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Management of *Tagetes minuta* under Different Sowing Methods and Plant Densities in Mid-Hill Condition of Himachal Pradesh (India)

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A B S T R A C T

A study was carried out for three years at Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan to evaluate the effect of different sowing methods and plant densities on oil yield of *Tagetes minuta.* Different planting methods *i.e.* broadcasting and seedling planting with varying plant densities S1 (30 x 15cm), S2 (30 x 30cm), S3 (30 x 45cm), S4 (45 x 45cm) and S5 (45 x 60cm) were evaluated under RBD Factorial design. The leaves biomass (pre-flowering stage), flower biomass and leaf + flower biomass (full bloom stage) yielded maximum oil at S3 (30 x 45cm) spacing. The leaf + flower biomass at full bloom stage yielded maximum BCR (Benefit Cost Ratio) in S3 (30 x 45cm).

Introduction

Tagetes minuta L. (synonymous *T. glandulifera* Schrank) commonly known as wild marigold is important source of "*Tagetes* oil". The oil, obtained from whole herbs or flowers, find extensive uses in food, flavour and cosmetic industry which makes it an economic industrial crop in Himachal Pradesh, Uttarakhand and Jammu & Kashmir. In India, it is found in Western Himalayas between altitudes of 1000-2500 m (Singh *et al.*, 2003; Prasad *et al.*, 2003). *T. minuta* is an annual herb characterized by an erect stem of about 1–2 m height (Wang and Chen, 2006). The leaves are pinnately compound, stalked, opposite, slightly glossy, green in colour, 7-15 cm long, pinnately dissected into 4-6 pairs of pinnae. The leaflets are lanceolate in shape with finely serrate margins (Singh *et al.*, 2003; Wang and Chen, 2006; Ofori *et al.*, 2013). Flower heads are numerous, yellowish green, usually in flat topped cymes, involucres cylindrical, 8-14 mm high and 2-3mm wide (Wang and Chen, 2006).

Flowers are arranged in solitary clustered panicled branches. Each head is surrounded by four or five involucres bracts fused together (Wanzala *et al.*, 2012). The major components of the essential oil from aerial parts are (Z)-β-ocimene, dihydrotagetone, (E)-β-ocimene, (Z)- and (E)-tagetones, and (Z)- and (E)-tagetenones (Gupta and Vasudeva, 2012; Singh *et al.*, 2015). In India, the freshly distilled *T. minuta* oil contained ocimene 54.97%, and dihydrotegetone 32.58% as major constituents (Singh *et al.*, 2003).

The essential oil obtained from this plant has been reported to have mosquito-larvicidal, anti-viral, hypotensive, spasmolytic, anti-inflammatory, anti-microbial, cytotoxic and anti-fungal properties (Shirazi *et al.*, 2014). The quantity of oil yield is significantly affected by both environment and agronomy (Voirin *et al.*, 1990).

A study was conducted to evaluate the effect of transplanting date on growth and yield of *T. minuta* (Kmar *et al.*, 2012). The effect of irradiance stress and plant spacing on growth, biomass and quality of wild *T. minuta* was also studied (Kumar *et al.*, 2014). Since *T. minuta* is an industrial crop of given area hence present study is conducted on the management of *T. minuta* under different sowing methods and plant densities.

Materials and Methods

The experiment was conducted out in the field of Department of Forest Products, College of Forestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the month of April to December for three years. The geographical location of the area having latitude 30^{o} 52’ N, longitude 77^{o} 11’ E and altitude of 1250m.

The site falls under mid hill zone of Himachal Pradesh and characterized by traced and undulating topography. During the experimental period, the highest temperature was observed in May (31.3ºC) followed by June (29.3ºC) and September (28.7ºC) whereas, average minimum temperature were 2.6ºC and 6.4ºC recorded during January and December.

The area received maximum rainfall of 294.4 mm during July followed by August (102.2 mm), June (91.1 mm) and September (41.6 mm), while minimum rainfall was received during December (6.8 mm) and November month (7.6 mm) during the period of study.

Soil samples were taken randomly from the entire experimental area before sowing and were thoroughly mixed together, thus a composite representative sample from whole of the area was taken for chemical analysis to evaluate the fertility status of soil.

The experiment was laid out in Randomized Block Design (RBD Factorial) with two methods of planting *i.e.* broadcasting @ 6kg/ha and seedling planting with varying plant densities i.e. S1 (30 x 15cm), S2 (30 x 30cm), S3 (30 x 45cm), S4 (45 x 45cm) and S5 (45 x 60cm). The seeds were sown in the field during last fortnight of April and irrigation was done till the establishment of plants.

After that the plants were left to grow under rain fed conditions and the field was kept free from weeds by doing manual weeding operations at 15 days interval. A basic dose of 120:60:30 kg NPK/ha was applied to supplement the nutritional demand of the crop. Observations were recorded at pre-flowering and flowering stage.

At pre flowering stage

Leaf biomass

Leaf biomass was recorded as mean from five sample plants after plucking the leaves.

Essential oil content of leaf biomass

The oil was extracted using Clevenger apparatus in the laboratory and oil per cent was calculated on v/w basis.

Essential oil yield of leaf biomass

The essential oil yield was estimated from the biomass of economic parts of the plant on the basis of per cent oil content from the biomass.

At full bloom stage

The data on leaf, essential oil content and essential oil yield of leaf biomass was recorded similarly as given above in the pre-flowering stage. The following additional observations were also recorded at flowering stage.

Flower biomass

Flower biomass was recorded as a mean from already selected five sample plants after plucking the flowers.

Total biomass

It was the sum total of mean of each leaf and flower biomass of already selected five plants.

Essential oil content of flower

The oil was extracted using Clevenger apparatus in the laboratory and oil per cent was calculated on v/w basis.

Essential oil yield of flower

The essential oil yield was estimated from the biomass of flower on the basis of per cent oil content from the biomass.

Cost benefit ratio

T. minuta L. is an important crop whose flower and leaf oil are used for medicinal purposes. Because of the importance, it is essential to find out the cost of cultivation of this crop. The crop was raised under different treatments and cost benefit ratio was calculated on the basis of cost of cultivation and returns on per hectare basis.

Statistical analysis

The data recorded was subjected to statistical analysis under Randomized Block Design and Randomized Block Design Factorial. Analysis of variance was worked out and critical difference at 5 per cent level of significance was calculated.

Results and Discussion

The data on leaf biomass per plant and leaf biomass per hectare of *T. minuta* at pre-flowering stage under different sowing methods *i.e.* Broadcasting and seedling planting with varying plant densities S1 (30 x 15cm), S2 (30 x 30cm), S3 (30 x 45cm), S4 (45 x 45cm) and S5 (45 x 60cm) is represented in Table 1 & 2. In seedling planting method, the pooled data of spacing S5 (45x60cm) yield was observed (72.11 g) maximum in leaf biomass per plant at pre-flowering stage as compared to full bloom stage (70.87 g) in the same spacing. Moreover, the leaf biomass per hectare yield was recorded maximum (50.19 q) in S3 (30 x 45cm) spacing at pre-flowering stage as compare to full bloom stage (45.61 q) in the same spacing. In broadcasting method, the leaf biomass per plant was recorded 18.43 g at pre-flowering stage as compared to full bloom stage i.e. 14.05 g and the same trend was also recorded in leaf biomass per hectare at pre-flowering stage i.e. 43.17 q as compared to full bloom stage i.e. 32.24 q. The results revealed that the large spacing increase more plant growth as compare to less spacing whereas large spacing reduces the number of plant per bed and that lead to reduce the overall yield per hectare. Such studies are also revealed by Meena *et al.,* 2015; Kumar *et al.,* 2019; Lakshmi *et al.,* 2014 in African marigold.

Table.1 Effect of sowing methods and plant densities on leaf biomass per plant and leaf biomass yield at pre flowering stage of *Tagetes minuta*

Method of Sowing	Leaf biomass/plant (g)				Leaf Biomass/ha (q)			
	1st Year	2nd Year	3rd Year	Pooled mean	1st Year	2nd Year	3rd Year	Pooled mean
Broadcasting	18.43	17.42	19.44	18.43	42.78	44.92	41.83	43.17
Transplanted seedlings								
S1 (30x15cm)	21.23	20.43	24.52	22.06	47.18	44.53	46.19	45.97
S2 (30x30cm)	37.78	34.65	36.88	36.43	41.89	43.02	42.45	42.45
S3 (30x45cm)	60.57	57.41	61.74	59.91	50.47	48.47	51.64	50.19
S4 (45x45 cm)	68.47	69.32	66.05	67.95	38.04	42.73	42.58	41.12
S5 (45x60 cm)	72.40	73.44	70.51	72.11	26.81	30.32	31.46	29.53
CD at 5%	4.69	4.16	4.62	4.14	2.99	2.72	2.84	2.12
CV at 5%	19.62	14.27	5.47	13.58	7.26	8.72	7.92	7.92

Table.2 Effect of sowing methods and plant densities on leaf biomass per plant and leaf biomass yield at full bloom stage of *Tagetes minuta*

Method of Sowing	Leaf biomass /plant (g)				Leaf Biomass/ha (q)			
	1st Year	2nd Year	3rd Year	Pooled mean	1st Year	2nd Year	3rd Year	Pooled mean
Broadcasting	14.45	12.48	15.22	14.05	33.79	30.78	32.16	32.24
Transplanted seedlings								
S1 (30x15cm)	17.10	20.36	18.25	18.57	38.00	36.96	40.12	38.36
S2 (30x30cm)	34.23	37.71	36.55	36.16	39.26	34.52	36.55	36.78
S3 (30x45cm)	56.87	53.73	59.06	56.54	45.64	42.57	48.62	45.61
S4 (45x45 cm)	64.30	63.32	69.46	65.69	35.72	32.67	37.14	35.18
S5 (45x60 cm)	68.48	72.74	71.39	70.87	25.33	24.86	28.81	26.33
CD at 5%	2.27	2.96	2.84	2.49	3.12	3.26	3.16	3.62
CV at 5%	12.52	10.62	9.82	10.45	14.26	12.91	11.52	12.78

Table.3 Effect of sowing methods and plant densities on flower biomass per plant and flower biomass yield at full bloom stage of *Tagetes minuta*

Method of Sowing	flower biomass/plant (g)				flower biomass/ha (q)			
	1st Year	2nd Year	3rd Year	Pooled mean	1st Year	2nd Year	3rd Year	Pooled mean
Broadcasting	15.87	13.37	16.44	15.23	32.86	29.64	32.33	31.61
Transplanted seedlings								
S1 (30x15cm)	16.60	18.21	21.54	18.85	36.89	32.89	39.26	36.34
S2 (30x30cm)	33.80	32.38	36.27	34.08	37.56	36.77	39.67	38.00
S3 (30x45cm)	50.00	43.89	52.28	48.72	41.67	43.62	44.08	43.12
S4 (45x45 cm)	59.87	61.77	57.39	59.68	33.26	34.35	36.27	34.62
S5 (45x60 cm)	67.93	69.51	69.19	68.87	25.16	28.94	28.53	27.54
CD at 5%	2.52	2.41	2.64	2.52	2.06	2.21	2.14	2.17
CV at 5%	8.22	9.37	8.49	8.69	9.21	8.23	8.31	6.71

Table.4 Effect of sowing methods and plant densities on oil yield from leaf biomass (kg/ha) at pre flowering and at full bloom stage of *Tagetes minuta*

Method of Sowing	Oil yield from leaf biomass at Pre-flowering stage (kg/ha)				Oil yield from leaf biomass at full bloom stage (kg/ha)			
	1st Year	2nd Year	3rd Year	Pooled mean	1st Year	2nd Year	3rd Year	Pooled mean
Broadcasting	14.11	14.82	13.80	14.24	9.70	8.42	9.23	9.14
Transplanted seedlings								
S1 (30x15cm)	15.57	14.69	15.24	15.17	11.40	10.83	10.47	10.9
S2 (30x30cm)	13.82	14.20	14.01	15.01	11.42	12.03	12.48	11.98
S3 (30x45cm)	16.66	15.10	17.04	16.26	13.69	12.78	13.72	13.40
S4 (45x45 cm)	12.55	14.11	14.05	13.57	10.71	9.48	11.79	10.66
S5 (45x60 cm)	8.85	10.01	10.38	9.75	07.60	08.61	08.49	8.23
CD at 5%	5.14	5.48	4.81	5.14	1.51	04.50	03.56	04.03
CV at 5%	18.12	12.91	10.46	13.83	5.62	10.56	8.34	11.24

Table.5 Effect of sowing methods and plant densities on oil yield from flower biomass (kg/ha) and leaf biomass + flower biomass at full bloom stage of *Tagetes minuta*

Method of Sowing	Oil yield from flower biomass at full bloom stage (kg/ha)				Oil yield from leaf + flower biomass at full bloom stage (kg/ha)			
	1st Year	2nd Year	3rd Year	Pooled mean	1st Year	2nd Year	3rd Year	Pooled mean
Broadcasting	14.78	16.88	13.93	15.19	24.48	25.30	23.16	24.11
Transplanted seedlings								
S1 (30x15cm)	18.07	17.45	18.23	17.92	29.47	28.28	28.70	28.81
S2 (30x30cm)	18.40	19.04	18.63	18.69	29.82	31.07	31.11	30.67
S3 (30x45cm)	20.42	19.67	20.38	20.16	34.11	32.45	34.10	33.55
S4 (45x45 cm)	16.30	18.29	16 52	17.04	27.01	27.77	28.31	27.70
S5 (45x60 cm)	12.33	13.06	13.95	13.11	19.93	21.67	22.44	21.35
CD at 5%	1.51	1.63	1.82	1.57	1.87	1.92	1.81	1.91
CV at 5%	5.72	6.78	6.82	7.48	6.92	5.38	6.71	7.52

Table.6 Effect of sowing methods and plant densities on gross income, net income and B: C ratio

Method of Sowing	Oil yield from leaf + flower biomass at full bloom stage (kg/ha)	Gross income	Net income	B:C Ratio
Broadcasting	24.11	41,770	10,337.5	2.62
Transplanted seedlings				
S1 (30X15 cm)	28.81	1,06,670	64,237.5	3.14
S2 (30X30 cm)	30.67	1,11.090	74,603.5	3.97
S3 (30X45 cm)	33.55	1,19,180	79,657.5	4.32
S4 (45X45 cm)	27.70	49,650	12,217.5	3.03
S5 (45X60 cm)	21.35	36,930	9,816	2.21
CD at 5%	1.91	968.03	1254.23	0.06
CV at 5%	7.52	24.02	36.12	0.19

The pooled data shown in Table 3 of seedling transplanting method depicts that the maximum flower biomass per plant (68.87 g) was observed in S5 (45x60 cm) spacing whereas the maximum flower biomass per hectare (43.12 q) was recorded in S3 (30 x 45cm) spacing. Such results occur due to greater number of plants per bed in S3 (30 x 45cm) as compared to S5 (45 x 60cm) spacing.

Simultaneously, greater number of plants per bed leads to higher growth and yield of flower biomass per hectare in S3 (30 x 45cm) spacing. Similar results are also studied by Karuppaiah and Krishna 2005 in *Tagetes erecta*. Whereas, in broadcasting method, the flower biomass per plant was recorded i.e. 15.23 g when compare to flower biomass per hectare i.e. 31.61 q at full bloom stage.

The pooled data shown in Table 4 & 5 of seedling planting method revealed that the maximum oil yield from leaf biomass at S3 (30 x 45cm) spacing was observed 16.26 kg/ha at pre flowering as compared to maximum oil yield from leaf biomass at full bloom stage i.e. 13.40 kg/ha in the same spacing. Whereas, maximum oil yield from flower biomass at full bloom stage was observed 20.16 kg/ha as compared to maximum oil yield from leaf + flower biomass at full bloom stage was observed 33.55 kg/ha. The results show that the higher biomass yield at S3 (30 x 45cm) spacing produces higher essential oil yield. Similar results were reported by Kumar *et al.*, 2014 in *T. minuta*. In broadcasting, oil yield from leaf biomass was observed 14.24 kg/ha as compared to oil yield from leaf biomass at full bloom stage i.e. 9.14 kg/ha at pre flowering and flowering stage.

Further, during full bloom stage, oil yield from flower biomass was recorded 15.19 kg/ha oil as compare to oil yield from leaf + flower biomass i.e. 24.11 kg/ha. Seedling planting method gives higher biomass and oil yield as compared to broadcasting as nursery sowing makes the plant better to adopt in the environment and reduce the mortality rate.

Table 6 revealed that maximum B:C ratio was observed 4.32 in S3 (30 x 45cm) whereas minimum was recorded 2.21 in S5 (45 x 60cm) as compared to broadcasting i.e. 2.62. The results depicted higher B:C ratio in S3 (30 x 45cm) spacing due to high yield and low cost of cultivation as compared to others. The type of sowing methods i.e. Broadcasting and transplanting seedlings under different plant densities S1 (30 x 15cm), S2 (30 x

30cm), S3 (30 x 45cm), S4 (45 x 45cm) and S5 (45 x 60cm) significantly affected the growth and yield of oil in *Tagetes minuta*. The seedlings planted at S1 (30 x 45cm) spacing yields maximum leaf, flower, leaf + flower biomass and essential oil yield. The comparative analysis of different sowing methods revealed that the transplanted seedlings at spacing (30 x 45cm) gives 14.18% increased oil yield from leaves than broadcasting method at pre-flowering stage whereas at full bloom stage, there is an increase of 39.15% oil yield from leaf + flower biomass than broadcasting method. Thus, seedling planting at spacing (30 x 45cm) is recommended for obtaining maximum benefits as due to high yield and low cultivation cost than the others method of sowing and spacing.

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