

Ergonomical Evaluation of Existing as well as Modified Sorghum Uprooter

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Abstract: Sorghum (*Sorghum bicolor* L. Monech) is the most important cereal crop grown in India. At present the harvesting of dry land as well as irrigated rabi sorghum in Maharashtra is done manually by uprooting. The harvesting of rabi sorghum is not done by cutting the sorghum stem because sorghum stalk are stored as fodder for cattle up to next year's harvesting and during rainy season there is fungus development at bottom open end of stem during rainy season due to which keeping quality of fodder is affected. The lot of energy is required for uprooting of rabi sorghum. It is cumbersome and laborious. The uprooting of irrigated rabi sorghum develops blister on hand and finally it develop wounds. To overcome the harvesting problem of the sorghum, the manually operated sorghum uprooter was developed for uprooting sorghum which can reduce the drudgery. But there was some technical problem and hence modifications are required in existing uprooter. Based on the feedback of field evaluation and the users, modified sorghum uprooter has been developed. The design of main frame, tyne and uprooter unit is changed in modified uprooter developed. The hinge was provided for attachment of uprooter unit to the main frame to facilitate easy movement of lever. Five tines are attached to foot pedal of uprooting unit for penetration in to the soil and uprooting of stalk. The modified sorghum uprooter was tested for its performance with irrigated and dry land condition. The performance was evaluated at the different crop moisture, different varieties, root length and its effect on uprooting time. The actual field capacity was observed 156.68 m² -h⁻¹ in dry region and 1130.4 m²-h⁻¹ under irrigated condition. Average uprooting time per plant using uprooter for irrigated sorghum and dry sorghum were found to be 10.40 seconds and 5.05 seconds respectively. Under dry land condition, uprooting time was less as compared to irrigated condition. The pull force required to uproot plant has been found to be directly proportional to the taproot length and independent of stalk height and stalk diameter while uprooting time is inversely proportional to the soil moisture.

Keywords: Sorghum, uprooter, ergonomics, field capacity.

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Monech) is the most important cereal crop in the world. It belongs to family gramineae. Nigeria is top most country while India is second largest producing country. Sorghum crop is grown in large area of Deccan plateau of Maharashtra. The crop is grown in two seasons, viz., Kharif and Rabi. Sorghum is a rabi season crop in

Western and Southern India and in Northern India it is grown as Kharif crop. Soils with clay loam or loam texture, having good water retention capacity are favourable for sorghum cultivation. It grows well in pH range of 6.0-8.5 as it tolerates considerable salinity and alkalinity. The hybrid varieties of sorghum are dwarf and short duration of about 100-120 days as compared to the local

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varieties. The recommended hybrid varieties of state and national level are MS-70, CSH-1, CSH-5, CSH-8, CSH-9, PKV-400, PKV-Kranti and SPSH-388. (Agriculture Today, 2013)

Harvesting is the most labour intensive operation followed by weeding operation. This is because of harvesting operation is done by manual method which involves cutting whole stalk of sorghum with sickles and separating ear-heads from stalk.

MATERIAL AND METHODS

Constructional Details of the Sorghum Uprooter

The manually operated whole stalk sorghum uprooter has following parts.

1. Main frame and handle
2. Uprooting unit (tines)
3. Foot paddle
4. Tension Spring
5. Shaft
6. Anchor bar

Heart Rate

The heart rate was measured with the help of polar heart rate monitor (FT 60).

Working of Modified Sorghum Uprooter

The sorghum uprooter is hammered exactly near the stalk just above the soil surface. The anchor bar is inserted into the soil surface just in the line of sorghum plant (parallel) near the stalk. A stationary handle is provided to the uprooter (equipment) at the apex end so as to immerse it in the soil beneath the roots with the help of manual power. After the adoption of above procedure, a foot paddle is pressed by the operator for uprooting and hence the sorghum plant.

Ergonomic Study of Modified Manually Operated Sorghum Uprooter

The performance evaluation study of manually Operated whole stalk sorghum uprooter was conducted at different farmer's field in Solapur

district of Maharashtra and University Farm of MPKV, Rahuri. The tests were analyzed to determine the working of machine, Body Part Discomfort Score (BPDS), heart rate measurement, overall discomfort scale. Ten farmers subjects in the age group of 20 to 50 were selected for the study.

Protocol to Conduct this Experiment with the Subjects

Following points were considered before developing the protocol to conduct this experiment with the subjects.

1. The subjects chosen for the study were physically fit for performing the activities. Subject having age of 20 to 50 years was taken for the study.
2. Subject was given training of using the machine with complete operational techniques involved in it.

Evaluation of Postural Discomfort

1. For the assessment of overall discomfort rating, a 10 point Visual Analogue Discomfort Scale (0- No discomfort, 10- Extreme discomfort) was used (Corlett and Bishop, 1976).
2. A scale having 0 to 10 digits marked on it equidistantly was used. A movable pointer was provided to indicate the rating.
3. At the end of each trial, subject was asked to indicate their overall discomfort rating on the scale. The overall discomfort rating given by each of the subjects were added and averaged to get the mean rating.
4. To measure localized discomfort in Corlett and Bishop (1976) technique. The subject body is divided into 27 regions.
5. Each body region was numbered differently to avoid confusion..
6. The number of different groups of body parts, which are identified, from extreme discomfort to no discomfort represented by a number for intensity level of pain experienced.
7. The maximum number of intensity levels of pain experienced under different treatments were six categories.

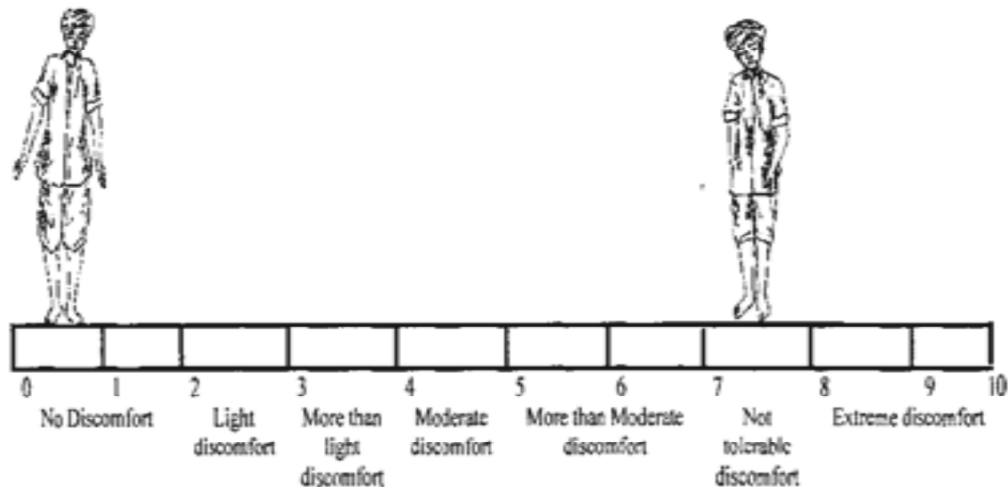


Figure 1: Overall Discomfort scale for sorghum uprooting methods using Corllet and Bishop (1976) technique

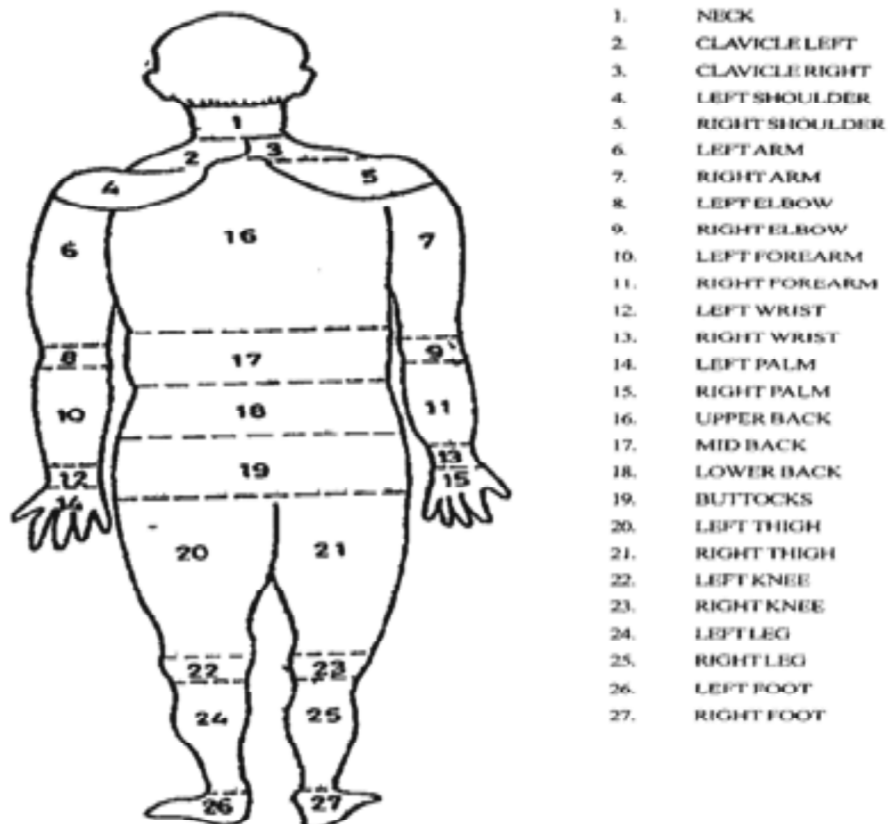


Figure 2: Region for evaluating body part discomfort score using Corllet and Bishop (1976) technique

8. The rating was assigned to these categories in an arithmetic order, viz., 1st category (body parts experiencing maximum pain) rating was allotted as '6' and for 2nd category (body parts experiencing next maximum pain) rating was allotted as '5' and so on, finally for the sixth category (body parts experiencing least pain) rating was allotted as '1'.
9. It was found that the number of intensity levels of pain experienced by different subjects varied. For example, if one subject has experienced '4' categories, 1st category rating was allotted as '6' and for 2nd category rating was allotted as '4.5' and so on for fourth category rating was allotted as '1.5'.

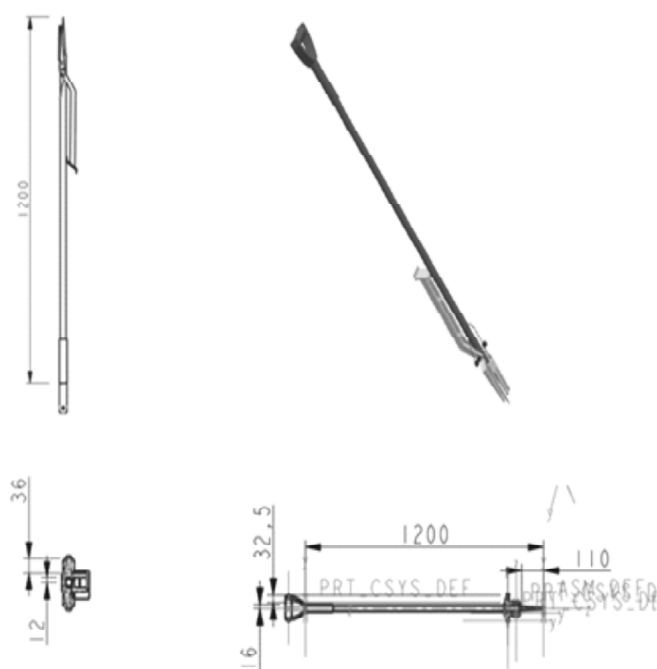


Figure 3: Modified sorghum uprooter

- In order to get an ideal analysis of results after ranking, each data was marked in a numerical way. All the marks were added for each body part. The body discomfort score of all the subjects is added and averaged to get mean score.

RESULT AND DISCUSSION

Ergonomically Test

Ergonomical test were conducted simultaneously with field test on the farmers field at different location in Solapur district. The purpose of this test was to find the suitability of uprooter also for the comparison between manual uprooting method, existing uprooter and modified sorghum uprooter. It also gives the human drudgery relationship in working condition of sorghum uprooting.

Ergonomic Evaluation of Sorghum Uprooter

The ergonomical evaluation of modified sorghum uprooter was carried out at farmers field in Solapur district. The minimum and maximum temperatures were 27 and 29 degree centigrade respectively.

Body Part Discomfort Scores

From Figure 1 and Table 1 body part discomfort rating as reported by the subjects, indicate that most



Figure 4: Measurement of heart rate with polar heart rate monitor

Table 1
BPDS scores during sorghum uprooting operation

Subject	Manual uprooter	Existing sorghum uprooter	Modified sorghum uprooting
S1	37	26	23
S2	36	27	26
S3	38	24	25
S4	40	30	29
S5	36	28	26
S6	30	36	35
S7	32	33	33
S8	37	31	28
S9	39	29	25
S10	41	32	29
Average	36.6	29.6	27.9

frequent body parts reported were lower back, left and right palm, left and right shoulder, left and right arm, left and right thigh. Most of the subject reported maximum discomfort in lower back. The BPDS in case of both type of uprooting has been reported in Table no.1 It was found that the average BPDS score for manual uprooting was 36.6. for existing sorghum uprooter was 29.6 and for modified sorghum uprooter was 27.9. This results are similar according to Solanki *et al.*, (2006).

Overall Discomfort Rating (ODR)

The mean values of ODR of subjects while operating in manual method and with existing as well as

modified sorghum uprooter method are presented in Table 2. The values of ODR were in the range 3 to 9. The value 7.1 indicates 'Not tolerable discomfort' for manual uprooting.

For existing sorghum uprooter the value 5.5 indicates 'more than moderate discomfort'. The value 4.8 indicates 'moderate discomfort' for modified sorghum uprooter. So the ergonomical performance of modified sorghum uprooter is better than existing uprooter and manual method.

Table 2
Mean values of Overall discomforts rating of subjects in operation of sorghum uprooting

Subject	Manual uprooting	Existing sorghum uprooter	Modified sorghum uprooting
No. of subjects	10	10	10
Overall Discomfort Rating (ODR)	7.1	5.5	4.8
Scales	Not tolerable discomfort	More than moderate discomfort	Moderate discomfort

Limit of Continuous Performance (LCP)

The subject wise mean values of resting heart rate, working heart rate and work pulse ("HR) for sorghum uprooting are furnished in Table 3.

The work pulse of the subjects varied from 47.4 to 72.4 bpm while uprooting. The mean value of Δ HR was 69.43 bpm in manual uprooting method which was greater than Limit of Continuous Performance (LCP). The mean value of "HR was 69.43 bpm in existing uprooter method which was greater than Limit of Continuous Performance (LCP).also in modified sorghum uprooter the mean value of Δ HR was 54.49 bpm which was greater than Limit of Continuous Performance (LCP).

CONCLUSIONS

The manually operated whole stalk sorghum uprooter was designed and developed with the objective to perform the sorghum uprooting having function to uproot the stalk. The newly developed implement of sorghum uprooter was tested in the field and its ergonomics evaluation was studied.

Table 3
Mean values of Work pulse (Δ HR) of all subjects while in sorghum uprooting

Subject	Manual method	Existing sorghum uprooter	Modified sorghum uprooting
No. of subjects	10	10	10
Resting HR, bpm	84.45	84.45	84.45
Working HR, bpm	153.88	141.07	138.94
Δ HR, bpm	69.43	56.62	54.49
LCP,40 bpm	> LCP	> LCP	> LCP

The field trials of newly developed implement indicate that it performed the intended function satisfactory with more field capacity observed in case of sorghum uprooter than that of manual method of uprooting in dry region as well as in irrigated region. Based on the analysis of results, the following conclusions are made.

1. The newly developed implement is suitable to any sorghum variety for uprooting.
2. Implement is suitable under rainfed as well as irrigated land for sorghum uprooting.
3. The average BPDS score for manual uprooting is 36.6, for existing uprooter 29.6 and for modified Sorghum uprooter was 27.9. Human drudgery is reduced in modified sorghum uprooter method.
4. The average of ten subjects heart rate for manual method is 153.88 BPM, 141.07 BPM for existing sorghum uprooter and 138.94 BPM for modified Sorghum uprooter.
5. According to Overall discomfort scale, manual method of uprooting indicates not tolerable discomfort, existing uprooter indicate 'more than moderate discomfort' and modified sorghum uprooter indicates 'moderate discomfort'.

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