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Studies on high density planting in almond in Kashmir valley

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ABSTRACT

The four planting density (1600, 1111, 816 and 625 plant/ha) as main plot and three almond variety (Makhdoom, Waris and Shalimar) as sub-plot treatment were laid out in Split Plot Design with three replication. Results clearly indicated that maximum cross-sectional area of tree, canopy volume, nut number, nut yield/tree, nut weight, nut size, kernel weight, kernel size, shell thickness and shell weight were recorded in lower plant density but have negative correlation. However, yield (4.01 t/ha) was maximum in higher plant density and have positive correlation. Among variety, Waris performed better in respect to growth and yield compared to Makhdoom and Shalimar during a three year experiment.

Key words: Plant density, variety, almond, canopy, yield and quality, trunk cross-sectional area.

INTRODUCTION

Almond (*Prunus amygdalus* Batsch) is one of the important nut crops of temperate region of India, although it is mainly grown in Kashmir valley. It is cultivated over an area of 23,200 ha with an annual production of 16,300 metric tonnes (NHB, 13). The productivity is very low (0.70 t/ha) as compared to other almond growing countries such as USA, Syria, Israel etc. The main reason for its low productivity is non-systematic planting of almond in Kashmir valley. The planting density plays an important role in improving the productivity of almond. The different planting density/systems have been successfully demonstrated in sub-tropical and temperate fruit crops (Bose *et al*., 3; Kumar and Singh, 10; Holubowicz, 8; Loreti *et al*., 11). However, very little information is available on high density and other planting system of almond. Since availability of solar radiation in high density planting system is the important factor as it governs photosynthesis in plant. The accumulation of carbohydrates in the system and its efficient utilization under abundant availability conditions will determines the final yield of almond to great extent. The variety of almond also plays an important role with higher nut yield and quality. The indigenous varieties such as Waris, Makhdoom and Shalimar is grown profitably well under Kashmir conditions. These varieties are regular bearer and exhibit upright and or spreading type of growth habit and can fit well under the concept of HDP.

Farmers plant them at a plant distance of 6-7 m as no systematic study has been conducted on standardization of planting density for these almond varieties. Keeping this in view, an attempt was made to evaluate the effect of different planting density and variety on growth, yield and quality of almond.

MATERIALS AND METHODS

The experiment was conducted at CITH, Srinagar, Jammu & Kashmir during 2008-09 to 2010-11 to study the effect of planting densities and varieties on growth, nut yield and quality of almond. The experiment was laid out in split plot design with four planting densities (1,600, 1,111, 816 and 625 plants/ha) as main plot and three almond varieties (Makhdoom, Waris and Shalimar) as sub-plot treatment with three replications. The planting was done during 2002-03 at 2.5 × 2.5, 3.0 × 3.0, 3.5 × 3.5 and 4.0 × 4.0 m spacing (6-year-old plant) and 24 plants per treatment during study period at experimental site have been maintained. The experimental farm falls under temperate region having cold conditions from November to February and total average annual rainfall received during the cropping season was 632.26 mm. The plants were given uniform cultural treatment and irrigated through drip irrigation on daily basis during summer. Canopy volume of tree was calculated using the formula devised by Castle (4) as given below: Tree volume = 0.5238 × canopy height (m) × [canopy diameter (m)]^2. The trunk cross-sectional area of tree was calculated by using formula TCSA = Girth 2/4 *n*. Fruit was harvested at maturity, hulled, dried and nut yield per tree was estimated in kilogram. Nut size was determined by observing the length and diameter was measured by Vernier calipers and thickness of shell was measured by Screw gauge and both were expressed in millimetre, The data were analyzed statistically as per Steel and Torrie (15) for interpretation of results and drawing conclusions.

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RESULTS AND DISCUSSION

Trunk cross-sectional area and volume of tree as influenced by plant density in almond. The trunk cross-sectional area of tree and canopy volume increased with decrease the plant density from 1,600 to 625 plants/ha. Significantly maximum cross-sectional area of tree and canopy volume were recorded in lower plant density (625 plants/ha) closely followed by medium density (1,111 and 816 plants/ha) and minimum in higher plant density (1,600 plants/ha) which was increased by 39.27, 37.20 and 33.56% Trunk cross-sectional area and 67.57, 57.21 and 45.46% canopy volume over higher plant densities during 2008-09, 2009-10 and 2010-11 (Table 1). The maximum trunk cross-sectional area of tree and canopy volume at lower plant density might be due to sufficient availability of natural resources, *i.e.*, space, light, moisture and nutrient thereby carbohydrate reserves resulted in vigorous growth of the tree. The trees having higher trunk cross-sectional area might be responsible for higher uptake and translocation of nutrient from the soil to aerial part of plants. These results are inconformity with the finding of Bose *et al*. (3), Pandey *et al*. (14), Kumar and Singh (10), and Kumar *et al*. (9). Minimum trunk cross-sectional area and canopy volume was recorded in higher plant density. Higher plant density adversely affected the canopy volume. Reduction in growth parameters was noted in apple trees planted at higher densities (Lorete *et al.*, 11). An adverse effect of dense planting on tree growth was noted by Holubowicz (8). Zimmerman and Steffens (16) concluded that the growth increase in response to greater space availability and constriction by close spacing in apple.

The maximum trunk cross-sectional area of tree and canopy volume were recorded in Waris followed by Shalimar and minimum in Makhdoom (Table 1). The maximum trunk cross-sectional area and volume of tree was recorded in Waris variety may primarily because of inherent vigour of tree (Ahmed and Verma, 1).

Nut number and yield increased with decrease in the plant density (Table 2). Significantly highest nut number and nut yield were recorded in lower plant density (625 plants/ha) closely followed by medium density and minimum in high plant density. The maximum nut number and yield per tree recorded in lower plant density might be due to sufficient availability of space leading to higher uptake and translocation of nutrient from soil to aerial part of the plants. The increasing planting densities resulted in decreased yield per tree was also reported by Costa *et al.* (5), while working in apple. Hill *et al.* (7) reported that almond yield related to tree size. Nut number and yield was also influenced by different almond varieties (Table 2). Maximum nut number (1031.94 /tree) was harvested in Makhdoorn variety during 2008-09 and 2009-10, respectively. This might be due to smaller fruit size leading to heavy bearing in Makhdoom. However, Waris variety registered highest fruit number (1540.75 /tree) during 2010-11, which may be due to vigourness of the Waris variety compared with Makhdoom and Shalimar (Ahmed and Verma, 1).

Nut yield per hectare increased with increase the plant density (Table 3). Significantly maximum nut yield was recorded in higher plant density followed by medium density and minimum in lower plant density, the maximum yield per hectare in higher plant density might be due to accommodation of more number of

Table 1. Effect of planting densities and varieties on vegetative growth of almond.

Factor	Trunk cross-sectional area (cm^2)			Canopy volume (m^2)		
	2008-09	2009-10	2010-11	2008-09	2009-10	2010-11
Plant density (/ha)						
1,600 plants (2.5 × 2.5 m)	53.34	64.02	71.81	5.15	6.24	7.72
1,111 plants (3 × 3 m)	64.35	76.85	83.76	5.66	6.73	8.51
816 plants (3.5 × 3.5 m)	69.41	80.35	89.95	6.81	7.95	9.63
625 plants (4 × 4 m)	74.29	87.84	95.91	8.63	9.81	11.23
$CD_{0.05}$	10.45	11.12	11.14	1.02	1.04	1.03
r with density*	-0.998	-0.998	-0.998	-0.899	-0.897	-0.986
Variety						
Makhdoom	59.07	69.75	79.04	5.98	7.22	8.99
Shalimar	65.59	65.59	84.93	6.21	7.35	8.45
Waris	71.37	84.02	92.10	7.45	8.48	10.38
$CD_{0.05}$	6.23	7.l3	6.21	0.71	0.62	0.68

*r Co-efficient of correlation: $p = 0.05$

Table 2. Effect of planting densities and varieties on nut yield in almond.

Factor	Nut number/tree			Nut yield (kg/tree)		
	2008-09	2009-10	2010-11	2008-09	2009-10	2010-11
Plant density (/ha)						
1,600 plants (2.5 × 2.5 m)	549.91	606.12	1139.47	1.14	1.19	2.50
1,111 plants (3 × 3 m)	725.23	818.98	1336.44	1.38	1.64	2.94
816 plants (3.5 × 3.5 m)	1081.94	1163.91	1648.03	2.10	2.22	3.75
625 plants (4 × 4 m)	l367.04	1417.29	1688.83	2.34	2.32	4.07
$CD_{0.05}$	418.l3	408.25	225.12	0.61	0.62	0.71
r with density*	-0.951	-0.966	-0.975	-0.949	-0.984	-0.971
Variety						
Makhdoom	1031.94	1077.97	1412.45	1.74	1.82	3.25
Shalimar	948.18	1 044.l 0	1406.37	1.69	1.80	3.09
Waris	812.97	882.65	1540.75	1.71	1.90	3.60
$CD_{0.05}$	109.24	97.56	68.64	NS	NS	NS

*r Co-efficient of correlation(*p=0.05*)

Table 3. Effect of planting densities and varieties on nut yield of almond.

Factor	Nut yield (t/ha)		
	2008-09	2009-10	2010-11
Plant density (/ha)			
1600 plants (2.5 × 2.5 m)	1.83	1.90	4.01
1111 plants (3 × 3 m)	1.71	1.83	3.26
816 plants (3.5 × 3.5 m)	1.52	1.81	3.06
625 plants (4 × 4 m)	1.40	1.45	2.54
$CD_{0.05}$	0.21	0.22	0.71
r with density*	0.972	0.780	0.983
Variety			
Makhdoom	1.66	1.73	3.16
Shalimar	1.59	1.70	2.99
Waris	1.61	1.81	3.50
$CD_{0.05}$	NS	NS	0.25

*r Co-efficient of correlation(*p=0.05*)

plants/ha. Similar findings were also reported in guava by Mahajan *et al.* (12).

Nut yield was also influenced by different varieties as maximum yield per hectare was recorded in Makhdoorn variety during 2008-09. However, 2009-10 and 2010-11, Waris variety registered the maximum nut yield (Table 3) might be primarily due to vigourness of Waris. Damvar and Hassani (6) reported that performance of almond variety depend on varietal character and environmental conditions.

Our results revealed significant variations in nut size, kernel size and shell thickness under different plant density (Table 4). Maximum nut weight, nut size, kernel weight, kernel size and shell thickness were recorded in lower plant density followed by medium and higher density. Whereas, non-significant variations were found in respect to nut weight, kernel weight and shell weight in almond. Although, increasing trends were recorded in all the parameters but variations were non-significant (Anon, 2). Similarly nut weight, nut size, kernel weight, kernel size, shell thickness and shell weight were influenced in different almond varieties (Table 4). Maximum nut weight, kernel weight and shell thickness were recorded in Waris variety. However, nut size, kernel size and shell weights were recorded in Shalimar variety. There is

Table 4. Effect of plant densities and varieties on nut characters m almond during 2010-11.

Factor	Nut weight (g)	Nut size (mm)	Kernel wt. (g)	Kernel size (mm)	Shell thickness (mm)	Shell wt. (g)
Plant density (/ha)						
1,600 plants (2.5 × 2.5 m)	1.98	32.58 × 18.71	1.23	23.56 × 11.73	2.10	0.75
1,111 plants (3 × 3 m)	2.02	33.16 × 18.91	1.24	24.18 × 11.72	1.43	0.78
816 plants (3.5 × 3.5 m)	2.04	33.50 × 19.07	1.27	24.64 × 11.34	1.49	0.76
625 plants (4 × 4 m)	2.07	34.42 × 20.25	1.35	24.96 × 12.03	2.10	0.71
$CD_{0.05}$	NS	1.02 × 0.89	NS	0.68 × 0.32	0.33	NS
r with density"	-0.989	-0.939 × -0.795	-0.833	-0.998 × -0.196	0.183	0.440
Variety						
Makhdoom	2.02	31.04 × 19.13	1.29	22.83 × .23	1.75	0.73
Shalimar	2.01	34.93 × 17.94	1.19	25.82 × 10.68	1.63	0.81
Waris	2.05	34.27 × 20.63	1.34	24.35 × 13.5	1.96	0.70
$CD_{0.05}$	NS	1.54 × 1.32	NS	1.45 × 1.12	0.16	NS

*r Co-efficient of correlation ($p = 0.05$)

no effect of variety on yield per hectare in almond (Anon, 2). Interaction effect of planting density and variety showed significant variations in respect to growth and nut yield of almond. Waris variety under lower plant density enhanced growth and nut yield per plant significantly. Whereas, same variety under high plant density registered maximum yield per hectare in almond due accommodation of more number of plant per hectare.

The correlations drawn between different dependent and interdependent variables on plant growth and nut yield in almond revealed that the growth parameters and nut yield were interrelated. Negative correlation was observed between plant density and trunk cross-sectional area (-0.998, -0.998 and -0.998), plant density and canopy volume (-0.899, -0.897 and -0.986), plant density and nut number (-0.951, -0.966 and -0.975), plant density and nut yield (-0.949, -0.984 and -0.971) during 2008-09, 2009-10 and 2010-11, respectively. However, positive correlation was obtained between plant density and yield per hectare (0.972, 0.980 and 0.983) during 2008-09, 2009-10 and 2010-11. Positive correlation was also obtained between plant density and shell thickness (0.183) and plant density and shell weight (0.440). Negative correlation was obtained between plant density and nut weight (-0.989), plant density and nut size (-0.939 × -0.795), plant density and kernel weight (-0.833) and plant density and kernel size (-0.998 × -0.196) during 2010-11 (Tables 1, 2, 3 & 4).

REFERENCES

1. Ahmed, N. and Verma, M.K. 2009. *Scientific Almond Cultivation for Higher Returns*. Booklet-0*1/2009,* CITH. Srinagar, J&K. pp. 1-14.
2. Anonymous. 2010. *Annual Report*, *2009-10*, *CITH*, Srinagar, J&K. pp. 1-72.
3. Bose, T.K., Mitra, S.K. and Chaudhury, P.K. 1992. Optimum planting density for some tropical fruit crops. *Acta Hort.* **296**: 171-76.
4. Castle, W. 1983. Growth, yield and cold hardiness of seven year old 'Bearss' lemon on twenty seven rootstocks. *Proc. Fla. Sta. Hort. Soc.* **96***:* 23-25.
5. Costa, G., Beltrame, E., Zerbini, P.E., Pianezzola, A., Barritt, B.H. and Kappel, F. 1997. High density planted apple orchards: effects on yield, performance and fruit quality. *Acta Hort.* **451**: 505-12.
6. Damvar, S. and Hassani, D. 2006. Evaluation of almond cultivars in Karaj. *Acta Hort.* **662**: 151-56.
7. Hill, S.J., Stephenson, D.W. and Taylor, K. 1987. Almond yield in relation to tree size. *Scientia Hort.* **33**: 97-111.
8. Holubowicz, T. 1981. Performance of nine apple cultivars in high density orchard in western part of Poland 1. Bearing of Azwellspur and StarKrimson cultivars budded on MM106 rootstock. *Fruit Sci. Rep.* **8**: 23-28.
9. Kumar, Dinesh., Pandey, V., Anjaneyulu, K. and Vishal Nath. 2008. Relationship of trunk cross-sectional area with fruit yield, quality and

leaf nutrient status in 'Allahbad Safeda' guava (*Psidium guajava* L). *Indian J. Agric. Sci.* **78**: 337-39.

10. Kumar, G. and Singh, H.P. 2000. Effect of planting system cum densities on growth, fruit size and yield of guava cv. Allahabad Safeda under rainfed condition. *Ann. Agric. Res.* **21**:152-53.

11. Loreti, F., Guerrriero, R. and Morini, S. 1978. Researchers on apple high density plantings. *Acta Hort.* **65**: 117-18.

12. Mahajan, A.R., Lal, S. and Tiwari, J.P. 2005. Effect of different planting systems on plant growth, flowering, fruiting and yield of guava. *Prog. Hort.* **37**: 27-30.

13. NHB. 2010. *Indian Horticulture Database*, National Horticulture Board, Gurgoan, Haryana. pp. 116-123.

14. Pandey, A., Sharma, A.B. and Patel, M.P. 1997. Effect of planting system-cum-high density on growth, yield and quality of Sardar guava (*Psidium guajava* L.). *Adv. Plant Sci.* **110**: 153-56.

15. Steel, R.G.T. and Torrie, J.H. 1986. *Principles and Procedure of Statistics*. McGraw Hill International Book Co., Singapore, pp. 348-54.

16. Zimmerman, R.H. and Stefens, G.L. 1995. Cultivar, planting density and plant growth regulator effects in growth and fruting of tissue - cultured apple trees. *J. American Soc. Hort. Sci.* **120**: 183-93.

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