wheel slip were reported 3.86% and 1.00 %, respectively. Whereas the average tractive wheel slip and ground wheel slip were found 16.95% and 2.658 %, respectively.

Table 3. Determination of tractive wheel slip of tractor wheel

Replications	No.of rotation	V_a km h^{-1}	Time (S)	Tractive wheel radius (m)	Revolution per minute	V_t, km h^{-1}	Slip,%
i	18	3.5	62	0.634	17.41	4.16	15.94
ii	18.5	3.1	70	0.634	15.85	3.7	18.65
iii	18	3.3	66	0.634	16.36	3.91	15.62
iv	18.5	3.0	72	0.634	15.41	3.68	18.60
v	18	3.5	62	0.634	17.41	4.16	15.94
Average	**18.2**	**3.30**	**66.4**	**0.634**	**16.48**	**3.922**	**16.95**
Std. dev.(SD)	0.27386	0.22803	4.56070	0.00	0.90632	0.23520	1.53473
CV %	1.50473	6.95228	6.86852	0	5.49686	5.99699	9.05446

The statistical analysis of tractive wheel slip across five replications showed an average slip of 16.95%, with a standard deviation of 1.53 and a Coefficient of Variation (CV) of 9.05%, indicating moderate consistency in the slip values. The actual forward speed (Va) averaged 3.28 km/h, while the theoretical speed (Vt) was 3.92 km/h, confirming a consistent slip trend across trials. The constant tractive wheel radius of 0.634 m ensured no structural variation. Low CV values for rotational speed (5.50%) and time (6.87%) further support the stability of operating conditions. The calculated slip values fall within acceptable agronomic limits, validating the reliability of the setup and consistency of traction under field conditions.

The analysis of ground wheel slip for the planter revealed an average slip of 2.66%, with a standard deviation of 1.21 and a high Coefficient of Variation (CV) of 45.55%, indicating notable inconsistency in slip values

Table 4. Determination of ground wheel slip of planter

Replications	No.of rotation	V_a km h^{-1}	Time S	Ground wheel Diameter, m	Revolution per minute	V_t, km h^{-1}	Slip,%
I	38.5	3.5	62	0.51	37.25	3.58	2.23
Ii	38	3.1	70	0.51	32.57	3.13	1.0
Iii	39	3.3	66	0.51	35.27	3.38	2.36
Iv	39	3.0	72	0.51	32.5	3.12	3.84
V	38.2	3.5	62	0.51	37.96	3.64	3.86
Average	38.54	3.30	66.4	0.51	35.11	3.37	2.658
Std. dev.(SD)	0.45607	0.22803	4.56070	0	2.54908	0.24351	1.21067
CV %	1.18337	6.95229	6.86853	0	7.26029	7.22599	45.5481

Table 5. Summarized data of the performance of Tractor operated 6 row planter with fertilizer drill for millet and other crops (CIAE design)

S.No.	Parameter	Tractor operated millet planter (CIAE design)	Traditional method
i	Location	BAU Farm	BAU Farm
ii	Area(ha)	2	-
iii	Crop	Finger Millet	Finger Millet
iv	Average depth of sowing (mm)	45	-
v	Average row spacing (mm)	300	211
vi	Width of coverage (mm)	1800	One row
vii	Average seed rate ($kgha^{-1}$)	16.34	19.12
viii	Average speed of operation (kmh^{-1})	3.30	-
ix	Fuel consumption (lh^{-1})	4.5	-
x	Field efficiency (%)	53.87	
xi	Actual field capacity (hah^{-1})	0.32	-
xii	Wages of labour per day of 8h (Rs day^{-1})	350	350
xiii	Wages of operator per day of 8h (Rs day^{-1})	500	-
xiv	No. of labourers	1	-
xv	No. of operators	1	-
xvi	Man-hour per hectare(hha^{-1})	6.25	200
xvii	Total cost of operation (Rs h^{-1})	629.09	87.50
xviii	Total cost of operation (Rs ha^{-1})	3,883.27	7,050

across replications. The mean actual forward speed (Va) was 3.28 km/h, while the calculated theoretical speed (Vt) was 3.37 km/h, confirming a small but variable slippage. The ground wheel diameter remained constant at 0.51 m, ensuring no dimensional variability (CV = 0%). Other parameters such as revolutions per minute and speed showed moderate variability (CV = 7%). Despite the relatively low average slip percentage, the high CV suggests irregular slip behavior possibly influenced by minor variations in groundwheel interaction. These results imply that while the average performance is within acceptable operational limits, consistency in field traction needs further optimization.

The summarized data of the performance of tractor operated 6 row planter with fertilizer drill for millet crops is shown in Table 5. The planter was tested under field condition in 2 ha area in research farm of Birsa Agricultural University Ranchi, Jharkhand on millet crop. The average depth and width of operation was 45 mm and 300 mm, respectively. The average actual field capacity, average field efficiency and average fuel consumption was 0.32 ha h^{-1}, 53.87 %, and 4.50 l h^{-1}, respectively. It depends on the soil condition, live load on tractor, draft and the experience of tractor driver.

The fixed and variable costs had been considered for the calculation of cost economics of the sowing of millets by the tractor operated 6 row planter with fertilizer drill for millets and other crops. The average labour requirement for planting of millet crop by planter was found 6.25 manh ha^{-1} whereas by traditional method it was 200 man-h ha^{-1}. The cost of operation of tractor operated planter was Rs. 3,883 ha^{-1} whereas by traditional method was Rs. 7,050 ha^{-1}. It shows the tractor operated planter was more efficient, economical and precise than the traditional conventional method as it saves Rs.3,167 ha^{-1}.

CONCLUSION

Field capacity of the tractor operated 6 row planter with fertilizer drill was 0.594 ha/h with field efficiency 53.87% at an average speed of operation 3.30 kmh^{-1}.The average seed rate of the planter on finger millet seeds was 16.34 kg ha^{-1} when compared to traditional manual sowing of 19.12kg ha^{-1}.The average seed to seed distance and average depth of sowing of finger millet seeds were 8.5 cm and 4.5 cm, respectively. The average tractive wheel slippage of the tractor wheel and the average ground wheel of the planter were 16.95 % and 2.65 %, respectively. The cost of operation of tractor operated planter was Rs. 3,883 ha^{-1} whereas by traditional method was Rs. 7,050 ha^{-1}. Thus, there was a saving of amount Rs.3167 ha^{-1}.Based on the experimental studies, it can be concluded that the planter is intended to minimize seed damage during planting while improving metering efficiency and field capacity.

REFERENCES

APEDA. 2021. Country Wise Production Data: Last Five Year. Agricultural and Processed Food Products Export Development Authority (APEDA).https://apeda.gov.in/milletportal/Production.html

APEDA.2022. Agricultural and Processed Food Products Export Development Authority (APEDA). https://apeda.gov.in/milletportal/assets/img/pro2.jpg

Bureau of Indian Standards. 1979. Guide for Estimating Cost of Farm Machinery Operation. IS: 9164-1979: 1-12.

Bureau of Indian Standards. 1993. Sowing equipment seed-cum-fertilizer drillspecification. IS: 6316:1993. https://archive.org/details/gov.in.is.6136.1971.

Chandra, D., Chandra, S., Pallavi and Sharma, A. K. 2016. Review of Finger millet (*Eleusine coracana* (L.) Gaertn): A power house of health benefiting nutrients; Food Science and Human Wellness, 5(3): 149-155.

Gomez, K.A., Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. International Paddy Research Institute Book, John Wiley and Sons, New York, 2nd Ed., 83-4556, pp: 680.

Kumar, A., Mani, I and Singh, J. K. 2018. Performance Evaluation of IARI Wheat Seed-Cum-Fertilizer Plot Drill for Pearl Millet-Wheat Cropping System on Permanent Raised Bed System. Journal of Agricultural Engineering, 55(4): 7-9.

Nandede, B., Sethilkumar, T., Chandel, N and Dhimate, A. 2018. Development of Manually Operated Single Row Millet Planter cum Fertilizer Drill. Indian Journal of Dryland Agricultural Research and Development, 33(1): 1-4.

Paliwal, H., Mishra, I and Warshini, A. 2023. Importance and Benefits of Millets Cultivation in India. Just Agriculture,3 (7): 146-147.

Sadhukhan, A and Debangshi, U. 2023. Millets in Meeting the Nutrition Security - A Review; Just Agriculture: multidisciplinary e- Newsletter, 3(5): 226-227.

Uttam Kumar, Gouarv Sahu, Sushma Kumari, Suman Kumari and Suman Kumar Pandit. 2025. Performance Evaluation of Tractor Operated Six Row Planter-cum-Fertilizer Drill for Millet and other Crops. The Journal of Research, ANGRAU, 53(3): 37-46.