Colour Improvement Studies in Apple cv. Fuji Strains

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Abstract

Present study was done at farmer's field during the year 2020-22 in district Kulgam. Various colour improvement techniques were used to test their efficacy. Colour improved significantly by various treatments as compared to control. Percentage of better coloured fruits (>80%) was the highest in Coe Red Fuji followed by Red Fuji (22.1%) by doing summer pruning one month before expected harvesting date. Irrespective of cultivar, lowest percentage of better coloured fruits (>80%) were harvested in control. Highest mean percentage (61.1%) of less coloured fruits irrespective of cultivars was obtained in control while as lowest less coloured fruits resulted by using reflective mulches however summer pruning in Fuji Zhen Aztech was the most effective technique in reducing percentage of least coloured fruits (<40%). Summer pruning was the most effective techniques for obtaining fruits having 60-80% colour (27.8%) although it varied non-significantly from reflective mulch treatment. Red Fuji responded well to summer pruning as compared to other cultivars in terms of obtaining fruits having 60-80% colour development. Least percentage (15.9%) of fruits having colour development of 40-60% was obtained by applying K_2O@200gm/tree while as highest percentage (31.8%) of fruits falling in 40-60% category was obtained in reflective mulch treatment.

Apple, king of temperate fruits has been cultivated in Jammu and Kashmir since last 100 years and has gained lot of popularity since it has been introduced [1]. Apple predominates in terms of area and production among various fruits grown in Jammu and Kashmir [2]. Among temperate fruits, it is the most preferred fruit crop due to better adaptability, high consumer preference, better benefit cost ratio and ease of production [3]. Apples are a crucial part of the food and are utilized in the food industry to make drinks and other food items. Apples contain vitamins (Vitamin C) [4], organic acids (malic acid), sugars [5-6], macronutrients (Ca, Na, K, Mg, and P), trace elements (zinc, copper, manganese and iron) [7], and fibrous materials [8]. Despite the availability of more than 20,000 cultivars, only a few are currently farmed commercially across the globe [9]. The wide range of qualitative features determines variability among apple cultivars [10]. The Kashmir region comprises mainly continental temperate climate [11]. In the Kashmir region, apples have the largest acreage and yield among temperate fruits. However, during recent times, Kashmir apple industry is challenged by various factors like climate change, change in spectrum of diseases and pests, deteriorated soil conditions, decrease in factor productivity, high production cost, apple trade liberalization [12]. Most predominant variety of apple in this part of the world is Delicious which has become almost obsolete in other apple growing regions. However recently various exotic cultivars have gained lot of ground in terms of production and area but still more than 80% of total apple production is Delicious or its improved strains [13]. Fuji strains of apple predominates the world in terms of production and acreage [5] but late maturity along with less colour development under Kashmir agro-ecology has been the most important limiting factor to gain popularity among apple growers [14]. Keeping fruit colour in consideration, a current study entitled colour improvement studies in apple cv. Fuji strains was carried out during the year 2020-22 by Krishi Vigyan Kendra, Kulgam at farmer's field.

MATERIAL AND METHODS

Experiment was laid at farmer's field, keeping in view his criteria of colour improvement in consideration. It was a two-year study replicated on 10 plants each of various Fuji strains (V_1 Fuji; V_2 Fuji Zhen Aztec; V_3 Coe Red Fuji and V_4 Red Fuji). Four treatments were given to each cultivar (T_1 K_2O application@200gm/tree; T_2 K_2So_4 spray @ 0.5% and T_3 Reflective Mulch and T_4 Summer Pruning) one month before expected harvesting date with T_0 as control. Plants were six-year-old grafted on MM-111 rootstock. Plants were trained to central leader system with uniform cultural practices as per the package of practices of SKUAST-Kashmir. Fruit colour was quantified visually by taking total area of fruit peel in consideration Observations were recorded in terms of colour intensity of >80%, 60-80%, 40-60% and <40% of fruit ground colour [14-15]. Different percentages out of total produce were assigned to above classes. Design of the experiment was randomized block design (RBD).

RESULTS AND DISCUSSION

Results revealed as shown in the (Table 1), that summer pruning (T_4) significantly improved percentage of >80% skin

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colour irrespective of Fuji Strain (21.4%). There was significant difference among various treatments irrespective of cultivar as far as colour development of >80% is concerned. On an average, irrespective of various treatment, better coloured fruits (>80%) were obtained in Coe Red Fuji (16.1%). Highest percentage of more than 80% colour fruits were obtained in summer pruned Coe Red Fuji cultivar (23.6%). Similarly, data in table 1 shows that there was non-significant difference between use of reflective mulch (T_3) and summer pruning (T_4) in improving fruit percentage having skin colour of 60-80%, although better results were obtained by using ground reflector (27.8%). Coe Red Fuji cultivar (V_3) excelled other strains significantly irrespective of various treatments in terms of fruit percentage of having 60-80% ground colour. However, more average percentage (30.7%) of fruits with colour between 60-80% resulted by using summer pruning (T_4) in Red Fuji (V_4) cultivar. From the data in table 1, highest mean percentage (31.8%) of fruits having skin colour of 40-60% resulted by using reflective mulch (T_3) irrespective of cultivar and it was significantly better than other treatment. More quantity of fruits in terms of percentage resulted in Fuji Zhen Aztech (26.5%) irrespective of various treatment as far as ground colour of 40-60% is concerned. There was non-significant difference between Fuji (V_1), Coe Red Fuji (V_3) and Red Fuji (V_4) in percentage of fruits having ground colour of 40-60%, irrespective of various treatment. As far interaction of various cultivar and treatment is concerned, least percent (14.4%) of fruits having colour intensity of 40-60% resulted by using K_2O @ 200gm/tree (T_1) in Fuji (V_1) while as highest percent (34%) of fruits resulted in 40-60% range by using reflective mulch (T_3) in Coe Red Fuji (V_3) although it differs non-significantly from by employing same treatment in Fuji (V_1) cultivar (33%).

Similarly, the data from (Table 1) infer that there is non-significant difference between T3 (reflective mulch) and T_4 (summer pruning) irrespective of various cultivars in decreasing fruit percentage falling <40% colour category. Results show that highest percentage (45.3%) of total produce

of Fuji cultivar (V_1) developed less than 40% colour irrespective of treatments while as other cultivars differ non-significantly. On observing interaction values in (Table 1), it can be inferred that there was non-significant difference in terms of reducing <40% colour fruit percentage in reflective mulch (T_3) and summer pruned (T_4) Fuji Zhen Aztech, Coe Red Fuji and Red Fuji cultivars. Less colour development in Fuji cultivars has been reported by various findings across globe and caused due to mutual shading, shorter autumn day length (photoperiod), decreasing light intensity (PAR and UV), decreasing solar angle and the occurrence of warm autumns with warm nights being late maturing cultivar [16-18]. Improved red skin colour of Fuji and other apple cultivars using reflective mulches has been reported earlier [19-22].Funke and Blanke [18] reported that when reflective mulch was applied only two weeks before the anticipated harvest in Fuji, colour improvement could already be observed after one week and concluded that reflective mulch 2 or 4 weeks before harvest improved fruit colouration significantly during maturation of the Fuji apples. Mika et al. [23] also reported that reflective mulches have profound effect on improving blush colour in apple cv. Jonagored, Jonagold and Pinnova significantly. Mulching with reflective material spread under tree canopies 3 weeks before apple harvest is commonly practiced in Japanese orchards to improve fruit color [24]. Bhusal et al. [25] reported the positive effects of summer pruning especially in high density apple orchards in improving light penetration to lower canopy portion thereby improving fruit quality especially colour. Naira et al. [26] reported that summer pruning significantly increases anthocyanin formation thereby improving colour formation in red delicious apple cultivar. Similar results on improved fruit colour development by potassium application in current study has been reported in various apple cultivars [27-32]. Similarly positive results between K_2SO_4 sprays and colour development in apple has been earlier reported [27], [33-35].

Table 1 Effect of various treatments on fruit skin colour (%) in various Fuji Strains

Cultivars	> 80%					60 - 80%				
Treatments	V₁	V₂	V₃	V₄	Mean	V₁	V₂	V₃	V₄	Mean
T_0	4.0	7.8	8.8	6.8	6.9[e]	8.1	12.2	11.5	12.6	11.1[d]
T_1	9.2	11.8	13.1	10.5	11.2[d]	11.6	13.9	14.2	16.4	14.0[c]
T_2	14.1	15.3	15.9	15.5	15.2[c]	19.9	18.1	18.5	22.9	19.8[b]
T_3	17.7	19.2	19.2	21.8	19.5[b]	24.8	28.2	30.4	27.7	27.8[a]
T_4	18.0	21.8	23.6	22.1	21.4[a]	23.9	26.0	27.8	30.7	27.1[a]
Mean	12.6[c]	15.2[b]	16.1[a]	15.3[b]		17.6[c]	19.7[b]	20.5[b]	22.1[a]	
CD (p<0.05)	Treatments (T) = 0.51 Cultivar (C) = 0.46 Treatments *Cultivar (T*C) = 1.03					Treatments (T) = 0.92 Cultivar (C) = 0.82 Treatments *Cultivar (T*C) = 1.85				
Cultivars	40 - 60%					< 40%				
Treatments	V₁	V₂	V₃	V₄	Mean	V₁	V₂	V₃	V₄	Mean
T_0	17.2	22.2	20.9	23.6	21.0[d]	70.7	57.8	58.8	57.0	61.1[a]
T_1	14.4	18.1	15.9	15.2	15.9[e]	64.9	56.2	56.8	57.9	58.9[b]
T_2	26.9	27.6	24.9	27.4	26.7[c]	39.1	39.0	40.7	34.2	38.3[c]
T_3	33.0	34.0	29.9	30.2	31.8[a]	24.5	18.6	20.5	20.2	21.0[d]
T_4	30.8	30.9	26.9	27.4	29.0[b]	27.3	21.2	21.6	19.8	22.5[d]
Mean	24.5[b]	26.5[a]	23.7[b]	24.8[b]		45.3[a]	38.6[bc]	39.7[b]	37.8[c]	
CD (p<0.05)	Treatments (T) = 1.15 Cultivar (C) = 1.02 Treatments *Cultivar (T*C) = 2.29					Treatments (T) = 1.78 Cultivar (C) = 1.59 Treatments *Cultivar (T*C) = 3.56				

Means with different superscripts differ significantly (p<0.05)

The (Fig 1) shows response of Fuji cultivar to various treatments, it is clearly visible from the (Fig 1) that percentage of less than 40% colour fruits decreases by applying any

treatment as compared to control and was lowest (24.47%) in Fuji cultivar by employing reflective mulch. Similarly, percentage of fruits having skin colour of 40-60% and 60-80%

was influenced by different treatment. Percentage of fruits with skin colour of 40-60% was lowest in K₂O @200gm (14.37%) and highest in reflective mulch (33.03%) applied Fuji plants. Highest percentage of fruits having skin colour of 60-80% was in reflective mulch (24.8%) and lowest in control Fuji plants (7.9%). From the (Fig 1), percentage of fruits with >80% skin colour was highest in summer pruned (18%) and lowest in case of control Fuji plants (4%).
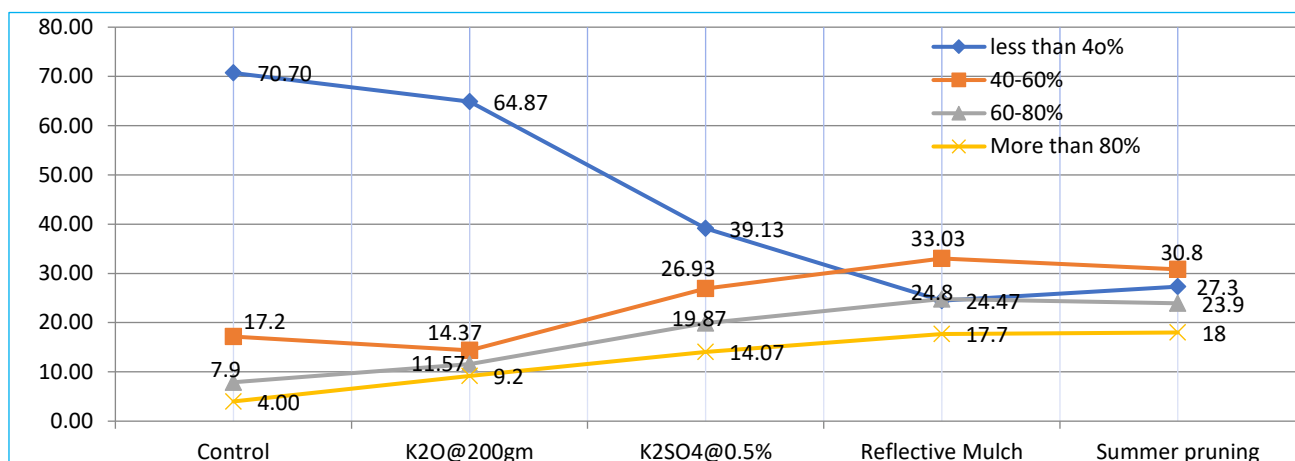

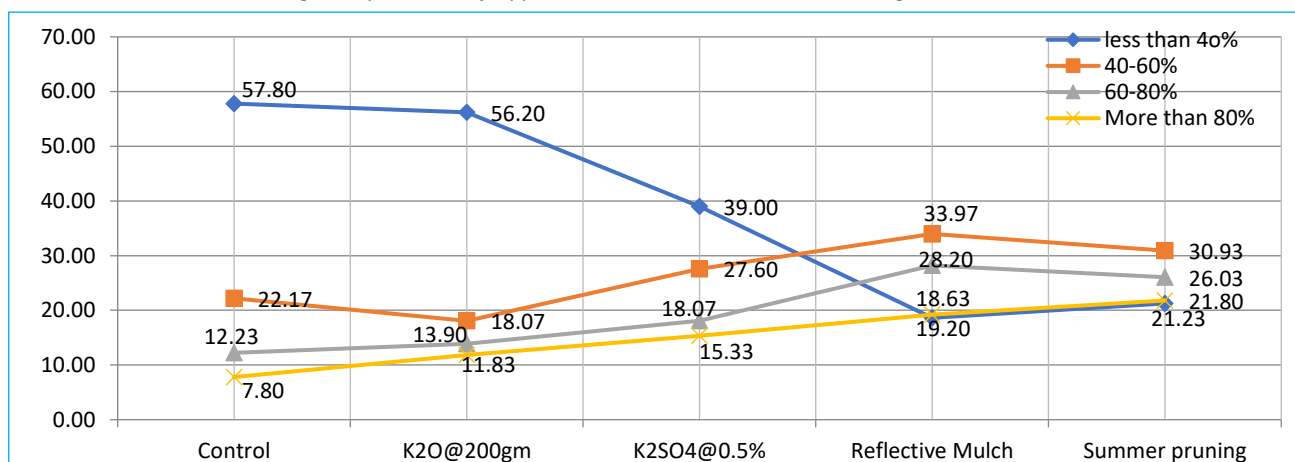Fig 1 Response of Fuji apple cultivar to various treatments along with control

Fig 2 Response of Fuji Zhen Aztech apple cultivar to various treatments along with control

Th (Fig 2) shows that percentage of fruits with skin colour of >80% in Fuji Zhen Aztech was highest (21.80%) in summer pruning treatment and least (7.80%) in control. Other observations more or less followed similar trend as clear from (Fig 2) in Zhen Aztech Fuji strain.

The (Fig 3) shows response of Coe Red Fuji cultivar to various treatments; it is clear from the (Fig 3) that percentage of less than 40% colour fruits decreases by applying any treatment as compared to control and was lowest (21.23%) by

employing summer pruning. Percentage of fruits with skin colour of 40-60% was lowest in K₂O @200gm (15.93%) and highest in reflective mulch (29.87%) applied Coe Red Fuji plants. Highest percentage of fruits having skin colour of 60-80% was in reflective mulch (30.40%) and lowest in control (11.47%). From the figure 3, percentage of fruits with >80% skin colour was highest in summer pruned (23.60%) and lowest in case of control Coe Red Fuji plants (8.83%).
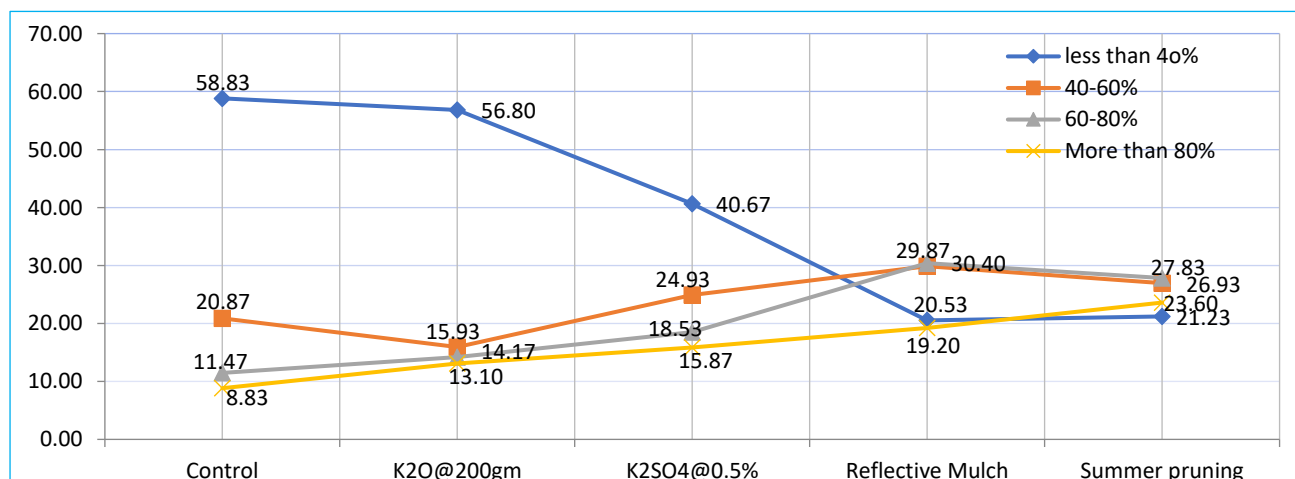

Fig 3 Response of Coe Red Fuji apple cultivar to various treatments along with control

887

The (Fig 4) depicts that the percentage of fruits having colour intensity of >80% varied using different treatments as compared to control. Reflective mulches and summer pruning were statistically at par in terms of fruits having colour development of > 80%. Similarly, fruit percentage having colour intensity of < 40% decreased with various treatments although reflective mulches and summer varied non-significantly when compared with each other.
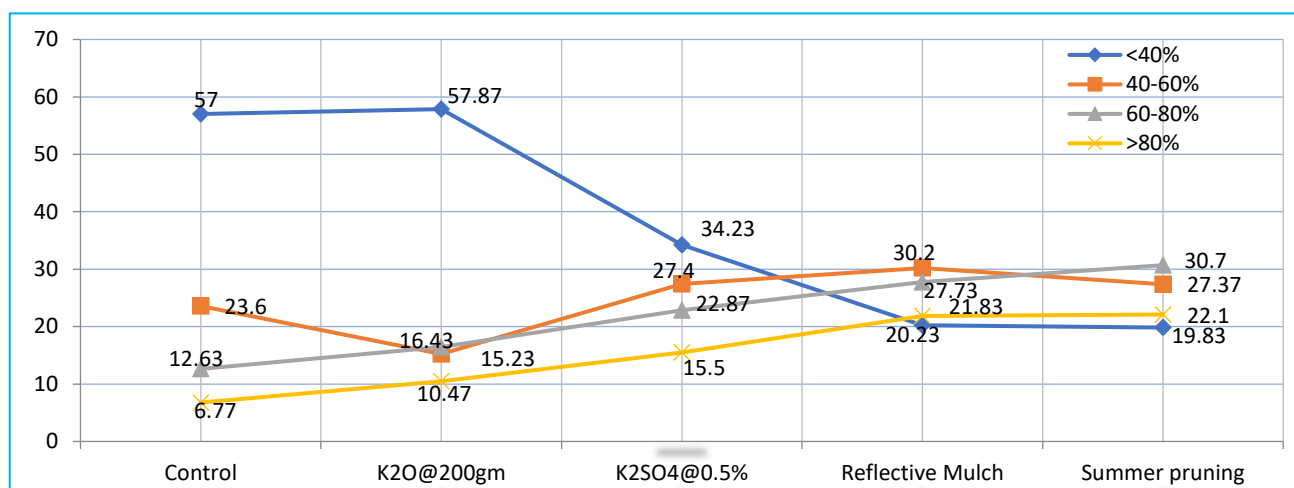

Fig 4 Response of Red Fuji apple cultivar to various treatments along with control

CONCLUSION

From the aforementioned investigation it could be concluded that Fuji strains although dominating the apple across the globe, however its cultivation in India and particularly Jammu and Kashmir is not gaining inroad among apple growers. Its colour along with late maturity under Kashmir conditions has remained a debatable issue since last few years. To overcome colour issue, this research problem was taken at ground level in the form of on farm trails at farmer's field. Various applied treatments showed the promising results in terms of colour improvement in various studied Fuji cultivars grown under different horticultural zones of Kulgam district. Response of various Fuji strains was different to various treatments although all cultivars more or less followed similar trend. Summer pruning showed promising results in terms of increasing fruit percentage having colour intensity of more than 80% irrespective of cultivars and location.

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