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Effect of speed of operation on performance of tractor drawn rotary spider weeder

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ABSTRACT

Weeding is an important, but, equally labour intensive agricultural operation. Mechanical weed control is very effective as it helps to reduce drudgery involved in manual weeding, it kills the weeds and also keeps the soil surface loose ensuring soil aeration and water intake capacity. Rotary type weeder stirs the soil more accurately, disturb the weed root and remove them from the soil and pulverize the soil effectively. Hence, a tractor drawn rotary spider weeder was developed and evaluated its performance under different moisture levels and different speeds for Cotton, Chillies and Maize. The rate of increase in weeding efficiency was increased with the increase of moisture content and also with the increase of forward speeds. At all the moisture levels and at all forward speeds, the plant damage was higher at 45 DAS when compared to 30 DAS in all the crops. Performance index increased with the increase of forward speed at all levels of soil moisture content both at 30 and 45 DAS in all the crops.

Key words: *performance, rotary spider weeder, soil moisture, tractor speed, Weed.*

Weeding is the removal of unwanted plants in the crops. Weeds are mostly removed from the field by manual process as they are seen more as a negative factor for crop growth.Various aspects of weeding equipments consist of ergonomical considerations, ease of handling by unskilled farmers, extent of ease of damage to crops, row spacing and efficiency.The 33 percent cost of cultivation is spent on weeding alone when carried out with the manual labour(Tajuddin and Job, 1997).

Intercultural operation in dryland crops aim at not only to remove the weeds, but also, to create soil mulch that would conserve soil moisture. Though manual and bullock drawn weeding methods are existing, the availability, efficiency and prevailing operational costs discourage the farmers to take up these methods. Availability of optimum moisture content in the soil is highly essential for effective weeding operation. In rain fed areas, the availability of enough labour and bullock power for weeding operations does not synchronize with the ideal rainy days. Hence, majority of the farmers could not complete the weeding operation in time.

Tractor operated weeding implements can save about 75 per cent time and 20 per cent cost as compared to bullock drawn methods(Rathod*et al.* 2010).Usually tractor mounted cultivators are used for weeding and inter-cultural operations in farm, but, these are not effective for soil pulverization. Rotary type weeder stirs the soil more accurately, disturb the weed root and remove them from the soil and pulverize the soil effectively. In addition, this helps in keeping the soil in loose condition for proper aerationand results in better aeration and runoff water conservation,especially for wide row spaced crops like cotton and maizewhere the tractor can be run. Keeping in view the above factors, an investigation was taken up to evaluate performance of developed tractor drawn rotary spider weeder for irrigated dry row crops.

MATERIAL AND METHODS

The aim of research work was to evaluate performance of developed spider weeder at forward speeds of 0.56, 1.11, 1.67 and 2.22 ms^{-1} at 10, 15 and 20 per cent soil moisture levels for Cotton, Maize and Chilli. Spider weeder was evaluated for its weeding efficiency, plant damage, field capacityand performance index.

Weeding Efficiency:

Weeding efficiency is a ratio between the number of weeds removed by a weeder to the no. of weeds present in an unit area and expressed as percentage (Anonymous, 1983). Number of weeds before and after the each test was counted and replicate thrice and average was calculated at all forward speeds of 0.56, 1.11, 1.67 and 2.228 ms^{-1} at 20, 15 and 10 per cent soil moisture levels for all three crops.

$$\text{Weeding Efficiency (\%)} = \frac{W_1 - W_2}{W_1} \times 100 \quad ....(1)$$

Where,

W_1 = Number of weeds before weeding

W_2 = Number of weeds after weeding

Plant Damage:

It is the ratio between the number of damaged plants in a row to the number of plants present and expressed in percentage. Number of plants in a 10 m row length were recorded before and after operation and replicated thrice and average plant damage percentage was calculated at all forward speeds of 0.56, 1.11, 1.67 and 2.228 ms^{-1} at 20, 15 and 10 per cent soil moisture levels for all three crops.

Plant damage, (%) = {1 - (q / p)} x 100 ......(2)

Where,

q = Number of plants left in a 10 m row length after weeding

p = Number of plants in a 10 m row length before weeding

Field capacity

It is the actual area covered by the machine based on its total time consumed and actual working width under field condition. It is expressed as in terms of area covered per unit time of operation. It can be calculated by formula,

Field capacity ($ha\ h^{-1}$) = Actual area covered/total time consumed ....(3)

Performance index of weeder

Performance of the weeder was assessed through performance index (PI) by using the following relation as suggested by Srinivas*et al.* (2010):

PI = FC X (100 - PD) X WE .... (4)

Where,

FC = Field capacity, $ha\ h^{-1}$,

PD = Plant damage, per cent,

WE = Weeding efficiency, per cent, an

P = Power, HP

Results and Discussion:

Performance evaluation of rotary spider weeder

The performance evaluation of developed tractor drawn rotary spider weeder was conducted on three crops namely Cotton, Maize and Chillies in terms of performance indicators, energy consumption and cost economics of weeder and results were discussed.

Effect of selected levels of variables on weeding efficiency

The influence of different forward speeds of operation at different soil moisture content on weeding efficiency for Cotton, Maize and Chillies at 30 and 45 days after sowing was observed.

Effect of soil and machine operational parameters on weeding efficiency in Cotton

The weeding efficiency for different treatment combinations is shown in Fig. 1.It was observed that the weeding efficiency increased with the increase of soil moisture content at all levels of forward speeds. The rate of increase in weeding efficiency was increased with the increase of moisture content and also with the increase of forward speeds. This is mainly due to retiling action of the rotary blades at higher forward speeds due to reduction in bite length (Beeny and Khoo, 1970; Chamen, 1979). It was also observed that the weeding efficiency increased at all soil moisture levels at 30 DAS. It was also observed that the weeding efficiency increased significantly when the forward speed increased from 0.56 $ms^{-1}$to 1.11 ms^{-1}.The lower weeding efficiencies obtained at all soil moisture levels at forward speed of 0.56 $ms^{-1}$is mainly due to lower interaction between soil and the tool. It was observed that the weeding efficiency was almost constant for further increase of forward speed from 1.11 to 2.22 ms^{-1}.

The same trend was observed at 45 DAS. However, weeding efficiency was found to be higher at all the moisture content levels and at all forward speeds comparatively. This is mainly due to the weeding path created in previous operation.

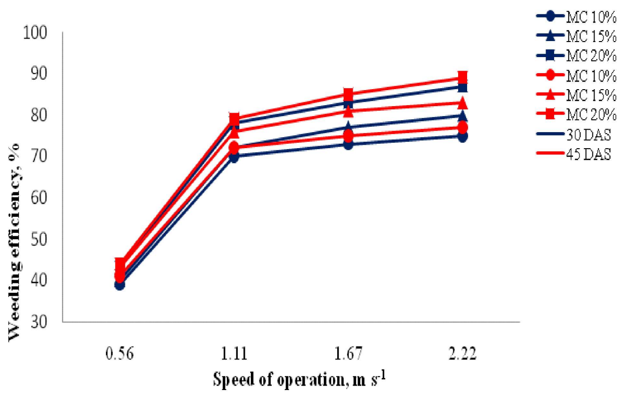

Fig. 1.Effect of soil and machine operational parameters on weeding efficiency in Cotton

Effect of soil and machine operational parameters on weeding efficiency in Maize

The weeding efficiency for different treatment combinations is shown in Fig. 2. It was observed that the weeding efficiency increased with the increase of soil moisture content at all levels of forward speeds. The rate of increase in weeding efficiency was increased with the increase of moisture content and also with the increase of forward speeds. This is mainly due to retiling action of the rotary blades at higher forward speeds due to reduction in bite length (Chamen, 1979). It was also observed that the weeding efficiency increased at all soil moisture levels at 30 DAS.

It was also observed that the weeding efficiency increased significantly from 40 to 72, 42 to 74 and 45 to 80 percent when the forward speed increased from 0.56 ms^{-1} to 1.11ms^{-1} at 10, 15 and 20 percent moisture levels, respectively. It was observed that the weeding efficiency was almost constant for further increase of forward speed from 1.11 to 2.22 ms^{-1}. The same trend was observed at 45 DAS. However, weeding efficiency was found to be higher at all the moisture content levels and at all forward speeds comparatively. This is mainly due to the weeding path created in previous operation.

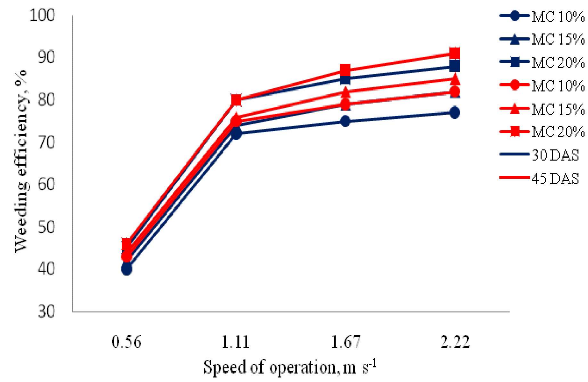

Fig. 2.Effect of soil and machine operational parameters on weeding efficiency in Maize

Effect of soil and machine operational parameters on weeding efficiency inChillies

The weeding efficiency for different treatment combinations is shown in Fig. 3.It was observed that the weeding efficiency increased with the increase of soil moisture content at all levels of forward speeds. The rate of increase in weeding efficiency was increased with the increase of moisture content and also with the increase of forward speeds. This is mainly due to retiling action of the rotary blades at higher forward speeds due to reduction in bite length (Chamen, 1979). It was also observed that the weeding efficiency increased at all soil moisture levels at 30 DAS.

It was also observed that the weeding efficiency increased significantly from 41 to 74, 42 to 75 and 44 to 77 per cent when the forward speed increased from 0.56 $ms^{-1}$to 1.11 ms^{-1}at 10, 15 and 20 per cent moisture levels, respectively. It was observed that the weeding efficiency was almost constant for further increase of forward speed from 1.11 to 2.22 ms^{-1}. However, the increase in the rate of weeding efficiencies were 3.9, 5.0 and 8.3 percent when forward speed increased from of 1.11 to 1.67 ms^{-1} at 10, 15 and 20 per cent soil moisture levels, respectively. The rate of increase was 2.5, 5.9 and 6.6 percent when forward speed increased from of 1.67 to 2.22 ms^{-1} at 10, 15 and 20 per cent soil moisture levels, respectively. The same trend was observed at 45 DAS.

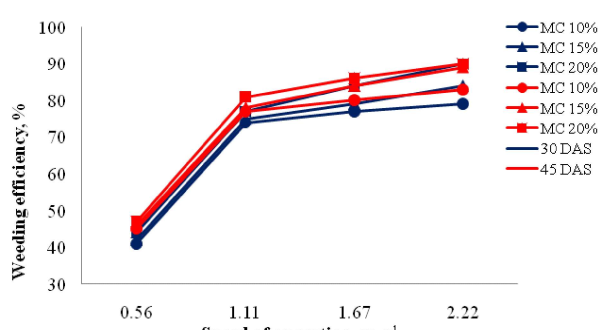

Fig. 3 Effect of soil and machine operational parameters on weeding efficiency in Chilies

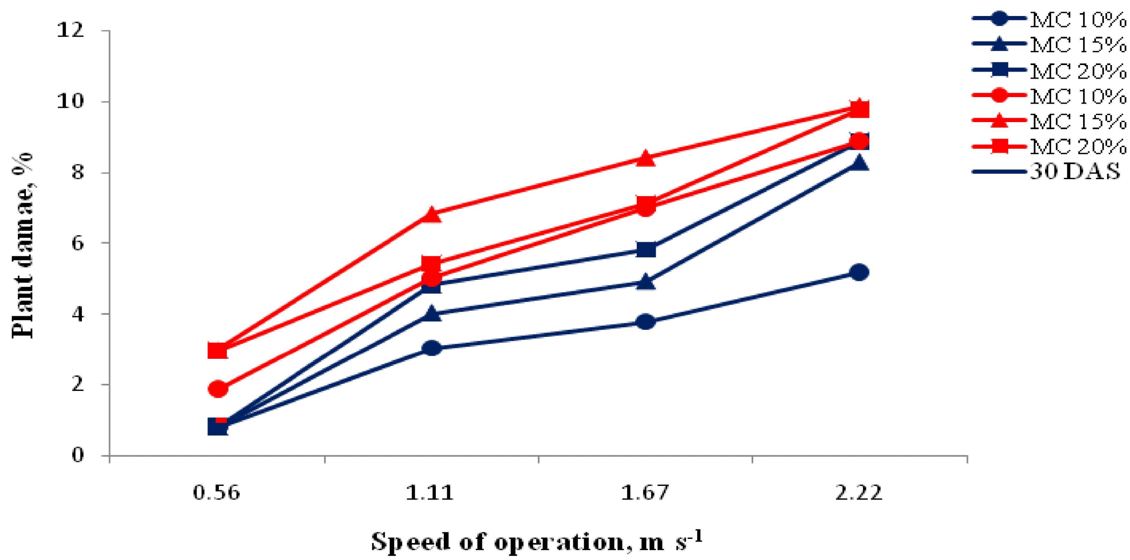

Fig. 4.Effect of soil and machine operational parameters on plant damage in Cotton

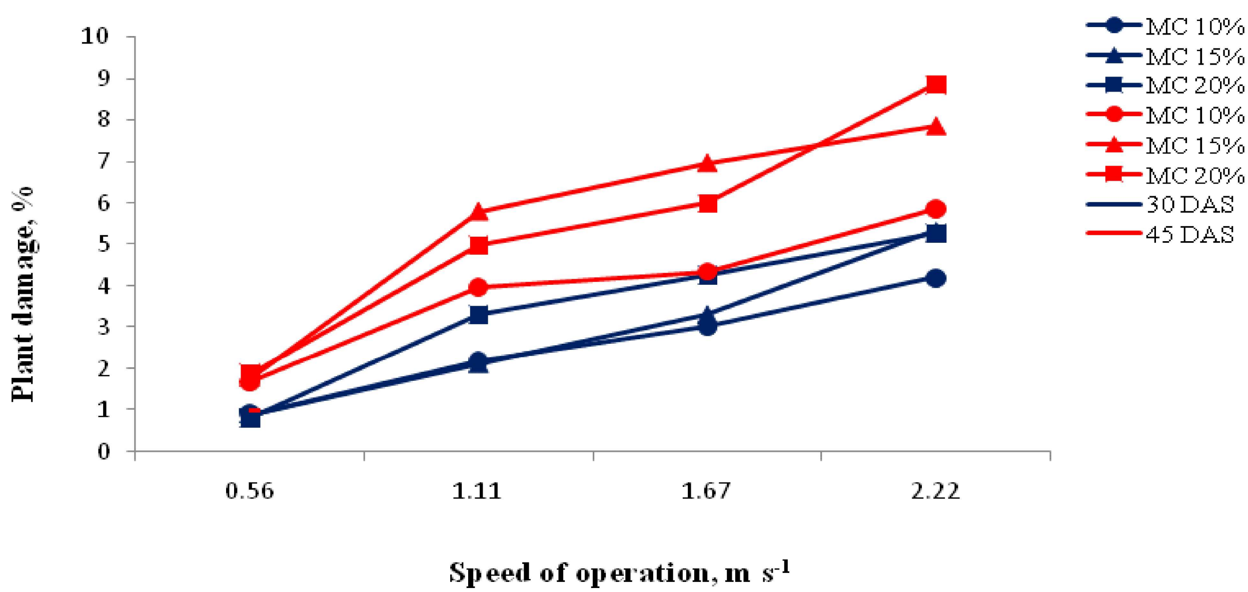

Fig.5 Effect of soil and machine operational parameters on plant damage in Maize

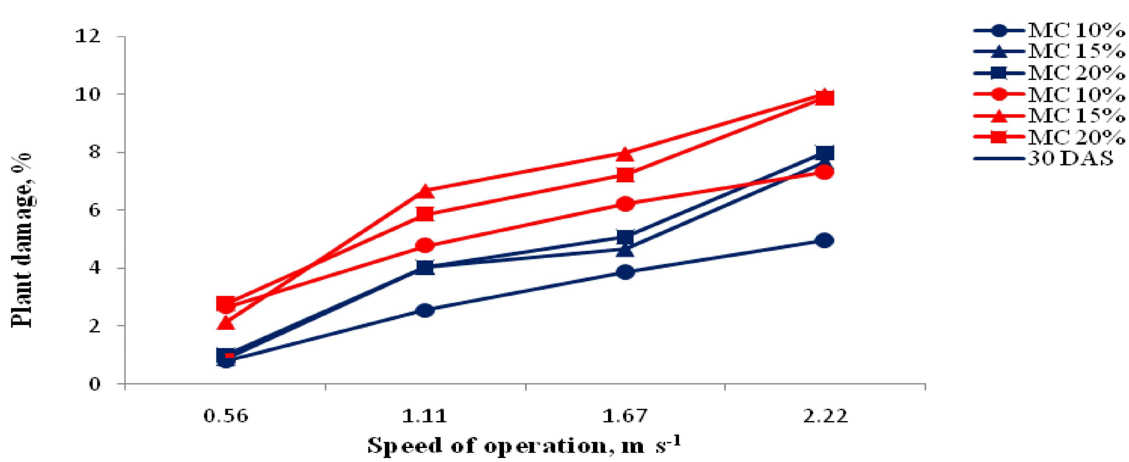

Fig.6.Effect of soil and machine operational parameters on plant damage in Chillies

Table 1.Effect of soil and machine operational parameters on field capacity of weeder

Moisture content (%)	speed of operation ($m\ s^{-1}$)	Field Capacity (ha^{-1})					
		30 days after sowing			45 days after sowing		
		Cotton	Maize	Chillies	Cotton	Maize	Chillies
10	0.56	0.326	0.322	0.319	0.312	0.319	0.316
	1.11	0.647	0.639	0.632	0.611	0.618	0.619
	1.67	0.973	0.962	0.951	0.929	0.919	0.922
	2.22	1.294	1.279	1.266	1.294	1.237	1.253
15	0.56	0.313	0.315	0.313	0.306	0.305	0.306
	1.11	0.625	0.627	0.619	0.613	0.614	0.614
	1.67	0.941	0.920	0.930	0.932	0.923	0.921
	2.22	1.280	1.260	1.225	1.255	1.234	1.212
20	0.56	0.309	0.312	0.309	0.310	0.308	0.306
	1.11	0.618	0.612	0.611	0.612	0.606	0.604
	1.67	0.930	0.911	0.903	0.920	0.902	0.899
	2.22	1.265	1.239	1.238	1.252	1.227	1.225

Table 2.Effect of soil and machine operational parameters on performance index

Moisture content (%)	speed of operation ($m\ s^{-1}$)	Performance index of weeder					
		30 days after sowing			45 days after sowing		
		Cotton	Maize	Chillies	Cotton	Maize	Chillies
10	0.56	28.25	28.62	29.06	27.90	29.18	30.61
	1.11	95.07	98.62	98.99	92.84	96.77	100.85
	1.67	151.86	153.97	155.64	144.01	154.32	153.70
	2.22	204.47	209.64	211.19	201.73	212.18	214.19
15	0.56	28.82	29.40	29.21	28.37	29.67	30.76
	1.11	98.95	100.92	101.27	96.46	98.08	101.32
	1.67	153.08	156.15	156.41	153.62	156.47	158.24
	2.22	208.69	217.34	211.23	208.58	214.77	215.76
20	0.56	29.53	31.20	30.21	29.41	30.89	31.07
	1.11	101.95	105.21	100.35	101.61	102.37	102.34
	1.67	161.53	164.75	159.98	161.39	163.94	159.39
	2.22	222.82	229.52	227.82	223.38	226.14	220.79

Effect of soil and machine operational parameters on plant damage in Cotton

The plant damage for different treatment combinations is shown in Fig. 4.It was observed that the plant damage increased with the increase of forward speed at all levels of soil moisture content. The rate of plant damage increased with the increase of forward speed.

The plant damage per cent was higher at higher forward speed of the tool. This is mainly due to the impact action of the rotary tynes to the tender plant branches. It was also observed that the plant damage percentage was more at 45 DAS when compared to 30 DAS. This is mainly due to the larger canopy of the cotton plant.

Effect of soil and machine operational parameters on plant damage in Maize

The plant damage for different treatment combinations is shown in Fig. 5.It was observed that the plant damage increased with the increase of forward speed at all levels of soil moisture content. The rate of plant damage increased with the increase of forward speed.

It was observed that there was no plant damage at a forward speed of 0.56 ms^{-1}at all soil moisture levels at 30 DAS. The plant damage percent was higher at higher forward speed of the tool. This is mainly due to the impact action of the rotary tynes to the tender plant branches. It was also observed that the plant damage percentage was more at 45 DAS when compared to 30 DAS. This is mainly due to the larger canopy of the cotton plant. The percentage of plant damage is comparatively low in maize crop at forward speeds and soil moisture levels compared to cotton and chilies both at 30 and 45 DAS. This is mainly due to erect and non-branching characteristics of maize crop.

Effect of soil and machine operational parameters on plant damage inChillies

The plant damage for different treatment combinations is shown in Fig. 6.It was observed that the plant damage increased with the increase of forward speed at all levels of soil moisture content. The rate of plant damage increased with the increase of forward speed.

The plant damage per cent was higher at higher forward speed of the tool. This is mainly due to the impact action of the rotary tynes to the tender plant leaves. It was also observed that the plant damage percentage was more at 45 DAS when compared to 30 DAS was mainly due to the larger canopy of the chilies.

Effect of soil and machine operational parameters on field capacity of the weeder

The influence of soil and machine operational parameters on field capacity for 30 and 45 DAS on Cotton, Maize and Chillies was summarized in Table 1. It was observed that the field capacity increased with the increase of forward speed at all levels of soil moisture content whereas the field capacity of the tool decreased as the soil moisture level increased in all the treatments. This may be due to the frequent sliding of tyne under higher moisture condition. This was more pronounced/prominent at 20 percent soil moisture level in all the crops. The same trend was observed at 45 DAS at all levels of soil moisture content and forward speeds in all the crops.

Effect of soil and machine operational parameters on performance index

The effect of soil and machine operational parameters on performance index of weederfor 30 and 45 DAS on cotton, maize and chillies was shown in Table 2. Performance index of the weeder is directly related to the field capacity, plant damage, weeding efficiency and inversely related to power exerted. It was observed that the performance index increased with the increase of forward speed at all levels of soil moisture content whereas the performance index of the weeder increased as the soil moisture level increased in all the treatments, because of high weeding efficiency at higher speeds. The same trend was observed at 45 DAS at all levels of soil moisture content and forward speeds in all the crops.

CONCLUSION

The weeding efficiency increased with the increase of soil moisture content at all levels of forward speeds. The rate of increase in weeding efficiency was increased with the increase of moisture content and also with the increase of forward speeds.At all the moisture levels and at all forward speeds, the plant damage was higher at 45 DAS when compared to 30 DAS in all the crops.The field capacity decreased from 1.265 to 1.252, 1.239 to 1.227 and 1.238 to 1.225 in cotton, maize and chillies, respectively when weeding operation performed at 45 DAS compared to 30 DAS. Performance index increased with the increase of forward speed at all levels of soil moisture content both at 30 and 45 DAS in all the crops.

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