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Weed dynamics, herbage and oil yield of sweet basil (*Ocimum basilicum*) under various weed management practices

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ABSTRACT

A field experiment was conducted during kharif season of 2013 in Medicinal Plant Research and Development Centre (MRDC), G.B. Pant University of Agriculture and Technology, Pantnagar to evaluate weed dynamics, herbage and oil yield of sweet basil (Ocimum basilicum) under various weed management practices. The experiment was laid out in a randomized complete block design with three replications to evaluate ten treatments viz. weedy check, weed free, manual weeding at 30 Days After Transplanting (DAT), manual weeding at 30 and 60 DAT, straw mulch (5 cm), straw mulch (8 cm), polythene mulch (100 gauge), polythene mulch (160 gauge), pre emergence application of pendimethalin @ 0.5 kg ha^{-1} and pendimethalin @1.0 kg ha^{-1}. The major weed species in the experimental plot were Echinochloa colona, Echinochloa crusgalli, Dactyloctenium agyptium, Eleusine indica, Caesulia axillaris, Celosia argentea and Cyperus rotundus, Echinochloa spp and Cyperus spp constituting of 42.8 and 49.4 per cent respectively, of the total weed population in weedy check plot at 100 DAT. Maximum weed population and dry matter was recorded under weedy check followed by pendimethalin @ 0.5 kg ha^{-1} and pendimethalin @1.0 kg ha^{-1}. Among all the treatments, weed free treatment followed by polythene mulch 160 gauge thickness was the most effective in minimizing weed population and dry matter. Weed free treatment recorded the highest fresh herbage and oil yield (5316 kg ha^{-1} and 22.41 kg ha^{-1}, respectively) followed by polythene mulch with 160 gauge thickness (5220 kg ha^{-1} and 22.10 kg ha^{-1}, respectively) and the lowest with weedy check (2974 kg ha^{-1}and 11.29 kg ha^{-1}, respectively). The highest benefit cost ratio was recorded with non chemical method of 160 gauge thickness of polythene mulch and it can be used as an alternative weed management practice, particularly, when labour is limiting factor in cultivation.

***Keywords*:** Mulch, pendimethalin, polythene, straw mulch, weed free, weed index, weed control efficiency

There is a growing demand for plant-based medicines, health products, pharmaceuticals, food supplements, cosmetics *etc*. in the international market. The international market of medicinal plants is over 60 billion US dollar per year, which is growing at the rate of 7 per cent per annum (Chatterjee, 2006). Medicinal and aromatic plants (MAPs) contribute significantly to rural economy and health security of the country. More than 90% of the formulations under the Indian systems of medicine contain plant-based raw materials. India exports herbal materials and medicines to the tune of nearly ₹ 600 crores annually **(**Planning Commission, 2000**).** While about 2000 medicinal plants are used in the Indian systems of medicine, 500 of these are more commonly used. However, less than 50 medicinal plants are considered on priority for development of agro-techniques by National Medicinal Plants Board, Government of India**.** It is necessary for individual countries to develop agro-technologies for medicinal plants based on these guidelines. It is estimated that medicinal plants are cultivated over more than 1.10 lakh ha and aromatic plants over more than 2 lakh ha in the country.

Sweet basil (*Ocimum basilicum*, family Lamiaceae) is also known as St. Joseph's Wort. The essential oil of Indian basil extracted *via* hydro or steam distillation from the leaves or whole plants is used to flavour foods, dental and oral products, in fragrances, and in traditional rituals and medicines. Extracted essential oil has also been shown to contain biologically active constituents that are insecticidal, nematicidal, fungicidal or which have antimicrobial properties. Sweet basil is grown mostly in *kharif* season. There is a serious problem of weeds leading to increase in cost of labour and reduction in herb yield. Research work on weed management in the crop is very meagre. It is necessary to evaluate various weed management practices to find out the most economically viable method for increasing herb yield of sweet basil. Hence, the study was undertaken to find out a suitable method of weed control for sweet basil, an important medicinal crop.

The field experiment was conducted during *kharif* season of 2013 in Medicinal Plant Research and Development Centre (MRDC), G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand to evaluate effect of 10 different weed management practices (Table 1) on weed dynamics, herbage and oil

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yield of sweet basil. The weed management treatments involved cultural method (straw mulch and polythene mulch), physical (hand weeding) and chemical method (use of herbicide *i.e.* pendimethalin). The experiment was conducted in randomized block design with 3 replications.

The soil of the experimental site was sandy loam having organic carbon (0.91%), available nitrogen (203.57 kg ha^{-1}), available phosphorus (28.58 kg ha^{-1}) and potassium (216.42 kg ha^{-1}). Sweet basil cv.'CIM Saumya' was transplanted in the main field on 25 May 2013 and harvested on 5 September 2013. Standard recommended package of practices were followed for raising the crop. The data recorded for different parameters were analysed with the help of analysis of variance (ANOVA) technique using MSTAT-C software. The results are presented at 5 per cent level of significance.

The major weed species in the experimental plot comprised of *Echinochloa colona*, *Echinochloa crusgalli*, *Dactyloctenium agyptium*, *Eleusine indica*, *Caesulia axillaris*, *Celosia argentea* and *Cyperus rotundus* (Table 1). Among weed species, *Echinochloa* spp and *Cyperus* spp constituted of 42.8 and 49.4 per cent respectively of the total weed population in weedy check plot at 100 DAT.

Table 1: Weed flora of the experimental field during *kharif*, 2013

Botanical name	Family	English name
Grass weeds		
Echinochloa colona (L.) Link.	Poaceae	Jungle rice
Echinochloa crus-galli (L.) Beauv.	Poaceae	Barn yard grass
Dactyloctenium agyptium (L.) Beauv.	Poaceae	Crowfoot grass
Eleusine indica (L.) Gaerth.	Poaceae	Goose grass
Broad leaf weeds		
Celosia argentea (L.)	Amaranthaceae	Cock's comb
Caesulia axillaris Roxb.	Asteraceae	Ghrilla
Sedge weeds		
Cyperus rotundus (L.)	Cyperaceae	Purple nutsedge

Table 2: Density of total weeds and dry matter accumulation of under different weed management practices at various growth stages

Treatments	Density of total weeds (No. $^{-2}$)			Dry matter accumulation			WCE at 100 DAT
	45 DAT	75 DAT	100 DAT	45 DAT	75 DAT	100 DAT	
Weedy check	4.97(144)	5.88(358)	5.93(378)	3.41(28.6)	3.99(53.4)	4.38(79.1)	0
Weed free	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	100
Manual weeding, 30 DAT	3.95(51)	4.27(71)	4.68(108)	2.37(11.1)	2.84(16.3)	3.21(23.8)	49.88
Manual weeding,30 and 60 DAT	3.55(35)	3.88(48)	4.35(77)	2.34(8.2)	2.49(11.2)	2.74(14.6)	81.51
Straw mulch, 5cm	4.25(70)	4.70(109)	4.75(115)	2.53(12.4)	3.51(32.4)	3.97(52.1)	34.09
Straw mulch, 8cm	3.91(49)	4.32(75)	4.64(103)	2.53(12.4)	3.39(28.8)	3.84(45.5)	42.47
Polythene mulch, 100 gauge	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	100
Polythene mulch, 160 gauge	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	100
Pendimethalin @0.5 kg *a.i.* ha^{-1}-PE	4.66(105)	4.83(125)	4.97(144)	2.78(16.5)	3.62(36.7)	4.06(56.8)	28.18
Pendimethalin @1.0 kg *a.i.* ha^{-1}-PE	4.33(76)	4.39(81)	4.78(120)	2.71(15.8)	3.54(33.6)	3.95(50.9)	33.12
LSD (0.05)	**0.22**	**0.17**	**0.14**	**0.15**	**0.14**	**0.10**	**20.40**

Note: DAT- Days after transplanting, Original values are given in parentheses

Effect of different treatments on weed density was significant at all the growth stages (Table 2). Total weed population increased with advancement of crop age up to 100 DAT. At 45 DAT, all the treatments resulted in significant decrease in total weed density as compared to weedy check. But total weed density recorded under weed free plot was significantly less than all the treatments, which was equally effective with 100 gauge

polythene mulch and 160 gauge polythene mulch treatment. Similarly two manual weeding at 30 and 60 DAT resulted in significantly lower total weed density over one manual weeding at 30 DAT. Pendimethalin @1.0 kg ha^{-1} as pre-emergence application resulted in significant decrease in total weed density as compared to Pendimethalin @ 0.5 kg ha^{-1} as pre-emergence application. Use of 8 cm thickness of straw mulch plot resulted in significant decrease in total weed density over 5 cm thickness of straw mulch plot. Manual weeding was better than both of straw mulch and pendimethalin in decreasing the total weed density.

Total dry matter accumulation of weeds increased with advancement of crop age. Effect of different treatments on dry matter accumulation of weeds was found significant at all the growth stages (Table 2). At 45 DAT, dry matter accumulation recorded under weed free treatment was significantly lower than all other treatments except 100 gauge polythene mulch and 160 gauge polythene mulch treatment. All the treatments recorded significantly lower weed dry matter accumulation than weedy check. Pre-emergence application of pendimethalin @1.0 kg ha^{-1} was statistically *at par* with pre-emergence application of pendimethalin @ 0.5 kg ha^{-1}. Similarly higher thickness of straw mulch was statistically *at par* with lesser thickness of straw mulch treatment in weed dry matter accumulation. Use of straw mulch resulted in more decrease in weed dry weight as compared to pre-emergence application of pendimethalin at both the doses. Application of straw mulch resulted in significantly decrease in dry matter accumulation of total weeds than the pre-emergence application of pendimethalin at both the rates. At 75 DAT, all the treatments had significantly lesser total weed dry weight than weedy check. Dry matter accumulation of weeds recorded under weed free treatment was significantly lower than all other treatments except 100 gauge polythene mulch and 160 gauge polythene mulch treatment. Higher thickness of straw mulch and higher dose of pendimethalin as pre-emergence application recorded lesser total weed dry matter accumulation as compared to lower thickness of straw mulch and lower dose of pendimethalin as pre-emergence application, respectively, but it was statistically *at par* with each other. Two manual weeding at 30 and 60 DAT resulted in significantly lesser total weed dry matter accumulation as compared to one manual weeding at 30 DAT. Application of straw mulch resulted in significantly decrease in dry matter accumulation of total weeds than the pre-emergence application of pendimethalin at both the rates. At 100 DAT, all the treatments had significantly lesser weed dry matter accumulation than weedy check. Dry matter accumulation of total weeds recorded under weed free treatment was significantly lower than all other treatments except 100 gauge polythene mulch and 160 gauge polythene mulch. Two manual weeding at 30 and 60 DAT resulted in significantly lesser total weed dry matter accumulation as compared to one manual weeding at 30 DAT. Use of 8 cm thickness of straw mulch was statistically *at par* with 5 cm thickness of straw mulch in relation to total weed dry matter accumulation. Higher dose of pendimethalin as pre-emergence application resulted in significantly lesser total weed dry matter accumulation as compared to lower dose of pendimethalin as pre-emergence application. Application of straw mulch resulted in significantly decrease in dry matter accumulation of weeds than the pre-emergence application of pendimethalin at both the rates. This might be due to effective control of weed population and their growth at critical period of crop weed competition which sustained weed free condition for rest of the crop growth period. Unweeded control (weedy check) recorded the maximum dry matter accumulation of weeds which may be attributed to greater density and good growth of weed species. Highest dry matter accumulation was recorded in weedy check. The increase in dry weight of weeds in weedy check may be attributed to more nutrition available to the weeds. The results are in conformity with the findings of Ehsanullah *et al.* (2009). The weed control efficiency (WCE) was the highest in weed free and polythene mulch treatment. This was followed by weed treatment receiving two manual weeding at 30 and 60 DAT. However, the latter treatment was *at par* with the former for WCE. These treatments recorded significantly higher WCE than all other treatments.

Fresh, shade dried and oven dried herbage yield differed significantly due to different treatments (Table 3). The maximum fresh herbage yield of 35.01 t ha^{-1} was obtained in weed free treatment which was succeeded by 160 gauge polythene mulch fresh herbage yield of 34.53 t ha^{-1}. All the treatments gave significantly more fresh herbage yield over weedy check. Weedy check gave the least fresh herbage yield. Weed free and 160 gauge polythene mulch were statistically *at par* with each other. Polythene mulch of 160 gauge thickness showed significant increase in fresh herbage yield compared to polythene mulch of 100 gauge thickness. Both pendimethalin *i.e.*, 0.5 kg ha^{-1} and 1.0 kg ha^{-1} as pre-emergence were statistically *at par* with each other, in relation to the fresh herbage yield over the weedy check. Two manual weeding at 30 and 60 DAT resulted in significantly higher fresh herbage yield than one manual weeding at 30 days DAT. Use of 8 cm and 5 cm thick straw mulch resulted in similar fresh herbage yield. Similarly, two manual weedings at 30 and 60 DAT exhibited significantly higher fresh herbage yield than one manual weeding at 30 DAT. Weed free treatment

Table 3: Yield of herbage (fresh, shade dried and oven dried), content and yield of oil and weed index under different weed management practices

Weed management practices	Herbage yield (t ha^{-1})			Oil content	Oil yield (kg ha^{-1})	Weed index (%)
	Fresh	Shade dry	Oven dry)			
Weedy check	17.92	5.55	1.83	0.63	113	49.38
Weed free	35.01	10.31	3.23	0.64	224	0
Manual weeding, 30 DAT	28.26	9.65	2.90	0.64	180	19.28
Manual weeding, 30 and 60 DAT	33.03	10.18	3.17	0.63	208	5.65
Straw mulch, 5cm	24.53	7.46	2.55	0.62	152	29.93
Straw mulch, 8cm	27.27	8.53	2.72	0.62	170	22.10
Polythene mulch, 100 gauge	32.06	9.81	3.01	0.64	205	8.42
Polythene mulch, 160 gauge	34.53	10.24	3.22	0.64	221	1.37
Pendimethalin @0.5 kg *a.i* ha^{-1}-PE	22.61	7.35	2.41	0.62	140	35.41
Pendimethalin @1.0 kg *a.i* ha^{-1}-PE	23.97	8.02	2.55	0.63	151	31.53
LSD (0.05)	**3.47**	**1.17**	**0.32**	**NS**	**23.01**	**9.68**

gave the maximum (10.31 t ha^{-1}) shade dried herbage yield followed by 160 gauge polythene mulch (10.24 t ha^{-1}). All the weed management treatments produced significantly higher shade dried herbage yield over weedy check. Weed free, 160 gauge polythene mulch, two manual weedings at 30 and 60 DAT and one manual weeding at 30 DAT resulted similar yield. Higher dose of pendimethalin and higher rate of straw mulch produced similar shade dried herbage yield with their lower dose of application.

All the treatments gave significantly higher oven dried herbage yield than weedy check. Oven dried herbage yields recorded under weed free, two manual weeding at 30 and 60 DAT, 100 gauge polythene and 160 gauge polythene mulch were significantly higher than all other treatments. Both the thickness of polythene mulch treatments were statistically *at par* with each other. Higher dose of pendimethalin and higher rate of straw mulch did not give significantly higher oven dried herbage yield than lower dose of pendimethalin and lower rate of straw mulch, respectively. Two manual weedings at 30 and 60 DAT did not give significantly higher oven dried herbage yield than one manual weeding at DAT. Lower herbage yield in weedy check might be due to severe crop-weed competition, as evident from higher weed density and dry matter. There was 95 per cent increase in fresh herbage yield of *O. basilicum* due to weed free condition as compared to weedy check. This corroborates the findings of Upadhyapa *et al.* (1978) in *Mentha arvensis*, in which weedy check reduced the herbage yield up to 73% compared to weed free condition. Manual weeding gave higher fresh herbage yields than pre-emergence application of pendimethalin @ 0.5 and 1.0 kg ha^{-1}. Similar result was reported by Ghosheh (2004). Increase in yield through straw mulch under hot and dry summer conditions was reported by Singh *et al*., 1987**.** Black polythene mulch provided a better soil environment for plant growth than plots without mulch. Use of 160 gauge thickness of polythene mulch resulted in 92 per cent increase in fresh herbage yield over weedy check, whereas weed free treatment resulted 95% increase in fresh herbage yield over weedy check.

All the treatments gave significantly higher oil yield than weedy check. Weed free treatment gave the maximum oil yield among all the treatments. Weed free, two manual weeding at 30 and 60 DAT, 100 gauge polythene mulch and 160 gauge polythene mulch were statistically *at par* with each other. Application of pendimethalin @ 1.0 kg ha^{-1} and @ 0.5 kg ha^{-1} as pre-emergence resulted in similar oil yield showing that higher rate of application of this herbicide has no added advantage. Similarly, the use of 8 cm thickness of straw mulch did not give significantly higher oil yield over the use of 5 cm thickness of straw mulch. Two manual weedings at 30 and 60 DAT gave significantly higher oil yield than one manual weeding at 30 days after transplanting. Both 100 gauge polythene mulch and 160 gauge polythene mulch were statistically *at par*. Higher oil yield of weed free treatment followed by 160 gauge thickness of polythene mulch treatment was due to higher herbage yield. Use of 160 gauge polythene mulch and weed free treatment gave 95 and 98 per cent higher oil yield, respectively, than weedy check.

Weed index differed significantly due to different treatments (Table 3). All the treatments were significantly superior to weedy check. The lowest weed index was found in weed free treatment which was significantly lesser than other treatments except 160 gauge polythene mulch, 100 gauge polythene mulch and

two manual weeding at 30 and 60 DAT. Two manual weeding at 30 and 60 DAT was significantly superior to one manual weeding at 30 DAT. Similarly pre-emergence application of pendimethalin at higher dose *i.e.,* pendimethalin @1.0 kg Ghosh was statistically *at par* with pre-emergence application of pendimethalin at lower dose *i.e.*, pendimethalin @0.5 kg Ghosh. Similar result was found in case of straw mulch *i.e.*, use 8 cm thickness of straw mulch was statistically *at par* with the use of 5 cm thickness of straw mulch. Lower weed index in weed free followed by 160 gauge polythene mulch treatment was due to higher herbage yield of these treatments over other treatments.

The maximum cost of weeding was recorded with weed free treatment (Table 4). Weed free treatment incurred the maximum cost of production among all the treatments. Among the treatments, the gross return was found to be the maximum with weed free treatment which was followed by 160 gauge polythene mulch treatment. Net profit was the highest in 160 gauge polythene mulch treatment followed by weed free treatment, while it was the lowest with weedy check treatment. This might be due to lowest production of herbage in this treatment. However, benefit cost ratio was found to be highest with 160 gauge polythene mulch treatment. Use of 160 gauge polythene mulch gave the maximum profit (72 763 ha^{-1}) which was also 4.02 per cent higher than the weed free treatment. The decreasing order of treatments for B:C ratio was use of 160 gauge polythene mulch recorded the maximum B:C ratio followed by 100 gauge polythene mulch > one manual weeding 30 DAT > pendimethalin @1.0 kg ha^{-1}-PE > use of 8 cm thickness straw mulch > manual weeding at 30 and 60 DAT > weed free > use of 5 cm thickness straw mulch, pendimethalin @ 0.5 kg ha^{-1}-PE > weedy check. Weed free treatment proved the best for yield and gross return followed by use of 160 gauge polythene mulch. Considering the economic indicators, use of 160 gauge polythene mulch proved the best with the maximum net return and B:C ratio.

Table 4: Cost of cultivation, gross return, net return and B:C ratio under different weed management practices

Treatment	Cost of cultivation (× 10^3 ha^{-1})	Gross return (× 10^3 ha^{-1})	Net return (×10^3 ha^{-1})	B:C ratio
Weedy check	44.51	79.10	34.59	1.77
Weed free	85.88	156.80	70.91	1.82
Manual weeding, 30 DAT	67.83	126.00	58.16	1.85
Manual weeding, 30 and 60 DAT	79.40	145.60	66.19	1.83
Straw mulch, 5cm	58.34	106.40	48.05	1.82
Straw mulch, 8cm	64.81	119.00	54.18	1.83
Polythene mulch, 100 gauge	76.80	143.50	66.69	1.86
Polythene mulch, 160 gauge	80.93	154.70	73.76	1.91
Pendimethalin @0.5 kg *a.i* ha^{-1}-PE	53.90	98.00	44.09	1.81
Pendimethalin @1.0 kg *a.i* ha^{-1}-PE	57.24	105.70	48.45	1.84

For an effective weed management in sweet basil (*O. basilicum*), use of polythene mulch proved to be the best practice with maximum oil and herbage yield and net return and B:C ratio. Polythene mulch treatment could better suppress the weed population and resulted in maximum weed control efficiency. Sweet basil being a medicinal crop, use of polythene mulch for weed control may be useful in long run since it is environment friendly.

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