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EFFECT OF VARYING ENVIRONMENTAL CONDITIONS AND GIBBERELLIC ACID AT REPRODUCTIVE STAGE OF STRAWBERRY

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Abstract
Strawberry is one of the most economical and nutritious fruit. As we know that worlds population is enhancing day by day and need of food is increasing day by day, thus we need to grow more from limited area. To achieve that we need to change our cultivation system and to think beyond than just fertilizer application. Therefore a study was conducted at research area of Horticulture Department, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi during 2017–2018. The experiment was comprised of four different treatments: untreated, 150, 300 and 450 ppm gibberellic acid, and four different environments were created as open field (E_1), plastic tunnel (E_2), glass house (E_3) and lath house (E_4). Growth regulator (GA_3) was applied with different concentration at vegetative phase i.e. before flowering. Strawberry cultivar "Chandler" was selected for this study, Twenty one plants per treatment were selected to investigate the impact of plant growth regulators on reproductive growth, yield and chemical attributes of strawberries under four environments. The study was comprised of pre and post-harvest reproductive growth and the fruit quality parameters. Throughout the research, the plants treated with gibberellic acid @ 450 ppm had a prominent effect on the reproductive parameters (days taken to flowering, number of flowers, number of trusses, fruit set percentage), quality parameters (TSS, Titratable acidity, and ascorbic acid) also responded positively. The current research concluded that the application of gibberellic acid at concentration 450 ppm in strawberry crop reacted for better flower stimulation, flower numbers and quality features while for maximum fruits production and improved quality, the lath house (E_4) showed better results. It was perceived that the treatments of gibberellic acid induced early reproductive growth.

Keywords: Fragaria× ananassa; Gibberellin; Photoperiod; reproductive growth

INTRODUCTION

Strawberry (*Frageria ananasa)* belongs to family *Rosaceae* which is grown in the temperate and subtropical regions of the world (Vishal et al., 2017). Strawberries have 5.84 million metric tons production and the USA ranked first with production of 1148510 metric tons (FAO, 2010). Pakistan's average strawberries yield is extremely low when compared with other countries like USA and Turkey due poor cultural practices, market and transportation, cold storages that decreased the value of strawberry (Mabood, 1994). Strawberry is a short day plant which grown for its delicious fruit that is used fresh or frozen or processed (Uddin et al., 2012). It also contains photochemical composition like foliate, ellagic acid and anti-cancer constituent protein. Strawberry compared to other horticultural berry fruits, it comprises a greater amount of fiber, phenolics, vitamins, and flavonoid (Kumra et al., 2018).

In the last decades the farming of strawberry was limited to temperate regions of world rendering it to price hiking. The breeding of new varieties are applicable for subtropical climate in recent years (Vishal et al, 2016). In the climate of Pakistan the following varieties of strawberry are grown namely Pajaro, Corona, Douglus, Toru, Tufts, and Chandler. The two main varieties Chandler and Toru are commercially grown in Islamabad and other area while others varieties pajaro and douglus are cultivated for research purpose (Khushk & Memon, 2009). Chandler is an excellent strawberries cultivar for plastic culture and which also performs excellent in open environmental conditions. Strawberry grown in the plastic tunnel began to bear fruit 30 days before those produced fruits in the open field (Jett, 2006). Strawberry cultivation in high tunnels provides benefit in economical production of strawberry for a long season (Rawley et al., 2010). Phillips & Reid (2008) recommended cultivation of strawberries in low tunnel due to best protection from climatic factor as compared to field and high tunnels.

For optimum growth and developments strawberry plants require full sun, moist, slightly acidic and well-drained soil in the pH range 5-6 and the best timing for planting of strawberry is early spring. Strawberry has chilling requirement like other temperate fruits to complete its life cycle properly. Prolong cold treatments boost vegetative growth before flowering (Cummings, 1994). The vegetative development of resting strawberry plant is extraordinarily bunged regardless the plants raised under ideal natural conditions (Fujime & Yamasaki, 1988).

Chilling is necessary to break the strawberry dormancy (Lieten et al., 1995) in light of chilling plant obtain and quicken blossoming capacity (Sung & Amasino, 2004). In the event that strawberry plants are developed under high temperature and long photoperiod, the petiole length of dormant plants does not extend when contrasted with appropriately chilled plants (Lee et al., 1970).

Gibberellin is a group of natural plant hormones, which got from the fungus gibberella and numerous higher plants. Naturally these are available in the apice of shoot, leaf primordia of plants, embryos, cotyledons of immature seeds and fruit tissues. A good amount of gibberellin is formed in roots. Gibberellins are effectively shipped both upward and descending all through the plant. Gibberellin are produced industrially in crystalline structure as acids or potassium salts. They play various regulatory function such as stimulation of development enhancing cell division, cell elongation, beginning of blossoming, sex assurance, fruit setting, fruit growth, ripening of certain fruits, senescence of leaves, and breaking dormancy period of seeds and buds. Gibberellins are said to be most effective and essential set of plant hormone (Malik & Bashir, 1994).

Plant growth regulators are commercially implemented in order to increase crop quality and productivity. In all the vegetative and reproductive parameters GA_3 played major function in plant height, flower numbers, fruit numbers, fruit set percentage, weight, size and quality of fruits and number of runners (Sharma & Singh, 2009a). The application of gibberellic acid (GA_3) is stated to increase leaf size, leaf area, leaf area index, petiole length, absolute growth rate, crop growth rate and regulates other bio chemical changes in strawberry plants. (Vishal et al., 2016). GA_3 lessened the time required for inflorescence initiation. It also boost flowers and improved number of buds and open flowers. The application of GA_3 controlled growth, flowering and stimulate earliness of cropping season in the strawberry fruit. The reaction of strawberry to GA_3 is comparable with natural climatic factors like long days and cold temperatures (Tehranifar & Battey, 1997). GA_3 stimulates flowering in unchilled strawberry plants (Avidov et al., 1977).

The present research on growth and yield response of strawberry was performed with the following objective:

- To examine the effect of GA_3 on reproductive growth of strawberry.
- To investigate the effect of environmental conditions on growth and yield of strawberry.

MATERIALS AND METHODS

The field experiment was carried out under different environments at Horticulture Section (PMAS-AAUR) Pir Mehar Ali Shah Arid Agriculture University Rawalpindi, during 2017-18. The research work was conducted to examine the impact of different environments and gibberellic acid on reproductive and some chemical attributes of strawberry. Strawberry runners of cultivar “Chandler” were obtained from Mingora, Swat. The clay pots of capacity 3L were used for plantation of runners. The components used in potting media were sand, silt and Farm Yard Manure (FYM) at the ratio 1:1:1.

The field experiment was designed according to Randomized Complete Block Design (RCBD) with three replications to check the effect of foliar impact of different concentrations (0, 150, 300 and 450 ppm) of gibberellic acid provided with four different environments (open field E_1, plastic tunnel E_2, glass house E_3 and lath house E_4) on growth, productivity and quality parameters of strawberry. 70 runners were planted in each treatment and treatment combinations are shown in table 1. Data was recorded on days taken to flower, count of flowers plant^{-1}, count of fruit set plant^{-1}, fruit set percentage, fruit size, total soluble solids, ascorbic acid content and titratable acidity.

Fruit Set Percentage (%)

The fruit set (%) was measured as per formula as under:

$$Fruit\ set\ (\%) = \frac{Total\ number\ of\ fruit\ set}{Total\ number\ of\ flowers} \times 100$$

Total Soluble Solids (TSS ^{0}Brix)

The refractometer was used at room temperature to measure the total soluble solids contents of ten fruits randomly chosen from each replication. A drop of strawberry juice have been placed on refractometer prism and the measurements in ^{0}Brix were noted (AOAC, 1990)

Ascorbic acid Content

In order to measure the ascorbic acid contents random selection of 10 fruits from each replication was made and 5 gram of fruit pulp had been blended with 5 ml 0.1 % hydrochloric acid and centrifuge for ten minutes at 10,000 rpm. The Ascorbic acid extract had been gathered as supernatant fluid. The data was recorded via spectrophotometer at 243 nm (wave length) (OPTIMA, SP-3000-plus).

Titratable Acidity in Strawberry

Extracted juice of 10 ml was taken in 100 ml volumetric flask and diluted with water. 10 ml concentrated sample has been put in the conical flask and 1-3 drops of phenolphthalein were added.

0.1 N NaOH was used to titrate this solution until the appearance of pink color and was calculated via using the following formula as under.

$$Titratable\ Acidity\ (\%) = \frac{m \times 0.0064}{100} \times 100$$

m = burette reading

STATISTICAL ANALISIS

The collected data were analyzed by using STATISTIX 8.1 analysis of variance technique was implemented and the least significant difference LSD test at 5 percent probability level to checked the considerable variation among the treatments and means results were compared (Steel et al., 1997).

RESULTS AND DISCUSSION

Days Taken to Flower

The results related to days taken to flower is present in Table 1. The mean data disclosed that there was a considerable influence of environments and GA_3 on days taken to flower. The interactive impact of environments and gibberellic acid on days to flower was also significant.

The results regarding gibberellic acid treatments indicated that the maximum (89.70) days taken to flowers was recorded in strawberry plants sprayed with distil water while minimum (73.61) days was observed in plants applied with 450 ppm gibberellic acid. The data regarding environments showed that the maximum days taken to flower (79.56) was recorded in plants grown open field (E_1), while the lowest days taken to flower (76.82) was recorded in lath house (E_4). In regards to the interactive effect of environments and GA_3 on days taken to flower, the maximum days taken to flower (90.35) was perceived in plants sprayed with distil water and were grown in open field (E_1), while the minimum days to flower (71.90) was recorded in plastic tunnel (E_2) and sprayed with 150 ppm GA_3. In all horticultural crops as well as strawberry, GA_3 induced early flowering. The related results are also described by (Kasim et al., 2007; Ouzounidou et al., 2010). The conceivable reason for early flowering might be gibberellic acid that boosts florigen hormone production. Sharma & Singh (2009b) reported that number of flowers, yield and harvesting season of strawberry were strongly affected by GA_3. Count of Flowers

Count of flowers

The mean data regarding count of flowers is presented in Table 2. There was a considerable variation in number of flower observed regarding environments, gibberellic acid and their interaction. The highest count of flowers (25.16) were perceived in plants sprayed with 450 ppm GA_3 however the least count of flowers (18.84) were noted in plants supplied with 150 ppm GA_3. The highest count of flowers (22.85) were recorded in strawberry plot under the plastic tunnel (E_2) while least count of flowers (20.95) were recorded plants grown in open field (E_1). The interactive effect of environments and GA_3 concentrations on count of flowers was that the maximum count of flowers (26.17) were observed in plants sprayed with 450 ppm GA_3 in plastic tunnel (E_2) while the lowest count of flowers (17.98) were noted in plant sprayed with 150 ppm GA_3 in open field (E_1). Result revealed that gibberellic acid enhances number of flowers, it is its known impact on the flowering and fruit set of various fruit plants including strawberry are stated by (Singh & Singh, 2006; Kappel & MacDonald, 2007). Growth promoter have shown important effects in increasing the flowers number plant^{-1}.The outcomes of present research are identical with the results of (Tafazoli & Vince, 1978) who stated that flower buds are increased by the treatments of gibberellic acid. Other results are parallel with our study that were presented by (EI-Shabasi et al., 2009; Sharma & Singh, 2009; Paroussi et al., 2002) who stated that the number of flowers in strawberry were increased by application of GA_3 alone or in the combinations with other chemicals.

Count of Fruit Set

The means data regarding count of fruit set is shown in Table 3 that disclosed that there was a considerable impact of environmental conditions and GA_3 on count of fruit set. The interactive effect of environments and gibberellic acid on count of fruit set was also considerable. The maximum fruit set (12.31) was recorded in strawberry plants sprayed with distil water while minimum number of fruit set (6.86) observed in plants sprayed with 150 ppm GA_3. A significant variation amongst number of fruit set was perceived regarding environments. The highest count of fruit set (9.37) was observed in plants grown in lath house (E_4) whereas the least count of fruit set (8.72) was recorded in plants raised in a glass house (E_3). Regarding the interactive effect of environments and GA_3 on count of fruit, highest count of fruit set (13.33) was perceived in plants sprayed with distil water in lath house (E_4) while the least number of fruit set (6.03) was observed in plants foliarly supplied with 150 ppm GA_3 in plastic tunnel (E_2). Gibberellic acid had resulted in important increase in the count of fruit set in strawberry plants. Our present research is in contrary with the scientific work of (Paroussi et al., 2000; Kasim et al., 2007; Sharmaa & Singh, 2009) who described that the number of flowers, fruit set and marketable yields were decreased significantly by application of GA_3. Parallel outcomes were exposed by Lolaei et al, (2012) who stated that treatments of gibberellic acid promotes the vegetative growth.

Fruit Set Percentage (%)

The results related to fruit set percentage are given in table 4. The means data revealed that there was a significant effect of gibberellic acid and environments on fruit set percentage of strawberry crop while the interactive effect of both GA_3 and environments on fruit set percentage of strawberry crop was also significant. Maximum fruit set percentage (92.83%) was recorded in strawberry plants sprayed with distil water while minimum fruit set percentage (68.92%) perceived in plants sprayed with 450 ppm of GA_3. Maximum fruit set percentage (80.18%) was recorded in strawberry crop cultivated in a lath house while minimum fruit set percentage (78.02%) was perceived in plants raised in plastic tunnel. As far as interactive effect of gibberellic acid and environments is concerned, the highest fruit set percentage (93.85%) was observed in plants sprayed with distil water in glass house (E_3) whereas, the minimum fruit set percentage (67.70%) was recorded in plants received 450 ppm gibberellic acid in glass house (E_3). The fruit set percentage and yield of strawberries improved considerably by application of GA_3. Gibberellic acid had extra ordinary effect on flowers and production of inflorescence (Takahashi et al. 1991).

Fruit Size (cm)

The data related to fruit size is shown in table 5. The ANOVA Table showed that there was a significant variation in fruit size regarding environments, gibberellic acid and their interaction. The highest fruit size (17.75 cm) was observed in plants sprayed with distil water, however the lowest fruit size (12.22 cm) was perceived in plant sprayed with 450 ppm of gibberellic acid. The highest fruit size (15.36 cm) were counted in open field (E_1) while minimum fruit size (14.86 cm) was recorded in plants kept in glass house (E_3). The interaction of environments and GA_3 also affect fruit size of strawberry, the maximum fruit size (18.44 cm) was recorded in plants sprayed with distil water that were grown in open field (E_1) while the lowest fruit size (12.08 cm) was reported in plants sprayed with 450 ppm GA_3 in a lath house (E_4). The maximum fruit size may be due to transfer of all biosynthates to fruits, whereas the GA_3 treatments used them for runner production as a results in a reduction in fruits quality in term of fruit weight and size. Our results are related to the study of (Paroussi et al., 2002) they stated that the percentage (%) of aborted flowers and deformed fruits was higher with GA_3, causing to a considerable decrease in total marketable yield (Sharma & Singh, 2009a). This could be the reason to sink of gibberellic acid treated plants promote toward early flowers production, fruits setting and runners production.

Table 1: Effect of gibberellic acid and environments on days taken to flower

	Gibberellic acid (ppm)				
Environments	0	150	300	450	**Means**
Open field	90.35 a	77.44 bc	73.71 cd	74.62 cd	**79.56 a**
Plastic tunnel	88.69 b	71.90 g	74.31 cd	72.37 fg	**79.03 ab**
Glass house	89.88 a	73.63 f	73.73 df	72.15 g	**77.24 bc**
Lath house	89.88 a	79.72 b	73.37 f	75.25 cd	**76.82 c**
Means	**89.70 a**	**75.67 b**	**73.67 b**	**73.61 b**	

Table 2: Effect of gibberellic acid and environments on count of flowers of strawberry

	Gibberellic acid (ppm)				
Environments	0	150	300	450	**Means**
Open field	21.25 efg	17.98 i	20.62 fg	23.96 cd	**20.95 c**
Plastic tunnel	23.34 d	20.24 g	21.52 ef	26.17 a	**22.85 a**
Glass house	23.68 d	18.72 h	21.68 ef	25.62 ab	**22.41 a**
Lath house	21.73 e	18.42 h	21.95 e	24.90 bc	**21.75 b**
Means	**22.50 b**	**18.84 d**	**21.43 c**	**25.16 a**	

Table 3: Effect of gibberellic acid and environments on number of fruit set of strawberry

	Gibberellic acid (ppm)				
Environments	0	150	300	450	**Means**
Open field	11.32 b	6.54 f	7.45 d	9.99 c	**9.25 ab**
Plastic tunnel	12.99 a	6.03 f	7.07 d	9.28 cd	**8.74 bc**
Glass house	11.59 b	6.85 f	7.29 d	9.40 c	**8.72 c**
Lath house	13.33 a	7.03 d	7.03 df	9.82 c	**9.37 a**
Means	**12.31 a**	**6.86 c**	**7.29 c**	**9.62 b**	

Table 4: Effect of gibberellic acid and environment on fruit set percentage of strawberry

	Gibberellic acid (ppm)				
Environments	0	150	300	450	**Means**
Open field (E_1)	91.54 b	83.47 c	75.25 e	69.81 g	**80.02 a**
Plastic tunnel (E_2)	93.48 ab	80.04 d	74.036 ef	68.40 gh	**78.02 b**
Glass house (E_3)	93.85 a	80.49 d	73.295 f	67.70 h	**78.83 b**
Lath house (E_4)	92.44 ab	83.22 c	75.302 e	69.78 gh	**80.18 a**
Means	**92.83 a**	**81.81 b**	**74.47 c**	**68.92**	

Table 5: Effect of gibberellic acid and environments on fruit size of strawberry

	Gibberellic acid (ppm)				
Environments	0	150	300	450	**Means**
Open field (E_1)	18.44 a	16.28 c	14.34 d	12.36 e	**15.35 a**
Plastic tunnel (E_2)	17.23 b	16.18 c	14.18 d	12.28 e	**14.92 b**
Glass house (E_3)	17.24 b	16.11 c	14.11 d	12.15 e	**14.86 c**
Lath house (E_4)	18.18 a	16.02 c	14.07 d	12.08 e	**15.15 ab**
Means	**17.75 a**	**16.15 b**	**14.17 c**	**12.22 d**	

Total Soluble Solids (TSS ^{0}Brix)

The data regarding total soluble solids is given in Table 6. Analysis showed that there was a significant variation in total soluble solid ^{0}Brix due to different environments and gibberellic acid. The highest TSS ^{0}Brix (10.84) was perceived in plants sprayed with 450 ppm gibberellic acid however the lowest TSS ^{0}Brix (6.56) were observed in plants sprayed with distil water. The maximum TSS ^{0}Brix (9.25) was recorded in crop grown in open field (E_1) while lowest TSS ^{0}Brix (8.98) was recorded in plants kept in lath house (E_4). The interactive effect of environments and gibberellic acid concentration on TSS was also significant. The highest TSS (11.17) was observed in plants sprayed with 450 ppm GA_3 which were kept in open field (E_1) while the lowest TSS (6.33) was recorded in plants treated with only distil water that were kept in lath house (E_4). TSS was increased by the application GA_3 in strawberry. Our finding are parallel with the study of Kappel & McDonald, (2007), they reported that GA_3 treatments on sweet cherry revealed high TSS level as compared with untreated. Singh & Singh (2006) also reported an increase in TSS after the treatments of GA_3, and the fruits were firmer, larger and have high soluble solids comparing with control.

Titratable Acidity

The mean results of Titratable Acidity (TA) are presented in Table 7. The means data indicated that there was a significant effect of gibberellic acid on TA of strawberry while environments effect was also significant on TA. It is clear from the data that the highest TA (0.73) was observed in strawberry plants, sprayed with 450 ppm gibberellic acid however, minimum TA (0.18) was perceived in plants sprayed with distil water. The maximum TA (0.53) was recorded in crop grown in glass house and lath house while lowest TA (0.5) was recorded in plants grown in open field. The maximum TA (0.75) was perceived in plants, sprayed with 450 ppm GA_3 that were kept in lath house (E_4), whereas, the minimum TA (0.16) was recorded in plants, in plastic tunnel (E_2) which were sprayed with distil water. Titratable acidity is linked to the concentrations of organic acid in fruits which are considerable parameter for maintaining quality of fruit. The results of present study showed that GA_3 had positively affected the elevation of TA which is unwanted with respect to consumption. These results coincide with the findings of Ouzounidou et al., (2010) who worked on impact of gibberellic acid. Citric acid is the important acid in strawberry which add 90 percent of total organic acid contents, our outcomes are parallel with Kappel & McDonald (2007).

Ascorbic Acid

The means results concerned with ascorbic acid is given in table 8. The means data revealed that there was a considerable effect of GA_3 on ascorbic acid of strawberry crop while environments effect was also significant regarding ascorbic acid content. The interactive effect of both GA_3 and environments regarding ascorbic acid of strawberry crop was non-significant. It is clear from the data that the highest ascorbic acid (93.24) was recorded in strawberry plants sprayed with 450 ppm GA_3 whereas minimum ascorbic acid (85.92) was observed in plants sprayed with distil water (control). The maximum ascorbic acid (89.09) was observed in plants grown in open field (E_1) whereas the least ascorbic acid (88.61) content was recorded in glass house (E_3) grown plants. The highest ascorbic acid (93.53) was observed in plants sprayed with 450 ppm gibberellic acid that were kept in open field (E_1), however, the minimum ascorbic acid (85.50) was recorded in plants that received distil water (control) under lath house (E_4) conditions. Strawberries are the main source of ascorbic acid that must be added in human diet (National Research Council, 1989) as it is a rich source of ascorbic acid than orange and guava (Ayub et al., 2010). The main qualitative parameter is Vitamin C which has been susceptible to degradation due to oxidation (Veltman et al., 2000) in comparison with other nutrients in food processing and storage. Our findings revealed that increasing dose of gibberellic acid enhances ascorbic acid content and our results are concurrent with the findings of Ouzounidou et al. 2010; Sharma & Singh, 2009, who observed same results in capsicum and strawberry crop.

Table 6: Effect of gibberellic acid and environments on Total soluble solids (TSS ^{0}Brix)

	Gibberellic acid (ppm)				
Environments	0	150	300	450	**Means**
Open field (E_1)	6.88 f	9.13 e	9.80 d	11.17 a	**9.25 a**
Plastic tunnel (E_2)	6.56 fg	9.33 e	9.70 d	10.93 ab	**9.11 ab**
Glass house (E_3)	6.48 g	9.20 e	9.80 d	10.70 bc	**9.03 b**
Lath house (E_4)	6.33 g	9.16 e	9.73 d	10.57 c	**8.98 b**
Means	**6.56 d**	**9.20 c**	**9.77 b**	**10.84 a**	

Table 7: Effect of gibberellic acid and environments on Titratable Acidity of strawberry fruits

	Gibberellic acid (ppm)				
Environments	0	150	300	450	**Means**
Open field (E1)	0.17 h	0.51 f	0.62 de	0.71 c	**0.50 b**
Plastic tunnel (E2)	0.16 i	0.55 e	0.62 de	0.71 bc	**0.51 b**
Glass house (E3)	0.21 g	0.55 e	0.64 d	0.74 ab	**0.53 a**
Lath house (E4)	0.17 h	0.57 e	0.65 d	0.75 a	**0.53 a**
Means	**0.18 d**	**0.54 c**	**0.63 b**	**0.73**	

Table 8: Effect of gibberellic acid and environments on Ascorbic acid of strawberry fruits

	Gibberellic acid (ppm)				
Environments	0	150	300	450	**Means**
Open field (E_1)	86.00 de	87.40 c	89.43 b	93.53 a	**89.09 a**
Plastic tunnel (E_2)	86.06 de	87.23 c	89.36 b	93.50 a	**88.74 b**
Glass house (E_3)	86.14 de	86.56 d	89.96 b	92.96 a	**88.61 b**
Lath house (E_4)	85.50 e	86.36 d	89.26 b	92.96 a	**88.87 ab**
Means	**85.92 d**	**86.89 c**	**89.25 b**	**93.24 a**	

CONCLUSION AND RECOMMENDATIONS

Findings of this research work concluded that all the reproductive and chemical parameters were significantly affected by the application of different concentrations of gibberellic acid and different environmental conditions. Results revealed that highest count of fruit set, fruit set percentage and fruit size was recorded in strawberry plants sprayed with distilled water less days to flowering, maximum count of flowers, TSS, ascorbic acid and titratable acidity was recorded in plants treated with 450ppm gibberellic acid. In regards to different environments, minimum days to flowering and maximum fruit set count, fruit set percentage and titratable acidity was observed in plants raised in lath house conditions. Maximum fruit size, TSS and Ascorbic acid was recorded in strawberry crop grown in open field. Regarding interaction of gibberellic acid and environments, the combination of both the factors are different for each parameter. Least days to flower was taken by plants grown in plastic tunnel with the application of 150ppm gibberellic acid, maximum count of flowers was observed in plants grown in plastic tunnel with the application of 450ppm gibberellic acid, maximum fruit set count was observed in strawberry crop raised under lath house with misting distilled water while maximum fruit set percentage was obtained when plants were grown in glass house with distilled water application. Highest fruit size was achieved when plants were grown in open environment with distilled water sprayed, maximum TSS and ascorbic acid content was recorded in strawberry fruits grown in open field and were sprayed with 450ppm gibberellic acid. Maximum titratable acidity was found in fruits raised under lath house and were sprayed with 450 ppm gibberellic acid. Based on the conclusion, it can be recommended that strawberries should be cultivated in a lath house and sprayed with 450ppm gibberellic acid to achieve high quality strawberry crop in Rawalpindi/Islamabad conditions. As majority of reproductive and chemical parameters responded well when crop was raised under a lath house and treated with 450 ppm gibberellic acid.

Data Availability Statement:
The data presented in this study are available in this article.

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No potential conflict of interest was reported by the author(s).

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