



## Evaluation of apple cultivars under sub-temperate mid hill conditions of Himachal Pradesh

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### ABSTRACT

The evaluation of 15 apple cultivars was carried out at Progeny cum Demonstration Orchard, Kwagdhara, district Sirmaur, under sub-temperate region of Himachal Pradesh during 2010 and 2011. The maximum tree height (3.29 m), tree spread (1.82 m) were recorded in 'Fuji Kiku', whereas, tree volume (8.34 m<sup>3</sup>), scion girth (30.25 cm), annual shoot growth (39.97 cm) and leaf area (38.77 cm<sup>2</sup>) in 'Gala Mischala'. The highest fruit set, yield and productivity were recorded (69.07%, 9.68 kg/tree and 24.21 t/ha, respectively) in 'Oregon Spur-II'. The bigger size fruits in terms of length (59.67 cm), breadth (67.12 cm), and ascorbic acid content (56.37 mg/100 g) were found in 'Red Chief', while, maximum fruit weight (155.6 g) was observed in Silver Spur. The highest TSS (15.95%) was recorded in 'Gala Gala', whereas, more acidic (0.90%) fruits were found in 'Breaburn'. The maximum total sugars (11.94%) were found in 'Sansa' and highest reducing sugars (6.56%) were found in Oregon Spur II. The best fruit shape and surface colour was observed in 'Super Chief' and 'Camspur'. The longer duration of flowering (16 days) were recorded in cultivar Sun Fuji and Silver Spur. The cultivar 'Super Chief' registered maximum spur density (10.80/ cm<sup>2</sup>), and lowest fruit drop (18.09%), whereas, 'Fuji Kiku' and 'Gala Gala' recorded the least spur density (2.56 and 3.19/ cm<sup>2</sup>, respectively). The cultivar Pink Lady was earliest to flower whereas; 'Red Fuji' was last to harvest. From the present investigations it may be concluded that 'Red Chief', 'Super Chief', 'Oregon Spur II' and 'Camspur' in Delicious group, 'Gala Mischala' in Gala group, and 'Auvil Early Fuji' and 'Sun Fuji' in Fuji group have good yield potential, earliness and better fruit quality within their respective groups and may be recommended for cultivation in sub-temperate conditions of Himachal Pradesh.

**Key words:** Apple cultivars, fruit quality, performance, vegetative growth.

### INTRODUCTION

Apple (*Malus domestica* Borkh.) has become number one commercial fruit crop in Himachal Pradesh, and is grown over an area of 1,01,485 ha with annual production of 8,92,112 MT (Anon, 2). The most widely grown commercial apple cultivars belong to Delicious group, which constitutes 90% of the apple plantations in H.P. (Jindal and Mankotia, 7). The area under apple cultivation in sub-temperate region is shrinking and the situation is likely to worsen further in times to come, because of non completion of chilling requirement, monoculture of non-spur Delicious group of varieties, erratic rainfall and prolonged drought period during critical stages of fruit growth and development.

The standard Delicious apple cultivars have comparatively higher chilling requirements, tendency towards irregular bearing, high sensitivity to temperature fluctuations, particularly during flowering, late maturity and comparatively low yield potential. It is evident from the past records that the apple growing pockets of low valley areas of state, viz., Rajgarh in Sirmour, Kumarsain in Shimla, parts of Sunder Nagar areas in Mandi and some parts of

Kullu districts had huge plantations of apple, which contributed significantly towards apple production upto early 90's. With changing climatic conditions apple has shown declining trend in productivity in these areas. Besides quantitative loss, the quality of fruit being produced in these areas has also degraded and orchardists have to resort to chemical sprays for colour development, which in turn affect the tree physiology adversely. It is emphasized upon that the sub-temperate region/ areas of the state shall regain its status of contributing sizable apple produce if new cultivars with low chilling requirements, high spur density and profuse bearing potential are screened for such areas. Therefore, the present study was carried out to evaluate the performance of some new apple cultivars with respect to growth, flowering, fruiting, quality and productivity for their suitability for commercial cultivation under changing climate scenario.

### MATERIALS AND METHODS

The experiment was conducted during 2010 and 2011 on 7-8 year-old apple plants in the Progeny cum Demonstration Orchard (PCDO), Kwagdhara, District Sirmaur, under sub-temperate region of Himachal Pradesh. The orchard is situated at 1700 m amsl. The

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uniform plants of 15 apple cultivars, viz. Auvil Early Fuji, Braeburn, Camspur, Fuji Kiku, Gala Mischala, Gale Gala, Golden Smoothy, Oregon Spur-II, Pink Lady, Red Chief, Red Fuji, Sansa, Silver Spur, Sun Fuji and Super Chief planted during March 2004 at a spacing of 2 m × 2 m. The data on vegetative characters like scion girth (cm), annual shoot growth (cm) and tree volume were recorded in the month of December. The leaf area (cm<sup>2</sup>) was recorded in the month of September with leaf area meter. The dates of bud swell, green tip, pink bud, initiation of flowering and date of petal fall were recorded visually by observing peculiar stage of respective parameter. The duration from date of initiation of flowering to the date of start of petal fall was calculated as duration of flowering. The full bloom period in each cultivar was noted when more than 75-80 per cent of the flowers had opened. The fruit set, fruit drop and spur density were recorded as per standard methods. Time of fruit harvest was recorded on the basis of total days after full bloom stage to harvest maturity for each replication of each cultivar. Mature fruits were harvested and the weight was recorded with the help of single pan electronic balance. Further, fruit yield per hectare was calculated by multiplying the fruit yield per plant to the number of plants per hectare. Physical characteristics of fruits like fruit length (mm), fruit diameter (mm), fruit shape, and fruit weight (g) were estimated as per standard methods (AOAC, 1). Fruit firmness was measured with the help of a fruit

pressure tester (Magness-Taylor). Colour of fruits was observed visually after harvesting compared with colour chart of Royal Horticultural Society, London and assessed accordingly. Total soluble solid (TSS) was determined by Erma hand-held refractometer (0-32°B). The acidity (%), reducing, non-reducing and total sugars were estimated as per standard methods (AOAC, 1), while ascorbic acid was calculated as per procedure given by Ranganna (10). Data was analysed according to randomized block design.

## RESULTS AND DISCUSSION

Among all the cultivars under study, 'Gala Mischala' recorded maximum scion girth with highest pooled mean (30.25 cm). It also gave highest mean tree spread (2.22 m) and tree volume (8.34 m<sup>3</sup>), whereas minimum tree vigour was observed in case of 'Super Chief' during both the years. The differences in the tree vigour may be attributed to the varietal characteristics and genetic makeup of the scion cultivar. The improved tree vigour of 'Gala Mischala' may be due to lower spur density, less fruit set and more fruit drop as evident from the (Table 1); as most of the metabolites were utilized for growth and *vice-versa* in case of 'Super Chief'. Maximum plant height (3.29 m), annual shoot growth (39.97 cm) and leaf area (38.77 cm<sup>2</sup>) was recorded for 'Fuji Kiku'. The minimum tree height (1.65 m) and annual shoot growth (14.13 cm<sup>2</sup>) were observed in 'Super Chief', which was probably due to high

**Table 1.** Performance of different apple cultivars with respect to plant growth characteristics (pooled mean).

Cultivar	Scion girth (cm)	Tree height (m)	Tree spread (m)	Tree volume (m <sup>3</sup> )	Annual shoot growth (cm)	Leaf area (cm <sup>2</sup> )
Auvil Early Fuji	15.70	2.33	1.54	2.93	29.17	24.92
Fuji Kiku	28.67	3.29	1.82	5.74	39.97	38.77
Red Fuji	20.65	3.04	1.67	4.47	26.23	25.32
Sun Fuji	16.75	2.13	1.38	2.13	29.27	21.93
Camspur	20.55	2.93	1.27	2.47	18.95	26.37
Oregon Spur II	10.25	1.88	1.25	1.54	15.88	30.53
Red Chief	18.02	1.76	1.16	1.29	14.93	29.85
Silver Spur	20.23	2.66	1.23	2.17	15.46	32.37
Super Chief	14.95	1.65	1.05	0.76	14.13	32.66
Golden Smoothy	13.93	2.11	1.45	2.35	30.93	25.87
Gala Mischala	30.25	3.23	2.22	8.34	30.07	32.35
Gale Gala	14.20	2.23	1.29	1.95	25.23	28.43
Sansa	14.25	1.95	1.34	1.93	24.42	26.40
Braeburn	18.95	2.33	1.30	2.12	25.53	21.72
Pink Lady	12.75	1.91	1.26	1.60	18.46	27.98
CD <sub>0.05</sub>	2.40	0.59	0.18	0.99	2.27	2.21

productivity of this genotypes and *vice-versa* in case of 'Fuji Kiku'. Minimum leaf area (21.72 cm<sup>2</sup>) was recorded in 'Braeburn' which was on par with 'Sun Fuji' (21.93 cm<sup>2</sup>). Similar variations for various plant vigour characteristics have also been reported by Crassweller *et al.* (5) in a range of geographical and climatic areas within North-America (tree height); Bhat *et al.* (4) under high-hill conditions of Jammu and Kashmir (tree spread and scion girth); Sharma *et al.* (11) under mid-hill conditions of Himachal Pradesh and Wazbinska *et al.* (21) under temperate conditions of Poland (scion girth).

The 'Pink Lady' was found earliest among all the cultivars for many flowering (Table 2) and fruit set characteristics, viz., date of bud swell (5<sup>th</sup> March), date of green tip stage (9<sup>th</sup> March), date of pink bud stage (12<sup>th</sup> March), date of anthesis (15<sup>th</sup> March), date of full bloom (21<sup>st</sup> March) and date of petal fall (27<sup>th</sup> March). Moreover, 'Auvil Early Fuji', 'Braeburn', 'Sansa', 'Silver Spur' and 'Sun Fuji' were also found early in flowering and fruit set characteristics, whereas the cultivars, 'Gale Gala', 'Golden Smoothy', 'Oregon Spur II' and Red Fuji' were found late for most of the above flowering characteristics. The marked differences in time and duration of flowering in different cultivars may be attributed to inherent genetic characteristics of the cultivars (Sharma *et al.*,

11; Biswajit *et al.*, 4). However, winter precipitation, temperature and ultimate accumulation of chilling hours are main factors for such drift in flowering (Jindal and Mankotia, 7).

The duration of flowering in different cultivars lasted for nearly two weeks under sub-temperate conditions of Kwagdhar, district Sirmaur, H.P. The maximum duration of flowering (16 days) was recorded in 'Sun Fuji' and 'Silver Spur', while minimum (12 days) in 'Pink Lady'. On the basis of duration of flowering, 'Sun Fuji', 'Auvil Early Fuji', 'Golden Smoothy' had longer blooming period, whereas, 'Pink Lady', 'Silver Spur', 'Red Chief', 'Gale Gala', 'Gala Mischala' and 'Fuji Kiku' had shorter duration of flowering ranging between 12-14 days. This may also be attributed to the varietal characteristics and prevailing climatic conditions at the time of flowering. These results are in line with Singh *et al.* (13) pink bud stage and time and duration of flowering; Sharma *et al.* (11) for duration of flowering; Biswajit *et al.* (4) for date of flowering and Mataa (9) for date of bud break.

The days from the full bloom to harvest was observed minimum (110.8 days) in 'Sansa' resulting into early fruit maturity, whereas the maximum period (186.5 days) from full bloom to harvesting were taken by 'Red Fuji' ensuing to the late crop maturity. On the

**Table 2.** Performance of different apple cultivars with respect to flowering traits.

Cultivar	Date of bud swell	Date of green tip	Date of pink bud	Date of anthesis	Date of full bloom	Date of petal fall	Duration of flowering (days)	Days from full bloom to harvest	Date of fruit harvest
Auvil Early Fuji	3 <sup>rd</sup> March	10 <sup>th</sup> March	14 <sup>th</sup> March	17 <sup>th</sup> March	24 <sup>th</sup> March	1 <sup>st</sup> April	15.00	146.5	16 <sup>th</sup> , Aug
Fuji Kiku	10 <sup>th</sup> March	13 <sup>th</sup> March	16 <sup>th</sup> March	20 <sup>th</sup> March	27 <sup>th</sup> March	2 <sup>nd</sup> April	13.00	144.8	18 <sup>th</sup> , Sep
Red Fuji	12 <sup>th</sup> March	14 <sup>th</sup> March	17 <sup>th</sup> March	20 <sup>th</sup> March	26 <sup>th</sup> March	3 <sup>rd</sup> April	14.00	186.5	27 <sup>th</sup> , Sep
Sun Fuji	6 <sup>th</sup> March	10 <sup>th</sup> March	13 <sup>th</sup> March	16 <sup>th</sup> March	23 <sup>th</sup> March	1 <sup>st</sup> April	16.00	146.0	16 <sup>th</sup> , Aug
Camspur	8 <sup>th</sup> March	11 <sup>th</sup> March	15 <sup>th</sup> March	19 <sup>th</sup> March	25 <sup>th</sup> March	2 <sup>nd</sup> April	14.00	115.5	18 <sup>th</sup> , Aug
Oregon Spur II	11 <sup>th</sup> March	14 <sup>th</sup> March	18 <sup>th</sup> March	21 <sup>th</sup> March	27 <sup>th</sup> March	4 <sup>th</sup> April	14.00	117.7	18 <sup>th</sup> , Aug
Red Chief	9 <sup>th</sup> March	13 <sup>th</sup> March	16 <sup>th</sup> March	20 <sup>th</sup> March	26 <sup>th</sup> March	2 <sup>nd</sup> April	13.00	117.7	18 <sup>th</sup> , Aug
Silver Spur	7 <sup>th</sup> March	11 <sup>th</sup> March	14 <sup>th</sup> March	17 <sup>th</sup> March	25 <sup>th</sup> March	2 <sup>nd</sup> April	16.00	115.2	18 <sup>th</sup> , Aug
Super Chief	10 <sup>th</sup> March	13 <sup>th</sup> March	16 <sup>th</sup> March	19 <sup>th</sup> March	26 <sup>th</sup> March	2 <sup>nd</sup> April	14.00	115.8	18 <sup>th</sup> , Aug
Golden Smoothy	10 <sup>th</sup> March	14 <sup>th</sup> March	17 <sup>th</sup> March	20 <sup>th</sup> March	28 <sup>th</sup> March	4 <sup>th</sup> April	15.00	142.5	16 <sup>th</sup> , Aug
Gala Mischala	10 <sup>th</sup> March	13 <sup>th</sup> March	16 <sup>th</sup> March	19 <sup>th</sup> March	27 <sup>th</sup> March	1 <sup>st</sup> April	13.00	113.5	27 <sup>th</sup> , July
Gale Gala	11 <sup>th</sup> March	14 <sup>th</sup> March	17 <sup>th</sup> March	20 <sup>th</sup> March	27 <sup>th</sup> March	2 <sup>nd</sup> April	13.00	116.7	27 <sup>th</sup> , July
Sansa	6 <sup>th</sup> March	9 <sup>th</sup> March	14 <sup>th</sup> March	17 <sup>th</sup> March	24 <sup>th</sup> March	29 <sup>th</sup> March	14.00	110.8	11 <sup>th</sup> , July
Braeburn	7 <sup>th</sup> March	10 <sup>th</sup> March	12 <sup>th</sup> March	16 <sup>th</sup> March	22 <sup>th</sup> March	30 <sup>th</sup> March	14.00	148.3	16 <sup>th</sup> , Aug
Pink Lady	5 <sup>th</sup> March	9 <sup>th</sup> March	12 <sup>th</sup> March	15 <sup>th</sup> March	21 <sup>th</sup> March	27 <sup>th</sup> March	12.00	185.5	18 <sup>th</sup> , Sep
CD <sub>0.05</sub>	-	-	-	-	-	-	1.40	2.47	-

basis of date of fruit harvesting all the cultivars can be grouped into early maturing ('Sansa', 'Camspur', 'Gala Mischala', 'Gala Gala', 'Oregon Spur-II', 'Red Chief', 'Silver Spur' and 'Super Chief'), mid season maturing ('Auvil Early Fuji', 'Braeburn', and 'Sun Fuji') and late maturing cultivars ('Fuji Kiku', 'Pink Lady', 'Golden Smoothy' and 'Red Fuji'). Time and duration of flowering are important traits in classification of apple with respect to their span of flowering under different regions and have been assessed by other workers (Biswajit *et al.*, 4).

The cultivar 'Super Chief' registered maximum spur density (10.80/ cm<sup>2</sup>), and lowest fruit drop (18.09%), whereas, 'Fuji Kiku' and 'Gala Gala' recorded least spur (Table 3) density (2.56 and 3.19/ cm<sup>2</sup>, respectively). Highest yield per plant (9.68 kg) and productivity (24.21 tonnes/ha) was recorded in 'Oregon Spur II', which was on par with 'Sun Fuji', 'Red Chief', 'Camspur', 'Red Fuji' and 'Super Chief' in terms of yield and productivity. The highest fruit set (69.07%) was recorded in 'Oregon Spur-II', which was closely followed by 'Red Chief', and 'Silver Spur'. The highest fruit drop (54.17%) was recorded in 'Gala Gala' but it was on par with 'Golden Smoothy', 'Gala Mischala', 'Sansa', 'Pink Lady' and 'Braeburn'. The higher productivity in Fuji and Spur type Delicious group may be due to the varietal characteristics and better adaptability of these cultivars under mid-hill conditions. Similar variations in different apple cultivars has also been observed for spur density,

fruit set and fruit drop per cent, fruit harvesting date and yield characteristics (Biswajit *et al.*, 4).

The maximum fruit length (57.93 mm), and ascorbic acid content (56.37 mg/100 g) was observed for the cultivar 'Red Chief'. The minimum fruit length (42.73 mm) and breadth (41.32) was found in 'Gala Gala'. The cultivar 'Silver Spur' recorded the highest fruit weight (155.6 g), and TSS : acid ratio (92.7). Maximum fruit firmness (10.30 kg/cm<sup>2</sup>) and acidity (0.90%) was observed in the cultivar 'Braeburn', whereas minimum fruit firmness (5.53 kg/cm<sup>2</sup> and acidity (0.15%) were recorded in 'Auvil Early Fuji and 'Silver Spur', respectively (Tables 4 & 5). Best shape and surface colour was observed in the cultivars 'Super Chief' and 'Camspur'. Among all the cultivars under study, the highest TSS (15.95°B) was recorded in 'Gala Gala', but had the poor fruit size. The cultivar 'Oregon Spur II' recorded highest reducing sugars (6.56%), whereas the highest total sugars (11.94%) and non-reducing sugars (5.47%) were recorded in the cultivar 'Sansa', which was at par with 'Silver Spur and 'Super Chief' in terms of non-reducing sugars. Similar variations for different traits were also been reported by Kumar and Verma (8) in mid-hill conditions of Kullu; Sumrah *et al.* (14) in Soan Valley of Pakistan; Dwivedi *et al.* (6) in Ladakh region of Jammu and Kashmir and Sharma *et al.* (14) under mid-hill conditions of Himachal Pradesh.

From the present investigation, it may be concluded that 'Red Chief', 'Super Chief', 'Oregon

**Table 3.** Performance of different apple cultivars with respect to fruiting parameters and productivity (pooled mean).

Cultivar	Spur density (No./cm <sup>2</sup> )	Fruit set (%)	Fruit drop (%)	Yield per tree (kg)	Productivity (t/ha)
Auvil Early Fuji	6.99	47.67 (43.66)	38.80 (38.51)	7.08	17.71
Fuji Kiku	2.56	18.57 (25.39)	28.58 (31.81)	3.83	9.67
Red Fuji	3.87	41.32 (40.00)	21.17 (27.14)	9.08	22.71
Sun Fuji	6.50	41.36 (40.02)	42.43 (40.57)	9.67	24.10
Camspur	8.28	53.52 (47.02)	33.11 (35.12)	9.52	23.79
Oregon Spur II	8.90	69.07 (56.40)	20.25 (26.64)	9.68	24.21
Red Chief	8.83	65.22 (53.86)	19.47 (26.16)	9.58	23.96
Silver Spur	8.82	61.52 (51.67)	19.52 (26.20)	8.20	20.50
Super Chief	10.80	55.75 (48.30)	18.09 (25.15)	9.00	22.50
Golden Smoothy	6.67	48.09 (43.90)	49.86 (44.91)	3.50	8.75
Gala Mischala	6.32	46.61 (43.05)	51.56 (45.90)	6.72	16.79
Gala Gala	3.19	34.23 (35.78)	54.17 (47.39)	5.22	13.04
Sansa	6.36	55.94 (48.43)	51.16 (45.67)	5.08	12.71
Braeburn	6.93	53.08 (46.77)	42.69 (40.79)	3.67	9.17
Pink Lady	7.15	37.93 (37.95)	49.03 (44.45)	3.60	8.58
CD <sub>(0.05)</sub>	1.82	8.67	11.03	1.27	3.11

**Table 4.** Performance of different apple cultivars with respect to fruit physical characteristics.

Cultivar	Fruit length (mm)	Fruit dia. (mm)	Fruit weight (g)	Fruit firmness (kg/ cm <sup>2</sup> )	Fruit shape	Surface colour
Auvil Early Fuji	54.37	73.28	142.7	5.53	Globose	RED GROUP 42 A
Fuji Kiku	43.90	58.16	114.8	7.28	Round to obloid	RED GROUP 43 D
Red Fuji	54.38	41.58	140.2	5.93	Obloid	RED GROUP 42 B
Sun Fuji	55.93	57.92	137.2	5.58	Globose	RED GROUP 42 A
Campspur	58.48	71.44	141.1	8.48	Conical	RED GROUP 46 B
Oregon Spur II	59.53	55.90	151.4	8.30	Conical globose	RED GROUP 45 A
Red Chief	59.67	67.12	154.7	8.58	Oblong conical	RED GROUP 46 B
Silver Spur	57.17	65.08	155.6	7.55	Ovoid to conic	RED GROUP 43 B
Super Chief	59.58	62.02	149.9	7.78	Conic to cylindrical waisted	RED GROUP 46 A
Golden Smoothy	51.78	49.83	104.3	7.76	Oblong	YELLOW GREEN GROUP 150 C
Gala Mischala	56.85	66.89	154.0	7.60	Obloid to globose	RED GROUP 42 A
Gale Gala	42.73	41.32	101.0	8.15	Obloid to globose	RED GROUP 43 B
Sansa	50.63	62.57	101.5	7.37	Obloid	RED GROUP 41 B
Braeburn	56.52	68.68	137.7	10.30	Globose to oblong	RED GROUP 41 B
Pink Lady	55.02	64.36	134.9	7.12	Conical to obloid	RED GROUP 41 A
CD <sub>0.05</sub>	2.82	3.83	5.86	0.37	-	-

**Table 5.** Performance of different apple cultivars with respect to fruit size and quality (pooled mean).

Cultivar	TSS (%)	Acidity (%)	Reducing sugars (%)	Non-reducing sugar (%)	Total sugars (%)	Ascorbic acid (mg/100g)	TSS : acid
Auvil Early Fuji	11.80	0.49	4.96	4.44	9.40	28.22	24.19
Fuji Kiku	11.67	0.44	4.98	4.13	9.11	22.20	26.25
Red Fuji	11.47	0.31	5.36	4.14	9.50	19.66	38.46
Sun Fuji	12.97	0.52	5.22	3.23	8.45	21.47	25.15
Campspur	10.98	0.41	5.58	2.53	8.11	50.42	26.74
Oregon Spur II	10.53	0.24	6.56	3.65	10.21	43.91	44.21
Red Chief	10.37	0.24	6.53	4.00	10.53	56.37	42.95
Silver Spur	12.32	0.15	5.26	5.46	10.72	50.47	92.70
Super Chief	11.25	0.29	5.30	4.93	10.23	33.83	38.32
Golden Smoothy	12.72	0.56	5.05	2.67	7.73	30.94	22.92
Gala Mischala	12.70	0.52	4.61	2.78	7.54	44.39	24.60
Gale Gala	15.95	0.57	4.23	3.36	7.54	44.21	28.16
Sansa	14.43	0.51	6.46	5.47	11.94	22.89	28.15
Braeburn	11.60	0.90	3.09	4.80	7.88	33.82	12.93
Pink Lady	11.07	0.55	5.73	5.19	10.92	28.04	20.26
CD <sub>0.05</sub>	0.61	0.04	0.33	0.55	0.53	3.36	12.66

Spur II' and 'Camspur' in Delicious group, 'Gala Mischala' in Gala group, and 'Auvil Early Fuji' and 'Sun Fuji' in 'Fuji' group have good yielding potentials, earliness and better fruit quality within their respective groups and can be grown commercially.

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