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STUDY ON CHEMICAL WEED MANAGEMENT PRACTICES AND ITS IMPACT ON CROP GROWTH AND BIOACTIVE COMPOUNDS OF INDIAN PENNYWORT (*CENTELLA ASIATICA* L.)

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ABSTRACT

An experiment was conducted at college of Horticulture, Mudigere during 2023-24 to evaluate the effectiveness of pre and early post emergent herbicides on managing weeds and its impact on crop growth, herbage yield and bioactive compounds. The experiment was designed in Randomized Complete Block Design with eight treatments and three replications. The results of the study revealed that among the herbicidal treatments, the treatment T_6 (Oxyflurofen 23.5% EC at 1 ml/l + one hand weeding at 45 DAT) recorded the lowest weed density (23.00 number/cm^2) and higher weed control efficiency (97.90 %) at 60 days after transplanting (DAT) along with weed index of 12.22 per cent. Among the various herbicides, the treatment T_6 recorded maximum values for all the growth parameters studied such as stolon length (113.64 cm), rosette length (24.04 cm), rosette diameter (20.07 cm), number of leaves per rosette (12.13), leaf area (23.60 cm^2) at harvest and total chlorophyll content of 3.59 mg/g at 120 DAT. Additionally, T_6 also attained early maturity of 123 days with significantly maximum fresh and dry herbage yield (1146.67 g/m² and 207.78 g/m², respectively). The significantly higher total terpenoids yield (47.69 kg/ha) was observed in the treatment T_6 (Oxyflurofen 23.5% EC at 1 ml/l + one hand weeding at 45 DAT).
Keywords**:** *Centella asiatica*, Chemical weed management, Oxyflourfen, Hand weeding, Bioactive compounds.

Introduction

Indian pennywort or Mandukaparni (*Centella asiatica* L.), is an important tropical and subtropical medicinal herb from the Apiaceae family, with a chromosome number of 2n=18. The plant is native to Southeast Asian countries including India, Sri Lanka, China and Malaysia and it has pantropical distribution. It thrives in moist environments from plains to hill ranges up to 2000 meters elevation (Seevaratnam *et al*., 2012). It is remarkable medicinal herb with rich history in traditional medicine. Its diverse therapeutic properties, primarily due to its bioactive compounds (triterpenoids), make it a valuable resource for enhancing cognitive function, treating skin conditions and addressing various systemic illnesses. It is also believed to be capable of boosting memory, increasing concentration and alertness, hence referred as “Brain food” (Lal *et. al*., 2017). The growing awareness of Indian pennywort has led to an expanding interest in its potential uses in contemporary healthcare and wellness products. As a result, the demand for the crude drug is rising, although commercial cultivation remains limited.

Indian pennywort is commonly cultivated for medicinal and cosmetic purposes and while its cultivation is generally easy across various altitudes but, it faces stiff challenges both from monocot and dicot weeds of annuals and perennials. Weeds compete with mandukaparni for nutrients, water, light and space, which could reduce fertilizer efficiency and negatively impact herb growth and quality, leading to lower yields and therapeutic value. The weed vegetation analysis on *Centella* plantations showed that there were 35 species of weeds identified from 20 plant families with dominance of *Cyperus rotundus* L. The most common and problematic weeds in *Centella* cultivation are *Oxalis* spp., *Cynodon dactylon* and *Cyperus rotundus*, as they reproduce through seeds, bulbs and rhizomes and also due to their high adaptability and allelochemical exudates (Susanti *et al*., 2021). Owing to its creeping habit, these weeds can obstruct crop growth, harvesting of the herbage and also contaminate the crude drug which interferes with sustainable cultivation and quality standards. Additionally, weed management can also increase cost of production.

Due to its creeping growth, mandukaparni presents challenges for mechanical weed control at later stages of crop growth, necessitating labour intensive manual weeding.

Chemical weed control methods enhance crop growth and yield more effectively than manual or mechanical methods by minimizing mechanical damage and reducing moisture loss. This approach is also faster and requires less labour, making it more cost effective (Woyessa, 2022). In this context, herbicides offer alternative solutions for promoting the commercial cultivation of *Centella asiatica* on sustainable basis.

Material and Methods

The field experiment was conducted at college of Horticulture, Mudigere during summer season of 2023-2024 to evaluate the effectiveness of pre and early post emergent herbicides in management of weeds and its impact on crop growth, herbage yield and quality (bioactive compounds). The experiment was carried out in Randomized Complete Block Design with eight treatments and three replications under 50 per cent shade net. The treatments consisted of T_1: Pendimethalin 38.7 CS @ 3m/l, T_2: Pendimethalin 38.7 CS @ 3m/l + Bispyribac sodium 10 % SC @ 0.4ml/l, T_3: Pendimethalin 38.7 CS @ 3m/l + one hand weeding @ 45 DAT, T_4: Oxyflurofen 23.5 % EC @ 1ml/l, T_5: Oxyflurofen 23.5 % EC @ 1ml/l + Bispyribac sodium 10 % SC @ 0.4ml/l, T_6: Oxyflurofen 23.5 % EC @ 1ml/l + one hand weeding @ 45 DAT, T_7: Weed free and T_8:Weedy check. The well grown stolons were transplanted in raised beds at spacing of 30 cm*30 cm. The pre-emergent herbicides pendimethalin 38.7 CS @ 3ml/l and oxyfluorfen 23.5 % EC @ 1ml/l were given as spray at 48 hours after transplanting, while the early post emergent herbicide bispyribac sodium 10 % SC @ 0.4 ml/l was sprayed at 10 DAT. For weed free treatment, hand weeding was conducted at weekly interval to maintain a weed free environment. All other standard cultural practices were followed throughout the cropping season.

Weed parameters

The preliminary identification of weed species was conducted visually and later confirmed with herbarium specimens and experts. The identified weeds were then categorized into their respective plant families based on their morphological characteristics and taxonomic relationships. The weed density was assessed by taking the count of all the weeds including grasses, sedges and broad-leaved weeds in 1 square meter area both at 45 and 60 DAT. The dry matter accumulation was also measured at 45 and 60 DAT by drying the weed samples in an oven at 60°C until constant weight was obtained. The weed control efficiency at 45 and 60 DAT and weed index at harvest were calculated using formulas given by Mani *et al.* (1973) and Gill and Kumar (1969), respectively.

$$\text{Weed Control Efficiency (WCE)} = \frac{DW_C - DW_T}{DW_C} \times 100$$

Where, DW_C - Dry matter accumulation of weeds in unweeded control plot

$$\text{Weed index (WI)} = \frac{Y_{WF} - Y_T}{Y_{WF}} \times 100$$

Where, Y_{WF} - Yield from weed free plot and Y_T - Yield from the treated plot

The data on weed parameters were subjected to square root transformation $\sqrt{(x+0.5)}$ where x is the value representing original data. Transformation makes analysis of variance more valid as suggested by Chandel (1984).

Growth parameters

The observations on growth parameters at harvest were recorded from five randomly selected rosettes in each plot, excluding border ones. The mean value of the data was taken to represent the treatment with respect to a parameter. The total chlorophyll content of leaf tissue was determined at 60 and 120 DAT by destructive method of chlorophyll estimation using the dimethyl sulfoxide (DMSO) as suggested by Shoaf and Lium, 1976.

Yield parameters

The fresh and dry weight of the herbage in one square meter area at the centre of the plots of each treatment was recorded and the mean weight was expressed as herbage yield per square meter based on which herbage yield per hectare was calculated.

Bioactive compounds

The bioactive compounds (triterpenoids) in the whole herb were assessed from composite samples of each treatment using High Performance Liquid Chromatography (HPLC) as per the method suggested by Agarwal and Murali (2010).

The statistical analysis of data was performed through analysis of variance to determine its significance (Panse and Sukhatme, 1967).

Results and Discussion

Weed parameters

Weed flora: The weed species identified in the experimental plot were belonged to 15 different families, with the Asteraceae and Poaceae families representing the largest proportions at 16.66 and 12.50 per cent, respectively (Fig-1). The similar findings were reported by Susanti *et al.* (2021) in Indian pennywort (*Centella asiatica* L.).

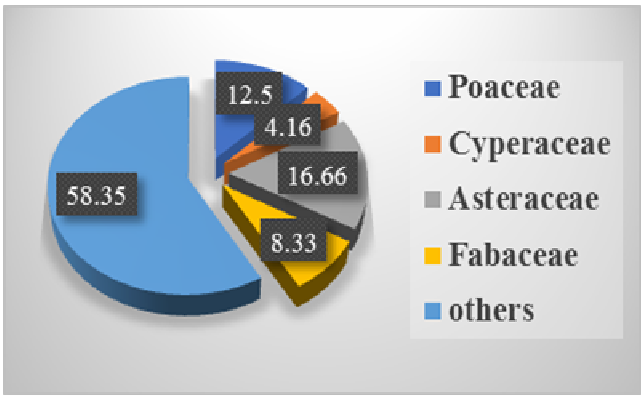

Fig. 1 : Weed flora in the experimental plots of *Centella asiatica* L.

Weed density

The data on weed density was significantly influenced by different pre and early post emergent herbicides (Table-1). At 45 and 60 DAT, the treatment T_7 (Weed free) recorded significantly minimum weed density (27.67 and 22.33 /m^2, respectively). However, among the herbicidal treatments, the treatment T_5: Oxyfluorfen 23.5 % EC @ 1 ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l (38.33/m^2) and T_6: Oxyfluorfen 23.5 % EC @ 1 ml/l + one hand weeding at 45 DAT (23.00 /m^2) recorded the lowest weed densities at 45 and 60 DAT, respectively. The treatment T_8 (Weedy check) recorded significantly maximum weed density (826.00 and 963.67 /m^2) both at 45 and 60 DAT. The lower weed density in weed free treated plots was attributed to effective manual uprooting of weeds, as noted by Yadav *et al.* (2015) and Dhakad *et al.* (2017) in coriander. The use of oxyfluorfen herbicide resulted in lower weed densities as compared to pendimethalin, potentially due to its ability to inhibit chloroplast, energy transfer and photosynthetic electron transport leading to free radical formation, lipid peroxidation and membrane disruption in weeds and also greater impact on broadleaf weeds leading to reduced densities at 45 and 60 DAT which was in line with the findings of Kumar *et al.* (2019) in fennel. Further, its combination with early post emergent herbicide bispyribac sodium might have potentially enhanced their efficacy against weeds resulting in minimum weed density.

Dry weight of weeds

The dry weight of weeds was significantly influenced by different herbicidal treatments (Table 1). At 45 DAT, the treatment T_5 (Oxyfluorfen 23.5 % EC @ 1ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l) recorded the minimum dry weight of weeds (0.70 g/m^2), while at 60 DAT, T_7 (Weed free) recorded significantly minimum dry weight of weeds (0.59 g/m^2) which was followed by the treatment T_6: Oxyfluorfen 23.5 % EC @ 1ml/l + one hand weeding @ 45 DAT (1.03 g/m^2). However, the significantly highest dry weight of weeds (40.90 and 49.34 g/m^2) was recorded in T_8: Weedy check at 45 and 60 DAT, respectively. The minimum dry weight of weeds in the treatment T_5 might be attributed to the ability of oxyfluorfen to create a chemical barrier that inhibited weed emergence and photosynthesis. Similar findings were reported by Singh *et al.* (2009) in menthol mint, where oxyfluorfen reduced weed dry matter and by Das *et al.* (2015) in rice, where bispyribac sodium significantly decreased weed dry weight compared to control.

Weed control efficiency

Weed control efficiency was significantly influenced by various pre and early post emergent herbicides at 45 and 60 DAT as mentioned in the Table-1. Among the herbicidal treatments studied at 45 DAT, the treatment T_5 (Oxyfluorfen 23.5 % EC @

1ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l) recorded the significantly highest weed control efficiency (98.29 %), while at 60 DAT, the maximum weed control efficiency (97.90 %) was observed in the treatment T_6 (Oxyfluorfen 23.5 % EC @ 1ml/l + one hand weeding @ 45 DAT). The treatment T_8 (Weedy check) recorded the least weed control efficiency (0.00 %) over rest of the treatments both at 45 and 60 DAT. The higher weed control efficiency in the treatment T_5 might be due to lower weed densities and dry weight of weeds. This aligns with Kumaran *et al.* (2015) who noted greater control efficiency with early post emergence application bispyribac sodium in rice and Kumar *et al.* (2019) who found oxyfluorfen more effective than pendimethalin in fennel. In weed free plots, effective manual removal of weeds might have reduced dry matter accumulation, supporting the findings by Dhakad *et al.* (2017) in coriander and Kumar *et al.* (2019) in fennel.

Weed Index

Among the treatments, T_7 (Weed free) exhibited the lowest weed index (0.00 %) which was followed by the treatment T_6 (Oxyfluorfen 23.5 % EC @ 1ml/l + one hand weeding @ 45 DAT (12.22 %) at harvest. Conversely, the treatment T_7 (Weedy check) exhibited the highest weed index (91.46 %). Studies of Nagar and Jain (2017) in coriander highlighted the benefits of pre-emergence herbicides and hand weeding in reducing weed dry matter, leading to higher crop yields and thereby higher weed index.

Growth parameters

All the growth parameters varied significantly by different herbicidal treatments and the related data is presented in Table-2. Among the herbicides, the treatment T_6 (Oxyfluorfen 23.5% EC + one hand weeding @ 45 DAT) recorded maximum values for all the growth parameters studied such as stolon length (113.64 cm), rosette length (24.04 cm), rosette diameter (20.07 cm), number of leaves per rosette (12.13) and leaf area (23.60 cm^2). The maximum total chlorophyll content of 2.78 and 3.59 mg/g at 60 and 120 DAT, respectively was recorded in T_6. All the growth parameters were recorded minimum values in the treatment T_8 (Weedy check) with lowest stolon length (63.05 cm), rosette length (13.69 cm), rosette diameter (12.56 cm), number of leaves per rosette (7.67) and leaf area (10.75 cm^2) at harvest with minimum total chlorophyll content of 1.54 and 2.10 mg/g at 60 and 120 DAT, respectively. The increased stolon length, rosette length, rosette diameter, leaf count and leaf area were observed in T_6 which might be attributed to effective weed management, which reduced weed density and biomass. This reduction might have enhanced nutrient and moisture availability to the crop, thereby supported improved crop growth and development. The higher rosette length and diameter reflected improved photosynthetic efficiency, as reduced weed competition allowed for better light capture which aligns with the findings of Meena *et al.* (2004) in *Bacopa monnieri* and Asha (2018) in menthol mint. Similarly, the greater leaf count and increased leaf area in T_6 might be linked to improved resource availability of water, nutrients, space and light, all of which fostered enhanced growth. These findings are align with Gohil *et al.* (2012) in fennel. In contrast, the weedy check, which had higher weed competition, experienced limited growth might be due to shading effect caused by weeds and reduced photosynthetic capacity, leading to smaller rosette diameters, lower leaf counts and reduced leaf area. The results are in accordance with Singh *et al.* (1995) in menthol mint.

Yield parameters

Duration of crop maturity

A significant variation was observed among the treatments as presented in Table-3. Among the diverse treatments, the treatment T_6 (Weed free) showed early maturity with 120.00 days whereas, the treatment T_8 (Weedy check) took maximum number of days to reach maturity (150 days).

Fresh and dry herbage yield

The fresh and dry herbage yield was significantly influenced by different herbicidal treatments (Table-3). The treatment T_7 (Weed free) recorded the highest fresh herbage yield (1283.00 g/m² and 12.83 t/ha). However, among the herbicidal treatments, the treatment T_6(Oxyfluorfen 23.5% EC + one hand weeding at 45 DAT) recorded the significantly maximum fresh herbage yield (1146.67 g/m² and 11.47 t/ha). The lowest fresh herb yield was noticed in T_8: Weedy check (474.33 g/m² and 4.74 t/ha). Similarly, the treatment T_7 (Weed free) also recorded the significantly highest dry herbage yield (236.71 g/m² and 2.37 t/ha). But, among the herbicides evaluated, T_6 (Oxyfluorfen 23.5% EC + one hand weeding at 45 DAT) recorded maximum dry herbage yield (207.78 g/m² and 2.08 t/ha), while the treatment T_8 (Weedy check) noted the least dry herbage yield (72.00 g/m² and 0.72 t/ha). The higher fresh and dry herbage yields in weed free plots could be attributed to improved growth parameters such as stolon length, rosette length and diameter, number of leaves, leaf area and chlorophyll content resulted from enhanced nutrient utilization due to reduced weed competition. Similar results were observed by Senthivel (2001) in coriander, Singh (2003) in *Mentha* species, Yadav *et al*. (2013) and Mehta *et al*. (2014) in fenugreek. The higher fresh and dry herbage yields was achieved in T_6 among different herbicidal treatments which might be due to effective weed control that could have enhanced nutrient availability. The increased leaf area captured more solar radiation, boosted photosynthesis, as noted by Singh *et al*. (2009) in menthol mint. In contrast, severe weed competition in the weedy check resulted in the lowest yield and findings are in consistent with Gohil *et al.* (2012) in fennel.

Quality parameters

Madecassoside content and its yield: The various herbicidal treatments significantly influenced the madecassoside content and its yield in mandukaparni (Table-4). The treatment T_8 (Weedy check) noted the highest madecassoside content of 0.96 % w/w, while the least was observed in T_5: Oxyfluorfen 23.5 % EC @ 1 ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l (0.45% w/w). The higher madecassoside yield was recorded in the treatment T_7: Weed free (19.49 kg/ha) and the least madecassoside yield was noted in the treatment T_5 (5.00 kg/ha).

Asiaticoside content and its yield: The treatments T_4 (Oxyfluorfen 23.5 % EC @ 1 ml/l), T_6 (Oxyfluorfen 23.5 % EC @ 1 ml/l + one hand weeding @ 45 DAT), T_7 (Weed free) and T_8 (Weedy check) recorded *on par* values for asiaticoside content (0.82 % w/w each) with T_5 recording the minimum asiaticoside content (0.46 % w/w). The herbicides significantly influenced asiaticoside yield in Indian pennywort (Table-4). The treatment T_7 recorded the highest asiaticoside yield (19.39 kg/ha) and the least asiaticoside yield was observed in T_5 (5.10 kg/ha).

Madecassic acid content and its yield: The maximum madecassic acid content was observed in the treatment T_3: Pendimethalin 38.7 CS @ 3ml/l + one hand weeding @ 45 DAT (0.28 % w/w) and the lowest (0.22 % w/w) was recorded in the treatment T_2: Pendimethalin 38.7 CS @ 3ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l. The madecassic acid yield was also significantly influenced by various treatments (Table-4) where the significantly highest madecassic acid yield was found in T_7 (6.20 kg/ha), while the least was recorded in T_8: Weedy check (1.80 kg/ha).

Asiatic acid content and its yield: The asiatic acid content and its yield was significantly influenced by various herbicidal treatments (Table-4). The treatment T_1 (Pendimethalin 38.7 CS @ 3ml/l) was found to have noted highest asiatic acid content (0.45 % w/w) , while the least was observed in T_2 (0.33 % w/w). The higher asiatic acid yield was recorded in T_7: Weed free (9.00 kg/ha), followed by T_6: Oxyfluorfen 23.5 % EC @ 1 ml/l+ one hand weeding @ 45 DAT (7.48 kg/ha) and the least asiatic acid yield was observed in the treatment T_8: Weedy check (2.75 kg/ha).

Total triterpenoids content and its yield: The total triterpenoids content and its yield in Indian pennywort was significantly influenced by various pre and early post emergent herbicides (Table-4). Among different treatments studied, the treatment T_8 (Weedy check) recorded the highest total triterpenoids content (2.42 % w/w), while the lowest was observed in the treatment T_5: Oxyfluorfen 23.5 % EC @ 1ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l (1.48 % w/w). The highest triterpenoids content in T_8 might be resulted from stress created in response to oxidative stress due to uncontrolled weed growth that stimulated triterpenoids biosynthesis, as noted by Selmar and Kleinwachter (2013). The total triterpenoids yield was found to be significantly highest in T_7: Weed free (55.17 kg/ha), followed by T_6: Oxyfluorfen 23.5 % EC @ 1 ml/l + one hand weeding @ 45 DAT (47.69 kg/ha), whereas the minimum total triterpenoids yield was exhibited by the treatment T_5 (16.44 kg/ha).

Conclusion

The present investigation on chemical weed management of Indian pennywort through the use of pre and early post emergent herbicides demonstrated that, the treatment T_6 resulted the maximum growth parameters, fresh and dry herbage yield along with triterpenoids yield. This treatment also provided substantial weed control with the least weed density and maximum weed control efficiency. While, the treatment T_8 (Weedy check) recorded the lowest growth, yield and quality indicators (bioactive compounds).

Table 1: Effect of pre and early post emergent herbicides on weed parameters at different stages crop growth period in Indian pennywort (*Centella asiatica* L.)

Treatments	Weed density (number/m^2)		Dry weight of weeds (g/m^2)		Weed control efficiency (%)		Weed Index (%)
	45 DAT	60 DAT	45 DAT	60 DAT	45 DAT	60 DAT	At harvest
T_1: Pendimethalin 38.7 CS @ 3ml/l	12.44 (154.33)	13.73 (188.00)	4.09 (16.25)	4.39 (18.77)	60.26	61.95	33.63
T_2: Pendimethalin 38.7 CS @ 3ml/l +Bispyribac sodium 10 % SC @ 0.4 ml/l	8.07 (64.67)	8.84 (77.67)	1.48 (1.70)	1.69 (2.36)	95.84	95.21	43.66
T_3: Pendimethalin 38.7 CS @ 3ml/l + one hand weeding @ 45 DAT	12.23 (149.00)	7.67 (58.33)	4.05 (15.87)	1.32 (1.23)	61.19	97.50	19.57
T_4: Oxyflurofen 23.5 % EC @ 1ml/l	8.97 (80.00)	9.53 (90.33)	1.52 (1.82)	1.70 (2.40)	95.56	95.14	25.14
T_5: Oxyflurofen 23.5 % EC @ 1ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l	6.23 (38.33)	7.13 (50.33)	1.09 (0.70)	1.38 (1.39)	98.29	97.18	53.08
T_6: Oxyflurofen 23.5 % EC @ 1ml/l + one hand weeding @ 45 DAT	8.69 (75.00)	4.85 (23.00)	1.54 (1.87)	1.24 (1.03)	95.43	97.90	12.22
T_7: Weed free	5.31 (27.67)	4.78 (22.33)	1.15 (0.83)	1.04 (0.59)	97.97	98.80	0.00
T_8: Weedy check	28.75 (826.00)	31.05 (963.67)	6.43 (40.90)	7.06 (49.34)	0.00	0.00	91.46
S. Em ±	**0.04**	**0.05**	**0.02**	**0.02**	**0.41**	**0.23**	**0.31**
CD at 5%	**0.11**	**0.15**	**0.07**	**0.06**	**1.23**	**0.70**	**0.95**

DAT-Days After Transplanting, Figures in the parentheses indicate the original value, data subjected for square root transformation $\sqrt{X+0.5}$ where x represents the original value.

Table 2 : Effect of pre and early post emergent herbicides on growth parameters of Indian pennywort (*Centella asiatica* L.) at harvest

Treatments	Stolon length (cm)	Rosette length (cm)	Rosette diameter (cm)	Number of leaves per rossette	Leaf area (cm^2)	Total Chlorophyll content (mg/g)	
	At harvest					60 DAT	120 DAT
T_1: Pendimethalin 38.7 CS @ 3ml/l	94.28	20.52	17.15	11.53	17.58	2.49	3.12
T_2: Pendimethalin 38.7 CS @ 3ml/l +Bispyribac sodium 10 % SC @ 0.4 ml/l	76.01	17.89	14.75	10.93	13.42	2.04	2.65
T_3: Pendimethalin 38.7 CS @ 3ml/l + one hand weeding @ 45 DAT	105.47	23.45	19.35	12.07	21.28	2.70	3.47
T_4: Oxyflurofen 23.5 % EC @ 1ml/l	100.33	22.95	18.37	11.53	20.96	2.61	3.39
T_5: Oxyflurofen 23.5 % EC @ 1ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l	67.59	15.38	13.08	9.73	11.31	1.88	2.63
T_6: Oxyflurofen 23.5 % EC @ 1ml/l + one hand weeding @ 45 DAT	113.64	24.04	20.07	12.13	23.60	2.78	3.59
T_7: Weed free	120.62	24.43	20.57	12.33	25.55	2.90	3.84
T_8: Weedy check	63.05	13.69	12.56	7.67	10.75	1.54	2.10
S. Em ±	**0.17**	**0.03**	**0.08**	**0.08**	**0.14**	**0.07**	**0.05**
CD at 5%	**0.52**	**0.10**	**0.25**	**0.23**	**0.42**	**0.22**	**0.17**

DAT- Days After Transplanting

Table 3 : Effect of pre and early post emergent herbicides on days to maturity and fresh and dry herbage yield of Indian pennywort (*Centella asiatica* L.) at harvest

Treatments	Days to maturity (days)	Fresh herbage yield		Dry herbage yield	
		Per square metre (g)	Per hectare (t)	Per square metre (g)	Per hectare (t)
T_1: Pendimethalin 38.7 CS @ 3ml/l	133.00	917.67	9.18	157.10	1.57
T_2: Pendimethalin 38.7 CS @ 3ml/l +Bispyribac sodium 10 % SC @ 0.4 ml/l	146.00	789.67	7.90	133.37	1.33
T_3: Pendimethalin 38.7 CS @ 3ml/l + one hand weeding @ 45 DAT	125.00	1060.67	10.61	190.39	1.90
T_4: Oxyflurofen 23.5 % EC @ 1ml/l	128.00	1002.33	10.02	177.21	1.77
T_5: Oxyflurofen 23.5 % EC @ 1ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l	150.00	676.00	6.76	111.07	1.11
T_6: Oxyflurofen 23.5 % EC @ 1ml/l + one hand weeding @ 45 DAT	123.00	1146.67	11.47	207.78	2.08
T_7: Weed free	120.00	1283.00	12.83	236.71	2.37
T_8: Weedy check	150.00	474.33	4.74	72.00	0.72
S. Em ±	**0.32**	**4.19**	**0.04**	**0.75**	**0.01**
CD at 5%	**0.96**	**12.72**	**0.13**	**2.26**	**0.03**

DAT- Days After Transplanting

Table 4: Effect of pre and early post emergent herbicides on triterpenoids content (% w/w) and tri terpenoids yield (kg/ha) of Indian pennywort (*Centella asiatica* L.) at harvest

Treatments	Triterpenoids content					Tri terpenoids yield				
	Madecassoside	Asiaticoside	Madecassic acid	Asiatic acid	Total triterpenoids	Madecassoside	Asiaticoside	Madecassic acid	Asiatic acid	Total triterpenoids
T_1: Pendimethalin 38.7 CS @ 3ml/l	0.70	0.66	0.26	0.45	2.08	11.00	10.38	4.10	7.07	32.68
T_2: Pendimethalin 38.7 CS @ 3ml/l +Bispyribac sodium 10 % SC @ 0.4 ml/l	0.63	0.57	0.22	0.33	1.76	8.40	7.63	2.91	4.40	23.46
T_3: Pendimethalin 38.7 CS @ 3ml/l + one hand weeding @ 45 DAT	0.63	0.58	0.28	0.38	1.88	11.93	10.99	5.31	7.23	35.82
T_4: Oxyflurofen 23.5 % EC @ 1ml/l	0.80	0.82	0.25	0.38	2.26	14.24	14.52	4.49	6.73	40.04
T_5: Oxyflurofen 23.5 % EC @ 1ml/l + Bispyribac sodium 10 % SC @ 0.4 ml/l	0.45	0.46	0.25	0.34	1.48	5.00	5.10	2.82	3.78	16.44
T_6: Oxyflurofen 23.5 % EC @ 1ml/l + one hand weeding @ 45 DAT	0.87	0.82	0.25	0.36	2.30	18.08	17.05	5.11	7.48	47.69
T_7: Weed free	0.82	0.82	0.26	0.38	2.33	19.49	19.39	6.20	9.00	55.17
T_8: Weedy check	0.96	0.82	0.25	0.38	2.42	6.89	5.92	1.80	2.75	17.43
S. Em ±	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.11**	**0.09**	**0.06**	**0.20**	**0.16**
CD at 5 %	**0.03**	**0.02**	**0.03**	**0.04**	**0.03**	**0.32**	**0.28**	**0.18**	**0.60**	**0.49**

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