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Effect of high density planting systems on the productivity of NA-7 *aonla* under rainfed conditions

A.K. Singh*, Sanjay Singh, V.V. Appa Rao, B.G. Bagle and T.A. More*
Central Horticultural Experiment Station (CIAH), Vejalpur, Panchmahals, Godhra, Gujarat

ABSTRACT

An investigation on high density planting systems was carried out on young trees of *aonla* (*Emblica officinalis* Gaertn), planted in 2001, to study the influence of different planting systems and densities on production and productivity of *aonla* under rainfed condition in the semi-arid ecosystem of western India. Plant height was recorded significantly highest in double hedgerow system having maximum number of plants per unit area, among the different planting systems. However, maximum values of root-stock girth, scion girth and plant spread were recorded in the square system of planting, but the differences among the treatments were non significant. Individual plant gave high yield in square system, but on per unit area basis, double hedgerow system exhibited almost double the crop over square system of planting. Planting systems and plant densities had considerable influence on TSS, vitamin C and sugar contents. Other physico-chemical characters of fruits were not affected significantly by the different planting systems. Based on the overall evaluation data, it can be concluded that by adopting double hedgerow system of planting in *aonla* the productivity per unit area can be enhanced to nearly double over conventional square system of planting under the rainfed condition in semi-arid ecosystem.

Key words: *Aonla*, paired systems, productivity.

Aonla (*Emblica officinalis* Gaertn.), also known as Indian gooseberry, is an important fruit crop of 21st century and in the recent years, *aonla* has been identified as an ideal plant for various kinds of wastelands, *viz.*, moisture stress, eroded, ravines, upland, riverbed and the areas with undulated topography (Korwar *et al.*, 8; Pathak and Pathak, 12) as it possesses some specific characters like intensive and deeper root system, summer dormancy of zygote, reduced leaf area, synchronization of fruit growth and development during optimum moisture availability period and selective absorption of cations and anions, which enable it to grow in fragile agro-climatic conditions particularly in saline and alkaline soils of arid and semi-arid region. NA-7, most popular variety, is precocious in bearing, comparitevely short stature, and upright semi-spreading growth habit and is relatively early maturing and prolific bearer cultivar of aonla that makes it to be suitable for high density planting. Orchards having relatively low tree number per unit area on way out and for intensive planting with smaller trees size are in vogue. High density planting not only provide high production and net return during initial stage of bearing, but also ensures better utilization of resources like land, labour, fertilizers, solar radiation, pesticides and management of weed, which ultimately leads to higher yield. With growing emphasis on high productivity per unit area, high density planting is becoming more and more popular in various fruit crops under varied climatic conditions (Chundawat *et al.*, 6).

Phenomenal increase in area under *aonla* cultivation particularly in semi-arid region and its production in the past few years are largely attributed to the adoption of high yielding variety like NA-7 and high density planting resulting in higher economic yield per unit area, making it economically more viable. Despite the fact that *aonla* is one of the important fruit crops having high therapeutical, nutraceutical and processing values, the information on suitable planting system are scarce. High density planting with combination of planting systems has been successfully demonstrated in mango (Singh *et al.*, 16), litchi (Rathore *et al.*, 14) and guava (Mahajan *et al.*, 10). Considering the condition, planting geometry and manipulation in the spacing seems to be an important tool to obtain higher production and productivity. Keeping this in view, an attempt was made to see the performance of different planting systems on growth, yield and quality parameters of *aonla* under semi-arid ecosystem of western India.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm of Central Horticultural Experiment Station (CIAH), Vejalpur, Panchmahals (Godhra), Gujarat (22° 4' 38'' N and 73° 33' 38'' and 110 to 115 m above mean sea level) on five-year-old trees of *aonla* cv. NA-7 during the year 2005-2007. The treatments comprised of five planting system, *viz.*, T_1, square (9 plants / plot

*Corresponding author's E-mail: aksbicar@gmail.com, aksbicar@yahoo.co.in
**Vice Chancellor, MPKVV, Rahuri, Maharashtra

and 100 plants / ha) T_2, hedgerow (15 plants / plot and 166 plants / ha) T_3, double hedgerow (20 plants / plot and 222 plants / ha) T_4, cluster system (16 plants/ ha and 177 plants / ha) and T_5, paired (12 plants/ ha and 133 plants / ha) planting systems. Number of plants per ha was calculated on the basis of number of plants per plot under different planting systems. Net area of plot of the each treatment (planting system) was 900 m^2 (30 m x 30 m) and total area of the experimental field was18,000 m^2, *i.e.* 1.8 ha. Prevailing planting distance 10 m x 10 m apart and its half distance 5 m x 5 m apart were followed in the trail plots. Normal planting distance was maintained in square system of planting (10 m x 10 m). In hedgerow planting system, distance between row-to-row and plant-to-plant was kept 10 and 5 m, respectively, while in double hedgerow system, two rows of hedge were planted at half of distance (5 m x 5 m). In case of paired planting system, pair of two plants at the distance of 5 m x 5 m in between the rows and 10 m within row and 6 pair per plot were maintained, whereas in cluster planting system a cluster of 4 plants at 5 m x 5 m apart were accommodated, hence 4 clusters per plot (30 m x 30 m) were adjusted.

The area is characterized by semi-arid hot climate. The annual potential evapotranspiration ranges between 1500 to 1600 mm, whereas actual mean usual precipitation is about 831 mm. The mean monthly maximum temperature ranges from 26 and 42° C, while the minimum monthly temperature varies between 10° and 26°C. The experiment was laid out in randomized block design, which was replicated four times. The soil type was clay to clay loam with available N 151.00, P 7.53 and K 170.50 kg/ha, while pH and EC were 7.90 and 0.13 dS m^{-1}, respectively. The soil depth range from 0.75 to 1.0 m, derived from mixed alluvial basalts, quartzite, granite, and having layers of limestone just below the soil depth. Uniform cultural practices were followed during the course of study in all the trees. Growth, yield and quality parameters were recorded and subjected to statistical analysis. Quality parameters such as total soluble solids (TSS) and acidity were determined by standard methods and for estimation of sugars, phenol and vitamin C, the methods as suggested by AOAC (1).

RESULTS AND DISCUSSION

Considerable differences for vegetative parameters were observed under various planting systems (Fig. 1). Plant height (5.67 m) was recorded highest in double hedgerow system, which was closely followed by cluster (5.55 m), hedgerow (5.49 m) and paired systems of planting (5.41 m), whereas it was observed minimum in the square system (5.37 m) during 6th year of planting. Percentage increase in plant height

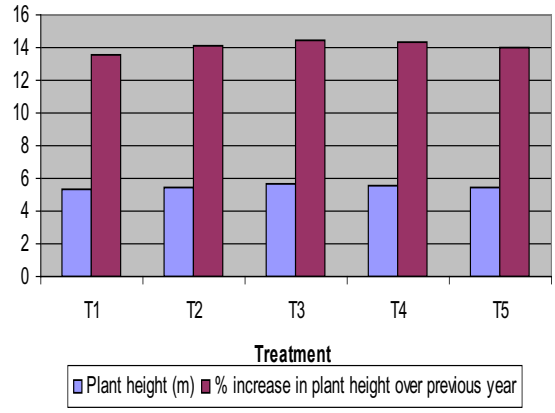

Fig. 1. Effect of planting systems on plant height during 6th year and per cent increase over previous year.

over previous year was recorded maximum in double hedgerow system followed by cluster, hedgerow and paired, while it was recorded lowest in square system of planting. It is generally expected that in closer spacing plants will have tendency to grow tall and the plants in square system (10 m x 10 m) had optimum space for lateral growth. These results are in accordance with the findings of earlier workers (Bose *et al*., 4; Pandey *et al*., 11; Chundawat *et al*., 6; Mahajan *et al*., 10) in different fruit crops under different agro-climatic conditions. Different planting systems and densities did not have significant influence on the rootstock girth, scion girth and plant spread up to 6th year of orchard life. However, maximum values of rootstock girth, scion girth and plant spread were recorded in the square system of planting during 6th year of planting (Figs. 2, 3 & 4). This might be due to the reason that the trees did not reach on their competitive age for these characters under different planting systems. These results are in close conformity with the findings of Rathore *et al.* (14),

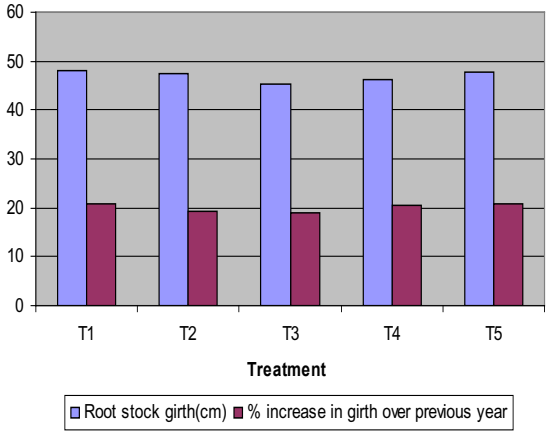

Fig. 2. Effect of planting systems on rootstock girth (cm) and per cent increase over previous year.

Fig. 3. Effect of planting systems on stem girth (cm) during 6th year and per cent increase over preious year.

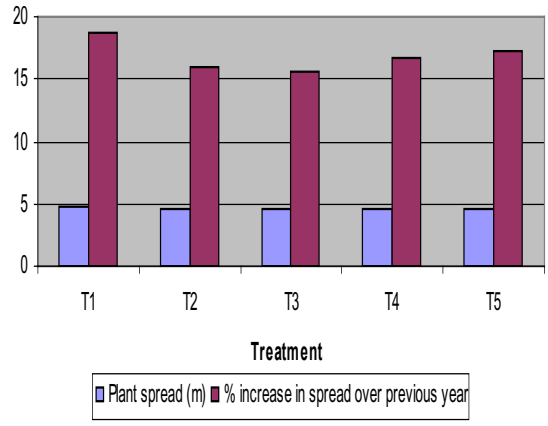

Fig. 4. Effect of planting systems on plant spread (m) during 6th year and per cent increase over previous year.

Stamper *et al.* (17) and Chundawat *et al.* (6) in litchi, *aonla*, apple and banana, respectively.

Results of the study on the yield and yield attributing characters revealed that the yield / plot and / ha was significantly influenced by different planting systems, whereas fruit yield per plant was non significant. Cumulative yield / plot (1,724.40 kg) was recorded maximum in double hedgerow system followed by cluster (1410.24 kg), hedgerow system (1,344.60 kg) and paired (1,116.36 kg), while minimum was recorded in square (882.00 kg) system of planting (Fig. 6).Cumulative fruit yield per tree varied considerably, being highest in square system of planting (98.00 kg) followed by paired system (92.03 kg) with identical trend in the fruit size resulting into higher yield per tree in square and paired system of planting (Fig. 5). This may be because, under wider spacing, plants had comparatively higher vegetation, higher leaf fruit ratio. Tree with bigger vegetative dimension normally give larger number of fruits per tree. However, if productivity per unit area basis is considered, it is clear that yield /plot had given significantly higher yield under double hedgerow due to higher plant population / unit area. With advancement of age, productivity rose significantly in all the systems of planting. The results clearly revealed that although productivity of individual tree under different planting systems were at par, but accommodation of more plant population in double hedgerow system led to almost double the production than square system. Such an increase in production through higher number of plants per unit area has been demonstrated in banana, *aonla*, mango, litchi, Satsuma mandarin and guava by Chundawat *et al.* (6), Ram and Sirohi (13), Tachibana (18), and Kumar and Singh (9). Percentage increase in yield was recorded maximum in double hedgerow system of planting (96.44) followed by cluster system (60.78), hedgerow system (52.79) and paired system (26.93) over square system of planting during the three years of experimentation (Fig. 7). More or less similar results have been reported by Chadha *et al.* (5) in pineapple, Singh *et al.* (16) in mango, Stamper *et al.* (17) in apple, and Sharma *et al.* (15) in mandarin.

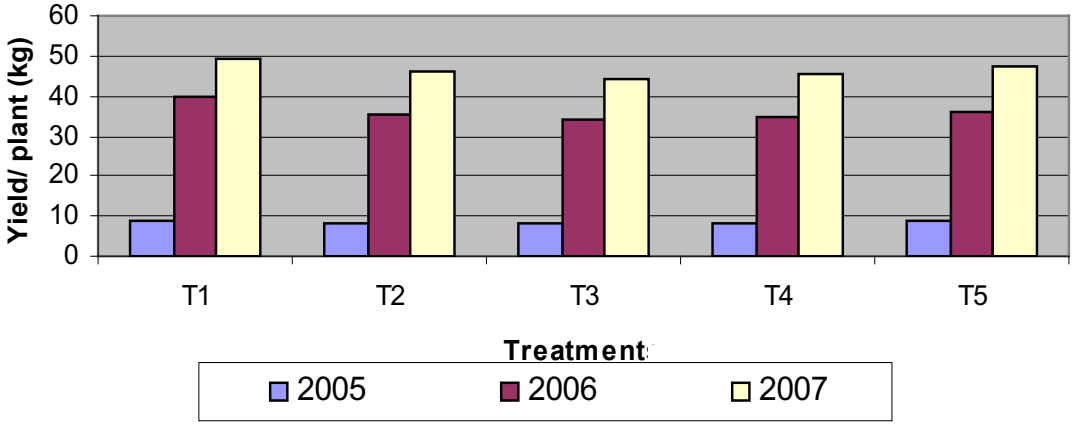

Fig. 5. Effect of planting systems on the yield/plant (kg).

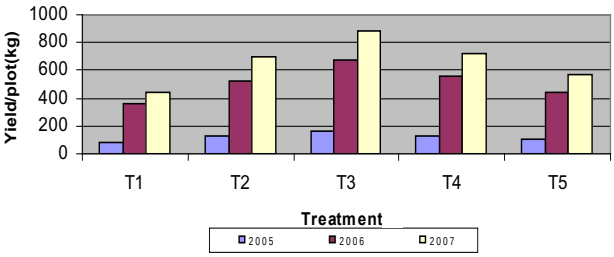

Fig. 6. Effect of planting systems on the yield/plant (kg).

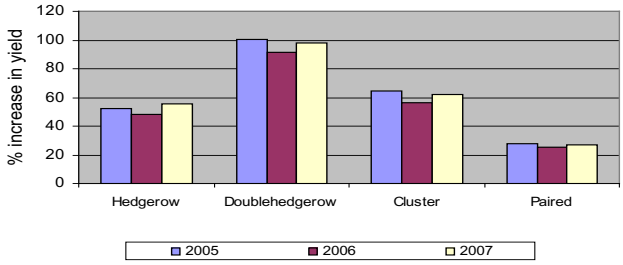

Fig. 7. Per cent increase in yield over square system.

Various planting systems had considerable effect on quality characters of aonla fruits under different planting systems (Table 1). Fruit weight (52.47 g), fruit diameter (4.43 cm), and fruit length (4.28 cm) were recorded maximum in square system of planting, but the differences among the various planting system with respect to these parameters could not reach the level of significance up to 5th year's of orchard life, so far. The tree with bigger dimension and high leaf and fruit ratio may be one of the reasons to bear larger fruits. The present findings are in close conformity with the results reported by Anbu *et al.* (2), Bal and Dhaliwal (3), Gupta and Bist (7), Chundawat *et al.* (6) and Rathore *et al*. (14). Similar trends with respect to pulp weight, seed weight and specific gravity were observed among different planting systems. Rathore *et al.* (14) and Vig and Kallay (19) also obtained similar results in litchi and apple, respectively.

The quality of *aonla* fruits in terms of TSS, total sugars, vitamin C, acidity and total phenols were estimated. Fruit from the trees in double hedgerow system tented to show comparatively higher values of TSS (8.20°B), total sugars (5.57%), and vitamin C (495.84 mg/100 mg) than rest of the planting systems. This may be due to comparatively smaller size of fruits on low spaced trees. More or less similar results have also been reported in *aonla*, mango, apple, litchi, pear, Satsuma mandarin, banana and guava by Stamper *et al.* (17), Gupta and Bist (7), Tachibana (19), Rathore *et al.* (14) and Chundawat *et al*. (6), respectively.

Based on the observations on various aspects, the overall results on high density planting in *aonla* demonstrated that double hedgerow system of planting may be adopted by *aonla* growers for getting better productivity per unit area even early stage of bearing.

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Table 1. Effect of planting systems on physico-chemical attributes of *aonla* fruits.

Treatment	Fruit wt. (g)	Fruit dia. (cm)	Fruit length (cm)	Pulp wt. (g)	Seed wt. (g)	Specific gravity	TSS (%)	Total sugars (%)	Acidity (%)	Total phenols (mg/100 g)	Vitamin C (mg/100 g)
T_1	52.47	4.43	4.28	49.42	2.05	1.03	7.83	5.54	2.20	167.25	492.72
T_2	50.30	4.37	4.22	47.81	2.05	1.02	8.00	5.55	2.06	168.83	494.28
T_3	49.00	4.33	4.12	46.98	2.02	1.02	8.20	5.57	2.02	171.14	495.84
T_4	49.33	4.34	4.16	47.31	2.04	1.02	8.07	5.50	2.07	169.63	491.26
T_5	51.17	4.44	4.25	49.12	2.05	1.01	7.91	5.42	2.14	168.06	485.69
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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