Journal of AgriSearch, 8 (3): 215-221
An Open Access International Peer Reviewed Quarterly

ISSN : 2348-8808 (Print), 2348-8867 (Online)
https://doi.org/10.21921/jas.v8i03.1665

Effect of Row Spacing and Organic Weed Management Practices on Growth and Yield of Sweet Basil in Northern Western Himalayan Region

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ABSTRACT

A field experiment on sweet basil was conducted to study the effect of spacing and organic weed management on growth and development of sweet basil under temperate conditions of Kashmir. Among weed management practices walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20- 25 DAT + walnut hull aqueous solution sprays just after hand weeding / hoeing (W_6) recorded significantly higher plant height, number of functional leaves, leaf area index, number of primary and secondary branches, dry matter accumulation, spike length, number of spikes plant^{-1}, number of spikelets spike^{-1}, number of spikelets plant^{-1}, number of seeds spike^{-1}, number of seeds plant^{-1}, seed weight plant^{-1}, test weight, fresh herbage yield, dry herbage yield per hectare, seed yield, harvest index. Spacing of 30cm × 30cm (S_{30}) recorded significantly higher pant height as compared to other spacing however, 40cm × 30cm (S_{40}) spacing recorded significantly higher no. of functional leaves, LAI, dry matter accumulation and fresh herbage yield. Spacing of 50cm × 30cm (S_{50}) recorded significantly higher no. of primary and secondary branches spike length, number of spikes plant^{-1}, number of spikelets spike^{-1}, number of spikelets plant^{-1}, number of seeds spike^{-1}, number of seeds plant^{-1},seed weight plant^{-1} and test weight.

KEYWORDS

Basil, Development, Growth, Spacing, Organic weed management

ARTICLE INFO

Received on	:	15/06/2021
Accepted on	:	18/08/2021
Published online	:	05/09/2021

INTRODUCTION

Ocimum basilicum L. is an annual culinary herb which is grown all over the world in several regions. It is also known as sweet basil and St. Joseph's wort. It was called 'king of herbs' by ancient Greeks possibly because the plant was believed to have been used in production of royal perfumes. Lamiaceae (Labiateae) family consists of genus, *Ocimum* which include about 60 species and certain varieties (Srivastava,1982). For production of essential oil as well as for fresh market purpose the most broadly grown species is *Ocimum basilicum* (Gupta *et al*, 2002; Zheljazkov *et al*, 2008). It's Kashmiri vernacular name is "Babribyool". Round the globe basil is among the most popular herbs grown in gardens and spice cabinets. It is a crucial constituent of many Ayurvedic cough syrups and expectorants, and commonly referred as "wonder herb".

Spacing has a key role to play in order to determine yield per unit area. Suitable density of plants helps in proper utilization of different growth factors like water, air, light and nutrients and results in minimum inter and intraspecific competition. Quantity and quality of basil is strongly affected by improper spacing. To optimize the rate of photosynthesis, facilitation of aeration and penetration of light into plant canopy is important. Therefore, for obtaining higher yield in *Ocimum basilicum* determination of optimum spacing is very important.

Weeds pose a problem in *Ocimum basilicum* production. They reduce yield by creating above and below ground competition for various growth factors like nutrient, moisture, light, space etc. Moreover, the quality of medicinal plants also gets degraded by adulteration or mixing seeds during post-harvest operations. Presence of weeds in basil results in slow germination and initial growth. Research work on weed management in *Ocimum basilicum* is very meager. *Ocimum basilicum* being a medicinal value crop and due to health consciousness more focus on organic weed management practices needs be given. As such it is imperative to evaluate various weed management practices involving organic material to evaluate most appropriate method for controlling weeds in *Ocimum basilicum*.

MATERIALS AND METHODS

The field experiment was carried out at Crop Research Farm of Division of Agronomy, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Wadura Sopore during *Kharif*, 2019. The site lies at a latitude of 34°21′ N and a longitude of 74°23′ E and at an altitude of 1590 meters above mean sea level. The experiment

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comprised of two factors, first was 3 spacing viz, $\mathbf{S}_{30}$:30 cm × 30 cm, $\mathbf{S}_{40}$:40 cm × 30 cm and $\mathbf{S}_{50}$:50 cm x 30 cm and second was 6 weed management practices described below:

$\mathbf{W}_1$**:** Weedy check

$\mathbf{W}_2$**:** hand weeding /hoeing at 20–25 DAT and 50–55 DAT,

$\mathbf{W}_3$**:** brown sarson stover mulching ,

$\mathbf{W}_4$**:** two applications of walnut hull aqueous solution spray (1:10) at the time of planting and 20-25 DAT ,

$\mathbf{W}_5$**:** walnut hull aqueous solution spray (1:10) at the time of planting +hand weeding 20–25 DAT,

$\mathbf{W}_6$**:** W_5 + Walnut hull aqueous solution spray (1:10) just after hand weeding / hoeing).

1 kg Walnut hulls were soaked in 10 litres of water for two days. The concentrate was then diluted with water to form 100 litre of aqueous solution spray which was then sprayed into the field as per treatment.

The experiment was laid out with factorial concept in a randomized block design with three replications. The gross plot size was 2.8 m × 2.5 m (7 m^2). During the cropping season 2019 the mean maximum and minimum temperatures varied between 23-32 °C and 7 to 17 °C, respectively and total precipitation during crop growth of 2019 amounted to 166.8 mm with maximum relative humidity ranging between 75.71–91.25 and minimum relative humidity between 42 - 71.29. The mechanical and chemical analysis of composite soil sample revealed that soil texture was clay loam and the soil was medium in organic carbon, available nitrogen, phosphorus and potassium with a neutral pH.

The nursery plot was brought to fine tilth by ploughing first by soil turning plough followed by cross ploughing with cultivator. Sowing of seeds was done @ 350 g for transplanting one-hectare area. The seeds were evenly sown in 10 cm row spacing and covered with FYM/ vermicompost 1-2 cm for proper germination in the nursery beds measuring 100m^2 for one hectare. Nursery beds were irrigated with fountain bucket to maintain proper moisture. Polyethylene was used to cover up nursery beds during period of low temperature (< 10 °C) in cloudy days. Thirty days old healthy, uniform sized seedlings were selected and transplanted in the experimental plots as per the treatments. The recommended dose of nutrients NPK @ 120 : 60 : 40 kg/ha were applied in the form of urea, DAP and MOP fertilizers and FYM @ 15 t per ha was added to all the plots. Out of total quantity, 50 per cent of nitrogen and full dose of phosphorous and potassium and FYM were supplied as basal dose at the time of field preparation. The remaining 50 per cent of nitrogen was given as top dressing in two equal splits at 30 and 50 days after transplanting. Weeds were managed as per the treatment. The crop was harvested at 80% physiological maturity of seeds and the whole plants were cut at 15 cm above the ground level.

The plant height and number of functional leaves of 5 labeled plants, leaf area index at 30 days interval and dry matter accumulation at 15 days interval and days taken to different phenological stages was recorded and the average was worked out. Number of primary and secondary branches, spike length, number of spikes plant^{-1}, number of spikelets spike^{-1}, number of spikelets plant^{-1}, number of seeds spike^{-1}, number of seeds plant^{-1}, seed weight plant^{-1}, test weight of 5 labeled plants was observed at harvest/maturity. In addition to this fresh herbage yield, dry herbage yield, seed yield quintal per hectare, and harvest index was recorded at the time of harvest. Oil content in basil was estimated by using hydro distillation and expressed in percentage (%) and accordingly oil yield was calculated.

RESULTS AND DISCUSSION

Growth Parameters

Plant height was remarkably affected by varied spacing and weed management practices. 30cm ×30cm (S_{30}) spacing recorded significantly taller plants over 40cm ×30cm (S_{40}) and 50cm×30cm (S_{50}) spacing (Table 1).

This may be ascribed to the fact that plants under closer spacing tend to grow vertically for more light and air and hence plants were taller. The results obtained are in agreement with the findings of Balyan *et al* (1987) in *Ocimum canum* and *Ocimum americanum*, Ahmad *et al* (2004) in fennel. Weed management practices have a profound effect on plant height. Plants treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20- 25 DAT + walnut hull aqueous solution sprays just after hand weeding / hoeing (W_6) have recorded significantly taller plants than W_1, W_2 and W_3 at 60 DAT and W_1, W_2, W_3 and W_4 at 90 DAT. However, at 30 DAT all the treatments recorded statistically similar plant height (Table 1). These results are in confirmation with the results of Kaur *et al* (2013) in Mentha arvensis.

In case of number of functional leaves plant^{-1} spacing of 40cm×30cm (S_{40}) produced significantly more number of functional leaves plant^{-1} at all stages. Significantly lower number of functional leaves plant^{-1} were recorded in 30cm ×30cm (S_{30}) spacing than rest of the spacing at all the stages (Table 1). This may be attributed to better resource procurement, development of sink and more branches due to greater availability of space. The results are in confirmation with the results of Salim *et al* (2014) in mint plants.

Table 1: Plant height and functional leaves of sweet basil as influenced by row spacing and organic weed management practice

Treatments	Plant Height (cm)			No. of functional leaves		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Row spacing						
S_{30}	35.22	66.03	81.20	104.6	210.2	101.3
S_{40}	33.55	59.09	72.81	110.2	222.1	111.9
S_{50}	30.71	50.58	62.28	110.1	215.2	106.1
SEm	0.91	0.72	0.62	0.85	1.45	0.81
CD ($p \leq$ 0.05)	**2.60**	**2.05**	**1.78**	**2.44**	**4.20**	**2.34**
Weed management practices						
W_1	29.59	54.70	67.24	100.9	196.7	96.95
W_2	32.02	56.04	68.92	109.7	218.2	106.15
W_3	33.10	57.88	71.46	111.2	217.6	107.22
W_4	34.12	59.77	73.65	112.2	219.2	108.34
W_5	34.72	60.92	74.94	113.4	220.9	109.53
W_6	35.41	62.09	76.37	114.4	222.4	110.40
SEm	1.35	1.01	0.88	1.20	2.05	1.15
CD ($p \leq$ 0.05)	**NS**	**2.91**	**2.52**	**3.45**	**5.88**	**3.31**

Table 2: Number of primary branches, secondary branches and Leaf Area Index as influenced by spacing and organic weed management practices

Treatments	Primary branches per plant	Secondary branches per plant	Leaf Area Index		
Row spacing			30 DAT	60 DAT	90 DAT
S_{30}	8.13	28.32	1.207	2.436	1.315
S_{40}	11.30	34.46	1.698	3.760	1.988
S_{50}	13.73	37.65	1.456	2.842	1.784
SEm	0.33	0.44	0.027	0.029	0.026
CD ($p \leq$ 0.05)	**0.95**	**1.26**	**0.077**	**0.082**	**0.074**
Weed management practices					
W_1	10.03	32.16	1.371	2.829	1.543
W_2	10.41	32.67	1.392	2.961	1.648
W_3	10.86	33.17	1.431	2.987	1.687
W_4	11.23	33.82	1.483	3.042	1.740
W_5	11.67	34.03	1.509	3.102	1.764
W_6	12.11	35.00	1.536	3.156	1.792
SEm	0.47	0.62	0.038	0.041	0.038
CD ($p \leq$ 0.05)	**1.35**	**1.78**	**0.108**	**0.117**	**0.104**

Plants treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20–25 DAT + walnut hull aqueous solution spray just after hand weeding / hoeing (W_6) had remarkably the highest number of functional leaves plant^{-1} than W_1 and W_2 at 30 DAT, W_1 at 60 DAT and W_1 and W_2 at harvest. Weedy check (W_1) recorded least number of functional leaves per plant at harvest (Table 1). This might be due to severe competition between crop and weeds under weedy check treatment for resources viz; sunlight, moisture and nutrients resulting in poor plant height and branching therefore reducing the strength of plants to produce more number of functional leaves. Similar reports of increase in leaf number due to less competition from weeds was reported by Daramoul *et al* (2019) in Soybean.

At harvest, number of primary and secondary branches plant-1 was significantly affected by spacing. 50cm × 30cm (S_{50}) spacing recorded remarkably maximum number of primary and secondary branches plant^{-1} than rest of the spacing at all the stages (Table 2). Significantly the lowest number of primary and secondary branches was recorded at 30cm × 30cm (S_{30}).

The increased branching could be attributed to more interception of light due to wider spacing and reduction in the competition for light, moisture, space, nutrients etc. The results are in confirmation with Pooja (2016) in *Ocimum sanctum* Linn. Plants treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20- 25 DAT + walnut hull aqueous solution spray just after hand weeding / hoeing (W_6) recorded significantly maximum number of primary and secondary branches. Significantly lowest number of primary and secondary branches was recorded in weedy check (W_1) plots than all other weed management practices (Table 2). The increased branching could be attributed to less population of weeds in these treatments, which provide more space and less competition to natural resources for spread of plants that resulted in increased number of branches per plant. Similar results were also found by Meena *et al* (2017a) in Kalmegh.

Yield Attributes

50cm × 30cm (S_{50}) spacing recorded significantly more spike length, spikes plant^{-1}, spikelets spike^{-1} and spikelets plant^{-1} than rest of the spacings and lowest were recorded at 30cm × 30cm (S_{30}) (Table 4).

Table 3: Dry matter accumulation (qha^{-1}) of sweet basil as influenced by row spacing and organic weed management practices

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Row spacing						
S_{30}	1.381	4.98	10.69	23.76	32.52	40.14
S_{40}	1.174	4.62	10.16	24.19	33.66	41.92
S_{50}	0.996	4.47	10.09	23.91	33.30	41.32
SEm	0.033	0.056	0.17	0.31	0.43	0.38
CD ($p\leq0.05$)	**0.095**	**0.160**	**0.48**	NS	NS	**1.09**
Weed management practices						
W_1	1.094	4.46	8.09	16.11	22.92	30.54
W_2	1.196	4.65	10.56	25.12	34.52	42.14
W_3	1.198	4.70	10.61	25.32	34.80	42.63
W_4	1.203	4.72	10.69	25.50	35.12	43.29
W_5	1.203	4.78	10.86	25.74	35.60	43.85
W_6	1.206	4.83	11.09	25.91	35.99	44.30
SEm	0.047	0.079	0.24	0.43	0.61	0.54
CD ($p\leq0.05$)	**NS**	**0.23**	**0.68**	**1.24**	**1.75**	**1.54**

This could be attributed to more space and proper nutrient and other resource utilization by plants to improve plant health and helps in enhancement of yield contributing components. Similar results were also found by Mirjalili (2014) in *Ocimum bascilicum* **.** Plants treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20- 25 DAT + walnut hull aqueous solution spray just after hand weeding / hoeing (W_6) recorded significantly highest spike length, spikes $plant^{-1}$, spikelets $spike^{-1}$ and spikelets $plant^{-1}$ and lowest was observed in weedy check (W_1) plots (Table 4). This could be attributed to the least weed competition and high weed control resulting in better growth and development of basil crop which led to higher photosynthetic efficiency and resulted in greater yield contributing components under weed management practices adopted.

The progressive increase in LAI was observed up to 60 days after transplanting in all three spacing levels. However, 40cm×30cm (S_{40}) observed significantly more LAI at all the stages compared to other spacing (Table 2). Significantly lowest leaf area index was observed in 30cm × 30cm (S_{30}). The lower leaf area index observed in closer spacing may be attributed to lower number of functional leaves due to overcrowding and mutual shading of plants, which gave very little chance for these plants to grow and spread. But in wider spacing leaf area index was greater due to presence of more number of branches and leaves and proper utilization of natural resources.

Table 4: Days taken to different phenological stages as influenced by row spacing and organic weed management practices

Treatments	Flowe- ring	Matur ity	Spike length (cm)	Spikes /plant	Spikelets /spike	Spikelets / plant
Row spacing						
S_{30}	49.6	87.5	20.58	47.72	10.71	512.96
S_{40}	49.3	87.3	22.01	51.39	12.64	642.49
S_{50}	51.3	88.3	22.88	55.83	14.03	784.78
SEm	0.31	0.34	0.55	0.84	0.45	31.41
CD ($p\leq0.05$)	**NS**	**NS**	**1.60**	**2.42**	**1.29**	**90.28**
Weed management practices						
W_1	50.1	86.8	18.96	48.77	10.54	504.70
W_2	49.4	87.4	21.70	51.14	12.36	642.43
W_3	50.7	87.9	20.46	50.79	12.23	627.68
W_4	50.0	88.0	21.97	51.87	12.85	674.90
W_5	50.4	88.3	23.10	53.20	13.24	702.17
W_6	49.8	87.8	24.76	54.07	13.53	728.59
SEm	0.43	0.48	0.78	1.19	0.64	44.42
CD ($p\leq0.05$)	**NS**	**NS**	**2.26**	**3.43**	**1.83**	**127.67**

These findings are in line with the findings of Mirjalili (2014) in basil. Plants treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20–25 DAT + walnut hull aqueous solution spray just after hand weeding / hoeing (W_6) have recorded significantly maximum LAI than W_1 and W_2 at 30 DAT and W_1, W_2 and W_3 at 60 and 90 DAT however rest was at par with each other. The least leaf area index was observed in weedy check plots throughout the crop season. It was mainly due to all weeds were effectively controlled when treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20–25 DAT + walnut hull aqueous solution sprays just after hand weeding / hoeing (W_6) which may be attributed to more number of branches and functional leaves by reduction of competition for space, light, nutrient, moisture and efficient resource utilization. The results are in confirmation with Meena *et al* (2017b) in Kalmegh.

The progressive dry matter increase was observed up to 90 days after transplanting in all three spacing levels Spacing of 30cm × 30 cm (S_{30}) observed significantly more dry matter accumulation at 15, 30 and 45 DAT. Significantly lowest dry matter was observed at 50cm × 30cm (S_{50}) spacing at 15 and 30 and 45 DAT. Spacing of 40cm × 30cm (S_{40}) observed significantly more dry matter accumulation at 90 DAT and was at par with 50cm × 30cm (S_{50}) however lowest dry matter was observed at 30cm × 30cm (S_{30}) spacing. Dry matter was not significantly affected by spacing at 60 and 75 DAT (Table 3).

Table 5: Number of seeds spike^{-1}, seed weight plant^{-1} and test weight as influenced by row spacing and organic weed management practices

Treatments	Number of seeds per spike	Number of seeds per plant	Seed weight per plant (g)	Test weight (g)
Row spacing				
S_{30}	67.68	3237	4.61	1.424
S_{40}	91.95	4732	6.83	1.444
S_{50}	100.1	5594	8.15	1.457
SEm	1.29	81	0.10	0.004
CD (p≤0.05)	**3.70**	**234**	**0.30**	**0.012**
Weed management practices				
W_1	72.1	3546	6.04	1.416
W_2	86.14	4449	6.63	1.437
W_3	89.22	4567	6.82	1.440
W_4	90.30	4729	7.05	1.439
W_5	89.99	4830	7.29	1.457
W_6	91.90	5006	7.57	1.461
SEm	1.82	115	0.15	0.006
CD (p≤0.05)	**5.24**	**330**	**0.43**	**0.017**

This may be attributed to the fact that closer spacing than optimum in cropped area may lead to greater reduction in dry matter accumulation as a result of competition also poor architecture of plant, less number of branches and less number of leaves leads to reduction in dry matter accumulation. Plants treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20–25 DAT + walnut hull aqueous solution spray just after hand weeding / hoeing (W_6) recorded significantly maximum dry matter accumulation (Table 3). Significantly lowest dry matter accumulation was noted in weedy check (W_1) plots than all other weed management practices. This might be due to the least competition for light, water, space and nutrients in these treatments as compared to weedy check which would have resulted in maintenance of high soil fertility status and content of moisture due to removal of less plant nutrients and moisture by weeds. Similar results were also found by Yadav *et al* (2019) in Japanese mint.

Number of seeds per spike, number of seeds per plant, seed weight per plant and test weight was significantly influenced by spacing and weed management practices. 50cm × 30 cm (S_{50}) spacing recorded significantly more average number of seeds per spike, average number of seeds per plant, seed weight per plant and test weight as compared to other spacing while as lowest was observed in 30cm × 30cm (S_{30}) (Table 5). This could be attributed to more spikes/ plant, spikelets/ spike and spikelets/ plant in 50cm×30 cm (S_{50}) spacing. Similar results were also found by Waskela *et al* (2017) in Foeniculum vulgare. Plants treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20-25 DAT + walnut hull aqueous solution spray just after hand weeding / hoeing (W_6) recorded significantly highest average number of seeds per spike, average number of seeds per plant, seed weight per plant and test weight. Significantly lowest were recorded in weedy check (W_1) plots than all other weed management practices (Table 5). Weed management practices resulted in less density and biomass of weeds and lower competition of crop with weed resulting in better growth and development of basil leading to higher photosynthetic activity that resulted in the production of enough assimilates for subsequent translocation from vegetative parts to developing seeds and seed yield attributing components.

Yield

Fresh herbage yield and dry herbage yield was significantly influenced by spacing and weed management practices. 40cm × 30cm (S_{40}) recorded significantly higher fresh and dry herbage yield than 30cm × 30cm (S_{30}) spacing however fresh herbage yield at 40cm × 30cm (S_{40}) was at par with 50cm × 30cm (S_{50}) spacing (Table 6). Significantly minimum fresh and dry herbage yield was recorded in 30cm × 30cm (S_{30}) spacing. It might be due to higher number of plants per unit area in closer spacing adjusted by branching in wider spacing and optimum population resulted more fresh and dry herbage yield per hectare.

These findings are in line with the results of Kumar *et al* (2017) in *tulsi*. With respect to weed management practices, fresh and dry herbage yield varied significantly. Plots treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20–25 DAT + walnut hull aqueous solution spray just after hand weeding / hoeing (W_6) have recorded significantly maximum fresh and dry herbage yield (Table 6). Significantly minimum fresh and dry herbage yield was recorded in weedy check (W_1) plots than all other weed management practices. This was due to the fact that adoption of weed management practices reduced the crop weed competition with natural and applied resources and enhanced crop growth parameters which helps to accumulate higher dry matter and resulted in more fresh and dry herbage yield. These findings are in line with the results of Lokesh *et al* (2019) in makoi.

Table 6: Fresh Herbage Yield, Dry Herbage Yield, Seed Yield, Harvest index and Herbage oil yield of sweet basil as influenced by row spacing and organic weed management practices

Treatments	Fresh herbage yield (q/ha)	Dry herbage yield (q/ha)	Seed yield (q/ha)	Harvest index (%)	Herbage oil yield (Kg/ha)
Row spacing					
S_{30}	106.20	42.88	5.12	11.89	20.37
S_{40}	124.79	47.43	5.69	11.99	23.60
S_{50}	120.52	46.81	5.43	11.90	22.91
SEm	1.82	0.91	0.052	0.18	0.17
CD ($p \leq 0.05$)	**5.23**	**2.62**	**0.151**	**0.52**	**0.48**
Weed management practices					
W_1	102.90	33.14	4.16	11.20	18.20
W_2	117.35	46.38	5.29	11.47	22.24
W_3	116.18	45.52	5.45	12.05	22.32
W_4	116.82	45.99	5.64	12.36	22.80
W_5	124.33	48.64	5.85	12.08	23.75
W_6	125.39	49.47	6.10	12.40	24.46
SEm	2.57	1.29	0.24	0.25	0.24
CD ($p \leq 0.05$)	**7.40**	**3.70**	**0.21**	**0.73**	**0.68**

A perusal of data indicated that spacing and weed management practices significantly affected seed yield and herbage oil yield at maturity of basil. 40cm×30 cm (S_{40}) spacing observed significantly higher seed yield and herbage oil yield at maturity compared to spacing of 30cm × 30cm (S_{30}) but was at par with 50cm × 30cm (S_{50}). Significantly the lowest seed yield and herbage oil yield was recorded in 30cm × 30cm (S_{30}) spacing (Table 6). This might be due to increasing competition for uptake of water, nutrients and reduced light interception due to more plant density resulted in poor photosynthesis and more respiration in closer planting responsible for decreased net assimilation and ultimately lower seed yield and herbage oil yield. With respect to weed management practices seed yield and herbage oil yield at maturity varied significantly. Plants treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20–25 DAT + walnut hull aqueous solution spray just after hand weeding / hoeing (W_6) have recorded significantly maximum seed yield and herbage oil yield (Table 6). Significantly lowest seed yield and herbage oil yield was recorded in weedy check (W_1) plots than any other weed management practices. This might be due to lower weed competition and higher weed control efficiency that led to better growth and development of basil and resulted in higher photosynthetic activity that resulted in the production of enough assimilates for subsequent translocation from vegetative parts to developing seeds and ultimately greater seed yield produced.

Spacing of 40cm × 30cm (S_{40}) recorded highest harvest index. However, it was at par with 50cm × 30cm (S_{50}) as well as 30 × 30cm (S_{30}) spacing (Table 6). Significantly the lowest harvest index was recorded in 30cm × 30cm (S_{30}) spacing. Higher harvest index indicates greater seed proportion than strover proportion in total dry matter production. With respect to weed management practices harvest index varied significantly. Plants treated with walnut hull aqueous solution spray (1:10) at the time of planting + hand weeding 20–25 DAT + walnut hull aqueous solution spray just after hand weeding / hoeing (W_6) have recorded significantly highest harvest index. The lowest harvest index was recorded in weedy check (W_1) plots than any other weed management practices (Table 6). This might be due to less quantity of seeds produced in weedy check than strover proportion in total dry matter accumulated.

CONCLUSION

Subsequent conclusion may be drawn keeping in view the above results and discussion of present investigation. 40cm × 30cm (S_{40}) spacing proved better in terms of herbage yield, seed yield and oil yield. Walnut hull aqueous solution spray (1:10) at the time of planting + Hand weeding 20–25 DAT + Walnut hull aqueous spray just after hand weeding / hoeing (W_6) showed efficient weed control. So that 40cm × 30cm (S_{40}) spacing with Walnut hull aqueous solution spray (1:10) at the time of planting + Hand weeding 20- 25 DAT + Walnut hull aqueous spray just after hand weeding / hoeing is suitable for sweet basil production in northern western Himalayan region.

ACKNOWLEDGMENT

We express our deep sense of gratitude to Division of Agronomy, FoA, Wadura, SKUAST-K for providing the platform and facilities to conduct this research.

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Citation:
Mushtaq I, Singh L, Masood A, Ali I, Fatimah N, Ashraf S and Bashir N. 2021. Effect of Row Spacing and Organic Weed Management Practices on Growth and Yield of Sweet Basil in Northern Western Himalayan Region. *Journal of AgriSearch* **8**(3): 215-221