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Research Article

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Influence of Plastic Mulch Colors and Application of Potassium Sulphate on Strawberry cv. Camarosa in Polyhouse

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Abstract

The present study was undertaken to find the effect of plastic mulch colors and foliar application of potassium on growth, yield and quality of strawberry in protected conditions. The combined effect of black polythene mulch and 1000 ppm potassium sulfate (K_2SO_4) enhanced the nutrient availability, efficient water use, moisture retention and temperature regulation which helps in strawberry growth, enhanced fruit quality and boost output. The study design of experiment was factorial randomized block design with 15 treatments and 3 replications with interaction of different plastic color mulch (Black, Blue, Red and Silver) with foliar application of K_2SO_4 (500, 1000, and 0 ppm) as treatments was used and analyzed the data using analysis of variance. Black mulch + 1000 ppm K_2SO_4 treatment gave the best results in term of increasing growth parameters i.e., plant height (16.13 cm^2), no. of leaves (25.7), no. of branches (8.08), no. of crown (4.31), fruit weight (12.32 g), no. of flowers (26.30), no. of fruits (15.8), fruit yield/ plant (189.6 g), and also increases quality parameters like total soluble solids (TSS) (7.6 °Brix), ascorbic acid (48.7 mg/100 g), reducing sugar (5.34%), non-reducing sugar (2.47%), total sugar (7.95%) by decreasing acidity (0.55%) of strawberry fruits. It is concluded that interaction P_1N_2 (black mulch + 1000 ppm K_2SO_4) had a significant effect on enhancing the plant growth, yield and quality parameters of strawberry cultivar "Camarosa".

Keywords

Mulch colors, Strawberry, Potassium, Plant growth, Yield, Fruit quality

Introduction

Strawberry is a hybrid fruit (*Fragaria virginiana*Fragaria chiloensis*) that belongs to family Rosaceae and *Fragaria* genus. It is the most perishable and delicate fruit crop grown around the world for its sweetness, juicy content, aroma, and crimson color. It is an "etaerio" fruit with a fleshy receptacle and having about 200 seeds on its external surface. This fruit is mainly propagated by runners and having shallow root system. Top strawberry producing countries are China, United States, Turkey, Mexico, Egypt, and Spain. In India, total production of strawberry is 13.52 (000) T where top three strawberry producing states are Haryana is leading with production of 4.26 (000) T (31.50% share) followed by Maharashtra has 3.28 (000) T (24.25%) and Jammu & Kashmir has 2.83 (000) T (20.93%) production. (NHB, 2021-22). Strawberry is cultivated in Haryana, Maharashtra, Sub-tropical areas in Jammu, Mizoram, Meghalaya, Madhya Pradesh, Himachal Pradesh, Tamil Nadu, Jharkhand, and Kerala also have the potential to grow the crop under irrigated condition (NHB).

Strawberry has high nutritional value and contains 7.68 g carbohydrates, 0.67 g protein, 59.6 mg/100 g vitamin C, Ca, Fe, P, K, organic acids (citric acid, malic

acid, oxalic, pyruvic, quinic acid and 91% water. Its regular inclusion in meals boosts consumption of antioxidant properties and other nutrients crucial for enhancing human health. The cultivars Ofra, Chandler, Festival, and Camarosa, show homogeneity (80%) for ascorbic acid and carotenoid contents as well as a favorable association between phenol concentration and vitamin C, carotenoid, and anthocyanin levels as well as yield [1]. It is now widely grown, particularly in Europe, and is available for consumption both fresh and processed into marmalade, jam, fruit juice, and beverages. For humans, strawberry fruits are a significant source of chemicals that are good for health [2].

In strawberry, adverse weather conditions such as frost, severe rains, hail and temperature variations during flowering and fruiting are limiting factors. Protected cultivation in a polyhouse is a preferable choice for protecting the strawberry crop from harsh weather conditions. Hoop houses, commonly referred to as high tunnels, and are made of metal or wooden ribs that are covered in polyethylene film [3]. In high tunnels, strawberries (*F. ananassa* Duch.) can be picked two to four weeks early than in open fields [4]. Strawberry requires moisture and temperature for it growth and fruiting. So, use of polythene mulching plays important role in conserving moisture, controlling weeds, protecting the fruit from direct soil contact. Growth, yield and productivity of strawberry plants are influenced by different mulch colors and foliar application of potassium. Potassium is mineral nutrient required by plants in large amount because it is important in different enzymatic reactions, photosynthesis and in phloem transport [5]. The heat and radiation properties of colored plastic, which vary based on geographic location and genotype, can be used to influence strawberry fruit yield and quality due to microclimatic fluctuations [6].

Different color plastic mulches like red, black, blue, silver, transparent, yellow and green used as covering over raised bed to grow strawberries. Different color plastic mulches has different role in strawberry plant growth. Colorful plastic films may have an impact on the anthocyanin content, associated enzyme activities, and flavonoid gene transcripts in strawberry fruit [7]. The mulch made of black polyethylene may have kept the soil at a greater temperature and moisture content while also decreasing nutrient losses by reducing weed growth. Black mulch may be responsible for the benefit that resulted in less water evaporation, warmer soil, less soil erosion, and less weed growth, all of which improved flowering characteristics [8]. Fruits grown beneath red plastic films were found to be less acidic than fruits grown under the control, whereas fruits grown under blue plastic films were found to be somewhat more acidic [9].

Black is mostly used as mulching material and it absorbs all light. Red mulch reflects more red and far-red light. The use of fertilizers in conjunction with mulching and watering led to the production of high-quality fruits and increased fruit yield-related characteristics [10]. So, the objective of this present investigation to see the effect of different mulch colors with foliar application of potassium sulfate on growth, yield and quality of strawberry cultivar.

Materials and Methods

The experiment was conducted at the Horticulture farm, School of Agriculture, Lovely Professional University during the year 2022-23 to see the effect of plastic mulch colors and foliar application of potassium on growth, yield and quality of "strawberry cv. Camarosa" in polytunnel. The location's climate can be described as sub-tropical, with hot, dry summers and freezing winters. The fresh runners for transplanting were obtained from Himachal Pradesh. Runners were kept under shade net for one day before transplanting. Raised bed was prepared inside the polytunnel half month before transplanting. Runners were transplanted into raised bed in double row with spacing of 30 x 45 cm on 1 December 2022. Raised bed was covered with four different mulch colors i.e., black, blue, red and silver before transplanting. Raised bed has two drip lines placed down on it, 45 cm apart, with 30 cm emitter spacing buried beneath the plastic mulch. This experiment used a factorial randomized block design with 15 treatments and 3 replications.

Different treatments are: T1; P_1N_1 (Black mulch + 500 ppm K_2SO_4), T2; P_1N_2 (Black mulch + 1000 ppm K_2SO_4), T3; P_1N_0 (Black mulch + 0 ppm K_2SO_4), T4; P_2N_1 (Blue mulch + 500 ppm K_2SO_4), T5; P_2N_2 (Blue mulch + 1000 ppm K_2SO_4), T6; P_2N_0 (Blue mulch + 0 ppm K_2SO_4), T7; P_3N_1 (Red mulch + 500 ppm K_2SO_4), T8; P_3N_2 (Red mulch +1000 ppm K_2SO_4), T9; P_3N_0 (Red mulch + 0 ppm K_2SO_4) T10; P_4N_1 (Silver mulch + 500 ppm K_2SO_4), T11; P_4N_2 (Silver mulch + 1000 ppm K_2SO_4), T12; P_4N_0 (Silver mulch + 0 ppm K_2So_4), T13; P_0N_1 (No mulch + 500 ppm K_2SO_4), T14; P_0N_2 (No mulch + 1000 ppm K_2SO_4), T15; P_0N_0 (Control). Micronutrients like K_2SO_4 i.e., 500 ppm and 1000 ppm were applied in two split doses first given 40 days after transplanting and after that second at the time of fruit setting.

Parameters analysis

Different vegetative growth, yield and quality parameters were observed during the experimental period. Plant height is measured with the help of meter scale (cm). No. of branches, no. of leaves, plant height were observed in different days interval. No. of crown, no. of flowers, no. of fruits were observed during growth period after transplanting. For lab analysis 10 fully ripened strawberry fruits were randomly selected from each treatments and used after harvesting for chemical analysis of strawberry i.e., TSS, acidity, ascorbic acid, reducing sugar, non-reducing sugar and total sugar. TSS was measured with the help of digital refractometer. Acidity is done with the help of titration method (AOAC). Reducing sugar and total sugars were estimated with help of Lane and Eynon method.

Statistical analysis

Data was analyzed where Critical Difference (C.D) at 5% level was used for finding the significance differences if any, among the treatment means. For each parameter under investigation, a two-factor analysis of variance was conducted to evaluate treatment differences that were significant at the 5% level and their interactions for all parameters.

Results and Discussion

Plant growth parameters like plant height, no. of branches, no. of leaves and no. of crown were significantly influenced by color plastic mulch and foliar application of K_2SO_4 (Table 1). Compare to control, other interaction of treatments significantly increased the plant growth but overall black mulch + 1000 ppm K_2SO_4 significantly enhanced the plant growth compared to other mulches in polytunnel. This may be due to mulch affect the microclimate around the plant and conserve the moisture for plant growth [11]. The potassium foliar application at 1000 ppm produced the greatest values for all examined vegetative growth parameters. Potassium is important for maintaining plant turgor pressure, regulating stomatal function, and promoting root growth, while sulfur is important for protein synthesis, enzyme activation, and stress tolerance [12]. Therefore, K_2SO_4 can have positive effects on the growth and development of strawberry plants [13].

No. of leaves was maximum recorded in (25.7) under the combined interaction of P_1N_2 (black mulch + 1000 ppm K_2SO_4) treatment followed by P_3N_2 (Red mulch + 1000 ppm K_2SO_4) compared to control (Table 1). Maximum no. of crowns was recorded in (4.31) from the interaction effect of P_1N_2 (black polythene mulch + 1000 ppm K_2SO_4) followed by red mulch + 1000 ppm K_2SO_4 and minimum no. of crowns was recorded in control i.e., (1.21) (Table 1). The increased soil temperature can lead to faster plant growth, while the reduced weed growth allows plants to access more nutrients and water. In addition, the mulch can help prevent soil erosion and soil compaction, which can also benefit plant growth. These factors can contribute to an increase in the number of leaves and number of crowns in plants. These results are in Zhang et al. [14] and Semwal et al. [15] noted greater vegetative growth in mulched plots, particularly under black polythene mulch. Potassium plays a role in many plant processes, including photosynthesis, water uptake, and nutrient transport. Adequate potassium levels can lead to increased plant growth, improved stress tolerance, and higher yield. K_2SO_4 is particularly effective in increasing the number of leaves and number of crowns in plants, as it promotes the growth of strong and healthy shoots and roots, which can lead to the development of more leaves and crowns these results as same as [16].

The no. of branches significantly differed by the interaction effect of mulch and foliar application. Maximum no. of branches recorded in (8.08) from the interaction of P_1N_2 (black polythene mulch + 1000 ppm K_2SO_4) followed by red mulch + 1000 ppm K_2SO_4 and minimum was recorded under control. Plant height was maximum recorded (16.13 cm^2) from P_1N_2 (black polythene mulch + 1000 ppm K_2SO_4) and minimum was recorded (11.3 cm^2) from control which was significantly differed by interaction effect of mulch and foliar application (Table 1). This might be as a result of the weeds being controlled by the black polythene mulch, which may

Table 1: Effect of different plastic mulch color and foliar application of potassium on vegetative growth parameters.

Treatments	Interaction	Plant height	No. of branches	No. of leaves	No. of crowns/plant
T1	P_1N_1	14.65	6.73	20.2	3.35
T2	P_1N_2	16.13	8.08	25.7	4.31
T3	$P1N_0$	14.13	6.66	24.2	2.71
T4	P_2N_1	12.66	7.41	24	2.71
T5	P_2N_2	12.33	7.58	22.2	2.38
T6	P_2N_0	11.42	7.01	22	2.32
T7	P_3N_1	14.17	7.22	22.3	3.45
T8	P_3N_2	15.06	7.93	24.6	3.68
T9	P_3N_0	14.95	7.28	22.1	2.34
T10	P_4N_1	13.72	7.55	23	2.4
T11	P_4N_2	14.73	6.5	21.8	2.05
T12	P_4N_0	13.73	6.23	19.4	2.31
T13	P_0N_1	11.58	6.97	20.2	2.41
T14	P_0N_2	13.77	7.08	19.8	2.15
T15	P_0N_0	11.03	5.76	18.8	1.21
	S.Em±	0.48	0.31	0.81	0.28
	CD at 5%	1.4	0.92	2.37	0.83

Note: Treatmentdetails are given in materials and methods.

have affected plant performance improved by the plants' higher nutrition absorption [17] and due to the role of potassium in maintaining plant turgor pressure and regulating cell elongation. This is likely due to the role of potassium in promoting root growth and nutrient uptake, which can lead to increased branching and shoot growth effect of potassium as same as [18] on no. of branches and plant height. K_2SO_4 can promote the growth of strong and healthy shoots and roots, which can result in taller plants and more branches.

The no. of flowers per plant significantly differed by the interaction effect of mulch and foliar application. Maximum no. of flowers was recorded in 26.30 from the treatment P_1N_2 (black polythene mulch + 1000 ppm K_2SO_4) followed by red mulch + 1000 ppm K_2SO_4 and minimum found under control. The benefit that resulted in decreased soil temperature and water loss, decreased soil erosion, and suppressed weeds which in turn promoted vegetative growth which positively reflected on flowering traits may be responsible for the prudent improvement effect of black polythene mulching on flowering parameters. The findings from Semwal et al. [15] in relation to several strawberry cultivars and those from in relation to strawberry cv. Chandler are likewise comparable to the current findings.

The interaction impact of mulch and foliar treatment significantly influenced the number of fruits produced per plant (Table 2). The combined effect of P_1N_2 (black mulch + 1000 ppm K_2SO_4) produced the most fruits per plant (15.8), whereas the treatment combination P_0N_0 (control) produced the fewest fruits per plant (7.36). Larger fruits result from improved plant growth because of the soil's favorable hydrothermal regime and completely weed-free environment. Semwal et al. [15], made a similar observation regarding an increase in yield with larger fruits after mulching with black polythene. High potassium levels encourage strawberry plant development that supports more fruits per plant. This is explained by the increased chlorophyll content of the leaves, which raises the rate of photosynthesis and carbohydrate synthesis, increasing the amount of fruit produced per plant and the number of fruits produced overall these results as same as [19]. Fruit weight was also maximum under this same treatment i.e., (12.32 g). The interaction impact of mulch and foliar application significantly influenced the fruit yield per plant and fruit weight. The robust growth of the plants under the black polythene mulches is the cause of the greater weight of fruit. The black mulch enhanced the fruit weight in cucumber. Maximum yield found in (189.6 g) from P_1N_2 (black mulch + 1000 ppm K_2SO_4) and minimum recorded (38.4 g) under control (Table 2). Improved yield due to increased fertilizer availability and severely reduced weeds in black mulch. This may be result of increased fruit yield. These results are the same as Tuzen et al. [20] discovered black mulch enhanced yield in tomato.

The interaction effect of mulch and foliar application influenced the quality parameters viz, TSS, acidity and ascorbic

Table 2: Effect of different plastic mulch color and foliar application of potassium on flowering and fruit yield parameters of strawberry.

Treatments	Interactions	No. of flowers	No. of fruits	Fruit weight	Fruit yield/plant (g)
T1	P_1N_1	22.06	12.8	10.9	130.8
T2	P_1N_2	26.3	15.8	12.32	189.6
T3	$P1N_0$	20.3	10.5	8.86	92.4
T4	P_2N_1	19.46	11.8	8.72	102.6
T5	P_2N_2	17.46	11.6	10.85	125.2
T6	P_2N_0	15.76	10.16	9.31	94.4
T7	P_3N_1	20.1	11.16	10.32	114.3
T8	P_3N_2	24.46	13.3	11.94	158.8
T9	P_3N_0	20.4	12.16	6.84	82.7
T10	P_4N_1	17.36	9.5	9.22	87.5
T11	P_4N_2	18.1	8.53	10.36	88.3
T12	P_4N_0	16.33	8.83	11.04	97.4
T13	P_0N_1	16.16	8.16	8.74	71.3
T14	P_0N_2	16.3	9.76	10.41	101.6
T15	P_0N_0	12.5	7.36	5.22	38.4
	S.Em±	0.67	0.47	0.364	0.16
	CD at 5%	1.97	1.36	1.059	1.44

acid under different treatments (Table 3). This may be due to potassium is regarded as a factor in determining strawberry quality indicators such fruit acidity, sugar content, and vitamin C content. With a potassium dose, these values often rise. In fact, the strawberry fruit quality was increased by a higher potassium concentration in the nutritional solution. It has crucial roles in the plant's production and transportation of proteins and carbohydrates, as well as in controlling water flow [21]. The maximum TSS was recorded in (7.6) from P_1N_2 (black mulch + 1000 ppm K_2SO_4) which was statistically par to (7.16) from red mulch + 1000 ppm K_2SO and minimum TSS found under control. Increased TSS may have been caused by the accumulation of CO_2 caused by plastic mulches around the plant canopy.

The minimum acidity was recorded in (0.55) from P_1N_2 (black mulch + 1000 ppm K_2SO_4) which was statistically par to (0.61) from red mulch + 1000 ppm K_2SO_4 and minimum acidity was found under control. The acidity of fruit was deceasing with increase in sugar accumulation in strawberry fruits. This may be rapid conversion of organic acid into sugars. Fruiting zone with plastic mulch increased conversion of carbohydrates and decreased acidity. These results also found in aonla by Johnson et al. [21].

The maximum ascorbic acid was recorded (48.7) from P_1N_2 (black mulch + 1000 ppm K_2SO_4) followed by (red much + 1000 ppm K_2SO_4) i.e., 46.8 and minimum ascorbic acid was recorded under control (Table 3). Wider spacing and increased light exposure could both contribute to higher ascorbic acid levels. Ascorbic acid content was dramatically altered by mulch treatments. Improvements in ascorbic acid in polythene treatments may be due to promotion influence of plant development and metabolic activities which lead to rise in chemical composition. Reflection of light from polythene mulches might have played a role in influencing microclimatic conditions [23]. Also found the same result as increase in ascorbic acid in tomato.

The interaction effect of plastic mulch and foliar application of K_2SO_4 significantly influenced the quality parameters like reducing, non-reducing and total sugar (Table 4). These results are the same as Singh et al. [24]. Neither mulch nor K_2SO_4 is likely to have a direct effect on reducing the total sugar content of strawberries. In fact, mulching can actually increase the sugar content of strawberries by regulating soil moisture and temperature, which can lead to better fruit development. Maximum reducing sugars was recorded in (5.34) from P_1N_2 (black mulch + 1000 ppm K_2SO_4) which was statistically similar (5.31) to P_3N_2 (red mulch + 1000 ppm K_2SO_4) and minimum found under control. Maximum non-reducing sugars was recorded in (2.47) from P_3N_2 (red mulch + 1000 ppm K_2SO_4) which was statistically similar (2.41) to P_1N_2 (black mulch + 1000 ppm K_2SO_4) and minimum found under

Table 3: Effect of different plastic mulch color and foliar application of potassium on TSS, acidity and ascorbic acid.

Treatments	Interactions	TSS (°Brix)	Acidity (%)	Ascorbic acid (mg/100 g)
T1	P_1N_1	6.5	0.72	43
T2	P_1N_2	7.6	0.55	48.7
T3	P_1N_0	6.3	1.28	35.4
T4	P_2N_1	5.5	1.5	32.2
T5	P_2N_2	6.03	1.99	34
T6	P_2N_0	5.7	1	35.2
T7	P_3N_1	5.13	1.01	28.6
T8	P_3N_2	7.16	0.61	46.8
T9	P_3N_0	6.6	0.94	26.4
T10	P_4N_1	5.9	1.14	27
T11	P_4N_2	6	0.71	43.3
T12	P_4N_0	5.96	1.13	29.8
T13	P_0N_1	5.93	1.02	28.2
T14	P_0N_2	5.76	1.24	25.9
T15	P_0N_0	4.6	1	24.5
	S.Em±	0.28	0.22	0.77
	CD at 5%	0.83	0.66	2.24

Table 4: Effect of different plastic mulch color and foliar application of potassium on quality parameters like reducing, non-reducing and total sugars.

Treatments	Interactions	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
T1	P_1N_1	4.7	1.91	6.72
T2	P_1N_2	5.34	2.47	7.95
T3	P_1N_0	4.87	1.19	6.12
T4	P_2N_1	4.82	1.027	5.85
T5	P_2N_2	4.1	0.98	5.13
T6	P_2N_0	3.34	0.91	4.3
T7	P_3N_1	5.15	1.84	7.15
T8	P_3N_2	5.31	2.41	7.85
T9	P_3N_0	4.74	1.31	6.06
T10	P_4N_1	3.44	2.3	5.75
T11	P_4N_2	5.84	1.04	6.95
T12	P_4N_0	3.18	0.95	4.18
T13	P_0N_1	4.15	0.95	5.15
T14	P_0N_2	4.64	0.96	5.65
T15	P_0N_0	3.14	0.46	3.62
	S.Em±	0.01	0.01	0.03
	CD at 5%	0.03	0.05	0.09

control. With the increase in total sugar and reducing sugar, non-reducing sugars were decreasing. Maximum total sugars were recorded in (7.95) from P_1N_2 (black mulch + 1000 ppm K_2SO_4) which was statistically similar (7.85) to P_3N_2 (red mulch + 1000 ppm K_2SO_4) and minimum found under control i.e., (3.62) (Table 4). Sugar content was found to be higher in fruits, possibly as a result of increased photosynthesis and the availability of metabolites due to increased photon absorption by individual plants and improved nutrient translocation and accumulation. The increased sugar content may have been caused by the high soil temperature and higher nutrient availability, which created a conducive microclimate [25].

Conclusion

The overall results found from this present investigation clearly revealed that the application of P_1N_2 (black mulch + 1000 ppm K_2SO_4) significantly increased the growth parameters like plant height, no. of branches, no. of leaves and no. of crown and flowering and fruit yield (g) and quality parameters like TSS, acidity, reducing, non-reducing and total sugar as compared to other treatments. In order to encourage strawberry plants' root development and nutritional uptake, plastic mulch serves to retain moisture in the ground, reduce weeds, and raise the temperature of the soil. On the other hand, K_2SO_4 is an instance of potassium that is vital for the development of fruit and plant growth.

Overall, the usage of plastic mulch and K_2SO_4 in strawberry farming appears to have a promising future. Farmers can achieve these objectives by using K_2SO_4 and plastic mulch, especially in regions with scarce water supplies and unfavorable soil conditions.

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Conflict of Interest

None.

References

1. Zeist AR, de Resende JT. 2019. Strawberry breeding in Brazil: current momentum and perspectives. *Horti Brasileira* 37(1): 7-16. https://doi.org/10.1590/S0102-053620190101
2. Agehara S, Nunes MCDN. 2021. Season and nitrogen fertilization effects on yield and physicochemical attributes of strawberry under subtropical climate conditions. *Agronomy* 11(7): 1391. https://doi.org/10.3390/agronomy11071391
3. Hasan W, Lnu M, Singh H, Moinuddin, Kumar A, et al. 2022. Advances in Agriculture for Doubling Farmers' Income. BFC Publications, Lucknow.
4. Li T, Bi G. 2019. Container production of southern high bush blueberries using high tunnels. *Horti Sci* 54(2): 267-74. https://doi.org/10.21273/HORTSCI13639-18
5. Xie K, Cakmak I, Wang S, Zhang F, Guo S. 2021. Synergistic and antagonistic interactions between potassium and magnesium in higher plants. *Crop J* 9(2): 249-256. https://doi.org/10.1016/j.cj.2020.10.005
6. Deschamps SS, Agehara S. 2019. Metalized-striped plastic mulch reduces root-zone temperatures during establishment and increases early-season yields of annual winter strawberry. *Horti Sci* 54(1): 110-116. https://doi.org/10.21273/HORTSCI13583-18
7. Miao L, Zhang Y, Yang X, Xiao J, Zhang H, et al. 2016. Colored light-quality selective plastic films affect anthocyanin content, enzyme activities, and the expression of flavonoid genes in strawberry (*Fragaria* × *ananassa*) fruit. *Food Chem* 207: 93-100. https://doi.org/10.1016/j.foodchem.2016.02.077
8. Kaur P, Kaur A. 2017. Effect of various mulches on the growth and yield of strawberry cv. chandler under sub tropical conditions of Punjab. *Int J Recent Trends Sci Technol* 25(1): 21-25.
9. Kang JH, Yoon HI, Lee JM, Kim JP, Son JE. 2022. Electron transport and photosynthetic performance in *Fragaria* × *ananassa* Duch. acclimated to the solar spectrum modified by a spectrum conversion film. *Photosynth Res* 151(1): 31-46. https://doi.org/10.1007/s11120-021-00875-7
10. Narayanankutty C, Sreelatha U, Prameela KP. 2017. Mulching and fertigation in okra (*Abelmoschus esculentus*). *Indian J Agri Sci* 87(7): 889-892. https://doi.org/10.56093/ijas.v87i7.71813
11. Agarwal A, Prakash O, Sahay D, Bala M. 2022. Effect of organic and inorganic mulching on weed density and productivity of tomato (*Solanum lycopersicum* L.). *J Agri Food Res* 7: 100274. https://doi.org/10.1016/j.jafr.2022.100274
12. Nawaz F, Shehzad MA, Majeed S, Ahmad KS, Aqib M, et al. 2020. Role of Mineral Nutrition in Improving Drought and Salinity Tolerance in Field Crops. In Hasanuzzaman (eds) Agronomic Crops: Volume 3: Stress Responses and Tolerance. Springer, Singapore, pp 129-147.
13. Mostofa MG, Rahman MM, Ghosh TK, Kabir AH, Abdelrahman M, et al. 2022. Potassium in plant physiological adaptation to abiotic stresses. *Plant Physiol Biochem* 186: 279-289. https://doi.org/10.1016/j.plaphy.2022.07.011
14. Zhang H, Miles C, Ghimire S, Benedict C, Zasada I, et al. 2019. Polyethylene and biodegradable plastic mulches improve growth, yield, and weed management in floricane red raspberry. *Sci Horti* 250: 371-379. https://doi.org/10.1016/j.scienta.2019.02.067
15. Semwal A, Singh S, Nautiyal P, Pandey S. 2022. Effect of mulching on growth, yield and economics of strawberry (*Fragaria* × *ananassa*) under subtropical conditions of Uttarakhand. *Int J Agric Environ Biotechnol* 15(04): 819-825. https://doi.org/10.30954/0974-1712.04.2022.5
16. Rawat J, Pandey N, Saxena J. 2022. Role of Potassium in Plant Photosynthesis, Transport, Growth and Yield. In Iqbal N, Umar S (eds) Role of Potassium in Abiotic Stress. Springer, Singapore, pp 1-14.
17. Amaren G, Desta B. 2021. Coloured plastic mulches: impact on soil properties and crop productivity. *Chem Biol Technol Agric* 8: 4. https://doi.org/10.1186/s40538-020-00201-8
18. Sustr M, Soukup A, Tylova E. 2019. Potassium in root growth and development. *Plants* 8(10): 435. https://doi.org/10.3390/plants8100435
19. Nakro A, Bamouh A, El Khatib O, Ghaouti L. 2022. Effect of potassium source and dose on yield and quality of strawberry fruit. *Am J Plant Sci* 13(9): 1196-1208. https://doi.org/10.4236/ajps.2022.139081
20. Tuzen B, Tütüncü AÇ, Tasdelen S, Pekşen A. 2021. Effect of polyethylene plastic mulch on yield and fruit quality parameters of tomato. *Turk J Food Agric Sci* 3(2): 56-59. https://doi.org/10.53663/turjfas.1022181
21. Johnson R, Vishwakarma K, Hossen MS, Kumar V, Shackira AM, et al. 2022. Potassium in plants: growth regulation, signaling, and environmental stress tolerance. *Plant Physiol Biochem* 172: 56-69. https://doi.org/10.1016/j.plaphy.2022.01.001
22. Sharma A, Pandya YH, Bakshi M. 2022. Mulching: its effect on fruit productivity and soil health: a review. *J Pharm Innov* 11(6): 1106-1109.
23. Bhagyashree M, Naik N, Koujalagi CB, Karadiguddi M, Manukumar HR. 2018. Effect of plant geometry and nutrients on nutrient status and fruit quality of guava (*Psidium guajava* L) cv. Sardar. *Inter J Chem Stud* 6(4): 3223-3227.

24. Singh N, Dwivedi DH, Kishor S, Maji S. 2021. Improvement in growth and yield of strawberry (*Fragaria* × *ananassa* Duch.) by mulch colour. *Environ Sustain* 4: 705-710. https://doi.org/10.1007/s42398-021-00167-9

25. Datta HS, Barua PC, Kotoky U, Das R, Saikia H, et al. 2023. Crop Geometry and Mulch on Strawberry Post Harvest Quality. In Kafkas NEY, Çelik H (eds) Edible Berries - New Insights. IntechOpen Limited, London.