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Short communication

Comparative performance of different weeding tools in maize

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Maize is considered as the third most important food crop among the cereals in India and contributes to nearly 9% of the national food basket and 5% to world's dietary energy supply. In Bihar, maize is grown in all three seasons with an area of 6.98 lakhs ha, producing 21.11 mt with an average productivity of 3.02 t/ha (Annual report 2012-13). The area under *Rabi* maize is gradually increasing in Bihar due to growing market demand by feed and starch industry and increase in minimum support price. Due to wider row spacing, winter maize suffers from severe competition of weeds resulting in 28-100% yield losses (Patel *et al.* 2006). Besides yield losses, weeds also deplete 30-40% of applied nutrients from soil (Mundra *et al.* 2003). The critical period for crop-weed competition in winter maize varies from 15-60 days after sowing (DAS). Thus, it is imperative to eliminate weeds at proper time with appropriate methods. Manual weeding is one of the most important and highly labour intensive farm operations. Mechanical weeding in maize may minimize the loss from 30 to 10% (Shekhar *et al.* 2010). Now, energy efficient manually operated weeders have been introduced for control of weeds in maize (Tajuddin *et al.* 1991), which are cheaper, more efficient, farmers friendly. The present experiment was conducted to evaluate the performance of different weeding tools and the energy embodied for inter-cultural operation in winter maize.

The experimental trial was conducted at ICAR Research Complex for Eastern Region, Patna (25^o 35.485 N latitude and 85^o 04.951 E longitude) during *Rabi* season of 2015-16 under irrigated ecosystem of Eastern Indo-Gangetic Plan zone. The climate of the experimental site was sub-tropical in nature exhibiting high humidity and medium rainfall. The soil of the experimental plot was clay loam (sand: 23.69%, silt: 39.64% and clay: 37.0%) The maize *'Pioneer hybrid-30R77'* (135 days duration) was sown on 28 December 2015. The crop was dibbled seeded at 18.75 kg/ha at a spacing of 50 × 20 cm. The weed samples *viz*. weed density/m^2 was recorded with using a quadrate of 1×1 m at 45 DAS. The moisture content in soil was recorded at weeding time before using the weeding tools from 0-15 and 15-30 cm soil depth. Mean moisture content of the experimental plot varied from 12.7-17.5%. The monthly mean maximum and minimum temperature during the crop growing period ranged from 22.17 ^{0}C- 32.69 ^{0}C and 8.72 ^{0}C-18.31 ^{0}C, respectively. The experiment was conducted in completely randomized block design with four replications. The weeding implements evaluated were: 'khurpi', (a to small tool for gardening) spade, grubber and wheel hoe. The weeding efficiency, field efficiency and field capacity were measured with standard formula and procedures given as follows:

Weed control efficiency was calculated by using equation.

$$\text{Weed control efficiency (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where, W_1 = number of weeds before weeding, W_2 = number of weeds after weeding

The field efficiency is the ratio of the effective field capacity to the theoretical field capacity and it is expressed in per cent

$$\text{Field efficiency (\%)} = \frac{\text{effective field capacity}}{\text{theoretical field capacity}} \times 100$$

$$\text{Field capacity} = \frac{W \times S}{10} \times \frac{E}{10}$$

Where, W = theoretical width of cut in meter

S = speed of travel in kilometer per hour, E = field efficiency in percent

Weed flora

The weed flora of the experimental plot was diverse in nature and the major weeds associated with crops were *Chenopodium album*, *Solanum nigrum*,

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Rumex dentatatus, *Cynodon dactylon*, *Cyperus iria* and *Euphorbia hirta*. Crop was mostly affected with broad-leaved weeds (84%) followed by grasses (11%) and sedges (5%). Maximum weed control efficiency was found with 'khurpi' (93.1%) followed by grubber (81.9%), spade (75.5%) and wheel hoe (72.2%) (Table 1). The maximum weeding efficiency with 'khurpi' was because of its capability to work between and within the rows. However, the wheel hoe and grubber cannot be used for removing the weeds within the rows. This might be the reason for lower weeding efficiency of these tools as compared to 'khurpi'. The grubber, wheel hoe and spade has the capacity to till the soil to the desired depth, therefore, it works much better between two rows for weeds control. But spade may cause damage to crop plant, if it is brought nearer to the rows. Because of this limitation of these implement, it gave lower weeding efficiency as compared to 'khurpi'. Similar results were also obtained by Shekhar *et al.* (2010).

Table 1. Effect of weeding tools on weed flora

Weeding tool	Initial weed density (no.)	Final weed density (no.)	Reduction in weed density (no.)	Weed control efficiency (%)
Khurpi	72.11	5.10	67.0	92.9
Grubber	77.20	14.11	63.9	82.8
Spade	74.33	18.13	56.2	75.7
Wheel hoe	70.42	19.12	51.3	72.9

The involvement of man power was also examined with respect to different weeding tools used in controlling the weeds of maize and it was noted that 'khurpi' consumed the maximum man days/ha (36.2) followed by spade (28.3), grubber (13.56) and wheel hoe (10.67). This might be due to more number of man power engaged for making the plot free from weeds in the respective treatment.

The field efficiency (Fig.1) was found maximum for 'khurpi' (84.18%) followed by grubber (81.02) spade (76.47%) and wheel hoe (77.26%). Similar results were found by other author also Shekhar *et al.* (2010). The higher field efficiency of hand tools were because of the minimum time loss such as turning time and other time during operation.

The Field capacity of wheel hoe was found to be 0.008 ha/hr followed by grubber (0.004 ha/hr), Khurpi (0.001 ha/hr) and spade (0.0002 ha/hr), respectively. Garg and Sharma (1998) reported that area coverage with wheel hand hoe in wheat crop was 0.36 ha/day, which was much faster than 'khurpi' 0.064 ha/day. The wide difference in field capacity of different implements is because of the width of soil cutting parts *i.e.* blade of the implement

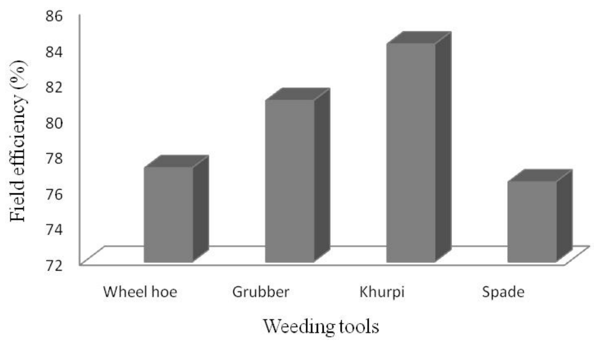

Fig. 1. Field efficiency under different weeding tools

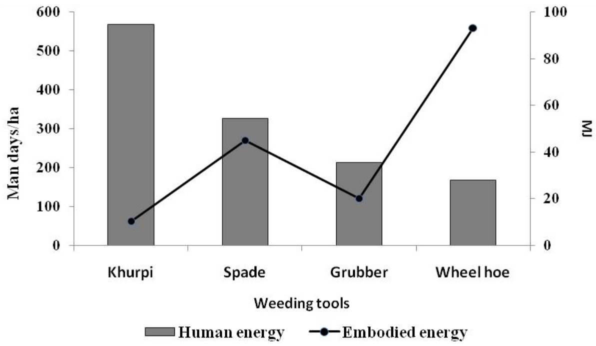

Fig. 2. Human energy *versus* embodied energy

as well as forward speed. Wheel hoe facilitates the worker to provide easy push and pull action to the implement as compare to the grubber. Distribution of embodied energy for different weeding tools in *Rabi* maize is shown in Table 2. It is clearly indicated that the highest embodied energy was found in case of wheel hoe (93.18MJ) followed by spade (45.05 MJ), grubber (20.17 MJ) and 'khurpi' (10.51MJ). The human energy requirement in different weeding tools operation is also shown in Table 3. The highest human energy was consumed by 'khurpi' (567.62 MJ/ha) followed by spade **(**326.62 MJ/ha), grubber **(**212.62 MJ/ha) and hand wheel hoe (167.30 MJ/ha), respectively. Among different weeding tools, wheel hoe had the highest embodied energy and resulting in lowest requirement of human energy. Wheel hoe was not only proved efficient but also useful in completing the weeding in lesser time. It is concluded that human energy can be saved by replacing energy efficient implements.

The human energy (98%) consumed maximum in case of 'khurpi' and the minimum in case of 'wheel hoe' (64%), while, wheel hoe consumed less human energy for using improved implements (Fig. 2).

It may be concluded that in future, the availability of labour for weeding operation will be a great problem due to rapid urbanization and migration of labours. Hence, the weeding tools like grubber and wheel hoe may be promoted for efficient weed control in winter maize.

Table 2. Distribution of embodied energy for different weeding tools in spring maize

Item	Total quantity	Weight (g)	Embodied energy (MJ/kg)	Total embodied energy (MJ)
Khurpi				
Metal plate	01	297.1	27.73	8.24
Plastic handle grip	01	25.2	90	2.27
Total				10.51
Spade				
Metal plate	01	1357	27.73	37.63
Hard wooden Boom	01	390	18.9	7.42
Total				45.05
Grubber				
Furrow -metal	03	715	27.73	19.83
Bamboo rod	01	526.8	0.5	0.26
Screw(1/2")	03	2.7	31.06	0.084
Total				20.17
Hand wheel hoe				
Metal furrow	03	692.6	27.73	19.20
Plastic handle grip	02	100.8	90	9.07
Wheel washer (plastic)	02	13.6	90	1.22
Wheel nut rod	01	70.9	32.0	2.27
Wheel bolt	08	54.1	32.0	1.73
Plastic wheel	01	663.3	90	59.69
Total				93.18

(Anonymous, 2016 and Hetz 1998)

Table 3. Human energy requirement for different weeding tools in spring maize

Items	Human (man-hr/ha)	Energy equivalent (MJ)	Energy requirement (MJ/ha)
Khurpi	289.6	1.96	567.6
Spade	166.6	1.96	326.6
Grubber	108.5	1.96	212.6
Hand wheel hoe	85.4	1.96	167.3

(Ref: Mandal *et al.* 2002 and De *et al.* 2001)

SUMMARY

A field experiment on weeding tools was conducted at farm of ICAR Research Complex for Eastern Region Patna during the *Rabi* season of 2015-16. Results revealed that treatment such as 'khurpi' was recorded the highest weed control efficiency (92.9%) followed by grubber (82.8%), spade (75.5%) and wheel hoe (72.2%). The highest human energy was also attained in case of 'khurpi' (567.62 MJ/ha) followed by spade (326.62 MJ/ha), grubber (212.62 MJ/ha) and wheel hoe (167.30 MJ/ha). The highest embodied energy was found in wheel hoe (93.18 MJ) followed by spade (45.05 MJ), grubber (20.17 MJ) and 'khurpi' (10.51 MJ). The field capacity of wheel hoe was found maximum (0.008 ha/hr) where as spade was minimum (0.0002 ha/hr). Hence, the wheel hoe was found to be the most efficient and cost effective weeding tool.

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