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Effect of integrated weed management practices on weed population and weed biomass in rubber plantation

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Abstract
An experiment was conducted to study the impact of varying herbicide dosages and intercropping on weed density and biomass in rubber plantation. Weed-free plots exhibited the lowest weed density and biomass throughout the experiment. Among herbicide treatments, Diuron at 3200 a.i. per ha displayed the best weed control, closely followed by Diuron at 1600 a.i. per ha. However, manual hand weeding at monthly intervals proved most effective in weed suppression, despite being less economically viable due to higher labour costs. Diuron at 3200 a.i. per ha emerged as the most effective herbicide in weed management, primarily due to its pre-emergent control of a broad spectrum of weeds. Intercropping, particularly with cowpea, coriander and fenugreek, also influenced weed density and biomass. Lower weed density and biomass were observed in cowpea intercropped plots, with strong suppression of weed growth during specific growth stages over the entire crop growth period.

Keywords: Indian mustard, path coefficient analysis

Introduction
Rubber produced from *Hevea brasiliensis* [Müll. Arg.], a perennial commercial crop, holds the reins of global natural rubber (NR) production. It is cultivated in tropical humid climates and the major global producers encompass Thailand, Indonesia, Malaysia, Vietnam, China and India. India, securing a commendable sixth position globally, acquires noteworthy productivity also. Among the total area of 8,22,000 ha under rubber in India, 6,14,500 ha is under mature yielding crop. The lion's share of production, standing at 81 percent, is attributed to traditional rubber-growing states like Kerala and Tamil Nadu. Yet, the presence of weeds presents a formidable hurdle in rubber cultivation. Effective weed control is therefore crucial in rubber plantations. However, manual weeding is economically not viable due to labour scarcity, and mechanization proves impractical for small-scale farmers. In light of this, chemical weed control and integrated management strategies emerge as pragmatic alternatives, facilitating practicality and application ease.

Among the recommended herbicides for rubber plantations, Diuron, Glyphosate, Paraquat, Simazine and Cyanazine are prominent. Notably, Diuron 80 WP stands out as a broad-spectrum herbicide utilized for curtailing wide spectrum of annual and perennial grasses and herbaceous weeds. As a residual herbicide, it is being applied for both pre-emergent and post-emergent weed management. In its pre-emergent role, Diuron permits seed germination while impeding chlorophyll production, ultimately starving and eradicating the germinating seeds (Ferrell *et al*., 2004) [2]. Diuron traverses the transpiration system through the xylem, inhibiting the Hill reaction during photosynthesis that impedes the production of vital high-energy compounds like adenosine triphosphate (ATP), pivotal for diverse metabolic processes (Hess and Warren, 2002) [3].

Considering these aspects, an experiment was conducted to study the impact of integrated weed management practices on weed population and weed biomass within rubber plantations.

Materials and Methods
A study was conducted at Horticultural Research Station, Pechiparai, located at the High Rainfall Zone of Tamil Nadu, with coordinates of 76 m MSL, 8º26'N latitude, and 77º19'E longitude. The rubber plantation was established in the year 2005 and the research was carried out from February, 2023 to July, 2023. The weed species present in the plantation were identified and documented. The herbicide formulation, Diuron 80 WP (Diuron % WP), was evaluated for its effectiveness in controlling the weed flora in rubber plantation at different

concentrations and in combination with intercrops, as well as compared to an un-weeded control and a weed-free check (Hand weeding- 20, 40 and 60 days). The experiment was designed as a Split Plot Design, with four main plot treatments and four subplot treatments, each replicated three times. Diuron 80% WP was applied as a pre-emergent herbicide following irrigation, according to the designated treatments.

Observations on weed density and dry weight were recorded in the weed populations of rubber plantation on 30, 60 and 90 days after application (DAA). Weed density was determined by counting populations of grassy weeds, broad leaf weeds (BLWs) and sedges in three fixed one-meter square areas at 30, 60 and 90 DAA. The weed biomass uprooted from a one-meter square area was sun-dried followed by oven drying to remove the moisture from them. The dry weight of weeds for each treatment was recorded and reported as grams per square meter (gm $^{-2}$).

Results and Discussion

The results of the weed flora, weed density per meter square and weed dry weight (g/m^2), in rubber plantations under different herbicidal applications and intercropping are furnished in Table 1 and 2. In general, majority of weeds belong to C4 perennial weed category and were broadly placed under five families and eight species. In the experimental plot, broad leaved weed species were more dominant in number as compared to grasses.

Table 1: Weed flora infested in the experimental area of rubber plantation

Botanical Name	Common Name	Family	Growth Habit	Photosynthetic Pathway	EPPO Abbreviated Name
Grasses					
Cynodon dactylon	Poaceae	Bermuda grass	Perennial	C4	Cynda
Digitaria sanguinali	Poaceae	Hairy crab grass	Annual	C4	Digsa
Axonopus compressus	Poaceae	Carpet grass	Perennial	C4	Axoco
Broad Leaved Weeds					
Clerodendron infortunatum	Lamiaceae	Hill glory bower	Perennial	C4	Clzif
Cyathula prostrata	Amaranthaceae	Pasture weed	Perennial	C4	Cyhpr
Chromolaena odorata	Asteraceae	Siam weed	Perennial	C3	Eupod
Parthenium hysterophorus	Asteraceae	Carrot grass	Annual	C3- C4 intermediate	Ptnhy
Mimosa pudica L.	Fabaceae	Touch me not plant	Perennial	C3	Mimpu

Effect of doses of herbicide on total weed density and biomass of weeds in rubber

The different dosage of herbicide had a significant influence on the density and biomass of the total weeds in the rubber crop. The least weed density and biomass was observed under the weed free plot throughout the experimental period. Among the other treatments, the density of the total weeds on the 30 DAS was recorded the least in the treatment Diuron sprayed at the rate of 3200 a.i. per ha (3.22). At 90 DAS, weed free treatment recorded a density of 1.73 and a biomass of 1.58 g per m^2, followed by Diuron 3200 sprayed at the rate of 3200 a.i. per ha which recorded a density of 4.99 and biomass of 3.98 g per m^2. Diuron sprayed at 1600 a.i. per ha was on par with that of Diuron 3200 a.i. per ha throughout the experimental period. Further, it can be affirmed that weed-free condition provided through manual hand weeding at monthly interval was the best treatment that effectively controlled the different category of weeds, *viz.*, grasses and BLWs throughout the growing season.

The reasons for better weed suppression with this treatment might be due to both the weeding operation was performed at the critical period of crop-weed competition that provide competitive advantage to the crop. However, it was not economically remunerative because of more manpower required for manual weeding coupled with high wage required for weeding operation (Yadav *et al.*, 2017) [12]. Among the dosage, Diuron sprayed at 3200 a.i. per ha was found to be the most effective in management of weeds. In fact, this treatment showed lowest density and biomass of from emergence to critical period of crop weed competition (0-90 DAS) due to the effect of pre-emergent control of broad spectrum of weeds.

Effect of intercropping on total weed density and biomass of weeds in rubber

The intercrops also had an influence on the weed density and biomass of total weeds in rubber plantation. Lower weed density and biomass were recorded in the cowpea intercropping with an incidence of 4.32 and 4.19 g/m^2 at 30 DAS and 5.82 and 5.22 g/m^2 of total weed density and weed biomass at 90 DAS respectively. It was followed by the coriander and fenugreek intercropping which were on par with each other. Due to higher vegetative growth of intercrops, weed growth was suppressed, especially during the 60 to 90 DAS and it was clearly reflected in terms of lower weed density and weed biomass during the entire crop growth period.

Table 2: Influence of herbicide mixtures and intercrop on density and biomass of total weeds in rubber

Treatments	Total Weeds					
	Density (m^2)			Biomass (g/m^2)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Herbicide dosage						
D 1600*	3.29 (10.32)	4.54 (20.11)	5.27 (27.27)	2.57 (24.50)	3.27 (17.22)	4.58 (15.42)
D 3200*	3.22 (9.87)	4.48 (19.57)	4.99 (24.40)	2.21 (4.38)	3.21 (13.64)	3.98 (15.34)
Weed free check	1.42 (1.52)	2.02 (3.58)	1.73 (2.49)	0.96 (24.70)	1.78 (2.67)	1.58 (2.00)

Un weeded control	7.84 (60.97)	10.54 (110.59)	9.78 (95.15)	5.05 (25)	8.24 (67.40)	8.19 (66.58)
S.Ed	0.40	0.89	0.80	0.18	0.27	0.47
CD (P=0.05 %)	1.15	2.61	2.33	0.52	0.75	1.38
Intercrops						
Coriander	4.78 (20.35)	7.43 (54.70)	7.29 (52.64)	4.42 (19.04)	6.98 (48.22)	6.89 (46.97)
Chilli	5.51 (29.86)	8.34 (69.06)	8.02 (63.82)	4.99 (24.40)	8.03 (63.98)	7.83 (60.81)
Cowpea	4.32 (18.16)	6.39 (40.33)	5.82 (20.48)	4.19 (17.06)	5.98 (35.26)	5.22 (14.48)
Fenugreek	4.79 (22.44)	7.87 (61.44)	7.81 (60.50)	4.49 (19.66)	7.36 (53.67)	7.28 (52.50)
S.Ed	0.09	0.27	0.27	0.13	0.13	0.25
CD (P=0.05 %)	2.51	0.78	0.77	0.34	0.34	0.77
A X B	NS	NS	NS	NS	NS	NS

D- Diuron; *- g a.i./ha; Data are subjected to square root transformation √0+0.5 and non-transformed data is mentioned in the parenthesis

Conclusion

The study highlighted the significant impact of different diuron dosages and intercropping on weed control in rubber plantations. While manual weeding is effective, it may not be economically viable due to higher labour costs. Diuron at 3200 g a.i per ha, proved to be effective, but higher concentrations could negatively affect if intercrops are to be cultivated. Therefore, an integrated weed management approach involving Diuron 1600 g a.i per ha along with intercropping cowpea and coriander efficiently control weeds in rubber crops and generated additional income for farmers through intercropping.

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