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Integrated Weed Management in Cassava (*Manihot esculenta* Crantz)

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Abstract

A field study was conducted at College of Horticulture, Vellanikkara to compare the different weed management practices for cassava (*Manihot esculenta* Crantz). The treatments included pre emergent herbicides such as oxyfluorfen, pendimethalin, imazethapyr and directed application of glyphosate, hoeing and earthing up, concurrent growing of cowpea and *in situ* incorporation and unweeded control. Higher tuber yields were obtained for the treatments hoeing and earthing up at 30 and 60 days after planting (DAP) (31.20 t/ha), pendimethalin + hoeing and earthing up at 60 DAP (30.60 t/ha) and glyphosate + hoeing and earthing up at 60 DAP (28.40 t/ha). The herbicide oxyfluorfen could control 99 per cent of weeds at 30 DAP. Pendimethalin + hoeing and earthing up was more effective in suppressing weeds at later stages giving 94 per cent control of weeds at harvest. The weed control efficiency of all herbicidal treatments increased with a follow up of earthing up at 60 DAP. Weed index was lower in the treatments hoeing and earthing up, pendimethalin + hoeing and earthing up and glyphosate + hoeing and earthing up. The highest B:C ratio of 2.41 was achieved in pre emergence application of pendimethalin + hoeing and earthing up.

Key words: Cassava, weeds, integrated weed management, weed control efficiency, weed index, tuber yield

Introduction

Cassava, because of its ability to sustain under marginal environmental conditions, plays an important role in ensuring food security and income generation of resource poor farmers. Although the crop is less susceptible to pests and diseases, its slow initial growth and incomplete canopy cover make the plant more susceptible to weed interferences during the first three to four months after planting. Reduction in tuber yield varies from 40 per cent in early branching cultivars to nearly 70 per cent in late and non branching cultivars (IITA, 1990). This indicates the requirement of effective weed management methods in cassava during initial growth phases to obtain higher yields. Traditionally, weed control is done manually by tillage practices followed by earthing up. However recent research results have shown that the use of pre emergent herbicides can effectively control weeds in cassava reducing the overall cost of production. However, relying only on chemical weed control may not be feasible in the long term. Developing a complete weed management package by integrating chemical, physical and cultural methods may be the best option for cassava to achieve optimum yield in cassava. Having considered these aspects, an experiment was conducted to develop an effective and economic weed management strategy for cassava which would ensure optimum yields with the lowest cost of production.

Materials and Methods

The experiment was carried out at the Agronomy farm, College of Horticulture, Kerala Agricultural University Vellanikkara, Thrissur during May to October, 2015. Geographically, the field is situated at 13° 32'N latitude and 76° 26'E longitude, at an altitude of 40 m above mean sea level with typical tropical humid climate. The

soil is sandy clay loam and acidic with a pH of 4.5. The experimental design adopted was randomized block design (RBD) with eleven treatments and three replications. The treatments were oxyfluorfen 0.2 kg/ha (pre emergence), pendimethalin 1.5 kg/ha (pre emergence), imazethapyr 80g/ha (pre emergence), glyphosate 0.8 kg/ha (directed application at 30 DAP), oxyfluorfen 0.2 kg/ha (pre emergence) + hoeing and earthing up at 60 DAP, pendimethalin 1.5 kg/ha (pre emergence) + hoeing and earthing up at 60 DAP, imazethapyr 80g/ha (pre emergence) + hoeing and earthing up at 60 DAP, glyphosate 0.8 kg/ha (directed application at 30 DAP) + hoeing and earthing up at 60 DAP, concurrent growing of cowpea and *in situ* incorporation and earthing up at 60 DAP, hoeing and earthing up at 30 and 60 DAP and unweeded control.

Vellayani Hraswa, a short duration variety of cassava was planted on mounds taken at a distance of 90 cm X 90 cm on 15th May 2015. Farmyard manure @ 12.5 t/ha was applied basally at the time of land preparation. Nitrogen, phosphate and potash @ 100:100:100 kg/ha was applied in three splits, at land preparation and two and three months after planting (MAP). Pre emergent spraying of oxyfluorfen, pendimethalin and imazethapyr was done on the second day after planting with a knapsack sprayer fitted with flat fan nozzle, and spray fluid of 300 L/ ha. Cowpea seeds (Kashi kanchan) were dibbled on the 3rd day after planting. Directed application of glyphosate was done on 30 DAP. Hoeing and earthing up was done twice at 30 and 60 DAP. The crop was harvested 5 months after planting (MAP) on 14th October 2015. Cowpea raised concurrently was incorporated at 60 DAP. Observations on weed count, weed dry weight, yield parameters and yield were recorded and the data were subjected to analysis of variance (ANOVA). Benefit : Cost ratio was worked out based on the prevailing market price. Weed index was worked out as per the formula suggested by Gill and Vijaykumar (1969) and weed control efficiency as per the formula suggested by Mani *et al*. (1973).

Results and Discussion

Yield attributes and yield

The number of tubers per plant was higher when cowpea was sown concurrently with cassava (Table 1) and in treatment with hoeing and earthing up two times. Higher value for girth of tuber (15.19 cm) was recorded for pre emergent application of imazethapyr + hoeing and earthing up at 60 DAP (Table 1). Longer tubers were observed in treatments with directed spray of glyphosate + hoeing and earthing up at 60 DAP and in plots with concurrent growing and *in situ* incorporation of cowpea + hoeing and earthing up (Table 1). Compared to the treatments

Table 1. Effect of treatments on yield attributes, yield (kg/ha) of cassava and B:C ratio

	Treatments	No. of tubers per plant	Length of tuber (cm)	Girth of tuber (cm)	Yield (kg/ha)	B:C ratio
T1	Oxyfluorfen 0.2 kg/ha	7.72	34.83	11.76	23272	2.27
T2	Pendimethalin @ 1.5 kg/ha	6.55	36.32	11.5	17169	1.73
T3	Imazethapyr @ 80g/ha	6.57	32.99	12.93	15535	1.56
T4	Glyphosate @ 0.8 kg/ha	7.61	38.33	11.82	21794	2.21
T5	Oxyfluorfen + hoeing and earthing up at 60 DAP	7.93	43.14	13.89	24556	1.93
T6	Pendimethalin + hoeing and earthing up at 60 DAP	7.88	41.93	14.28	30605	2.41
T7	Imazethapyr + hoeing and earthing up at 60 DAP	7.75	39.98	15.19	23720	1.87
T8	Glyphosate + hoeing and earthing up at 60 DAP	7.88	45.19	12.69	28436	2.24
T9	Concurrent growing of cowpea and *in situ* incorporation and earthing up at 60 DAP	8.22	44.61	13.08	23062	1.79
T10	Hoeing and earthing up at 30 and 60 DAP	8.16	43.63	14.07	31177	1.89
T11	UWC	3.99	26.82	9.243	13584	1.42
	CD(0.05)	1.561	8.045	2.814	3469.9	

with pre emergent application of herbicides alone, the treatment with hoeing and earthing up showed better yield attributing parameters. This showed the positive influence of secondary tillage on root enlargement and thickening in cassava. According to Maurya and Lal (1980), plants grown without tillage were stunted due to greater bulk density of soil lower porosity and inadequate nutrient distribution in root zone which might slow down root growth and development. The favourable effects of yield attributes are also due to the beneficial effects of nitrogen fixation and subsequent soil enrichment. Padmapriya *et al.* (2008) reported enhancement of yield components of cassava when intercropped with cowpea. Higher tuber yields of 31.2 t/ha, 30.6 t/ha and 28.4 t/ha were recorded in the treatments hoeing and earthing up at 30 and 60 DAP, pendimethalin + hoeing and earthing up at 60 DAP, and glyphosate + hoeing and earthing up at 60 DAP respectively (Table 1). Yields obtained in the treatments with application of pre emergent herbicides + hoeing and earthing up at 60 DAP were higher compared to those without hoeing and earthing up. As Olorunmaiye *et al*. (2009) reported, application of pre emergent herbicides followed by one hoe weeding promoted season long weed control and thus better yield.

Weed count and dry weight

The experimental field was predominantly infested with monocot and dicot weeds and some sedges. The monocot weeds found in the experiment plots were *Panicum maximum, Allopteropsis cimicina, Commelina diffusa, Brachiaria milliformis, Axonopus compressus, Eleusine indica, Digitaria ciliaris, Imperata cylindrica, Cynodon dactylon* and *Pennisetum polystachion.* The dicot weeds were *Borreria hispida, Cleome burmanii, Ageratum conyzoides, Alternanthera bettzickiana, Pueraria phaseoloides, Hyptis suaveolens, Synedrella nodiflora, Euphorbia heterophylla, Boerhaavia diffusa* and *Tridax procumbens. Cyperus rotundus, Mariscus alternifolius* and *Cyperus haspan* were the major sedges.

Broadleaf weeds outnumbered grass weeds at 30 DAP. The lowest counts and dry matter production for grass and broad leaf weeds were noticed in the plots which received pre emergent application of oxyfluorfen (Table 2 and 3) . The plots with concurrent growing of cowpea and *in situ* incorporation of biomass showed higher total

Table 2. Effect of treatments on weed count

Treatments		No./m^2			
		30 DAP	60DAP	90DAP	Harvest
T1	Oxyfluorfen @ 0.2 kg/ha	26.67**	93.33	146.67	73.33
		(5.12)	(9.64)	(12.07)	(8.52)
T2	Pendimethalin @ 1.5 kg/ha	58.67	70.67	121.33	42.67
		(7.66)	(8.31)	(10.98)	(6.45)
T3	Imazethapyr @ 80g/ha	81.30	74.00	122.67	89.33
		(8.98)	(8.58)	(11.06)	(9.44)
T4	Glyphosate @ 0.8 kg/ha	198.67	78.67	96.00	69.33
		(14.07)	(8.8)	(9.8)	(8.3)
T5	Oxyfluorfen + hoeing and earthing up at 60 DAP	47.07	110.67	61.33	60.00
		(6.83)	(10.50)	(7.8)	(7.69)
T6	Pendimethalin + hoeing and earthing up at 60 DAP	61.60	83.33	34.67	65.33
		(7.83)	(8.99)	(5.88)	(8.07)
T7	Imazethapyr + hoeing and earthing up at 60 DAP	130.67	114.00	58.67	102.67
		(11.35)	(10.66)	(7.64)	(10.13)
T8	Glyphosate + hoeing and earthing up at 60 DAP	206.67	78.67	49.33	49.33
		(14.36)	(8.84)	(7.02)	(6.99)
T9	Concurrent growing of cowpea and in situ incorporation and earthing up at 60 DAP	281.3	148.00	65.33	101.00
		(16.73)	(12.14)	(8.07)	(10.05)
T10	Hoeing and earthing up at 30 and 60 DAP	237.33	54.33	60.00	69.33
		(15.37)	(7.36)	(7.74)	(8.33)
T11	UWC	261.33	150.67	217.33	117.33
		(16.12)	(12.27)	(14.73)	(10.82)
CD(0.05)		1.85	1.89	1.18	1.29

** Original values, $\sqrt{X+0.5}$ transformed values are given in parentheses

Table 3. Effect of weed control treatments on weed dry matter production of cassava

	Weed control treatments	DMP (g/m^2)			
		30 DAP	60DAP	90DAP	Harvest
T1	Oxyfluorfen @ 0.2 kg/ha	1.01**	17.52	200.6	334.53
		(0.99)	(4.16)	(14.16)	(18.28)
T2	Pendimethalin @ 1.5 kg/ha	2.79	49.03	125.73	237.33
		(1.66)	(7.00)	(11.19)	(15.37)
T3	Imazethapyr @ 80g/ha	9.93	103.81	328.56	370.53
		(3.09)	(10.17)	(18.12)	(19.15)
T4	Glyphosate @ 0.8 kg/ha	109.2	29.64	143.73	413.60
		(10.45)	(5.36)	(11.92)	(20.29)
T5	Oxyfluorfen + hoeing and earthing up at 60 DAP	1.87	29.73	19.65	72.93
		(1.37)	(5.45)	(4.39)	(8.46)
T6	Pendimethalin + hoeing and earthing up at 60 DAP	2.78	45.07	15.61	41.47
		(1.65)	(6.67)	(3.95)	(6.36)
T7	Imazethapyr + hoeing and earthing up at 60 DAP	11.14	96.78	16.16	140.53
		(3.32)	(9.83)	(4.01)	(11.84)
T8	Glyphosate + hoeing and earthing up at 60 DAP	93.20	24.82	16.23	77.87
		(9.63)	(4.98)	(4.02)	(8.82)
T9	Concurrent growing of cowpea and in situ incorporation and earthing up at 60 DAP	36.41	120.53	22.31	199.07
		(5.99)	(10.96)	(4.72)	(14.11)
T10	Hoeing and earthing up at 30 and 60 DAP	118.67	48.83	21.65	118.27
		(10.89)	(6.94)	(4.61)	(10.86)
T11	UWC	140.40	197.97	546.17	773.87
		(11.84)	(14.07)	(23.36)	(27.76)
CD(0.05)		0.79	1.23	1.27	2.43

** Original values, $\sqrt{X+0.5}$ transformed values are given in parentheses

weed count (281 nos.) compared to other treatments. A probable reason is the low canopy development of the cowpea variety (Kashi kanchan) used. According to Dwivedi and Shrivastava (2011), intercropping may not be able to provide satisfactory weed control at the early stages of crop growth due to low canopy development. The least counts of dicot weeds and total weeds at 60 DAP was recorded in the treatments receiving hoeing and earthing up at 30 and 60 DAP. However, the weed dry matter production was lower in treatments applied with pre emergent oxyfluorfen and directed application of glyphosate (Table 2 and 3). At 90 DAP, pendimethalin + hoeing and earthing up at 60 DAP showed the lowest total weed count. All the treatments with a follow up earthing up at 60 DAP recorded lower weed dry matter production at 90 DAP (Table 2 and 3). At the time of harvest, least count and dry weight was noticed in treatments with pre emergent application of pendimethalin (Table 2 and 3). Leela (1993) recommended pendimethalin + one hand weeding for effective control of weeds in long duration vegetable crops.

Weed control efficiency and weed index

At 30 days after planting, higher weed control efficiency was noticed in the treatments pre emergent application of oxyfluorfen, oxyfluorfen + hoeing and earthing up at 60 DAP, pendimethalin, pendimethalin + hoeing and earthing up at 60 DAP, imazethapyr and imazethapyr + hoeing and earthing up at 60 DAP which were statistically on par (Table 4). At 60 DAP higher weed control efficiencies were shown by pre emergent oxyfluorfen, oxyfluorfen + hoeing and earthing up at 60 DAP, directed application of glyphosate and glyphosate + hoeing and earthing up at 60 DAP. All the treatments with follow up

Table. 4. Weed control efficiency and weed index of different weed management methods

Treatments		WCE (%)				WI(%)
		30 DAP	60DAP	90DAP	Harvest	
T1	Oxyfluorfen @ 0.2 kg/ha	99.29	91.11	63.11	55.56	25.09
T2	Pendimethalin @ 1.5 kg/ha	97.98	75.22	76.82	69.27	44.88
T3	Imazethapyr @ 80g/ha	92.80	47.57	39.67	50.16	50.02
T4	Glyphosate @ 0.8 kg/ha	22.05	85.11	73.24	46.15	29.85
T5	Oxyfluorfen + hoeing and earthing up at 60 DAP	98.66	84.95	96.35	90.4	21.24
T6	Pendimethalin + hoeing and earthing up at 60 DAP	98.03	77.17	97.00	94.33	1.65
T7	Imazethapyr + hoeing and earthing up at 60 DAP	91.95	51.18	97.00	81.29	23.88
T8	Glyphosate + hoeing and earthing up at 60 DAP	32.85	87.46	97.03	89.77	8.64
T9	Concurrent growing of cowpea and *in situ* incorporation and earthing up at 60 DAP	73.66	39.04	95.88	73.93	25.75
T10	Hoeing and earthing up at 30 and 60 DAP	14.86	75.29	96.08	84.36	0
T11	UWC	0	0	0	0	56.28
	CD(0.05)	10.39	9.55	5.47	11.18	10.69

hoeing and earthing up at 60 DAP showed higher weed control efficiencies at 90 DAP. At the time of harvest pendimethalin + hoeing and earthing up at 60 DAP showed the highest weed control efficiency, but it was on par with oxyfluorfen + hoeing and earthing up at 60 DAP and glyphosate + hoeing and earthing up at 60 DAP. The treatments directed application of glyphosate, pre emergent application of imazethapyr and oxyfluorfen without hoeing and earthing up showed very low weed control efficiencies towards later stages of crop. This shows low persistent nature of these herbicides. According to Alister *et al.* (2009), soil half life value of oxyfluorfen was 34 to 52 days in sandy loam soils.

In general weed index was lower in plots with hoeing and earthing up at 30 and 60 DAP, pendimethalin + hoeing and earthing up at 60 DAP and glyphosate + hoeing and earthing up at 60 DAP (Table 4). The treatment with pre emergent application of imazethapyr showed higher weed index. Low weed control efficiency and high weed index in treatments with imazethapyr showed the ineffectiveness of imazethapyr for checking crop weed competition in cassava.

Economic analysis

The treatment with pre emergent application of pendimethalin + hoeing and earthing up at 60 DAP showed the highest B:C ratio of 2.41 (Table 2). Application of pre emergent oxyfluorfen was the next best alternative with a B:C ratio of 2.27. Although hoeing and earthing up produced higher tuber yields, the B:C ratio was lower because of the additional labour requirement. As Odoemenem and Otanwa (2011) reported, the negative influence of labour charges may affect the profitability of cassava cultivation.

Conclusion

Weed control by hoe weeding and earthing up alone may increase the cost of production because of higher labour requirement. However, it was better to practice application of pre emergent herbicides like pendimethalin along with hoeing and earthing up at 60 DAP for effective weed control and reduction in cost of cultivation.

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