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Effect of pre-sowing treatments on seed germination and vigour of seedlings of commercial acid lime cultivars of Andhra Pradesh

J Usha Rameswari, Dr. VNP Sivarama Krishna, Dr. M Siva Prasad, Dr. P Syam Sundar Reddy and Dr. Lalitha Kadiri

Abstract
The present experiment was conducted at commercial nursery block, College of Horticulture, Anantharajupeta, Dr. Y.S.R. Horticultural University, Andhra Pradesh during the year 2022. The experiment was laid out in randomized block design with two factors and three replications. The first factor comprises of 2 levels of cultivars (Balaji and Petluru Pulusu Nimma) and the second factor comprises of 10 levels of different seed treatments *viz*. F_1 (GA_3 @ 250 ppm), F_2 (GA_3 @ 500 ppm), F_3 (NAA @ 25 ppm), F_4 (NAA @ 50 ppm), F_5 (KNO_3 @ 1%), F_6 (KNO_3 @ 2%), F_7 (KNO_3 @ 3%), F_8 (GA_3 @ 250 ppm + KNO_3 @ 1%), F_9 (NAA @ 25 ppm + KNO_3 @ 1%). F_{10} (control) with a total of 20 treatment combinations. Result revealed that the acid lime seeds soaked in F_8 (GA_3@ 250 ppm + KNO_3 @ 1%) found minimum days for initiation of germination (12.26), minimum days for 50% germination (19.69), maximum germination percentage (78.34), maximum germination index (5.3), maximum survival percentage of germinated seedlings (95.97).

Keywords: GA_3, KNO_3, germination, growth regulators, seed treatment, Balaji, Petluru Pulusu Nimma

Introduction
Citrus fruits have a prominent place among popular and extensively grown tropical and subtropical fruits. Among them, acid lime (*Citrus aurantifolia* Swingle) is an important citrus crop which is grown on commercial scale in India and Andhra Pradesh. It is a member of the family Rutaceae and originated in the tropical and sub tropical regions of South East Asia, particularly India and China. In India, Acid lime covers an area of 333 thousand hectares with a production of 3750 thousand MT.

In India, Andhra Pradesh ranks first in production and it covers 30 thousand hectares with a production of 731 thousand MT. It is also known as Pati lime, Kagzi lime and Mexican lime *etc*. Acid lime is used for table purpose in daily life of Indians for flavouring vegetable curries, salad, fish and meat. It is also used in the preparation of refreshing cold drinks especially to beat the hot summer. Acid lime contains 6.3-6.6% citric acid. It is an appetizer, anti scorbutic, anti helminthic and it checks biliousness besides a good source of nutrients, vitamins and other antioxidant compounds. It is used in making candies, chocolates, ice-creams and pastries etc.

Acid lime is commercially propagated by seeds as it is the easiest and cheapest method of propagation. Acid lime propagation is hampered by high mortality at the nursery stage, moreover; seeds lose their viability very soon. In acid lime germination percentage is low and it varies between 27-58% and it takes about 3 weeks to germinate (Cheema *et al*., 1954) [10]. Nurserymen and growers thus face problems like lower seed germination and poor vigour of seedlings. The growth of acid lime seedlings is very slow and therefore, to raise seedlings with in the shortest possible time, growth has to be accelerated for which pre sowing treatments can be employed. The use of growth regulators in overcoming the inhibitory action of certain chemical substances that delay the germination has been reported by Abohassan *et al.* (1979) [1] in kagzi lime and Chaudhari and Chakrawar (1980) [12] in Rangpur lime. Nitrate ions stimulate germination of dormant seeds (Alboresi *et al*., 2005) [2]. Keeping this in view, an experiment entitled "Effect of pre-sowing treatments on seed germination and vigour of seedlings of commercial acid lime cultivars of Andhra Pradesh.

Material and Methods

The present experiment was carried out at commercial nursery block, College of Horticulture, Anantharajupeta, YSR Kadapa district, Andhra Pradesh during the year 2022 to study the effect of pre-sowing treatments on seed germination and vigour of seedlings of commercial acid lime cultivars of Andhra Pradesh which was falls under southern agro-climatic zone of Andhra Pradesh at an elevation of 162 m (531 feet) above mean sea level; geographically it lies between 130 59' North latitude and 790 19' East longitude. The experiment was laid out in factorial randomized block design for germination parameters The treatments comprised of different seed treatments *viz*. F_1 (GA_3@ 250 ppm), F_2 (GA_3 @ 500 ppm), F_3 (NAA @ 25 ppm), F_4 (NAA @ 50 ppm), F_5 (KNO_3 @ 1%), F_6 (KNO_3 @ 2%), F_7 (KNO_3 @ 3%), F_8 (GA_3 @ 250 ppm + KNO_3@ 1%) F_9 (NAA@ 25 ppm + KNO_3@ 1%), F_{10} (control). were soaked for 24 hr and with a total of 20 treatment combinations are employed in this seed treatments, the seeds were collected from disease free and fully ripened fruits of acid lime and uniform size, healthy seeds were selected and used for the experimental purpose. Seeds were sown during the last week of January in nursery beds, immediately watered by using rose cane and also maintained optimum moisture level when required. The observation on days taken for initiation of germination, Days to 50% germination, germination percentage, germination index, survival percentage, The data recorded from the present studies were subjected to analysis by using standard method suggested by Panse and Sukhatme (1967) [22].

Results

Germination parameters

Days for initiation of seed germination

The information regarding the effect of seed treatments with growth regulators and chemicals on the days for initiation of seed germination presented in table 1 and figure 1.

Among the two cultivars significantly minimum days for initiation of seed germination was observed in C_2 (Petluru Pulusu Nimma) cultivar (14.76 days).than that of Balaji (18.91) cultivar.

The recorded data clearly indicated that the days for initiation of seed germination was significantly influenced by the seed treatment with plant growth regulators and various chemicals. Minimum number of days taken for seed germination was recorded when the seeds were treated with F_8 (GA_3 @ 250 ppm + KNO_3 @ 1%) (12.26 days), while maximum number of days for germination was recorded in F_{10} (control) (20.88 days).

Among the interaction effect of cultivars and seed treatments was recorded significantly minimum number of days when the seeds were treated with (C_2F_8) (Petluru Pulusu Nimma treated with GA_3 @ 250 ppm + KNO_3 @ 1%) (11.03 days), which was on par with the (C_2F_9) (Petluru Pulusu Nimma treated with NAA @ 25 ppm + KNO_3 @ 1%) (11.67), while the maximum number of days for germination was recorded in (C_1F_{10}) (Balaji with control) (23.47 days).

Days for 50% seed germination

The information regarding the effect of seed treatments with growth regulators and chemicals on the days for 50% seed germination was presented in table 2.

Among the two cultivars, significantly minimum days for 50% seed germination was observed in C_2 (Petluru Pulusu Nimma) cultivar (23.09 days), than that of Balaji cultivar (26.84).

The recorded data clearly indicated that the days for 50% germination was significantly influenced by the seed treatment with plant growth regulators and various chemicals. Minimum number of days taken for 50% germination was recorded when the seeds were treated with F_8 (GA_3 @ 250 ppm + KNO_3 @ 1%) (19.69 days), while maximum number of days for 50% germination was recorded in F_{10} (control) (29.78 days).

Among the interaction effect of cultivars and seed treatment was observed significantly for 50% germination with minimum number of days when the seeds were treated with (C_2F_8) (Petluru Pulusu Nimma treated with GA_3 @ 250 ppm + KNO_3 @ 1%) (18.74 days), which was on par with the (C_2F_9) (Petluru Pulusu Nimma with NAA @ 25 ppm + KNO_3 @ 1%) (19.71), while maximum number of days for 50% germination was recorded in (C_1F_{10}) (Balaji with control) (30.41 days).

Germination percentage

The information regarding the effect of seed treatments with growth regulators and chemicals on the germination percentage was presented in table 3 and figure 2.

Between the two cultivars, significantly highest germination percentage was observed in C_2 (Petluru Pulusu Nimma) cultivar (78.69%), than that of Balaji cultivar (69.18).

The recorded data clearly indicates that the germination percentage was significantly influenced by the seed treatment with plant growth regulators and various chemicals. Significantly highest germination percentage was observed when the seeds were treated with F_8 (GA_3 @ 250 ppm + KNO_3 @ 1%) (78.34%) while, minimum germination percentage was observed in F_{10} (control) (67.42%).

Among the interaction effect of cultivars and seed treatment significantly maximum germination percentage was observed when the seeds were treated with (C_2F_8) (Petluru Pulusu Nimma treated with GA_3 @ 250 ppm + KNO_3 @ 1%) (83.14%), which was on par with the (C_2F_9) (Petluru Pulusu Nimma treated with NAA 25 ppm + KNO_3 @ 1%) (81.70) while, minimum seed germination percentage was observed in (C_1F_{10}) (Balaji with control) (64.57%).

Seed germination index

The information regarding the effect of seed treatments with growth regulators and chemicals on the seed germination index was presented in table 4.

Between the two cultivars, significantly highest seed germination index was observed in C_2 (Petluru Pulusu Nimma) cultivar (6.08), than that of Balaji cultivar (2.93).

The recorded data clearly indicated that the germination index was significantly influenced by the seed treatment with plant growth regulators and various chemicals. Significantly highest germination index was observed when the seeds were treated with F_8 (GA_3 @ 250 ppm + KNO_3 @ 1%) (5.30), which was on par with the F_9 (NAA @ 25 ppm + KNO_3 @ 1%) (5.18), while minimum germination index was observed in F_{10} (control) (3.10).

Among the interaction effect of cultivars and seed treatments significantly affected the seed germination index. Maximum germination index was observed with (7.40) when the seeds were treated with (C_2F_8) (Petluru Pulusu Nimma treated with GA_3 @ 250 ppm +KNO_3 @ 1%) which was on par with the (C_2F_9) (Petluru Pulusu Nimma treated with NAA 25 ppm with

KNO_3 @ 1%) (7.26).

Final survival percentage of seedlings

The information regarding the effect of seed treatments with growth regulators and chemicals on the survival percentage of seedlings was presented in Table 5 and Figure 3.

Between the two cultivars, significantly highest survival percentage was observed in C_2 (Petluru Pulusu Nimma) cultivar (91.35), than that of Balaji.

The data recorded clearly indicates that the survival percentage was significantly influenced by the seed treatment with plant growth regulators and various chemicals. Significant highest survival percentage was observed when the seeds were treated with F_8 (GA_3 @ 250 ppm + KNO_3 @ 1%) (94.47), which were on par with the F_9 (NAA @ 25 ppm with KNO_3 @ 1%) (93.24), F_2 (GA_3 @ 500 ppm) (93.18), F_1 (GA_3 @ 250 ppm) (92.61), while minimum survival percentage was observed with control (85.13).

The interaction effect of cultivars and seed treatment significantly affected the highest survival percentage. The maximum survival percentage was observed when the seeds were treated with (C_2F_8) (Petluru Pulusu Nimma treated with GA_3 @ 250 ppm with KNO_3 @ 1%) (95.29), which were on par with the (C_2F_9) (NAA @ 25 ppm with KNO_3 1%) (94.23), (C_2F_1) (Petluru Pulusu Nimma treated with GA_3 @ 250 ppm) (93.25), (C_2F_5) (Petluru Pulusu Nimma treated with Arka Citrus Special @ 2%) (94.31), (C_2F_2) (Petluru Pulusu Nimma treated with GA_3 @ 500 ppm) (94.23) while, minimum survival percentage was observed when seeds were treated with (C_1F_{10}) Balaji with control (82.60).

Discussion

Early germination in seeds treated with GA_3 may be attributable to the compound's direct action in releasing the embryo from its state of dormancy by encouraging protein synthesis, elongating the coleoptile, primary leaves, and aiding in the formation of ethylene. GA_3 stimulates the manufacture of hydrolases, particularly amylase enzyme, which promotes early seed germination. Several studies also confirmed the GA_3 treated seeds shown same results. Kumari *et al.*, 2007 [19] in Aonla, Garge *et al*., 2011[15] in custard apple, Athani *et al*., 2013 [4] in guava and Lalitha *et al*., 2020 [20] in aonla, Anusha 2009 [3] in avocado, chaudary 2020 [9] in Kagzi lime, Kadam *et al* 2010 [18] in kagzi lime, Joshi *et al*. (2015) [17] in acid lime, Chiranjeevi *et al.* (2017) [11] in Aonla, Dilip *et al.* (2017) [13] in rangapur lime and Panda *et al*. (2018) [21] in Kagzi lime.

KNO_3 promotes germination by lowering the endogenous abscisic acid levels in embryosdue to increased oxidation of NADPH to NADP and enzymes that have been allocated to provide nutrients for germination, resulting in cell shrinkage and weakening of the aleurone layer's cell wall (Bethke *et al*. 2007, participation in the pentose phosphate pathway) [7]. (Finkelstein *et al*. 2008) [15], the buildup of nitrogen and potassium ions in seeds may also contribute to the rise in germination. (Hegazi *et al*. 2011 and Banik *et al.* 2015) [16, 5] increasing the production of amino acids, which may have helped in enhancing germination and growth in plant tissues. promote germination among different species and same results observed in Bindu *et al*. (2014) [8] in mango, Patel *et al*. 2018 [23] in jamun. Barathkumar [6], 2019 in Aonla and Sheoran *et al*. 2019 [24] in ber.

Table 1: Days for initiation of seed germination as influenced by pre sowing treatments of growth regulators and chemicals in two commercial cultivars of acid lime.

Pre-sowing treatments	Days for initiation of germination		
	Cultivars		
	C_1(Balaji)	C_2(Petluru Pulusu Nimma)	Mean
F_1 (GA_3@ 250 ppm)	17.74	13.62	15.68
F_2 (GA_3@ 500 ppm)	15.84	13.41	14.62
F_3 (NAA@ 25 ppm)	21.37	16.28	18.82
F_4 (NAA@ 50 ppm)	22.48	17.51	19.99
F_5 (KNO_3@ 1%)	19.69	14.64	17.17
F_6 (KNO_3@ 2%)	20.89	16.25	18.57
F_7 (KNO_3@ 3%)	19.57	15.10	17.31
F (GA_3@ 250 pp+KNO_3@1%)	13.49	11.03	12.26
F_9 (NAA@ 25 pp+KNO_3@1%)	14.62	11.67	13.14
F_{10} (Control)	23.47	18.29	20.88
Mean	18.91	14.76	
Factors	C.D (5%)	S.E(m)±	
C	0.24	0.08	
F	0.53	0.18	
C X F	0.75	0.26	

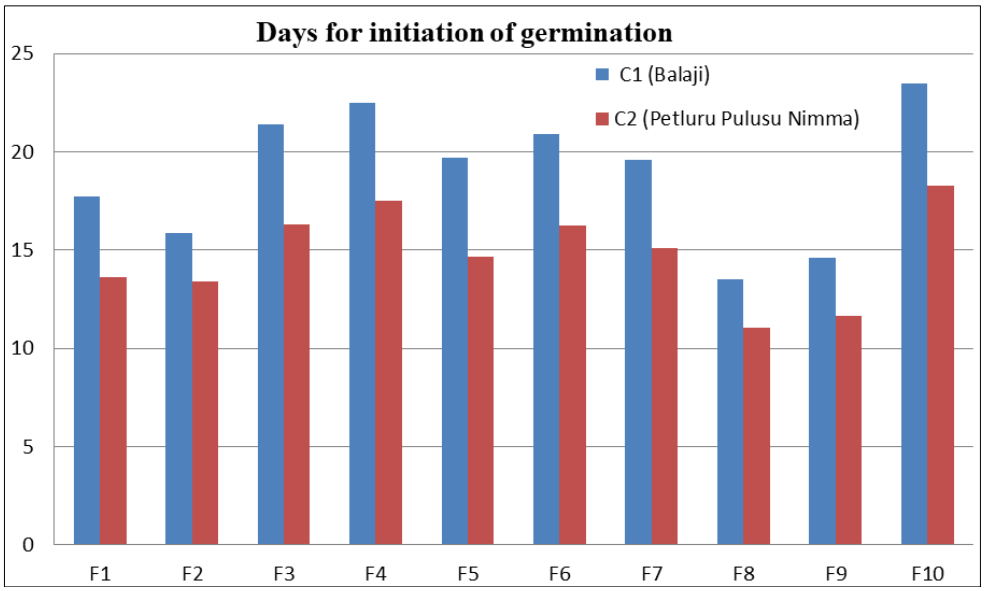

Fig 1: Days for initiation of germination

Table 2: Days for 50 percentage of seed germination as influenced by pre sowing treatments of growth regulators and chemicals in two commercial cultivars of acid lime.

Pre-sowing treatments	Days for 50 seed percentage		
	Cultivars		
	C_1(Balaji)	C_2(Petluru Pulusu Nimma)	Mean
F_1 (GA_3 @ 250 ppm)	25.84	22.19	24.02
F_2 (GA_3@ 500 ppm)	24.47	21.31	22.89
F_3 (NAA@ 25 ppm)	29.63	24.64	27.12
F_4 (NAA@ 50 ppm)	29.74	25.46	27.60
F_5 (KNO_3@ 1%)	27.71	22.47	25.09
F_6 (KNO_3@ 2%)	29.43	24.14	26.78
F_7 (KNO_3@ 3%)	27.97	23.08	25.52
F (GA_3@ 250 ppm +KNO_3@1%)	20.64	18.74	19.69
F_9(NAA@ 25 ppm +KNO_3@1%)	22.57	19.71	21.14
F_{10} (Control)	30.41	29.17	29.78
Mean	26.84	23.09	
Factors	C.D (5%)		S.E(m) ±
C	0.31		0.11
F	0.71		0.24
C X F	0.99		0.34

Table 3: Seed germination percentage as influenced by pre sowing treatments of growth regulators and chemicals in two commercial cultivars of acid lime

Pre-sowing treatments	Seed germination percentage		
	Cultivars		
	C_1(Balaji)	C_2(Petluru Pulusu Nimma)	Mean
F_1 (GA_3 @ 250 ppm)	71.63	76.58	75.10
F_2 (GA_3@ 500 ppm)	70.58	79.95	75.27
F_3 (NAA@ 25 ppm)	67.86	77.61	72.73
F_4 (NAA@ 50 ppm)	65.92	76.50	71.13
F_5 (KNO_3@ 1%)	68.55	80.03	74.29
F_6 (KNO_3@ 2%)	66.14	79.07	72.61
F_7 (KNO_3@ 3%)	66.43	80.06	74.25
F (GA_3@ 250 ppm +KNO_3@1%)	73.55	83.14	78.34
F_9(NAA@ 25 ppm +KNO_3@1%)	72.62	81.70	71.16
F_{10} (Control)	64.57	70.26	67.42
Mean	69.18	78.69	
Factors	C.D (5%)		S.E(m) ±
C	0.181		0.063
F	0.405		0.141
C X F	0.573		0.199

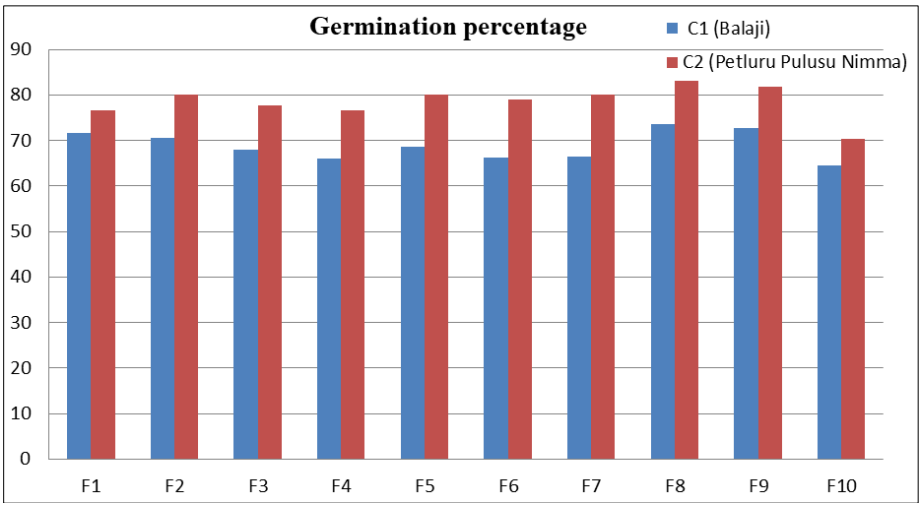

Fig 2: Germination percentage

Table 4: Seed germination percentage as influenced by pre sowing treatments of growth regulators and chemicals in two commercial cultivars of acid lime

Pre-sowing treatments	Germination index		
	Cultivars		
	C_1(Balaji)	C_2(Petluru Pulusu Nimma)	Mean
F_1 (GA_3 @ 250 ppm)	3.16	5.60	4.38
F_2 (GA_3@ 500 ppm)	3.26	6.50	4.88
F_3 (NAA@ 25 ppm)	2.80	5.30	4.05
F_4 (NAA@ 50 ppm)	2.70	6.42	4.56
F_5 (KNO_3@ 1%)	3.00	5.00	4.30
F_6 (KNO_3@ 2%)	2.70	6.30	4.47
F_7 (KNO_3@ 3%)	2.80	6.90	4.85
F (GA_3@ 250 ppm +KNO_3@1%)	3.20	7.40	5.30
F_9(NAA@ 25 ppm +KNO_3@1%)	3.11	7.26	5.18
F_{10} (Control)	2.60	3.60	3.10
Mean	2.93	6.08	
Factors	C.D (5%)		SE(m) ±
C	0.03		0.01
F	0.08		0.02
C X F	0.12		0.04

Table 5: Survival percentage as influenced by pre sowing treatments of growth regulators and chemicals in two commercial cultivars of acid lime

Pre-sowing treatments	Survival percentage		
	Cultivars		
	C_1(Balaji)	C_2(Petluru Pulusu Nimma)	Mean
F_1 (GA_3 @ 250 ppm)	91.97	93.25	92.61
F_2 (GA_3@ 500 ppm)	92.14	94.23	93.18
F_3 (NAA@ 25 ppm)	89.57	90.55	90.06
F_4 (NAA@ 50 ppm)	86.52	86.57	91.15
F_5 (KNO_3@ 1%)	87.92	94.31	89.81
F_6 (KNO_3@ 2%)	89.40	90.38	89.89
F_7 (KNO_3@ 3%)	90.06	92.18	91.12
F (GA_3@ 250 ppm +KNO_3@1%)	93.65	95.29	94.47
F_9(NAA@ 25 ppm +KNO_3@1%)	92.26	94.23	93.24
F_{10} (Control)	82.60	84.23	85.13
Mean	89.62	91.35	
Factors	C.D (5%)		S.E(m)±
C	1.24		0.43
F	2.78		0.97
C X F	3.94		0.37

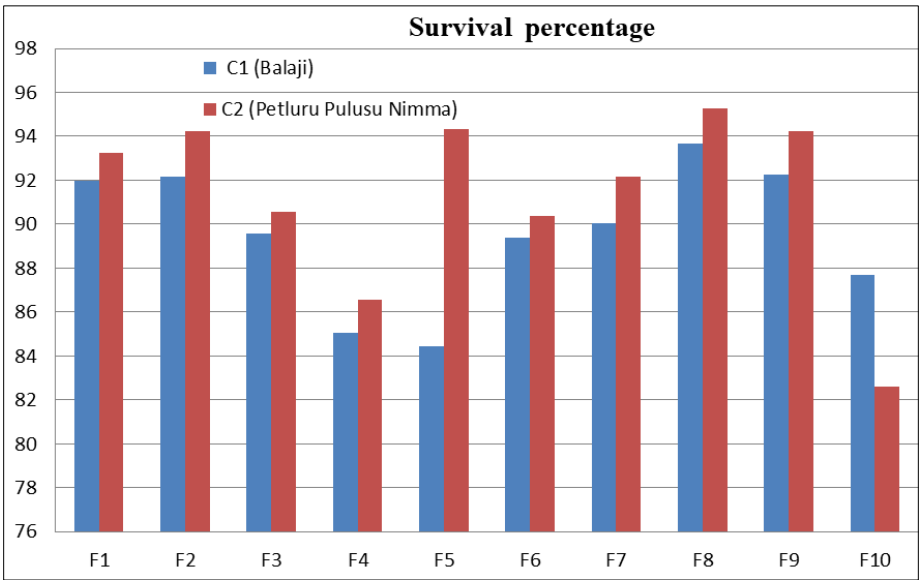

Fig 3: Survival percentage

Conclusion

By the present experimental results, it can be concluded that seed soaking with GA3 @ 250 ppm + $KNO_3$1% has showed best germination attributes of acidlime cultivars, Between two cultivars Petluru Pulusu Nimma cultivar has recorded the best performance.

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