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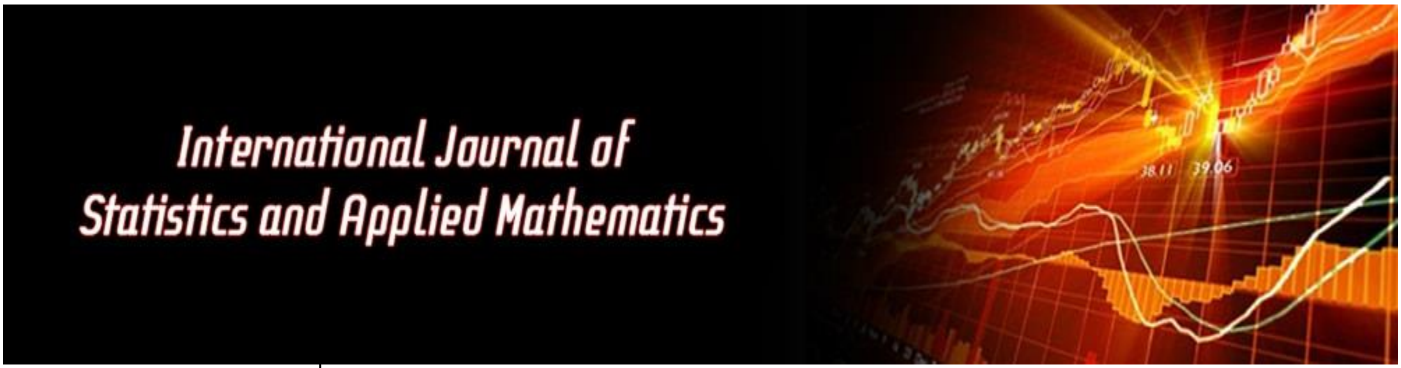

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Assessment of floral arrangement and weed behavior in chickpea with Jatropha-based agroforestry by statistical procedures

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Abstract
A field experiment was carried out to ascertain the floral arrangement and weed behavior in chickpea with Jatropha-based Agroforestry during the Rabi seasons 2019–20 and 2020–21 at Research Farm, Department of Forestry, JNKVV, Jabalpur. The experiment was set up using a Randomized Complete Block Design (RCBD) with three replications and there were twelve herbicidal treatments. The studied results showed that weed free at harvest hand weeding 30DAS obtained the lowest overall weed density, overall weed dry weight, and the maximum weed control effectiveness, followed by Pendimethalin 1000 g ha^{-1}, Atrazine (50% WP) 1000 g ha^{-1}, and oxyfluorfen (23.5% EC) 100 g ha^{-1}. Pre-emergence herbicides and manual weeding can further improve the crop's weed-suppressing capabilities in Agroforestry systems based on Jatropha.

Keywords: Weed dry weight, weed control efficiency, weed density, weeds, and herbicides

Introduction

One option for managing natural resources sustainably is Agroforestry. It has been used by farmers for ages as a land use strategy that integrates trees or woody perennials, crops, and animals. Increase, diversification, and sustainability of production of economic, environmental, and social benefits are the goals of Agroforestry systems. The most important and effective agricultural strategy for reducing land degradation is Agroforestry. It increases soil fertility, lessens weed infestation and erosion, promotes water quality, boosts biodiversity, improves aesthetics, and sequesters carbon. Agroforestry is consistently profitable for farmers and remains productive. Agroforestry systems with the inclusion of perennial woody trees are the most appropriate technology for enhancing overall food, fodder, and fuel productivity and minimizing the danger of weed infestation in farming when per capita land availability decreases. Numerous creative farmers have created new Agroforestry systems or altered already existing ones to better fit regional needs. Tree Born Oil Seeds (TBO) may be incorporated into the majority of these systems, which will increase overall production and farm profitability. Jatropha (Jatropha curcas) plantations on wastelands were the main focus of the initial programs, but under low input regimes, seed yields proved to be low and highly variable, leading to limited economic viability and production potential (Achten *et al*., 2014; van Eijck *et al*., 2014) [1, 13]. One of India's oldest and most widely cultivated pulse crops is the chickpea. It is mostly grown in the states of Madhya Pradesh, Maharashtra, Andhra Pradesh, Rajasthan, and Odisha in our nation. 75% of the world's output of chickpeas is produced in India, which is also the greatest producer. Due to its sluggish early development and small stature, chickpea is very sensitive to weed competition, and if weeds are not treated at the appropriate time, significant losses may sometimes result. Due to the crop's post-rainy season sowing under rainfed and dry land conditions, weed competition with chickpeas gains greater relevance, necessitating prompt and efficient weed control. Weeds fiercely fight with crops for nutrients, moisture, light, and space, which reduces chickpea output by up to 75%. In high input agricultural methods, herbicides are employed to remove undesired weeds and reduce production losses brought on by these noxious plants (Cork and Krueger, 1992) [5]. Herbicides are plant protection chemicals. It is crucial to manage weeds at the right time and with the right techniques to have a greater yield. Herbicides are now widely used since controlling weeds is easy and labor is scarce, especially during the crucial time. Chickpea crops are infested by more than 75 different weed species. The majority of these species are dicotyledonous, and they are members of 26 distinct families (El-Brahli, 1988) [6]. Up to 40 days make up the key time of crop-weed competition for chickpea. More weed infestation during the crop's early growth phase is one of the causes of the low production of chickpeas. There are now several techniques developed by various researchers to provide the greatest weed control outcomes. Herbicidal methods of weed management must be developed since they are more affordable. Given that they may replace human labor, herbicides will play a significant role in Indian agriculture. Weed not only reduces the quality of the pods but also raises the cost of plowing and other cultivation techniques. The combination of hand weeding and tilling are the traditional weed management techniques used by farmers in the chickpea industry. These weed control techniques rely on labor availability and agreeable weather. However, weed flora during Rabi crops' crucial growing stage increases agricultural weed competition and significantly lowers crop production. Cultural practices can be employed to boost agricultural output, however when labor becomes scarcer and salaries rise, cultivation costs climb as well, and worsening crop damage from late weeding. Additionally, it was discovered that there are some weeds that, when they are already well-established and unable to be effectively managed by hoeing or manual weeding, develop many branches that stunt crop development and production. As a result, the traditional methods of weeding and tilling are successful at controlling weeds but are impractical in fields that are wet and have limitations owing to a lack of labor during a crucial time. In these situations, the chemical approach of weed management can be quite efficient in eliminating weeds both before and after their appearance. Herbicide use has grown significantly, especially in large-scale farming, as a result of its capacity to provide rapid, efficient, selective, and cost-effective weed control in terms of labor, expense, and time.

Materials and Methods

A field experiment was carried out to ascertain the floral arrangement and weed behavior in chickpea with Jatropha-based Agroforestry during the Rabi seasons 2019–20 and 2020–21 at Research Farm, Department of Forestry, JNKVV, Jabalpur. The experiment was set up using a Randomized Complete Block Design (RCBD) with three replications. There were twelve herbicidal treatments: Weedy check (control), hand weeding (30 DAS), Pendimethalin (1000 g ha^{-1}), Atrazine (1000 g ha^{-1}), Imazethapyr (900 g ha^{-1}), Oxyfluorfen (100 g ha^{-1}), Metribuzin (300 g ha^{-1}), Pendimethalin (500 g ha^{-1}) fb Oxyfluorfen (50 g ha^{-1}), Pendimethalin (500 g ha^{-1}) fb Imazethapyr (450 g ha^{-1}), Atrazine (500 g ha^{-1}) fb Metribuzin (150 g ha^{-1}), Metribuzin (150 g ha^{-1}) fb Oxyfluorfen (50 g ha^{-1}), and Imazethapyr (450 g ha^{-1}) fb Atrazine (500 g ha^{-1}). A quadrate (0.50 m X 0.50 m) was used to measure the number of weeds in each plot, and its size was converted to square meters (m^2). After weeds were removed from the ground, the dry matter was measured from the quadrates, oven dried at 700 °C, and converted to m^2. Prior to the statistical evaluation, the weed variables were square-root transformed.

The weed control efficiency (WCE): In the work of Mani *et al.* (1973) [9], the weed control efficiency (WCE) of the treatments against the weedy check was determined using the weed's dry weight.

$$WCE\ (\%) = \frac{WD_c - WD_t}{WD_c} \times 100$$

Where

WCE= Weed control efficiency, WD_c = Dry weight of weeds in un weeded control plot

WD_t = Dry weight of weeds in treated plot.

Weed count was transformed by square root by X+0.5. After statistically analyzing all of the experimental data, the crucial difference (CD) was calculated using the method outlined by Gomez and Gomez (1984) [7].

Result and Discussion

Weed flora

The experimental field was infested by number of weed species. This includes weeds with both wide leaves and grassy leaves, i.e., purple nut sedge, Bermuda grass, common vetch and burr medic.

Total weeds density (m^2)

Significantly the highest weed density (Table 1 and Fig 1) of weeds noted under weedy check (control) at all the growth stages of chickpea. All the weed management treatments on total weed density were apparent during both years and mean. The significantly reduced weed density was found in hand weeding 30DAS (8.38, 7.83 and 8.10 m^{-2}) it was at par with Pendimethalin 1000 g ha^{-1} (10.15, 9.22 and 9.69 m^{-2}) over weedy check (21.60, 19.78 and 20.69 m^{-2}) which recorded maximum total weed density during both the year and mean. Whereas, Oxyfluorfen (23.5% EC) 100 g ha^{-1}, Imazethapyr (10% SL) 900 g ha^{-1}, Atrazine (50% WP) 1000 g ha^{-1}, have similarly contributed for reducing total weed density at harvest during both years and mean basis. This may be the outcome of successful weed management in the corresponding treatments, whether manual or herbicidal or both, which led to a notable decrease in weed density. These results are quite similar to those that were reported by Ahlawat (1978) [2], Virender. P. Singh *et al.*, (2016) [14] and Balyan *et al.* (1987) [3].

Weed dry weight

Significantly the highest weed dry weight (Table 2 and Fig 2) of weeds noted under weedy check (control) at all the growth stages of chickpea. All the weed management treatments on total weed dry weight were apparent during both years and mean. The significantly reduced weed dry weight was found in hand weeding 30DAS (6.71, 8.12 and 7.42 g m^{-2}) it was at par with Pendimethalin 1000 g ha^{-1} (8.74, 8.65 and 8.70 g m^{-2}) over weedy check (71.30, 15.43 and 16.37 g m^{-2}) which recorded maximum total weed density during both the year and mean. Whereas, Atrazine (50% WP) 1000 g ha^{-1}, Oxyfluorfen (23.5% EC) 100 g ha^{-1}, Metribuzin 150 g ha^{-1} fb Oxyfluorfen 50 g ha^{-1} have similarly contributed for reducing total weed dry weight at harvest during both years and mean basis. This may be the outcome of successful weed management in the corresponding treatments, whether manual or herbicidal or both, which led to a notable decrease in weed density. These results are quite similar to those that were reported by Ahlawat (1978) [2], Virender. P. Singh *et al.*, (2016) [14] and Balyan *et al.* (1987) [3]

Table 1: Effect of weed management practices on total weed density (m^{-2}) under gram - *Jatropha curcus* based Agroforestry system.

Treatment		Total weed density (m^{-2})		
		2019-20	2020-21	Mean
T_1	Pendimethalin (38.7% EC) 1000 g ha^{-1}	10.15 (103.0)	9.22 (85.0)	9.69 (94.0)
T_2	Imazethapyr (10% SL) 900 g ha^{-1}	11.94 (142.7)	10.98 (120.0)	11.46 (131.3)
T_3	Atrazine (50% WP) 1000 g ha^{-1}	11.46 (131.7)	10.63 (113.3)	11.04 (122.5)
T_4	Metribuzin (70% WP) 300 g ha^{-1}	13.23 (175.0)	11.96 (143.3)	12.60 (159.2)
T_5	Oxyfluorfen (23.5% EC) 100 g ha^{-1}	11.26 (127.3)	11.28 (126.7)	11.27 (127.0)
T_6	Pendimethalin 500 g ha^{-1} fb Imazethapyr 450 g ha^{-1}	11.64 (135.7)	11.49 (132.7)	11.56 (134.2)
T_7	Pendimethalin 500 g ha^{-1} fb Oxyfluorfen 50 g ha^{-1}	12.01 (145.0)	10.76 (116.0)	11.38 (130.5)
T_8	Metribuzin 150 g ha^{-1} fb Oxyfluorfen 50 g ha^{-1}	12.59 (159.0)	12.10 (146.3)	12.35 (152.7)
T_9	Atrazine 500 g ha^{-1} fb Metribuzin 150 g ha^{-1}	13.64 (186.0)	12.86 (165.3)	13.25 (175.7)
T_{10}	Imazethapyr 450 g ha^{-1} fb Atrazine 500 g ha^{-1}	13.04 (170.0)	12.60 (158.3)	12.82 (164.2)
T_{11}	Hand weeding (30 DAS)	8.38 (70.0)	7.83 (61.3)	8.10 (65.7)
T_{12}	Weedy check (control)	21.60 (469.3)	19.78 (391.0)	20.69 (430.2)
SEm±		0.69	0.40	0.39
Treatment (T) CD (P=0.05)		2.00	1.17	1.11
Year (Y) CD=0.05		-	-	0.45
Interaction (Y x T) CD (P=0.05)		-	-	1.57

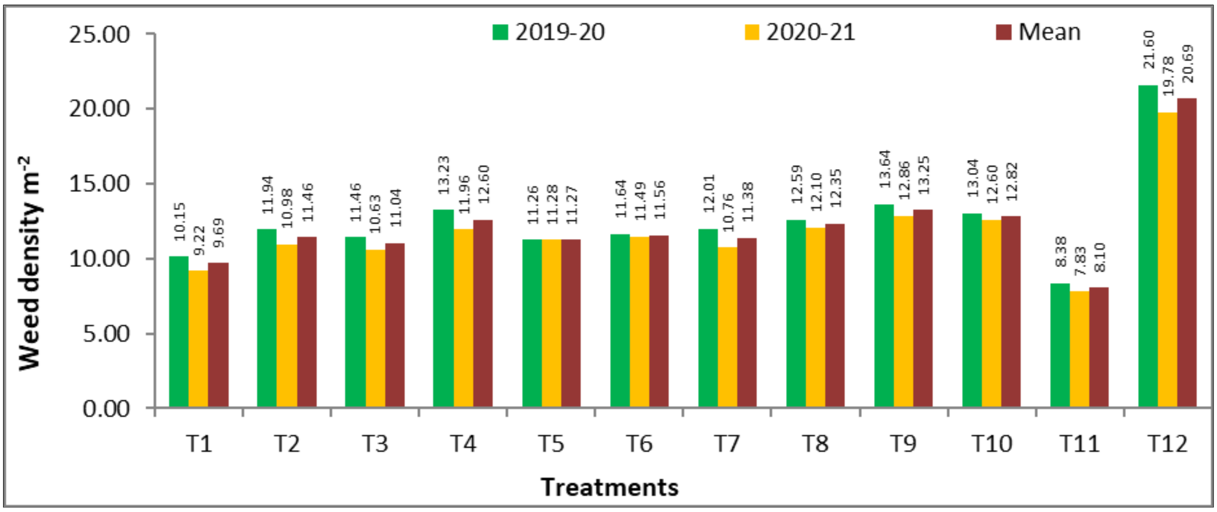

Fig 1: Effect of various weed management methods on the overall weed density

Table 2: Effect of weed management practices on weed dry weight under gram - *Jatropha curcus* based Agroforestry system

Treatment		Weed dry weight (g m^{-2})		
		2019-20	2020-21	Mean
T_1	Pendimethalin (38.7% EC) 1000 g ha^{-1}	8.74 (76.3)	8.65 (74.6)	8.70 75.5)
T_2	Imazethapyr (10% SL) 900 g ha^{-1}	11.84 (140.3)	10.56 (111.3)	11.20 (125.8)
T_3	Atrazine (50% WP) 1000 g ha^{-1}	10.37 (107.7)	9.63 (93.0)	10.00 (100.3)
T_4	Metribuzin (70% WP) 300 g ha^{-1}	12.05 (144.7)	10.66 (113.3)	11.36 (129.0)
T_5	Oxyfluorfen (23.5% EC) 100 g ha^{-1}	10.45 (110.3)	9.62 (92.6)	10.03 (101.5)
T_6	Pendimethalin 500 g ha^{-1} fb Imazethapyr 450 g ha^{-1}	11.68 (138.0)	10.82 (119.3)	11.25 (128.7)
T_7	Pendimethalin 500 g ha^{-1} fb Oxyfluorfen 50 g ha^{-1}	11.45 (132.7)	10.39 (108.6)	10.92 (120.7)
T_8	Metribuzin 150 g ha^{-1} fb Oxyfluorfen 50 g ha^{-1}	10.66 (114.0)	9.59 (92.3)	10.12 (103.2)
T_9	Atrazine 500 g ha^{-1} fb Metribuzin 150 g ha^{-1}	12.39 (153.0)	10.98 (120.3)	11.68 (136.7)
T_{10}	Imazethapyr 450 g ha^{-1} fb Atrazine 500 g ha^{-1}	12.39 (153.0)	10.49 (109.6)	11.44 (131.3)
T_{11}	Hand weeding (30 DAS)	6.71 (44.7)	8.12 (66.0)	7.42 (55.3)
T_{12}	Weedy check (control)	17.30 (299.0)	15.43 (237.6)	16.37 (268.3)
SEm±		0.51	0.45	0.33
Treatment (T) CD (P=0.05)		1.50	1.31	0.95
Year (Y) CD=0.05		-	-	0.39
Interaction (Y x T) CD (P=0.05)		-	-	1.34

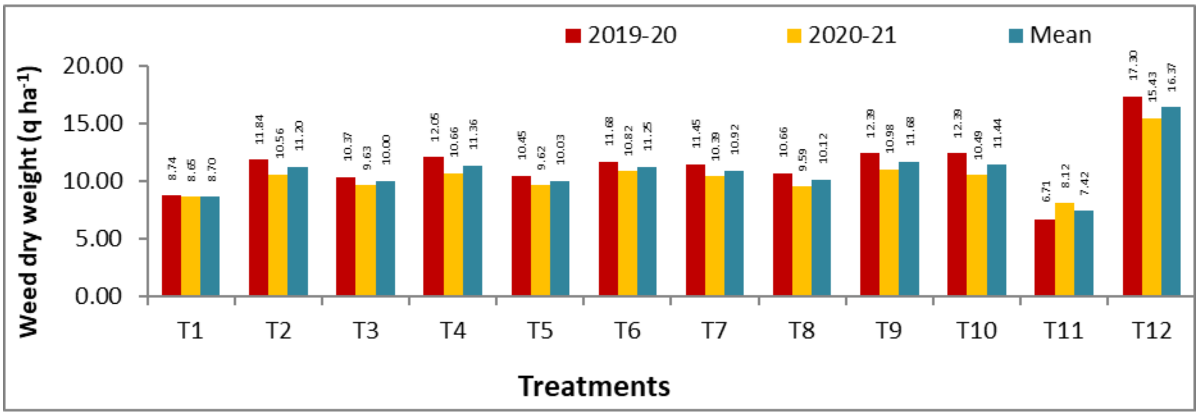

Fig 2: Effect of various weed management methods on the overall weed dry weight

Weed Control Efficiency

Significantly the highest weed control efficiency (Table 3 and Fig 3) of weeds noted under weedy check (control) at all the growth stages of chickpea. Weed control efficiency were apparent during both years and mean basis. The significantly highest weed control efficiency was found in hand weeding 30DAS (85.1, 72.2 and 78.6%) it was at par with Pendimethalin 1000 g ha^{-1} (74.4, 68.6 and 71.5 %) over weedy check (0.0, 0.0 and 0.0 %) which recorded maximum total weed density during both the year and mean. Whereas, Atrazine (50% WP) 1000 g ha^{-1}, Oxyfluorfen (23.5% EC) 100 g ha^{-1}, Metribuzin 150 g ha^{-1} fb Oxyfluorfen 50 g ha^{-1} have similarly contributed for reducing total weed dry weight at harvest during both years and mean basis. This may be the outcome of successful weed management in the corresponding treatments, whether manual or herbicidal or both, which led to a notable increase weed control efficiency. These results are quite similar to those that were reported by Ahlawat (1978) [2], Virender. P. Singh *et al.*, (2016) [14] and Balyan *et al.* (1987) [3].

Table 2: Effect of weed management practices on weed control efficiency of total weeds under gram - *Jatropha curcus* based Agroforestry system

Treatment		Weed Control Efficiency (%)		
		2019-20	2020-21	Mean
T_1	Pendimethalin (38.7% EC) 1000 g ha^{-1}	74.4	68.6	71.5
T_2	Imazethapyr (10% SL) 900 g ha^{-1}	53.2	53.2	53.2
T_3	Atrazine (50% WP) 1000 g ha^{-1}	64.1	60.9	62.5
T_4	Metribuzin (70% WP) 300 g ha^{-1}	51.6	52.3	51.9
T_5	Oxyfluorfen (23.5% EC) 100 g ha^{-1}	63.3	61.0	62.2
T_6	Pendimethalin 500 g ha^{-1} fb Imazethapyr 450 g ha^{-1}	54.1	49.8	51.9
T_7	Pendimethalin 500 g ha^{-1} fb Oxyfluorfen 50 g ha^{-1}	55.8	54.3	55.0
T_8	Metribuzin 150 g ha^{-1} fb Oxyfluorfen 50 g ha^{-1}	62.0	61.2	61.6
T_9	Atrazine 500 g ha^{-1} fb Metribuzin 150 g ha^{-1}	48.7	49.4	49.1
T_{10}	Imazethapyr 450 g ha^{-1} fb Atrazine 500 g ha^{-1}	48.8	53.9	51.4
T_{11}	Hand weeding (30 DAS)	85.1	72.2	78.6
T_{12}	Weedy check (control)	0.0	0.0	0.0
SEm±		3.75	3.94	2.69
Treatment (T) CD (P=0.05)		10.96	11.49	7.63
Year (Y) CD=0.05		-	-	3.12
Interaction (Y x T) CD (P=0.05)		-	-	10.79

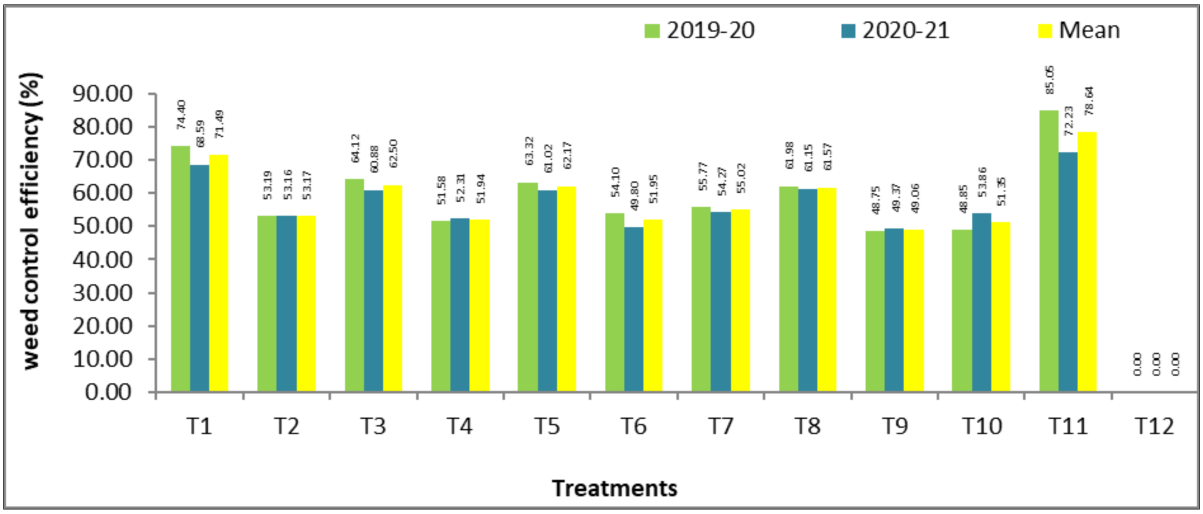

Fig 3: Effect of various weed management methods on the overall weed control efficiency

Conclusion

It is concluded that weed free at harvest hand weeding 30DAS obtained the lowest overall weed density, overall weed dry weight, and the maximum weed control effectiveness, followed by Pendimethalin 1000 g ha^{-1}, Atrazine (50% WP) 1000 g ha^{-1}, and oxyfluorfen (23.5% EC) 100 g ha^{-1}. Pre-emergence herbicides and manual weeding can further improve the crop's weed-suppressing capabilities in Agroforestry systems based on Jatropha.

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