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Effect of different training system on fruit yield and quality of pear (*Pyrus communis* L.)

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Abstract

Pear (*Pyrus communis* L.) is one of the most important temperate fruit crops after apple, belonging to the Rosaceae family. An investigation was conducted during 2020-2021 at the Horticulture Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), to evaluate the effect of training systems on fruit yield and quality of pear. The study involved three varieties (V₁-Baggugosha, V₂-Punjab Beauty, and V₃-Punjab Gold) and four training systems (T₁-Y-Trellis, T₂-Cardon, T₃-Espalier, and T₄-Control). The experiment was laid out in a Factorial Randomized Block Design (FRBD) with four replications. The maximum number flowers per tree, Number of fruit per tree (46.53), Fruit setting (21.01 %), fruit size (6.77 cm), fruit weight (177.03 gm), fruit yield (10.89 kg tree⁻¹), fruit yield (87.65 q ha⁻¹) However, The maximum Total soluble solids (13.69 °Brix), Total sugar (11.64 %), Reducing sugar (6.30%), Non-reducing sugar (5.08%), Acidity (0.39 %) were observed in Espalier system with variety Baggugosha. Conversely, the minimum values for the above parameters were recorded in the control treatment with the variety Punjab Gold.

Keywords: Pear, training system, varieties and yield

Introduction

Pear (*Pyrus communis* L.) is an important temperate fruit after apple in the family Rosaceae. It is originated from China. Pears rank second only to apples in importance, production, and varietal diversity among temperate fruits. Pears are mildly sweet fruits with a fibrous centre. In India, pears hold the second position among temperate fruits in both area and production, cultivated on 44,000 hectares with an annual production of 318 metric tons (Anonymous, 2018) [2].

Pears are rich in essential antioxidants, plant compounds, and dietary fiber. Primarily consumed as table fruit, pears provide important nutrients including protein (0.4 g/100 g), carbohydrates (15 g/100 g), fat (0.1 g/100 g), dietary fiber (3.1 g/100 g), potassium (116 mg/100 g), sodium (1 mg/100 g), iron (1%), magnesium (1%), and vitamin C (7%) (USDA National Nutrient Database). Pear consumption is associated with reduced risk of cardiovascular disease, improved gut health, and anti-cancer effects."

Pear fruits are recommended for patients with diabetes due to their low sucrose content. They help lower blood pressure and regulate heart pulse. Pears contain 3.1 g of dietary fiber, which promotes gut health, and are a good source of antioxidants, with 27 to 41 mg of phenolics per 100 g of fruit. Pears also exhibit vasodilator and anti-arrhythmic properties, contributing to blood pressure reduction and heart pulse regulation. They provide folic acid, a form of vitamin B complex, and contain a glycoside called arbutin, which can be used to treat urinary tract infections. Pears aid in the expulsion of uric acid from the body. Additionally, pear leaves are used to treat sores, swelling, fever, anemia, and general debility, while the bark may be used as a digestive aid. Pears are commonly processed into drinks (such as RTS and squashes), candies, preserved fruits, and jam (Reiland and Slavin, 2015) [29].

Pear fruits are pyriform (pear-shaped) pomes, and their flesh contains stone cells. They develop from the fleshy thalamus of a monocarpellary or multi carpellary syncarpous inferior ovary, known as a pseudocarp or false fruit. Pears are typical fruits with a pleasant taste and flavor and are generally consumed fresh, dried, or preserved. The pear fruits available in the world market mainly belong to *Pyrus communis*, *Pyrus pyrifolia*, and their hybrid species.

Pear ranks second after apples as the most frequently consumed and economically important tree fruit in temperate regions worldwide (Ahmed *et al.*, 2011) ^[1].

In new plantations, initial training is provided to develop a strong framework for the tree, whereas in older plantations, the goal of canopy management is to reduce tree height and improve solar radiation penetration inside the canopy by thinning excessive biomass (Wani *et al.*, 2021) ^[51]. Effective canopy management practices result in better sunlight penetration and improved yield. They enable profitable cropping, consistent high yields, and enhanced farm management, ultimately leading to increased productivity. This approach produces high-quality fruits with regular yields while reducing labor requirements, helping to control rising production costs. Plant canopy is the main driver for management of energy from sunlight to the sink organs particularly the fruits. Therefore, conversion of sunlight energy into fruits is the important task. There are a number of factors affecting the availability of sunlight and energy too is like location, climate and year. Training plays a significant role in obtaining regular and prolific quality fruit production. The size, colour, nutritional quality, and postharvest shelf life of fruits are all significantly affected by the training done during the pre-harvest stages in orchard (Sharma *et al.* 2018) ^[48].

Training begins at the nursery stage of the plant. The main goal of tree training is to encourage favorable growth patterns. Training helps bring trees into production earlier, develop a strong structural framework capable of supporting heavy crop loads without breaking, promote good sunlight penetration through the canopy, and make the trees easier to manage (Hassan *et al.*, 2010) ^[13].

Training helps establish a strong framework of scaffold limbs capable of supporting heavy yields and high-quality fruits, ensures regular annual crop succession, maximizes leaf exposure to sunlight, and directs tree growth to make cultural operations such as spraying and harvesting more economical. Additionally, it protects the tree from sunburn and promotes early production (Kaith *et al.*, 2011) ^[14]. In pear cultivation, training systems are a preferred choice for high-density planting compared to the use of dwarfing rootstocks or cultivars. Various training systems such as Open Vase, Espalier, Cardon, Palmette, Fuestoo, Free Spindle, and Y-Trellis are employed in pears to enhance fruit quality.

Materials and Methods

The experiment titled “Studies on canopy management on yield and quality in Pear (*Pyrus communis* L.) Under western U.P. conditions.” was carried out during 2020-2021 at the Horticulture Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh. It involved ten-year-old pear plants planted at a spacing of 6 m × 6 m. The experimental material consisted of 48 pear trees, and the experiment was carried out using different training systems and varieties. The design of the experiment was a Factorial Randomized Block Design (FRBD) with 12 treatments and four replications.

Treatment details

Factor A: Variety,

V₁= Baggugosha,

V₂= Punjab Beauty,

V₃= Punjab Gold

Factor B: Training System,

T₁= Y-trellis

T₂= Cardon

T₃= Espalier

T₄= Control

Treatment combinations

T₁=V₁T₁

T₂=V₁T₂

T₃=V₁T₃

T₄=V₁T₄

T₅=V₂T₁

T₆=V₂T₂

T₇=V₂T₃

T₈=V₂T₄

T₉=V₃T₁

T₁₀=V₃T₂

T₁₁=V₃T₃

T₁₂=V₃T₄

Yield attributes

• Number of fruits per tree

The number of fruits per tree was recorded by counting the fruits in each of the experimental tree and it was expressed in numbers.

• Fruit setting (%)

The number of fruit set against number of flowers recorded in previous observation was counted and percent was calculated against total number fruit set on the tagged shoot.

$$\text{Fruit setting (\%)} = \frac{\text{Number of fruit set}}{\text{Number of flowers}} \times 100$$

• Fruit size (cm)

The length and breadth of 10 fruit samples from each treatment were measured using digital Vernier calipers and expressed in centimetres.

• Fruit Weight (g)

The weight of the sampled fruits was measured using a physical balance, and the average weight was expressed in grams per fruit.

• Fruit yield (kg tree⁻¹)

Fruit yield per tree was estimated by multiplying the total number of fruit per tree with average fruit weight and was expressed in kg per tree.

• Fruit yield (q ha⁻¹)

Fruit yield in quintal per hectare was estimated by multiplying the average fruit yield per tree with total number of plants per hectare.

$$\text{Fruit yield (q ha}^{-1}\text{)} = \text{Fruit yield (kg tree}^{-1}\text{)} \times \text{Number of plants (ha}^{-1}\text{)}$$

Bio-Chemical attributes

• Total soluble solids (°Brix)

Total soluble solids in ripened fruit were measured using an electronic hand refractometer (0-32 °Brix) by

placing one to two drops of juice on the prism. The refractometer was calibrated with distilled water before each use. The results were expressed in °Brix.

- **Total sugar (%)**

The sum of reducing and non-reducing sugars was expressed as total sugars.

$$\text{Total sugar (\%)} = \text{Reducing sugar (\%)} + \text{Non-reducing sugar (\%)}$$

- **Reducing sugar (%)**

The reducing sugar content was determined by the procedure given by Rangana (1986). Weighed 5g of fruit and macerated with a small amount of distilled water, filtered in a 100 mL volumetric flask and volume was maintained with distilled water up to 100mL. 5 ml sample was taken and 5 ml of Fehling Solution 'A' and 5 ml of Fehling Solution 'B' in each tube. The solution was titrated with 1 % of glucose solution and boiled. The solution was checked by the methylene blue indicator and the endpoint was marked by the appearance of brick red color.

$$\text{Reducing Sugar (\%)} = \frac{\text{Blank titre value (ml)} - \text{Sample titre value (ml)} \times \text{Vol. made up (ml)}}{\text{Weight of the sample (g)} \times \text{Weight of aliquot taken (ml)}} \times 100$$

- **Non-reducing sugar (%)**

The amount of non-reducing sugar was worked out by taking the difference between total sugars and reducing sugar.

$$(\text{Total invert sugars} - \text{reducing sugar}) \times 0.95$$

Titration Acidity (%)

The titratable acidity of macerated juice samples was determined by the visual titration method (AOAC, 1984) as briefed below:

Preparation of sample: Five ml of macerated juice was taken in a 250 ml conical flask, and the volume was made up to 100 ml with distilled water, and the colour was removed with the use of activated charcoal. Then an aliquot is used.

Procedure: Ten ml of an aliquot was taken in a conical flask and titrated against 0.1N NaOH solution using 1 or 2 drops of phenolphthalein indicator (pH 8.2 to 10.0). Formation of pink colour was reckoned as the endpoint of titration. Then, the titratable acidity was calculated as follows:

$$\text{Titratable acidity (\%)} = \frac{\text{Titret value} \times \text{Equivalent wt. of acid} \times \text{Normality of NaOH}}{100 \times \text{Weight of aliquot taken for titration}} \times 100$$

Economics of treatments

- **Total Cost of cultivation (Rs./ha)**

Cost of cultivation was worked out by taking into consideration the charges of spraying, cost of fertilizers, cost of seed, harvesting charges and treatment cost.

- **Gross return (Rs./ha)**

Gross returns include the guava yields per hectare multiplied by local market rate for guava.

- **Net return (Rs./ha)**

Net returns were calculated by deducting cost of cultivation from gross returns.

- **Cost: Benefit ratio analysis**

In order to find out benefit cost ratio, gross return of individual treatment per hectare was divided, by their respective cost of cultivation per hectare including fixed and treatment cost.

Results and Discussion

In present investigation, yield, quality and economics parameters includes number of fruit per tree, Fruit setting (%), fruit size (cm), fruit weight (gm), fruit yield (kg tree⁻¹) fruit yield (q ha⁻¹), Total soluble solids (°Brix), Total sugar (%), Reducing sugar (%), Non-reducing sugar, Titrable Acidity (%) and Economics of treatments which was found significant among all the treatments as compare to control and presented in Table 1, 2& 3..

1. Yield Parameters

1.1 Number of fruits per tree

The maximum number of fruits per tree (42.36) was recorded in variety V₁ (Baggugosha), which was significantly superior to the other treatments, while the minimum average (40.37) was observed in variety V₃ (Punjab Gold). The training system had a significant impact on the number of fruits per tree. The highest average number of fruits per tree (45.42) was recorded under training system T₃ (Espalier), whereas the lowest average (37.32) was found with T₄ (Control). The interaction between training system and variety was also significant for the number of fruits per tree. The highest average number (46.53) was observed in the combination of Espalier training system with variety V₁ (V₁T₃), while the lowest average (35.47) was recorded in the Control with variety V₃ (V₃T₄). Similar findings have also been reported by Moniruzzaman *et al.* (2007) [25], MA *et al.* (2012), Fisher and Orduz-Rodriguez (2012), Lawande *et al.* (2014) [18] and Goncalves *et al.* (2014) [10].

1.2 Fruit setting (%)

The maximum fruit setting (17.47 %) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (16.50 %) was recorded with variety V₃ (Punjab Gold). Training system has the significant impact on fruit setting per cent. The average maximum fruit setting (18.70 %) was found to be significantly higher with T₃ (Espalier). Whereas, the average minimum (15.62 %) was found to be lower with T₄ (Control). The interaction impact of training system and variety for fruit setting per cent was found significant. The average maximum fruit setting (21.01 %) was found to be significantly higher with Espalier (V₁T₃). While, the average minimum fruit setting (14.43 %) was recorded with Control (V₁T₄). Similar results were also reported by several investigators such as Hassan *et al.* (2010) [13], Mohamed, (2012), Li *et al.* (2013), Goncalves *et al.* (2014) [10], Sahoo *et al.* (2017) [47] and Lei *et al.*, (2021) [21].

1.3 Fruit size (cm)

The maximum fruit size (5.95 cm) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (5.70

cm) was recorded with variety V₃ (Punjab Gold). Training system has the significant impact on fruit size. The average maximum fruit size (6.45 cm) was found to be significantly higher with T₃ (Espalier). However, the average minimum (5.38 cm) was found to be lower with T₄ (Control). The interaction impact of training system and variety for fruit size was found significant. The average maximum fruit size (6.77 cm) was found to be significantly higher with Espalier (V₁T₃). Moreover, the average minimum fruit size (5.25 cm) was recorded with Control (V₃T₄). Similar findings were also reported by Robinson *et al.* (2006) [31], Moniruzzaman *et al.* (2007) [25], MA *et al.* (2012), Sharma L. K. (2014) [40], Goncalves *et al.* (2014) [10] and Lordan *et al.* (2017) [20].

1.4 Fruit weight (gm)

The maximum fruit weight (156.42 gm) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (150.08 gm) was recorded with variety V₃ (Punjab Gold). Training system has the significant impact on fruit weight. The average maximum fruit weight (169.55 gm) was found to be significantly higher with T₃ (Espalier). However, the average minimum (142.99 gm) was found to be lower with T₄ (Control). The interaction impact of training system and variety for fruit weight was found significant. The average maximum fruit weight (177.03 gm) was found to be significantly higher with Espalier (V₁T₃). Moreover, the average minimum fruit weight (139.26 gm) was recorded with Control (V₁T₄). Similar results were also reported by Feng *et al.* (2014) [8], Sharma, L. K. (2014) [40], Dallabetta *et al.* (2014) [6], Rutkowski *et al.*, (2015) [38], Sahoo *et al.* (2017) [47], Ranjit and Ghosh (2019) [28] and Kiramani, S. (2020) [16].

1.5 Fruit yield (kg tree⁻¹)

The maximum Fruit yield (7.09 kg tree⁻¹) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (6.44 kg tree⁻¹) was recorded with variety V₃ (Punjab Gold). Training system has the significant impact on Fruit yield. The average maximum fruit yield (8.46 kg tree⁻¹) was found to be significantly higher with T₃ (Espalier). Whereas, the average minimum (5.49 kg tree⁻¹) was found to be lower with T₄ (Control). The interaction impact of training system and variety for fruit yield was found significant. The average maximum fruit yield (10.89 kg tree⁻¹) was found to be significantly higher with Espalier (V₁T₃). While, the average minimum fruit yield (5.28 kg tree⁻¹) was recorded with Control (V₃T₄). Similar results were also reported by several investigators such as Lu *et al.* (2003), Rufato *et al.* (2004) [32], Morgan (2005), Rivas (2008) [30], Komaya *et al.* (2012) and Lei *et al.* (2021) [21].

1.6 Fruit yield (q ha⁻¹)

The maximum Fruit yield (72.16 q ha⁻¹) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (69.99 q ha⁻¹) was recorded with variety V₃ (Punjab Gold). Training system has the significant impact on Fruit yield. The average maximum fruit yield (79.65 q ha⁻¹) was found to be significantly higher with T₃ (Espalier). However, the average minimum (62.99 q ha⁻¹) was found to be lower with T₄ (Control). The interaction impact of training system and variety for fruit yield per tree was found significant. The

average maximum fruit yield (87.65 q ha⁻¹) was found to be significantly higher with Espalier (V₁T₃). Moreover, the average minimum fruit yield (60.03 q ha⁻¹) was recorded with Control (V₃T₄). Similar results were also reported by Sosna and Czaplicka (2008) [45], Caruso *et al.* (2008) [3], Kiprijanovski *et al.* (2009) [15], Lavee *et al.* (2012) [19], Ramirez and Kallarackal (2015) [27] and Seki *et al.*, (2018) [39].

2. Bio-Chemical parameters

2.1 Total soluble solids (⁰Brix)

The maximum Total soluble solids (13.69 ⁰Brix) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (12.82 ⁰Brix) was recorded with variety V₃ (Punjab Gold). Training system has the significant impact on Total soluble sugar. The average maximum Total soluble solid (14.24 ⁰Brix) was found to be significantly higher with T₃ (Espalier). However, the average minimum (12.81 ⁰Brix) was found to be lower with T₄ (Control). The interaction impact of training system and variety for Total soluble solids (⁰Brix) was found significant. The average maximum Total soluble solid (14.43 ⁰Brix) was found to be significantly higher with Espalier (V₁T₃). Moreover, the average minimum Total soluble solid (12.05 ⁰Brix) was recorded with Control (V₂T₄). Similar findings were reported by Ferina *et al.* (2005) [7], Cortell and Kennedy (2006) [5], Moniruzzaman *et al.* (2007) [25], Ristic *et al.* (2007) [36], Nilsson and Gustavsson (2007) [26], Sousa *et al.* (2008) [46], He *et al.* (2008) [12], Feng *et al.* (2014) [8], Goncalves *et al.* (2014) [10], Sharma, L. K. (2014) [40], Rahmani *et al.* (2015) [35], Lordan *et al.* (2017) [20], Ranjit and Ghosh (2019) [28] and Gill *et al.*, (2021) [11].

2.2 Total sugar (%)

The maximum Total sugar (11.64 %) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (10.89 %) was recorded with variety V₃ (Punjab Gold). Training system has the significant impact on Total sugar per cent. The average maximum Total sugar (11.82 %) was found to be significantly higher with T₃ (Espalier). Whereas, the average minimum (10.61 %) was found to be lower with T₄ (Control). The interaction impact of training system and variety for Total sugar (%) was found significant. The average maximum Total sugar (12.43%) was found to be significantly higher with Espalier (V₁T₃). While, the average minimum Total sugar (9.51 %) was recorded with Control (V₂T₄). Similar findings were also reported by Singh, (2001) [43], Cortell and Kennedy (2006) [5], Li *et al.* (2006) [22], Ristic *et al.* (2007) [36], Rahmani *et al.* (2015) [35], Sahoo *et al.* (2017) [47] and Ranjit and Ghosh (2019) [28].

2.3 Reducing sugar (%)

The maximum Reducing sugar (6.30%) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (6.15 %) was recorded with variety V₃ (Punjab Gold). Training system has the significant impact on Reducing sugar per cent. The average maximum Reducing sugar (6.59 %) was found to be significantly higher with T₃ (Espalier). However, the average minimum (5.49 %) was found to be lower with T₄ (Control). The interaction impact of training

system and variety for reducing sugar (%) was found significant. The average maximum Reducing sugar (6.95 %) was found to be significantly higher with Espalier (V₁T₃). Moreover, the average minimum Reducing sugar (5.32 %) was recorded with Control (V₃T₄). Similar results were also reported by several investigators such as Robinson *et al.* (1997)^[37] and Singh and Chauhan (1998)^[44].

2.4 Non-reducing sugar (%)

The maximum non-reducing sugar (5.08%) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (4.77 %) was recorded with variety V₃ (Punjab Gold). Training system has the significant impact on non-reducing sugar. The average maximum non-reducing sugar (5.26%) was found to be significantly higher with T₃ (Espalier). While, the average minimum (4.55%) was found to be lower with T₄ (Control). The interaction impact of training system and variety for non-reducing sugar (%) was found significant. The average maximum non-reducing sugar (5.58 %) was found to be significantly higher with Espalier (V₁T₃). Whereas, the average minimum Non-reducing sugar (4.37%) was recorded with Control (V₃T₄). Similar findings were also reported by Rather, G. H. (2006)^[33], Kaith *et al.* (2011)^[14], Singh *et al.* (2012)^[41], Sharma, L. K. (2014)^[40] and Marini, R. (2014)^[23].

2.5 Titrable Acidity (%)

The maximum Acidity (0.39 %) was recorded with variety V₁ (Baggugosha) which was found significantly superior over the treatments and the average minimum (0.38 %) was recorded with variety V₃ (Punjab Gold) and it was also at par with V₂ (Punjab Beauty). Training system has the significant impact on Acidity per cent. The average maximum Acidity (0.45 %) was found to be significantly higher with T₃ (Espalier). However, the average minimum (0.34 %) was found to be lower with T₄ (Control). The interaction impact of training system and variety for Acidity (%) was found significant. The average maximum Acidity (0.47%) was found to be significantly higher with Espalier (V₁T₃). Moreover, the average minimum Acidity (0.34 %) was recorded with Control (V₃T₄) and it was also at par with Control (V₂T₄). Similar findings were also reported by Rath *et al.* (2001)^[34], Choi *et al.* (2014)^[4], Rahmani *et al.* (2015)^[35], Mmoradiedigehsara *et al.* (2015)^[24], Rutkowski *et al.* (2015)^[38] and Lordan *et al.* (2017)^[20].

3. Economics study

3.1 Total Cost of cultivation (Rs. /ha)

A perusal of data presented in Table 4.4 and Figure 4.4 indicated that total cost of cultivation varied as variation in different treatments. The total cost of cultivation was recorded highest (163647.00 Rs./ha) with the treatments T₃ (Espalier system and Baggugosha variety), T₇ (Espalier system and Punjab Beauty variety) and T₁₁ (Espalier system and Punjab Gold variety). Whereas, the minimum (62922.00 Rs./ha) total cost of cultivation was recorded for the treatments T₄ (Control), T₈ (Control) and T₁₂ (Control), respectively. Similar results were also reported by Tiwari and Lal (2007)^[49] and Singh, G. (2010)^[42].

3.2 Gross return (Rs./ha)

Data on gross return was calculated under different treatment. The maximum gross return (701200.00 Rs./ha)

were obtained with the treatment T₃ (Espalier system and Baggugosha variety). While, the lowest gross return (158730.00 Rs./ha) was recorded with the treatment T₄ (Control).

3.3 Net return (Rs./ha)

Data presented in Table 4.4 revealed that the maximum net return (537553.00 Rs./ha) was recorded with the treatment T₃ (Espalier system and Baggugosha variety). However, the minimum Net return (95808.00 Rs./ha) was obtained with the treatment T₄ (Control).

3.4 Cost: Benefit ratio analysis

Data pertaining to costs benefit ratio shown in Table 4.4 revealed that the maximum cost: benefit ratio (1:4.28) was recorded with the treatment T₃ (Espalier system and Baggugosha variety). Whereas, the minimum cost: benefit ratio (1:2.52) was obtained with the treatment T₄ (Control).

Conclusion

Based on the above investigation, It can be concluded that the training system had a significant effect on pear yield, influencing parameters such as number of fruits per tree, fruit setting (%), fruit size (cm), fruit weight (g), fruit yield (kg tree⁻¹), fruit yield (q ha⁻¹), total soluble solids (°Brix), total sugar (%), reducing sugar (%), non-reducing sugar (%), acidity (%), and the economics of the treatments. The best results were observed with the Espalier training system using the Baggugosha variety. This combination is recommended for achieving higher pear yields under the conditions of western Uttar Pradesh.

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