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Performance evaluation of automated inter and intra row weeder for precision farming

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Abstract
A weed is unwanted plant which grows any wrong time and place. Weed control is generally challenging tasks in agriculture. Weeds grow far more quickly than crops do, and if they are not controlled and maintained, they may take over the entire field (Balas et ai., 2022C). Weeding is very difficult task and it increasing the extra cost change of farmer. Weeding not easy by manually and any machine/ equipment. Which may more chances to damage main crops. The automated inter and intra row rotary weeder cum sprayer was tested in three crops as brinjal, castor and cotton. The lowest as hourly fuel consumption (2.01, 2.04 and 2.06 l/h), fuel consumption on area basis (13.12, 13.35 and 13.49 l/ha), plant damage (8.71, 8.14 and 10.14%) and highest as intra weeding efficiency (78.36, 74.41 and 67.89%), weeding efficiency (80.94, 78.90 and 75.79%), field efficiency (85.28, 85.00 and 84.99%), performance index (197.08, 187.93 and 176.73) of brinjal, castor and cotton crop respectively. The theoretical field capacity of weeder was found as 0.180 ha/h while effective field capacity were 0.153, 0.152 and 0.152ha/h of brinjal, castor and cotton crop respectively.

Keywords: Weeds, weeding efficiency, weed management

Introduction
A weed can be growing in the wrong place at the wrong time and it is used more nutrient, to grow a successful crop, weed management frequently requires significant resource inputs (Balas *et al*., 2022) [7]. Weeds are the major biological constraints that bad effect on crop growth and productivity (BAlas *et al*., 2022B) [3]. All most one third percent cost increased in weeding operation, so it reduced the farmer's net profit (Chavan *et al*., 2015). Weeding by mechanically is can be not only weeding. It is also increasing soil aeration, ensuring moisture conservation and water intake capacity (Lamm 2002) [14]. India has huge amount of agriculture land area, so massive residues are produced here (Makavana *et al*., 2018) [15-17]. India ranks second worldwide in horticulture produces. The scenario of horticultural crops in India has become very encouraging. The percentage share of horticulture output in agriculture has become more than 30% (Agravta *et al*., 2018) [1]. Farmers have been using manual device for operation, they were time consuming, laborious, boring, tedious and costly also (Balas *et al*., 2018A) [4]. The productivity of agricultural farms depends greatly on the availability and judicious use of farm power by the farmers. Indian agriculture has faced serious challenges like scarcity of agricultural labour, not only in peak working seasons but also in normal time (Agravat *et al*., 2023) [2]. The automated inter and intra weeder was developed and testing at ASPEE, Agricultural Research and Development Foundation, Tansa Farm, Malad (West), Mumbai. The automated inter and intra row rotary weeder cum sprayer consisted of a main frame, weedicide tank, weedicide tank platform, gear box, rotary blades with end discs and back cover. Two holders with nozzles and ultrasonic sensors on both side mounted on the main frame. Other components for automation i.e. controller, relay circuit and battery were covered by MS sheet box. MS sheet box was mounted at rear side of main frame. Developed machine performed in inter row weeding by PTO powered rotary weeder and intra row weeding by weedicide spraying. The intra row weeds were detected by ultrasonic sensors, which transferred signal to the controller. Controller guided the pump cum motor based on received signal whether the obstacle was a weed, a crop plant or a soil clod. If the obstacle was a weed, the controller started the pump cum motor to spray the weedicide, and if the obstacle was a crop plant, the pump cum motor did not spray the weedicide. This reduces the human efforts which have been the principal motivating force in mechanization (Chavada *et al*., 2022) [10]. A small capacity (5 kg/batch) biomass pyrolyser was designed and developed for making bio-char from the shredded cotton stalk as feed stalk.

Pyrolysis at various experimental temperatures 200, 300, 400 and 500 °C and residence time 60, 120, 180 and 240 min carried out for optimal parameter estimation (Makavana er. Al., 2020) [16-18].

The automated weeder machine was tested and evaluated in three crops like Brinjal, Castor and Cotton. The performance was evaluated by carried out with completely randomized design (Large Plot techniques) with seven replications with three different levels of forward speed (1.5, 2.0 and 2.5 km/h). It is determining its fuel consumption (l/ha & l/h), plant damage (%), weeding efficiency (%), field efficiency (%), and performance index.

2. Methodology

2.1 Fuel Consumption

The fuel consumption of the tractor while using implement was measured by auxiliary tank method (Mehta *et al.*, 1995) [19]. The time of operation by mini tractor and fuel consumed in auxiliary tank were recorded (Balas, *et al.* 2018B) [5]. Fuel consumption of mini tractor was determined by dividing the fuel consumed by the time of operation.

Fig 1: Setup of Fuel Consumption Measurement

2.2 Plant Damage

Number of crop plants present before the weeding (p) were counted. After the weeding, No. of plants damaged (q) were counted for the same row length. The percentage of plant damage was calculated with the help of following formula. The theoretical field capacity, actual field capacity and efficiency of installation were 1.35 ha/h, 0.85 ha/h and 63.68% and the same for retrieval were 1.35 ha/h, 0.90 ha/h and 66.66% respectively (Balas *et al.*, 2018C) [6].

$$\text{Percentage of plant damage (\%)} = \frac{q}{p} \times 100$$

Where;
R = Plant damage, %
P = No. of plants present before the weeding
q = No. of plants damaged after the weeding

2.3 Intra Row Weeding Efficiency

Weeding efficiency was measured by the ratio of total number of time spray on target to total number of weeds. Weeding area has 0.40 m width and 2 m length taken (Review).

$$\text{Intra row weeding efficiency} = \frac{\text{Noofsprayontargets}}{\text{Totalnoofweeds}} \text{x } 100$$

2.4 Inter Row Weeding Efficiency

Weeds uprooted and mixed before and after operation were counted to calculate as a weeding efficiency. Weeding area has width 0.80 m and length 2 m taken.

$$\text{Inter row weeding efficiency (\%)} = \frac{X-Y}{X} \times 100$$

Where;
X= No. of weeds before operation
Y= No. of weeds after operation

2.5 Theoretical Field Capacity

It is the rate of area covered without loss of time (Kepner *et al.*, 2005) [13].

$$\text{Theoretical field capacity (ha/h)} = \frac{\text{Width of coverage (m)} \times \text{Speed (km/h)}}{10}$$

2.6 Effective Field Capacity

It is the actual area covered per unit time including the time lost in turning at the end of rows and refilling of weedicide tank (Kepner *et al.*, 2005) [13].

$$\text{Effective field capacity (ha/h)} = \frac{\text{Width of coverage (m)} \times \text{Length of strip (m)}}{\text{Time taken (h)} \times 10{,}000}$$

2.7 Field Efficiency

Field efficiency was calculated by using following formula (Kepner *et al.*, 2005) [13].

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

2.8 Performance Index

Performance index of the weeder is directly related to the field capacity (ha/h), plant survival, weeding efficiency (%) and inversely related to power (hp) exerted (Devojee *et al.*, 2019) [11].

$$\text{P.I.} = \frac{A \times E \times (1-D)}{P}$$

Where;
PI = Performance index
A = Effective field capacity of weeder, ha/h
E = Weeding efficiency, per cent
D = Plant damage, fraction
P = Power input, hp

3 Results

3.1 Fuel Consumption

The results regarding fuel consumption (l/h & l/ha) for all crops, like brinjal, castor and cotton were analyzed statistically to see the effect of different forward speeds are given in Table 1 and Table 2 respectively, and graphically in Fig. 2 and Fig. 3 respectively.

Table 1: ANOVA Showing the Effect of Different Forward Speed on Hourly Fuel Consumption

Crop	Source	DF	SS	MSS	F-Cal	F-Tab	Test	SE(m)	CD
Brinjal	Treat	2	7.3588	3.6794	258.756	3.555	**	0.0451	0.1339
	Error	18	0.2560	0.0142	-	2.989	CV % = 0.6216		
	Total	20	7.6148	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	Test	SE(m)	CD
Castor	Treat	2	7.6763	3.8381	538.005	3.555	**	0.0319	0.0949
	Error	18	0.1284	0.0071	-	2.989	CV % = 0.4336		
	Total	20	7.8047	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	Test	SE(m)	CD
Cotton	Treat	2	7.2186	3.6093	830.212	3.555	**	0.0249	0.0740
	Error	18	0.0783	0.0043	-	2.989	CV % = 0.3398		
	Total	20	7.2969	-	-	-			
		** Significant at 1%							

Table 2: Mean Values of Hourly Fuel Consumption at Different Forward Speeds

Forward Speed (km/h)	Fuel Consumption (l/h)		
	Brinjal	Castor	Cotton
1.5	2.01	2.04	2.06
2.0	2.74	2.78	2.75
2.5	3.46	3.52	3.50
SE(m)	0.0451	0.0319	0.029
CD	0.1339	0.0949	0.0740

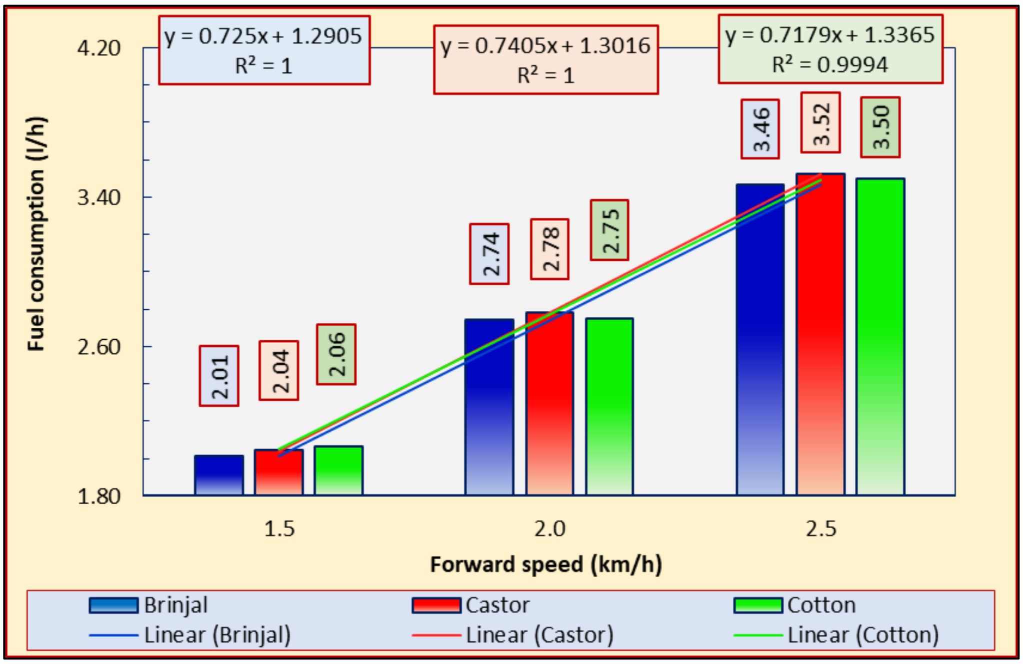

Fig 2: Effect of Different Forward Speed on Hourly Fuel Consumption

The forward speed increased from 1.5 to 2.5 km/h, the fuel consumption has shown increasing trend in all crops. Minimum fuel consumption 2.01, 2.04 and 2.06 l/h were observed at 1.5 km/h of forward speed for brinjal, castor and cotton crop respectively. Maximum fuel consumption 3.4, 3.50 and 3.52 l/h were observed at 2.5 km/h of forward speed for brinjal, cotton and castor crops respectively. Particular specific forward speed, fuel consumption was observed nearly same in all crops. The reason for minimum fuel consumption at lower forward speed because it is directly proportional to forward speed. These findings are in close agreement with the result reported by Perez-Ruiz *et al*. (2014) [21], Jakasania, (2019) [12].

Table 3: ANOVA Showing the Effect of Different Forward Speed on Fuel Consumption on Area Basis

Crop	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Brinjal	Treat.	2	7.6624	3.8312	14.385	3.555	**	0.1951	0.5795
	Error	18	4.7939	0.2663	-	2.989	CV = 0.5309 %		
	Total	20	12.4563	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Castor	Treat.	2	7.6763	3.8381	538.005	3.555	**	0.0319	0.0949
	Error	18	0.1284	0.0071	-	2.989	CV = 0.4336 %		
	Total	20	7.8047	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Cotton	Treat.	2	7.2186	3.6093	830.212	3.555	**	0.0249	0.0740
	Error	18	0.0783	0.0043	-	2.989	CV = 0.3399 %		
	Total	20	7.2969	-	-	-			
		** Significant at 1%							

Table 4: Mean Values of Fuel Consumption on Area Basis at Different Forward Speeds

Forward Speed (km/h)	Fuel Consumption (l/ha)		
	Brinjal	Castor	Cotton
1.5	13.12	13.35	13.49
2.0	13.93	14.25	14.08
2.5	14.60	14.89	14.83
SE(m)	0.1951	0.0319	0.0249
CD	0.5795	0.0949	0.0740

It was observed that as the forward speed increased from 1.5 to 2.5 km/h, the fuel consumption has shown increasing trend in all crops. Minimum fuel consumption 13.12, 13.35 and 13.49 l/ha were observed at 1.5 km/h of forward speed for brinjal, castor and cotton crop respectively.

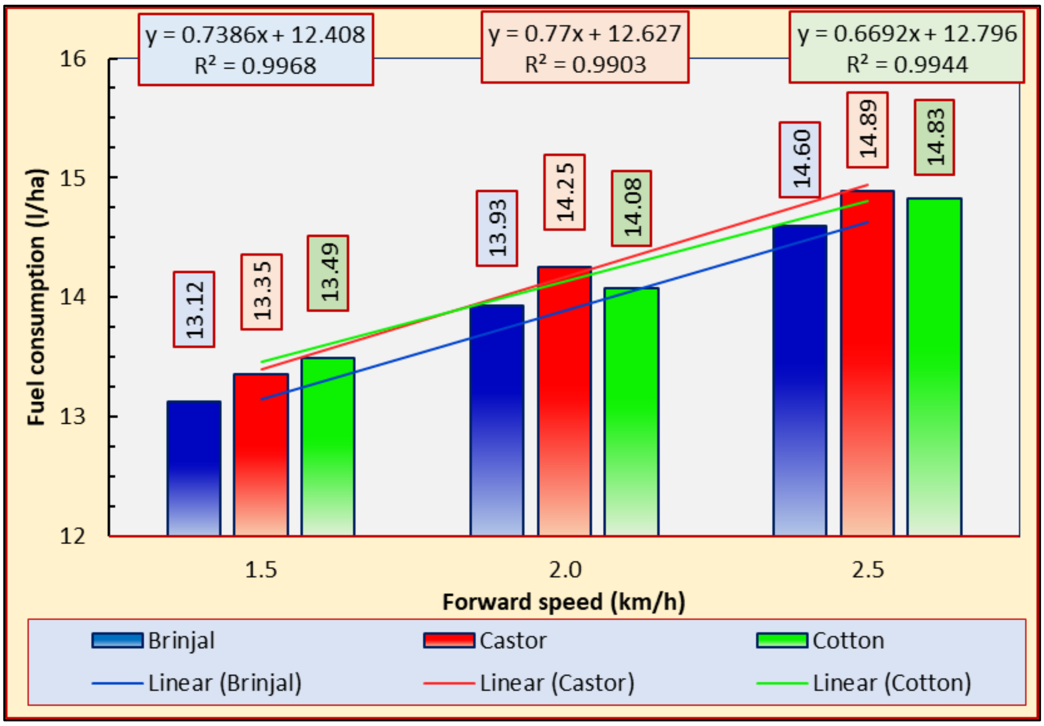

Fig 3: Effect of Different Forward Speed on Fuel Consumption on Area Basis

Maximum fuel consumption 14.60, 14.89 and 14.83 l/ha were observed at 2.5 km/h of forward speed for brinjal, cotton and castor crop respectively. Particular specific forward speed, fuel consumption was observed nearly same in all crops. The reason for minimum fuel consumption at lower forward speed because it is directly proportional to forward speed. These findings are in close agreement with the result reported by Perez-Ruiz *et al*. (2014) [21], Jakasania, (2019) [12].

Plant Damage

The plant damage for all crops, like brinjal, castor and cotton were analyzed statistically to see the effect of different forward speeds are given in Table 5 and graphically in Fig. 5.

Fig 4: Plant Damage

Table 5: ANOVA Showing the Effect of Different Forward Speed on Plant Damage

Crop	Source	DF	SS	MSS	F-Cal	F-Tab	Test	SE(m)	CD
Brinjal	Treat.	2	312.0000	156.0000	106.826	3.555	**	0.4567	1.3571
	Error	18	26.2857	1.4603	-	2.989	CV = 1.299 %		
	Total	20	338.2857	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	Test	SE(m)	CD
Castor	Treat.	2	292.6667	146.3333	109.750	3.555	**	0.4364	1.2967
	Error	18	24.0000	1.3333	-	2.989	CV = 1.207 %		
	Total	20	316.6667	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	Test	SE(m)	CD
Cotton	Treat.	2	283.7143	141.8571	190.149	3.555	**	0.3265	0.9700
	Error	18	13.4286	0.7460	-	2.989	CV = 0.846		
	Total	20	297.1429	-	-	-			
		** Significant at 1%							

Table 6: Mean Values of Plant Damage at Different Forward Speed

Forward Speed (km/h)	Plant Damage (%)		
	Brinjal	Castor	Cotton
1.50	8.71	9.14	10.14
2.00	13.00	13.57	14.43
2.50	18.14	18.29	19.14
SE(m)	0.4557	0.4364	0.3265
CD	1.357	1.297	0.970

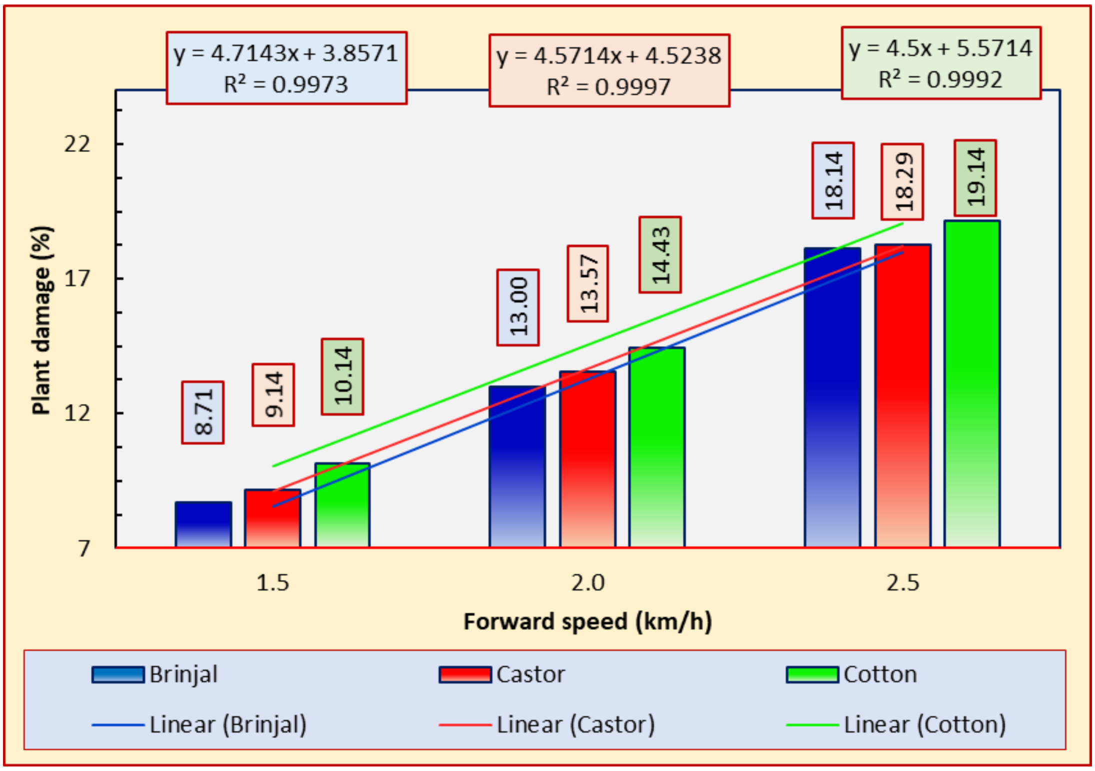

Fig 5: Effect of Different Forward Speed on Plant Damage

The effect of different forward speed on plant damage was found increasing trend in all crops. If the forward speed of developed machine was high, then plant damage was high. By different forward speed, S_3 (2.5 km/h) speed showed maximum plant damage 19.14, 18.29 and 18.14% as well as S_1 (1.5 km/h) speed obtained minimum plant damage 10.14, 9.14 and 8.71% of cotton, castor and brinjal crops respectively. These findings are in close agreement with the result reported by Perez-Ruiz *et al*. (2014) [21], Jakasania, (2019) [12]. Study on the development of a small capacity (5kg) fixed bed reactor pyrolyser for shredded cotton stalk as feed stalk (Makavana and Sarsavadia, 2018) [15-17].

Weeding Efficiency

The results regarding weeding efficiency (%) for all crops, like brinjal, castor and cotton were analyzed statistically to see the effect of different forward speeds are given in Table 7 and graphically in Fig. 8

Fig 6: Field before Weeding

Fig 7: Field After Weeding

Table 7: ANOVA Showing the Effect of Different Forward Speed on Weeding Efficiency

Crop	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Brinjal	Treat	2	207.3589	103.6795	21.722	3.555	**	0.8257	2.4534
	Error	18	85.9128	4.7729	-	2.989	**CV = 0.4067 %**		
	Total	20	293.2717	-	-	-			
		** Significant at 1%							
	Source	**DF**	**SS**	**MSS**	**F-Cal**	**F-Tab**	**TEST**	**SE(m)**	**CD**
Castor	Treat	2	161.4697	80.7349	24.279	3.555	**	0.6892	2.0478
	Error	18	59.8552	3.3253	-	2.989	**CV = 0.3458 %**		
	Total	20	221.3249	-	-	-			
		** Significant at 1%							
	Source	**DF**	**SS**	**MSS**	**F-Cal**	**F-Tab**	**TEST**	**SE(m)**	**CD**
Cotton	Treat	2	156.4627	78.2313	18.521	3.555	**	0.7768	2.3080
	Error	18	76.0323	4.2240	-	2.989	**CV = 0.4072 %**		
	Total	20	232.4950	-	-	-			
		** Significant at 1%							

Table 8: Mean Values of Weeding Efficiency at Different Forward Speed

Speed (km/h)	Weeding Efficiency (%)		
	Brinjal	Castor	Cotton
1.5	80.94	78.90	75.79
2.0	75.88	74.94	71.27
2.5	73.39	72.14	69.26
SE(m)	0.825	0.689	0.776
CD	2.45	2.05	2.31

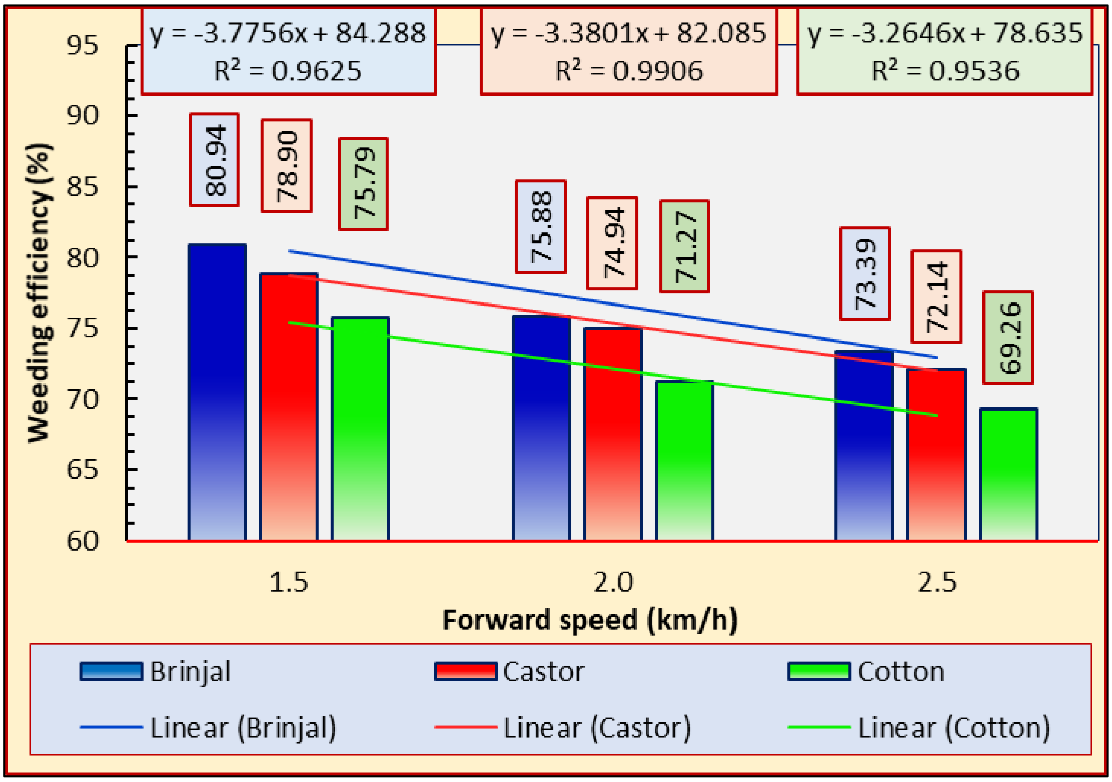

Fig 8: Effect of Different Forward Speed on Weeding Efficiency

The effect of different forward speed on weeding efficiency was found decreasing trend in all the crops. If the forward speed of automated machine was low, then weeding efficiency was high. By different forward speed, S_3 (2.5 km/h) speed showed minimum weeding efficiency 69.26, 72.14 and 73.39% as well as S_1 (1.5 km/h) speed obtained maximum weeding efficiency 75.79, 78.90 and 80.94% of cotton, castor and brinjal crops respectively. These findings are in close agreement with the result reported by Perez-Ruiz *et al*. (2014) [21], Jakasania, (2019) [12]. Intra row weeding efficiency was observed decreasing trend with increasing forward speeds, so weeding efficiency decreased. Food and energy are required for human population, a concept of integrating PV-based electricity generation and crop production from a single land unit, commonly referred to as agrivoltaic system (Makavana *et al*., 2020) [16-18].

Intra Row Weeding Efficiency

The results regarding intra row weeding efficiency (%) for all the crops, like brinjal, castor and cotton were analyzed statistically to see the effect of different forward speeds are given in Table 9 and graphically in Fig. 9.

Table 9: ANOVA Showing the Effect of Different Forward Speed on Intra Row Weeding Efficiency

Crop	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Brinjal	Treat.	2	610.7452	305.3726	20.411	3.555	**	1.4620	4.3437
	Error	18	269.3026	14.9613	-	2.989	CV = 0.7723 %		
	Total	20	880.0478	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Castor	Treat.	2	823.1806	411.5903	37.826	3.555	**	1.2468	3.7044
	Error	18	195.8632	10.8813	-	2.989	CV = 0.7131%		
	Total	20	1019.0437	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Cotton	Treat.	2	518.4016	259.2008	51.234	3.555	**	0.8501	2.5259
	Error	18	91.0649	5.0592	-	2.989	CV = 0.5217 %		
	Total	20	609.4664	-	-	-			
		** Significant at 1%							

Table 10: Mean Values of Intra Row Weeding Efficiency at Different Forward Speed

Speed (km/h)	Intra Row Weeding Efficiency (%)		
	Brinjal	Castor	Cotton
1.50	78.36	74.41	67.89
2.0	71.11	64.54	61.16
2.5	65.17	59.31	55.74
SE(m)	1.47	1.25	0.86
CD	4.34	3.71	2.53

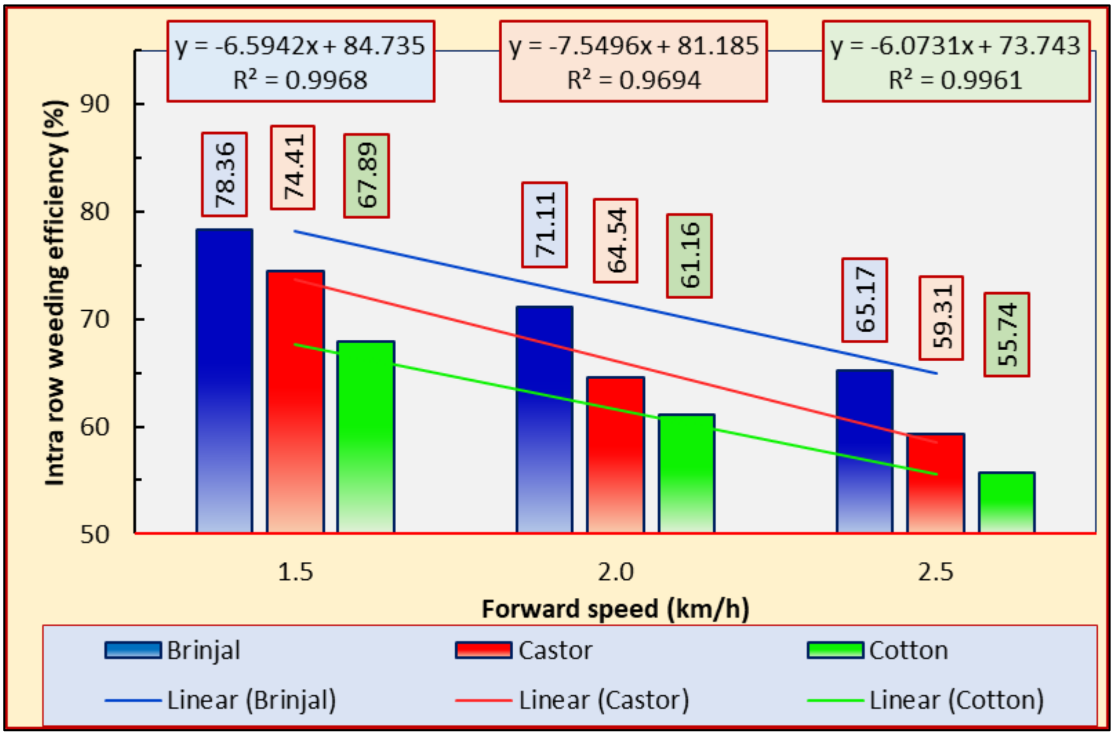

Fig 9: Effect of Different Forward Speed on Intra Row Weeding Efficiency

The effect of different forward speed on intra row weeding efficiency was found decreasing trend in all crops. If the forward speed of automated machine was low, then intra row weeding efficiency was high. By different forward speeds, S_3 (2.5 km/h) speed showed minimum intra row weeding efficiency (65.17, 59.31 and 55.74%, as well as S_1 (1.5 km/h) speed obtained maximum intra weeding efficiency 78.36, 74.41 and 67.89% of brinjal, castor and cotton crops respectively. Intra row weeding efficiency of developed machine was directly proportional to forward speed. Intra row weeding efficiency was depended on sensing accuracy of ultrasonic sensor. Ultrasonic sensor was required some short of time for sensing and based on that taken action. Intra row weeding efficiency was observed decreasing trend with increasing forward speeds in all three crops. These findings are in close agreement with the result reported by Jakasania, (2019) [12].

Field Efficiency

The field efficiency for all crops, like brinjal, castor and cotton were analyzed statistically to see the effect of different forward speeds are given in Table 11 and graphically in Fig. 10.

Table 11: ANOVA Showing the Effect of Different Forward Speed on Field Efficiency

Crop	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Brinjal	Treat.	2	134.5249	67.2625	124.337	3.555	**	0.2780	0.8260
	Error	18	9.7374	0.5410	-	2.989	CV = 0.1279 %		
	Total	20	144.2624	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Castor	Treat.	2	132.9235	66.4617	125.181	3.555	**	0.2754	0.8183
	Error	18	9.5567	0.5309	-	2.989	CV = 0.1274 %		
	Total	20	142.4801	-	-	-			
		** Significant at 1%							
	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Cotton	Treat.	2	140.1317	70.0658	119.625	3.555	**	0.2893	0.8594
	Error	18	10.5428	0.5857	-	2.989	CV = 0.1338 %		
	Total	20	150.6745	-	-	-			
		** Significant at 1%							

Table 12: Mean Values of Field Efficiency at Different Forward Speed

Speed (km/h)	Field Efficiency (%)		
	Brinjal	Castor	Cotton
1.5	85.28	85.00	84.99
2.0	82.00	81.29	81.47
2.5	79.09	78.88	79.68
SE(m)	0.279	0.276	0.289
CD	0.827	0.819	0.859

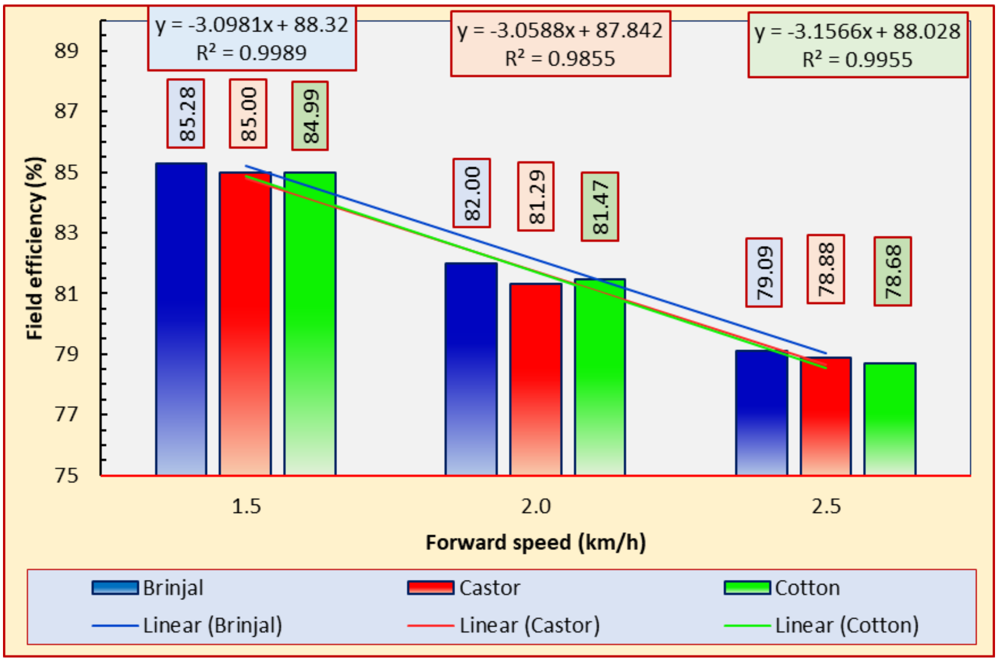

Fig 10: Effect of Different Forward Speed on Field Efficiency

The effect of different forward speed on field efficiency was found decreasing trend in all crops. The data revealed that maximum field efficiency as 85.28, 85.00 and 84.99% of brinjal, castor and cotton crops respectively, at S_1 (1.5 km/h) forward speed. Whereas minimum field efficiency 79.09, 78.88 and 78.68% of brinjal, castor and cotton crops respectively, were recorded at S_3 (2.5 km/h) forward speed. So, it was clear that field efficiency was reduced at great extent with increased forward speed. (Jakasania, 2019 [12]. obtained similar results.)

It was happened because as forward speed of machine increased from S1 to S3, the T.F.C. was also increased from S1 to S3 but E.F.C was not increased in the same rate as T.F.C increased. The reason behind this was that though the speed of operation during straight field was increased at higher speed but tractor could not take a turn with same speed and at the time of turning tractor speed was very less as compare to tractor working on straight field. It means that turning loss was remained same in all levels of forward speed which reduced the rate of increase in E.F.C. with increased forward speed.

Performance Index

Performance index of the developed automated weeder is directly related to the field capacity (ha/h), plant damage (%) and weeding efficiency (%) and inversely related to power (hp) exerted. The results regarding performance index for all the crops, like brinjal, castor and cotton were analyzed statistically to see the effect of different forward speeds are given in Table 13 graphically in Fig. 11.

Table 13: ANOVA Showing the Effect of Different Forward Speed on Performance Index

Crop	Source	DF	SS	MSS	F-Cal	F-Tab	TEST	SE(m)	CD
Brinjal	Treat	2	9850.37	4925.1881	82.330	3.555	**	2.9234	2.5909
	Error	18	1076.80	59.8226	-	2.989	CV = 0.6532 %		
	Total	20	10927.18	-	-	-			
		** Significant at 1%							
	Source	**DF**	**SS**	**MSS**	**F-Cal**	**F-Tab**	**TEST**	**SE(m)**	**CD**
Castor	Treat	2	8575.7181	4287.8591	110.203	3.555	**	2.3576	7.0049
	Error	18	700.3558	38.9087	-	2.989	CV = 0.5503 %		
	Total	20	9276.0739	-	-	-			
		** Significant at 1%							
	Source	**DF**	**SS**	**MSS**	**F-Cal**	**F-Tab**	**TEST**	**SE(m)**	**CD**
Cotton	Treat	2	6965.2620	3482.6310	92.646	3.555	**	2.3173	6.8852
	Error	18	676.6316	37.5906	-	2.989	CV = 0.5704 %		
	Total	20	7641.8936	-	-	-			
		** Significant at 1%							

Table 14: Mean Values of Performance Index at Different Forward Speed

Speed (km/h)	Performance Index		
	Brinjal	**Castor**	**Cotton**
1.50	197.08	187.93	176.73
2.00	166.06	159.23	151.71
2.50	144.30	138.65	132.24
SE(m)	2.924	2.358	6.886
CD	2.59	7.00	6.885

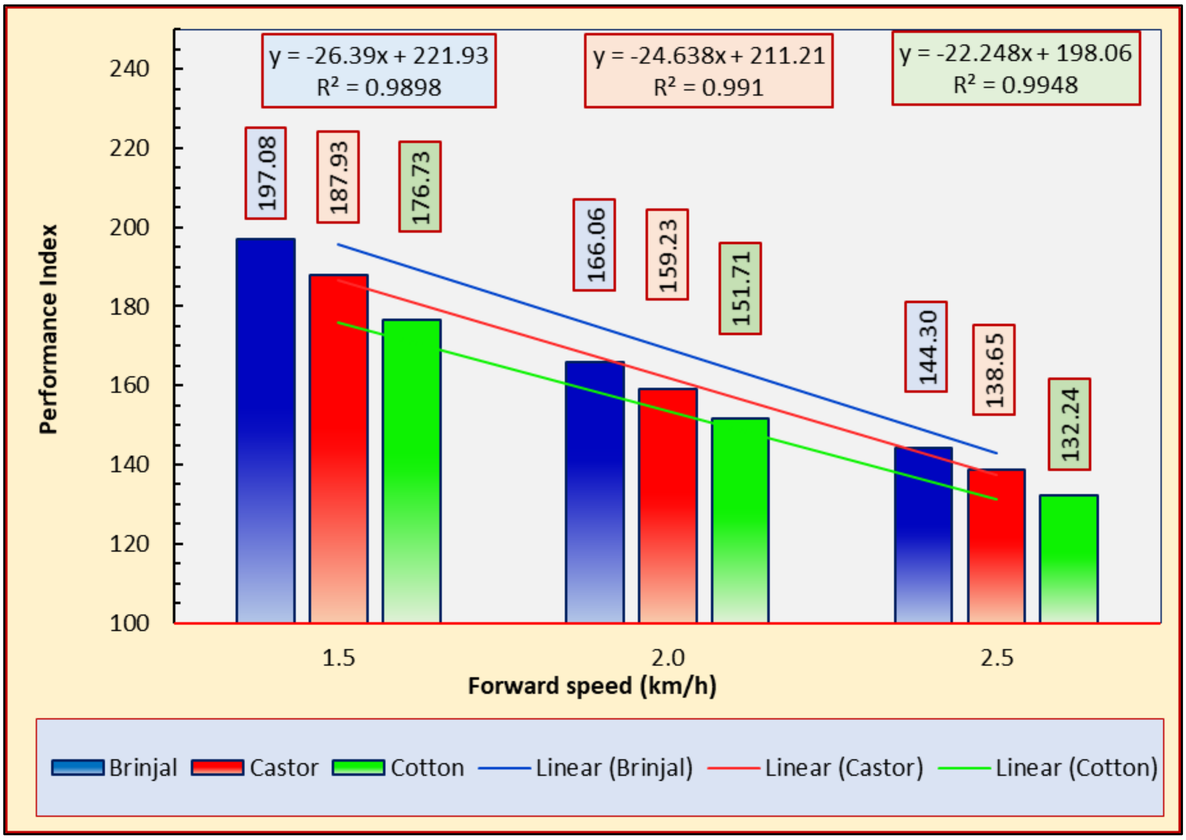

Fig 11: Effect of Different Forward Speed on Performance Index

The effect of different forward speed on performance index was found increasing trend in all crops (Devojee *et al.*, 2019) [11]. It was observed that the performance index increased with the increase of forward speed. If the forward speed of developed machine was high, then performance index was high. By different forward speed, S_3 (2.5 km/h) showed maximum performance index 144.30, 138.65 and 132.24 as well as S_1 (1.5 km/h) obtained minimum performance index 197.08, 187.93 and 176.73 of brinjal, castor and cotton crops respectively. (Jakasania, 2019 [12]. obtained similar results.) Average bulk density of whole cotton stalk and shredded cotton stalk was found as 29.90 kg/m3 and 147.02 kg/m3 respectively (Makavana *et al.*, 2020) [16-18].

Conclusion

1. Minimum fuel consumption of the automated weeder was found as 2.01, 2.04 and 2.06 l/h and fuel consumption on area basis of automated weeder was founds as 13.12, 13.35 and 13.49 l/ha at 1.5 km/h of forward speed for brinjal, castor and cotton crop respectively. Effect of forward speed on fuel consumption and fuel consumption on area basis were highly significant.
2. The lowest plant damage of automated weeder was found as 9.0, 8.0 and 7.71% at 1.5 km/h forward speed of cotton, castor and brinjal crop respectively.
3. The Maximum intra row weeding efficiency of automated weeder was found as 78.35, 74.40 and 75.15% at 1.5 km/h forward speed of cotton, castor and brinjal crops respectively.
4. The Maximum weeding efficiency of automated weeder was found as 80.94, 78.90 and 75.79% at 1.5 km/h forward speed of brinjal, castor and cotton crop respectively. If the forward speed of automated machine was low, then weeding efficiency was high. Effect of forward speed on weeding efficiency was highly significant.
5. The theoretical field capacity of automated weeder was found as 0.180 ha/h, while effective field capacity as 0.1535, 0.1529 and 0.1529 ha/h were found for brinjal, castor and cotton crop plot respectively. The highest field efficiency of automated weeder was found as 85.28, 85.00 and 75.16% at 1.5 km/h forward speed of brinjal, castor and cotton crop respectively.
6. Maximum performance index of automated weeder was found as 197.08, 187.93 and 176.73 at 1.5 km/h forward speed of brinjal, castor and cotton crops respectively.

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