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Growth and yield of *Artemisia Annua* as affected by different plant geometry

■ RAJESH CHOUDHARI[1] AND ROSHAN CHOUDHARY

AUTHORS' INFO

Associated Co-author :
[1]Directorate of Research, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA

Author for correspondence :
ROSHAN CHOUDHARY
Directorate of Research, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA
Email : roshan6109@yahoo.co.in

ABSTRACT : A field experiment was conducted at G. B. Pant University of Agriculture and Technology, Pantnagar, U. S. Nagar (Uttarakhand) during the *Rabi* 2007-08 to find out the effect of planting geometry on *Artemisia annua* crop. The experiment consisted eight treatments of different planting geometry *viz.,* (30x30 cm, 30x45 cm, 30x60 cm, 45x60 cm, 45x75cm, 45x90 cm, 60x75 cm and 60x90 cm) were laid out in Randomized Block Design with three replications. Result revealed that maximum leaf yield (2.46 t/ha) was recorded at 45x60 cm which was significantly higher than all other treatments. However, because of significant difference in variation of dried leaf yield of crop, artemisnin yield varied significantly over the treatments. Plant geometry that 45x60 cm spacing was optimum for getting higher leaf yield (2.46 t/ha) and Artemisinin yield (5.16 kg/ha) in *Tarai region* of Uttarakhand.

Key Words : Artemisinin yield, Leaf yield, Plant geometry

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Medicinal plants constitute an important resource in the process of drug development. Numerous plants derived active principles and their derivatives have been developed as drugs against many diseases for their effective treatments. Multiple drug resistance of parasites/ pathogens still poses problems. One important plant genus in traditional chinese medicine (TCM) which is known to contain many bioactive components is *Artemisia annua*. The genus belongs to the family of Asteraceae and about 500 species belong to it (Van Agtmael, 1999). Most Artemisia herbs are perennials and grown in the northern hemisphere. *Artemisia annua* L. is a vigorous, annual, aromatic, herbaceous medicinal plant attaining 1-3 m height and 1 m in width. The plant produces anti-malarial, antibacterial agents and natural pesticides. The main chemical constituents of *Artemisia annua* L. include volatile essential oils and nonvolatile sesquiterpenoids, flavonoids, coumarins, proteins and steroids. The sesquuiterpenes include artemisinin, artemisnin, artemisinin, artemisinin, artemisinin, artemisinin, artemisic acid, artemisilactone, artemisinol and epoxyarteannuinic acid (Peigen, 2002; Anonymous, 1977; Ying *et al*., 1982). Artemisinin content in *Artemisia annua* L. is very low being 0.01-0.8 per cent (Van Agtmael *et al*., 1999). Artemisinin contains an endoperoxide bridge, rarely found in secondary metabolites. For improving artemisinin production, *Artemisia annua* plant is still the most potent and economic source for production of cheap and large quantities of artemisinin and thus it is very important to optimize site specific agronomy of this crop for harvesting maximum biomass leaf of the crop. Crop geometry is very important and primary information required for cultivation of any crop for getting optimum production.

RESEARCH PROCEDURE

A field experiment was conducted at College Agronomy Farm, G. B. Pant University of Agriculture and Technology, Pantnagar, during *Rabi*, 2007. The soil had pH 6.8, 0.91 per cent organic carbon, 211 kg/ha available nitrogen, 32.64 kg/ha available P_2O_5 and 172.4 kg/ha available K_2O. The experiment consisted of eight treatments of different planting geometry *viz.,* (30x30 cm, 30x45 cm, 30x60 cm, 45x60 cm, 45x75 cm, 45x90 cm, 60x75 cm and 60x90 cm) were laid out in Randomized Block Design with three replications. The experiment was transplanted on 6-2-2007 with the 35 days old seedlings. The crop was raised under irrigated conditions.

RESEARCH ANALYSIS AND REASONING

The results of the present study as well as relevant discussions have been presented under following sub heads:

Effect on growth :

The results revealed that the effect of different spacing on plant height was significant at all the growth stages. At 60 days after sowing, the maximum plant height (46.00 cm) was recorded with 30×30 cm spacing, which was significantly higher as compared to 30×60 cm, 45×60 cm, 45×75 cm, 45×90 cm , 60×75 cm and 60×90 cm spacings. But height of crop spacing on 30×45 cm was at par with 30×30 cm crop spacing. This might be due to the competition among plants to get more light for photosynthesis at narrow row spacing and plant growth was erect because they did not get the space to spread. Similar results were reported by Hangovan *et al*.(1990), Umesha *et al.* (1990) Malav and Yadav (1998).

Highest number (48.67) of primary branches was recorded at 30×30 cm plant geometry. The increased number of primary branches in narrow spacing may be due to increased plants per unit area at narrow spacing and more height of plants which led to less spread and as that condition favoured to produce erect type of plants having more primary branches. Similarly, this result has been well supported by Singh *et al*. (2005) by concluding the results of varying spacing in crop of fenugreek where the number of branches (19) got increased at closer spacing (22.5 cm) over wider spacing (30 cm) led to higher yield.

The various plant geometries have pronounced significant affect on angle of top as well as middle branches of the *Artemisia annua* plant at all the growth stages considered for this study. Angle of bottom branches also varied significantly during 60 days after sowing. The effect of the spacing on dry weight of florets/plant was well pronounced in the advanced planting geometry. At harvest highest dry weight of florets was recorded at 60×90 cm spacing. The increase in dry weight of florets in wider spacing may be due to decrease number of plants per unit area in wider spacing. A result of reduction in dry weight of florets under narrow spacing has also been supported by various workers. Hangovan *et al.* (1990) reported that wider spacing exhibited more dry weight of florets due to robust growth with intense branching and more number of leaves. The leaf stem ratio was also affected by plant spacing and it was highest at 60×75 cm and lowest at 30×30 cm. However, it was found non-significantly affected due to variation in treatments.

Table 1: Plant height (cm) and number of primary branches per plant as influenced by different spacing at various stages of crop growth

Treatments	Specing (cm)	Plant height (cm)			Number of primary branches/plant			Angle of top		
		60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
T_1	30×30	46.00	88.30	146.6	23.33	37.67	48.67	35.00	35.67	36.33
T_2	30×45	43.67	85.70	139.00	23.00	36.67	48.00	40.67	41.33	43.33
T_3	30×60	41.67	81.70	135.00	22.67	36.67	47.67	41.33	40.00	45.33
T_4	45×60	37.33	76.10	132.33	22..67	36.33	47.00	45.00	48.67	51.33
T_5	45×75	36.67	76.00	130.00	18.33	30.33	42..33	45.67	49.33	50.33
T_6	45×90	34.33	76.00	125.67	17.33	29.33	41.00	48.00	50.33	51.67
T_7	60×75	32.67	75.00	127.00	16.33	28.33	39.67	51.67	53.33	55.33
T_8	60×90	36.33	73.70	127.00	15.33	27.67	38.00	52.67	55.67	56.67
	S.E.±	1.20	1.49	2.13	0.92	0.76	0.77	1.37	1.05	1.19
	C.D. (P=0.05)	3.64	4.52	6.44	2.80	2.30	2.34	4.15	3.19	3.59

Table 2 Dry weight of florets, yield, artemisinin content and artemisinin as influenced by different spacing at various stages of crop growth

Treatments	Specing (cm)	Dry weight of florets/plant			Leaf:stem ratio	Yield (t/ha)	Artemisinin content (kg/ha)	Artemisinin (%)
		60 DAS	90 DAS	120 DAS				
T_1	30×30	5.36	8.20	15.57	0.80	1.84	0.20	3.67
T_2	30×45	5.78	12.13	22.87	0.83	1.79	0.23	4.14
T_3	30×60	6.42	16.54	32.80	0.85	1.94	0.22	4.26
T_4	45×60	7.57	33.63	69.63	0.87	2.46	0.21	5.16
T_5	45×75	8.23	34.80	69.83	0.85	1.99	0.20	3.99
T_6	45×90	8.93	40.77	80.03	0.95	2.04	0.21	4.25
T_7	60×75	8.92	38.47	78.10	0.95	1.65	0.20	3.31
T_8	60×90	9.11	49.33	99.33	0.84	1.97	0.19	3.74
	S.E.±	0.33	0.86	0.74	0.06	0.04	0.010	0.20
	C.D. (P=0.05)	1.01	2.60	2.24	NS	0.12	NS	0.61

NS=Non-significant

The effect of the spacing on dried leaf yield was pronounced in the planting geometry. At harvest highest leaf yield was recorded at 45×60 cm crop geometry. The increasing trend of dried leaf yield from (30×30 cm) to (45×60 cm) spacing may be due to the compensation with growth of number of plants per unit area up to (45×60 cm) spacing (medium) by efficient utilization of available resources *viz.*, nutrients, water, light and space and having comparatively less competition between intra and inter row spacing resulting more, number of branches, florets, optimum spreading, optimum growth rate and ultimately good growth as compared to closer and wider spacing. The same results have been supported by various workers (Khanda and Mishra,1999; Santhi and Vijayakumar 1997; Chandra *et al.*, 1996 and Pareek *et al.*, 1991).

Effect on yield :

The artemisinin yield was significantly influenced by spacing. Artemisinin yield was found to be highest (5.16 kg/ ha) at 45x60 cm spacing and lowest (3.31 kg/ha) at 60×75 cm spacing. This is because of variation in plant population and more herbage yield from T_1 to T_4 spacing combinations. This finding has been supported by many workers in other crops *viz.*, Singh (1996) reported that neither irrigation nor plant spacing affected the essential oil content, in patchouli significantly the increased oil yield was just because of increase in herb yield. This finding has also been supported by Sood *et al.* (1997) that medium spacing (30×30 cm) in the crop of *Matricaria chamomilla* was significantly superior to the other spacings (15×10 cm and 15×20 cm). This may be due to the fact that at medium spacing with optimum plant density, the competition between the plants for nutrients, light and water etc was relatively low, resulting good growth. The essential oil yield of *Matricaria chamomilla* is increased mainly due to large size of flower and more number of oil glands/unit areas. Tiwari (2006) reported that in safed musli closer spacing of 30×10 cm resulted in significantly higher yield upto 229 kg/ha may be due to increased plant population per unit area under closer spacing. Singh (1996) reported that in marigold among the different spacing, 30×30 cm produced highest flower yield, and 30×40 cm produced the highest carotenoid yield. The variation in flower yield and carotenoid yield might be due to variation in plant population. Similar results have been reported in clocimum, matricaria, mints, and lemon grass.

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