

Original Research Article

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## Comparison of Nutrient Use Efficiencies and Cost Benefit Ratios in Wine vs. Table Grape Vineyards in Northern Dry Zones of Karnataka, India

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### ABSTRACT

#### Keywords

Table grapes, Wine grapes, Productivity, Nutrient use efficiency, Cost-benefit ratio

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Grape is the most commercially valuable crop in India and it is consumed as fresh table grapes and its juice; and processed raisins and its wine. The cultivars of wild and table grapes are evolved over centuries and possess distinct plant phenology, nutrient requirements and finally, the fruit quality. A study was conducted to compare the nutrient use efficiencies in wine and table grapes. Application of three major nutrients was found significantly higher in table grape vineyards in contrast to wine grape orchards. The fresh grape yields of wine and table grapes varied significantly. The wine grape yields were lesser with a mean yield of  $12.0 \pm 1.2 \text{ t ha}^{-1}$ . In contrast, table grape yields were higher with mean yield  $24.0 \pm 1.50 \text{ t ha}^{-1}$ . Productivity of grapes per unit of applied N, P and K nutrients were derived using total individual nutrients added and the corresponding yields. It was interesting to observe that the productivity –nutrient ratios of table grapes were found to be significantly higher while, wine grape orchards recorded lower productivity–nutrient ratios. The cost-benefit ratios were found to be 1.44 and 1.57 for wine and table grapes respectively.

### Introduction

Grape is the most commercially valuable crop in India and world over. Large volume of fruits is processed into wine while, a significant portion is also consumed as fresh table grapes, dried raisins and processed fresh juice (Yogeeshappa, 2007). The purpose of its consumption/ utilization is determined by the grape fruits and thus, they are broadly categorized into wine and table types. It is documented that the present grapes, belonging to *Vitis vinifera* sub species *vinifera*, are

originated from the near east (between Iran and Turkey) from its wild progenitor *Vitis vinifera* sub species *sylvestris*. There are archeological evidences of wine making in Iran region during the second half of sixth millennium BC (McGovern, 2003). Archeological and genetic studies on grapes indicate that the grape (*Vitis vinifera* L.) is one of the first domesticated perennials, in the human history and its cultivation dates back to 6000-8000 y ago (Aradhya *et al.*, 2003; Zoe Migicovsky *et al.*, 2017). Dominance of wine cultivars distinctly over table types in the

Europe, in contrast to dominance of table type in the East Asia over wine cultivars have been attributed to prevailed past religions in the respective regions. As the quality of fruits needed for wine and table are distinctly different, the cultivars are evolved over centuries in accordance with the nutrient management practices (Zoe Migicovsky, 2017). Appreciable levels of differentiation between table and wine grape cultivars as well as fruits have been reported (Aradhya *et al.*, 2003). Thus, the nutrient management practices, soil nutrient contents, grape plant tissues (petioles) and finally, the yields are expected to differ to a great extent. Considering these issues, a study was conducted to compare the nutrient use efficiencies in wine and table grapes cultivated in northern dry zone of Karnataka.

Patrice *et al.*, (2006) reported that “the Catholic church replaced the Romans and enabled spread of grape cultivation to new regions. Crusaders enabled germplasm exchange and spread their religion in northern Europe. The extension of Islam to North Africa and Middle East also had similar significant role in spreading the table grapes”.

## **Materials and Methods**

### **Study area**

Vijayapur and Bagalkot are the two major grape growing districts of Krishna valley (Figure 1) exists at 500-550m MSL. The region comes under semi-arid climate with low rainfall and high summer temperature associated with cold winter. Thus, the Krishna valley provides ideal conditions for grape cultivation.

### **Survey of vineyards**

Vineyards of both wine and table grape types were chosen for the study. Information on

grape type variety, age soil type, nutrient management practices in terms of major nutrients added (organic and inorganic) and fertigation; organic manures used, amendment by direct soil application etc were collected for each vineyards. The data from vineyards of wine type (n=20) and table type (n=58) were collected separately and general information are furnished in Table 1.

### **Nutrient additions in vineyards**

The amount of nutrients added in the form of fertilizer through fertigation and direct soil application were derived by considering the quantity and nutrient composition of the fertilizer used. The amounts of organic manures added in each orchard was used to estimate the amounts of nutrients added using per cent nutrient contents of N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O ratios of 1:0.5:1. These values were pooled together to derive the total amounts of individual nutrients added in each vineyard.

### **Collection and analysis of grape soil**

Representative soil sample were collected from pre selected orchards. From three different points along the row in the orchard (at 45-60cm away from the main stem and 45cm away from the main row) after harvest of the crop (February-march). Pooled samples were mixed thoroughly and reduced it to half a kilo by quartering technique. The samples were air dried, sieved (2mm) and stored in air tight container for analysis. Standard protocols adopted for soil fertility analysis are presented in Table 2. The data obtained were subjected to simple statistical tests using student's t-tests and F-tests were made.

### **Grape yields and productivity-nutrient ratios**

Some of the grape orchards were visited after the harvest of the crop and the data maintained

by the grape growers on fresh fruit yields and raisins produced were recorded while, grape yields from other orchards were obtained by contacting them over phone. Finally, the total fresh grape yields were derived for each vineyard. Finally, the productivity of grapes per kg of individual nutrient were calculated separately by using the formula given below

$$\text{Productivity - Nutrient Ratio} = \frac{\text{Fresh grape yields (in kgs)}}{\text{Individual nutrient added (in kgs)}}$$

## Results and Discussion

### Nutrient inputs

Use of both manures and fertilizers was observed in wine as well as table grape vineyards. However, supplementation of nutrients through fertilizers was substantially higher compared to nutrients from organic manure sources (Figure 2). Among two grape types, application of three major nutrients were found significantly higher in vineyards of table grape types with mean values of  $554.1 \pm 75.4 \text{ kg-N ha}^{-1}$ ,  $495.2 \pm 73.1 \text{ kg-P}_2\text{O}_5 \text{ ha}^{-1}$  and  $807.2 \pm 207.6 \text{ kg-K}_2\text{O ha}^{-1}$ . Contrastingly, the vineyards of wine grapes received significantly lesser amounts of N, P and K with respective quantities of  $453.1 \pm 44.7 \text{ kg-N ha}^{-1}$ ,  $427.5 \pm 60.2 \text{ kg-P}_2\text{O}_5 \text{ ha}^{-1}$  and  $526.5 \pm 46.6 \text{ kg-K}_2\text{O ha}^{-1}$ . Potassic fertilizer usage was found high while, phosphatic fertilizer application was found least in orchards of both wine and table grape types. Thus, quantities of three major nutrients used among wine and table grape orchards were found in the order: potash > nitrogen > phosphorus fertilizers.

The grape yields are known to respond to nutrient applications (Ganeshmurthy *et al.*, 2011). Achieving/ targeting higher yields with good quality might have forced the farmers to apply higher doses of fertilizer nutrients. This could be the reason for applying large amounts of fertilizers in high yielding table

grape types. In terms of its fruit qualities, high sugar contents and less total acidity is achieved by applying high amounts of K-fertilizers during fruit development (Shikamany *et al.*, 1989). Contrastingly, wine grapes are cultivated under nutrient as well as moisture stress conditions to increase total acidity; and enhance tannins and other phenolic compounds (van Leeuwen *et al.*, 2009). These quality parameters are very important to enhance wine quality.

### Soil fertility profiles of vineyards

Soil nutrient availability in a soil is largely determined by soil reaction (pH) and soil organic carbon. Both wine and table rape vineyards recorded moderately alkaline soil reaction with pH ranging from 7.51 to 8.61. All the vineyard soil samples were found to be non-saline with  $\text{EC}_{2.5}$  values ranging from 0.37 to  $0.50 \text{ dS m}^{-1}$  and the soil organic-C contents were observed in higher range (>0.75 %). However, the nutrient/ crop management practices for wine/ table grape types did not show any significant influence on the above pH, EC and SOC contents (Table 3/ Figure 3).

The soils of northern Karnataka, belonging to black soils, derived mostly from basalt and gneisses, are formed under semi-arid conditions. Excess applications of manures and fertilizers might have stabilized the soil pH to around 8.0 (Shranbhupal Reddy *et al.*, 2014; Anita *et al.*, 2018<sup>a</sup>; and Shreekanth *et al.*, 2018). Judicious use of water through drip irrigation systems might have kept low salt contents near the root zone. High soil organic-C contents in vineyards may be attributed to annual and localized applications (in trenches) of organic manure. Similar values of pH and EC in vineyards were reported earlier by Shreekanth (2016) and Vinod (2016).

In terms of nutrient availability, both wine and table grape orchards recorded nitrogen,

potassium, sulphur and DTPA-micronutrients in higher availability range (Shivakumar *et al.*, 2016). Available phosphorus in wine grape orchards was the only nutrient observed in medium range while, table grape orchards recorded P-availability in higher range. Comparative analysis of soil fertility of two categories of orchards indicated that the table grape vineyards recorded significantly higher availability of nitrogen, phosphorus, potassium, sulphur, zinc and copper (DTPA-Cu and Zn). However, the availability of calcium, magnesium, iron and manganese (DTPA-Fe and Mn) did not differ significantly among two categories of vineyards.

Higher nutrient availability in grape vineyards could be attributed to high nutrient applications by farmers (Anita *et al.*, 2018<sup>b</sup>). Among two categories, significantly higher nutrient availability in table grape orchards, compared to wine grape orchards, may be attributed to high dose of NPK fertilizer applications. Use of Zn and Cu fungicides in table grape vineyards might have caused their build up in soils. Use of high amounts of fertilizer nutrients in horticultural systems

especially, in vegetables and fruit crops and corresponding build up of respective nutrients are well documented (Shikamany *et al.*, 1989; Ganeshmurthy *et al.*, 2011; Puneethraj *et al.*, 2013). Higher sulphur contents in grape soils may be due to preference for sulphate of potash instead of muriate of potash as grape is sensitive for chlorides (Shreekanth *et al.*, 2018). Unutilized fertilizers which are immobile in nature are more likely to build up in surface soils (Anita, 2016) and may even induce micronutrient deficiencies due to their antagonistic effects (Shivakumar *et al.*, 2016).

### Grape yields and productivity-nutrient ratios

The fresh grape yields of wine and table grapes varied significantly (Figure 4). The wine grape yields were lesser and it ranged from 10.0 to 13.3 t ha<sup>-1</sup> with a mean yield of 12.0 ± 1.2 t ha<sup>-1</sup>. In contrast, table grape yields were higher ranging from 21.3 to 27.0 t ha<sup>-1</sup> and mean yield 24.0 ± 1.50 t ha<sup>-1</sup>. Productivity of grapes per unit of applied N, P and K nutrients were derived using total individual nutrients added and the corresponding yields.

**Table.1** General nutrient management practices adopted for wine and table grape cultivation in northern dry zone of Karnataka

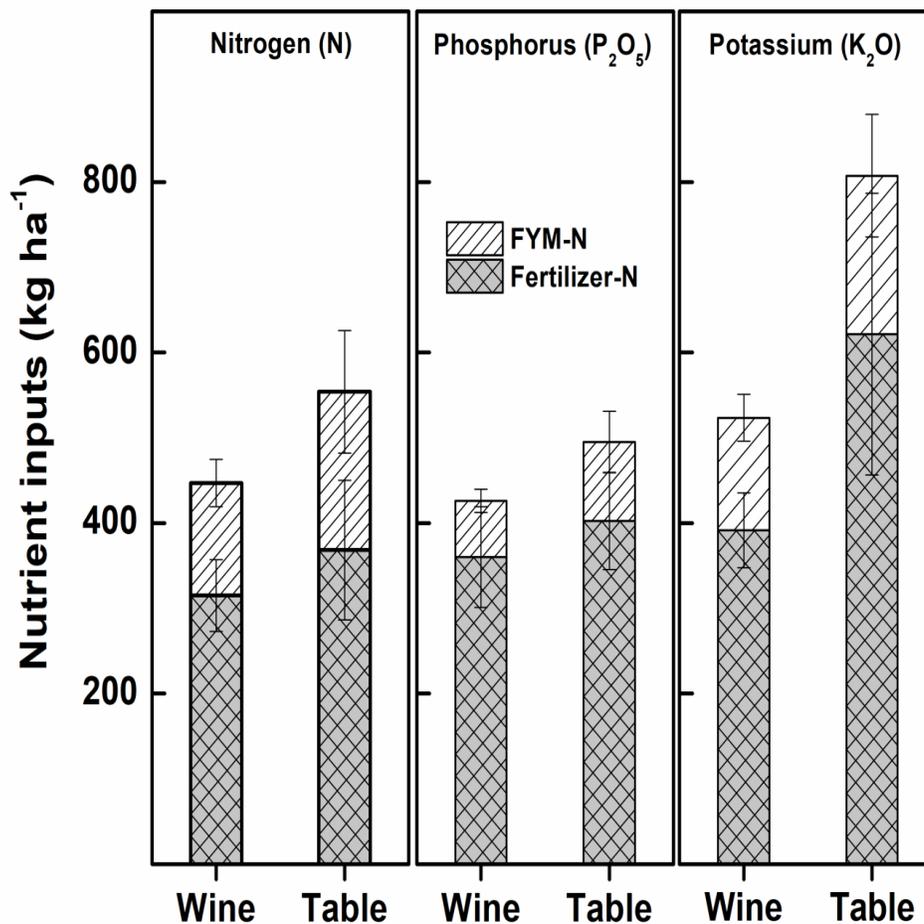
Grape type	Major varieties of the region	Management	Recommended	Farmer's practice
Wine	Souvignon Blanc, Cabernet, Tempranillo, Shiraj and Medika	Spacing (ft)	8 x 6	10 x 5, 12 x 6
		N (kg ha <sup>-1</sup> )	100	375-525
		P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	165	335-543
		K <sub>2</sub> O (kg ha <sup>-1</sup> )	335	450-625
		FYM (t ha <sup>-1</sup> )	10	10-15
Table	Thompson Seedless Sonaka, ManikChaman, Manjre Naveen, Sharad Seedless, Krishna Sharad, Fantasy Seedless and Red Globe	Spacing (ft)	8 x 6	10 x 5, 12 x 6
		N (kg ha <sup>-1</sup> )	300	365-715
		P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	500	325-640
		K <sub>2</sub> O (kg ha <sup>-1</sup> )	1000	525-1280
		FYM (t ha <sup>-1</sup> )	25	14-28

**Table.2** Cost- benefit analysis of table and wine grape cultivation (per ha basis) in northern dry zone of Karnataka

Sl.No	Particulars	Unit	Wine Grapes	Table Grapes
1	Cost of cultivation excluding fertiliser nutrient cost	Rs.	3,00,615	3,37,622
	Cost of fertilizer nutrient		31,549	42,055
	Total cost of cultivation		3,32,164	3,79,678
2	Yield	Kgs	12,000	23,952
3	Rate	Rs / Kg	40	25
4	Gross Returns	Rs.	4,80,000	5,98,815
5	Net Returns	Rs.	1,47,836	2,19,137
6	B-C ratio		1.44	1.57

**Note:** Fertilizer nutrient cost used in calculation are N - Rs.13/kgs; P<sub>2</sub>O<sub>5</sub> - Rs. 28/kgs; K<sub>2</sub>O - Rs. 26/kgs

**Fig.1** Amounts of major nutrients used in grape vineyards



(Data used with permission from Contemporary Research Journal - Anita Kondi *et al.*, 2018a)

Fig.2 Available major nutrient status among grape vineyards

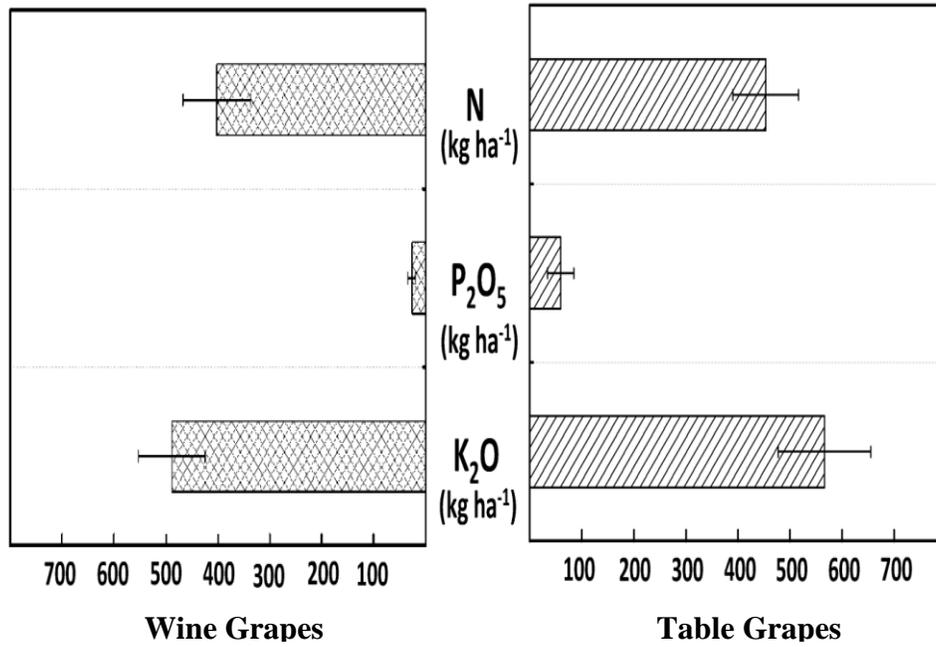
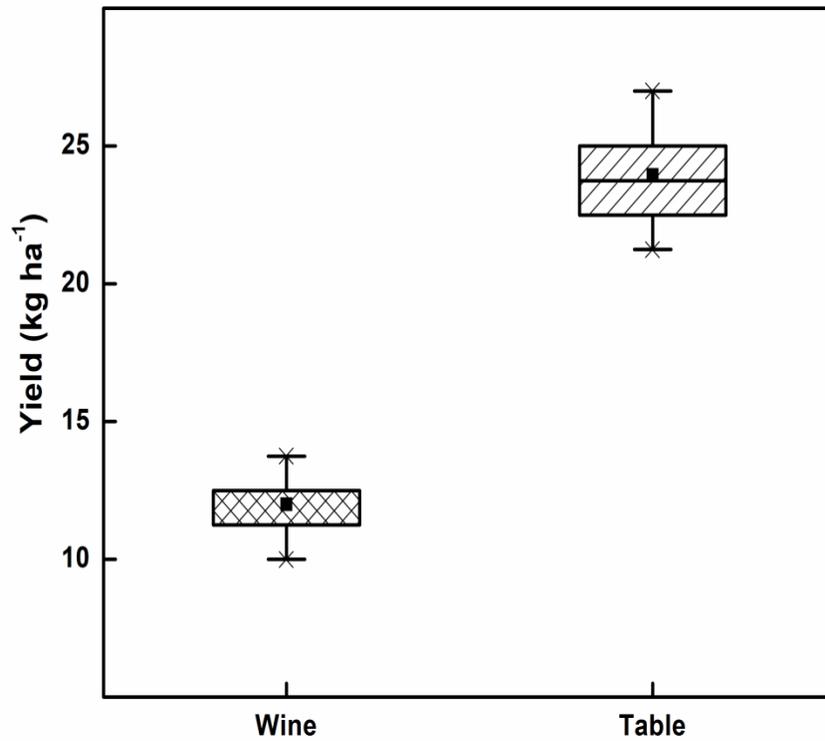
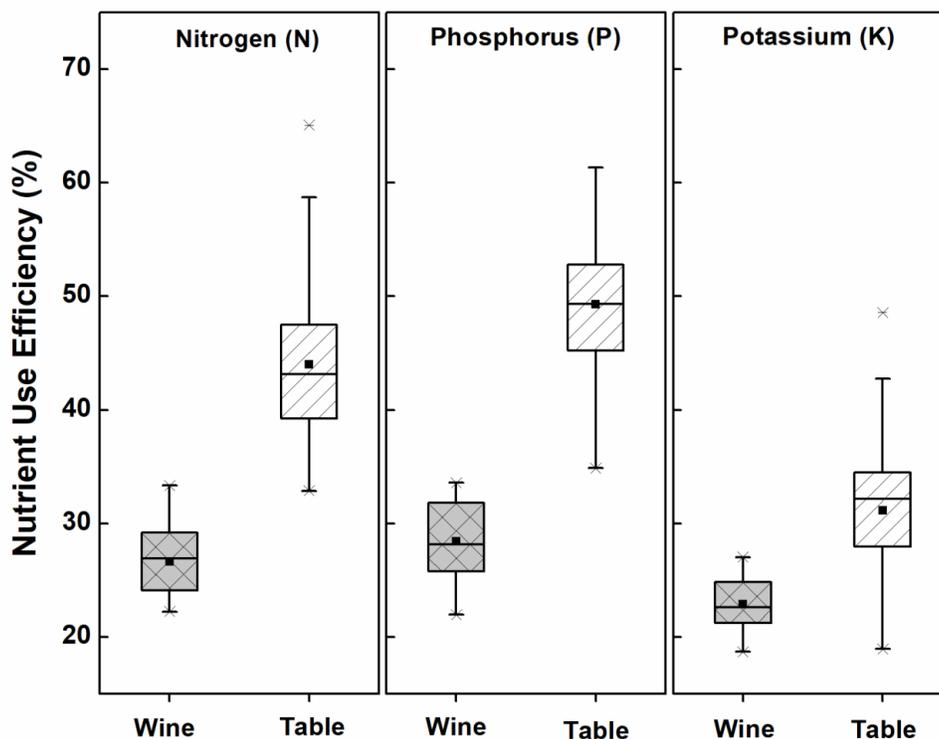


Fig.3 Grape yields of different grape vine yards



(Data used with permission from Contemporary Research India; Anita Kondi *et al.*, 2018a)

**Fig.4** Nutrient use efficiencies in grape vineyards



It was interesting to observe that the productivity –nutrient ratios of table grapes were found to be significantly higher while, wine grape orchards recorded lower productivity-nutrient ratios (Figure 4). The grape yields per kg of nitrogen were found to be  $44.0 \pm 6.4$  kg in table grape types compared to lower values of  $26.6 \pm 3.0$  kg in wine grapes. Similarly, the productivity per kg of phosphorus was found to be  $49.3 \pm 7.2$  and  $28.4 \pm 3.7$  kgs in table and wine grape vineyards respectively. Interestingly, the productivity per kg of potassium nutrient added was found substantially lower compared to other two nutrients ( $31.2 \pm 6.6$  and  $22.9 \pm 2.4$  kgs in table and wine grape orchards respectively).

Higher yields in table grape types and contrasting lower yields in wine grape types may be attributed to their inherent genetic nature of the varieties/genotypes (Patrice *et*

*al.*, 2006). Table grape types are known to be highly nutrient responsive compared to wine type and thus, higher yields may be mostly due to higher nutrient applications (Anita *et al.*, 2018<sup>a</sup> and Vinod Naraboli *et al.*, 2017). Response of the crop to nutrient applications also indicated higher productivity per kg of nutrients in table grape types.

### Cost-benefit analysis

The information on cost of cultivation, nutrient input cost, gross and net returns and cost-benefit ratios of wine and table grapes are given in Table 2. The cost of cultivation of wine and table grapes was found to be Rs. 3,00,615/- and Rs. 3,37,622/- respectively. The corresponding nutrient input costs were found to be Rs. 31,549/- and Rs. 42,055/-. Based on the present market price of Rs. 40 per kg of wine grape and Rs. 25 per kg of table grape (Jan, 2019), the gross returns were

found to be Rs. 4,80,000/- and Rs. 5,98,815/-. The respective net returns were estimated to be Rs. 1,47,836/- and Rs. 2,19,137/-. Thus, the worked out cost-benefit ratio were found to be 1.44 and 1.57 respectively for wine and table grapes. Thus, it clearly suggests that the cultivation of grape is a lucrative option for the farmers.

Considering the economic importance of the table grape types, breeders have evolved / developed several nutrient responsive genotypes. In contrast, the wine industry demands for grapes with high tartaric acid and flavonoids and low sugar contents to produce best quality wines. The fruits attain these qualities when they are grown under water stress conditions resulting in lesser yields (Van leeuwen *et al.*, 2009). This could be the reason for observing lower nutrient productivity values in wine grapes indicating scope for reducing the present levels of nutrient application.

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