

Original Research Article

Effect of *Trichoderma asperelloides* (TA41) on production and quality of Strawberry (*Fragaria ananassa*) c.v. Winter Dawn

Abstract

The present experiment was conducted at Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. Prayagraj during the session 2023-2024. The experiment was laid out in randomized block design with three replications, and the study consists of nine treatment combinations including control by using different Effect of *Trichoderma asperelloides* (TA41) on production and quality of strawberry. The best treatment was T₈ (TA 41 – 80ml/15 L) & T₇ (TA41–70ml/15L) which show highest values in all the parameters viz., number of leaf/plant (30.72), plant spread N-S (cm) (31.31 cm), plant spread E-W (cm) (35.31 cm), Days taken to first flower initiation (22.29), Days taken to initiation of fruit set (29.07), Days taken to first harvest (54.02), Days taken to final harvest (91.53), Number of pickings (10.98), Fruit length (mm) (55.46 mm), Fruit width (38.89 mm), Fresh weight (g) (40.36), Number of fruit/plant (16.92), Fruit yield/plant (g) (682.91), Fruit yield/ha. (61.46 q), TSS (11.55 brix), Vitamin C (52.76 mg/100g), Acidity (1.96 %). All the treatments were significantly superior in their growth, flowering, fruit yield and quality of strawberry over control (T₀) and (T₈).

Key words: Strawberry, TA41, growth, yield, quality, *Trichoderma asperelloides*

INTRODUCTION

The strawberry (*Fragaria × ananassa* Duch.) has gained prominence as a fruit of global importance (Zeist and Resende 2019). The garden strawberry (*Fragaria × ananassa*) is a cross between the wild strawberries *Fragaria virginiana* and *Fragaria chiloensis*. The ancestry of the current hybrid species can be traced back to the Americas. Nonetheless, the current hybrid species was cultivated in Europe using imported specimens and then introduced to the United States in the latter half of the 18th century (Hernández-Martínez *et al.* 2023). A strawberry is an aggregated fruit that develops from receptacular tissue. Multiple ovaries develop on a single receptacle to produce achenes, which are fruits with a single seed. According to Flachowsky *et al.* (2011) the enlarged receptacle containing achenes is considered a berry, but is commonly referred to as a 'fruit' in a horticultural sense. Strawberry plants are perennial, herbaceous and of low stature. Typically, strawberry flowers have five white petals. Strawberry plants are capable of vegetative propagation through the production of runners (stolons), which trail above-ground and can establish new, clonal daughter plants at their nodes (Davis *et al.* 2007).

There are day-neutral and short-day varieties of strawberries based on their photoperiodic response. Sweet Charlie, a cultivar with a day-neutral photoperiod, has dark red berries with dark green and semi-glossy leaves. It possesses specific characteristics in its composition that appeal to consumers, such as its intense bright red colour, characteristic odour, soft texture and slightly acidic flavour (Gabriele *et al.* 2019).

It is a temperate-zone crop that can also be found in the subtropics and grows at an altitude of 3000 m above mean sea level. In India, 14,000 MT of strawberries are produced annually on an area of 3000 ha (NHB 2022). Maharashtra, Punjab, Haryana, the Himachal Pradesh hills, Jammu & Kashmir, Uttarakhand, Uttar Pradesh, Rajasthan, and West Bengal are the main strawberry-growing states in India. In Himachal Pradesh, it is cultivated in Sirmour, Kullu, Kangra, Solan and Shimla districts, covering a combined total of 40 ha and producing 210 MT annually (NHB 2022). The plants thrive at temperatures between 15 and 35°C, with flowering occurring best at 14°C to 18°C (Rani and Ahmad 2012). It thrives best in soil that ranges in pH from 5.7 to 6.5 and is sandy loam to loamy.

The biocontrol agent *Trichoderma* is prevalent in almost all types of soils but naturally their population is too low in soil that they are not very effective in action. There are two important species of *Trichoderma* which are *Trichoderma harzianum* and *Trichoderma viride*, which are to be known as bio-control agents. *Trichoderma* is used as a successful bio-control agent to suppress soil-borne pathogens. It induces defense responses and systemic resistance

in addition to control of plant pathogens by spraying plant above ground of soil (Freeman, et al., 2004 and Alfano, et al., 2007). *Trichoderma* is very effective in controlling the diseases and hence increases the yield of fruit crops.

MATERIALS AND METHODS

This experiment was laid out during the August 2023 to March 2024 at Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The horticulture research farm is situated at 25°39'42" N latitude, 81°67'56" E longitude and at an altitude of 98 m above mean sea level. The treatment consisted of T₀ - (RDN) + Control (Water Spray) N, P, K (100:50:50 Kg/h), T₁ - TA41- 10ml /15L, T₂ - TA41- 20ml /15L, T₃ - TA41-30ml/15L, T₄-TA41-40ml/15L, T₅-TA41-50ml/15L, T₆-TA41-60ml/15L, T₇-TA41-70ml /15L, T₈ - TA41- 80ml /15L. The experiment was laid out in a Randomized Block Design with 9 treatments and replicated thrice. Data recorded on different aspects of fruit crop, viz., growth, yield were subjected to statistical analysis by analysis of variance method. (Gomez and Gomez, 1984) and economic data analysis mathematical method.

RESULTS AND DISCUSSION PLANT STAND AND GROWTH

Number of leaves plant⁻¹

The data on number of leaves plant⁻¹ of strawberry as influenced by *Trichoderma asperelloides* (TA41) are summarized in table number 1.

The data reveal that the number of leaves plant⁻¹ of strawberry increased significantly by the application of *Trichoderma asperelloides* (TA41) essence under experiment over the control. The maximum number of leaves plant⁻¹ of (30.72) was recorded with treatments 8 (TA41-80ml /15L) 120 DAT recorded, while the minimum (25.41) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* (TA41) to the amount of water required for foliar spray significantly influenced the number of leaves plant⁻¹.

The maximum number of leaves plant⁻¹ in treatment in *Trichoderma asperelloides* (TA41) was closely observed by Sharma et al. (2016). Higher levels of sugar due to *Trichoderma asperelloides* application might be explained behind increase in P^H content which is synthesized from sugar Kumar (2010).

Plant spread (cm) (East-West)

The data on plant spread E-W (cm) of strawberry as influenced by *Trichoderma asperelloides* are summarized in table number 1.

The data reveals that the plant spread E-W (cm) of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum plant spread E-W (cm) of (35.31 cm) was recorded with treatments 8 (TA41-80ml/15l) in 120 DAT recorded, while the minimum (27.39 cm) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount of water required for significantly influenced the plant spread E-W (cm).

The maximum plant spread in treatment in *Trichoderma asperelloides* was closely observed by Sharma et al. (2016b). Higher levels of sugar due to *Trichoderma asperelloides* application might be explained behind increase in P^H content which is synthesized from sugar Mandalet et al., (2021).

Plant spread (cm) N-S

The data plants spread N-S (cm) of strawberry as influenced by *Trichoderma asperelloides* are summarized in table number 1

The data reveal that the plants spread N-S (cm) of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum plant spread E-W (cm) of (31.31 cm) was recorded with treatments 8 (TA41-80ML/15L) in 120 DA recorded, while the minimum (23.39 cm) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount or water required for foliar spray significantly influenced the plant spread N-S (cm).

The maximum plant spread in treatment in *Trichoderma asperelloides* was closely observed by **Mandal et al., (2021)**. Higher levels of sugar due to *Trichoderma asperelloides* application might be explained behind increase in P^H content which is synthesized from sugar **Kumaret al., (2018)**.

YIELD ATTRIBUTES

Fruit length (mm)

The data Fruit length (mm) of strawberry as influenced by *Trichoderma asperelloides* are summarized in Table number 2

The data reveal that the Fruit length (mm) of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum Fruit length (mm) of (55.46) was recorded with treatments 9 (TA41-80ml/L) in recorded, while the minimum (37.98) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount or water required for foliar sprays significantly influenced the Fruit length (mm).

The maximum increase in fruit length (mm) following use of *Trichoderma asperelloides* might be due to its effect in cell division and cell elongation. *Trichoderma asperelloides* is also reported to promote growth by increasing plasticity of cell wall followed by hydrolysis of starch into sugar which reduces cell wall potential, resulting in the entry of water into the cell and causing its elongation **Kumar (2010)**.

Fruit width (mm)

The data Fruit width (mm) of strawberry as influenced by *Trichoderma asperelloides* are summarized in Table number 2.

The data reveal that the Fruit width (mm) of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum Fruit width (mm) of (38.89) was recorded with treatments 9 (TA41-80ml/15L) in recorded, while the minimum (30.42) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount or water required for foliar sprays significantly influenced the Fruit width (mm).

The maximum increase in fruit width following use of *Trichoderma asperelloides* might be due to its effect in cell division and cell elongation. The beneficial effect of *Trichoderma asperelloides* on fruit set and reducing fruit drop might be due to the higher availability of photosynthates. These chemicals are also associated with hormone metabolism

which promotes synthesis of auxin, These results are in conformity with **Abdelmoaty et al., (2022)**.

Fresh weight of fruit (g)

The data Fruit weight of fruit (g) of strawberry as influenced by *Trichoderma asperelloides* are summarized in Table number 2.

The data reveals that the Fruit weight of fruit (g) of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum Fruit weight of fruit (g) of (40.36 g) was recorded with treatments 9 (TA-80ml/15L) in recorded, while the minimum (13.49g) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount of water required for foliar spray significantly influenced the Fruit weight of fruit (g).

The maximum Increase in fruit weight following use of *Trichoderma asperelloides* might be due to its effect in cell division and cell elongation. *Trichoderma asperelloides* is also reported to promote growth by increasing plasticity of cell wall followed by hydrolysis of starch into sugar which reduces cell wall potential, resulting in the entry of water into the cell and causing its elongation **Abdelmoaty et al., (2022)**.

Number of fruit plant⁻¹

The data Number of fruit plant⁻¹ of strawberry as influenced by *Trichoderma asperelloides* are summarized in Table number 2

The data reveals that the Number of fruit plant⁻¹ of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum Number of fruit plant⁻¹ of (16.92) was recorded with treatments 9 (TA41-80ml/15L) in recorded, while the minimum (8.38) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount of water required for foliar spray significantly influenced the Number of fruit plant⁻¹.

Increase in number of fruits per plant with the use of *Trichoderma asperelloides* might be due to fact that benzyl adenine causes the production of large number of fruits with rapid elongation of peduncle, leading to full development of flower buds having all reproductive parts functional which increases the fruit set and number of berries per plant. It could also be due to the fact that *Trichoderma asperelloides* application accelerates the development of differentiated inflorescence. **Mandalet et al., (2021)**.

Fruit yield plant⁻¹

The data Fruity yield plant of strawberry as influenced by *Trichoderma asperelloides* are summarized in Table number 2

The data reveals that the Fruity yield plant⁻¹ of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum Fruity yield plant⁻¹ of (682.91) was recorded with treatments 9 (TA41-80ml/15L) in recorded, while the minimum (118.70) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount of water required for foliar spray significantly influenced the Fruit yield plant.

The maximum increase in fruit yield/plant following use of *Trichoderma asperelloides* might

beduetoitseffectincelldivisionandcellelongation.Thebeneficialeffectof*Trichoderma asperelloides* on fruit set and reducing fruit drop might be due to the higher availability of photosynthates. These chemicals are also associated with hormone metabolism which promotes synthesis of auxin, These results are in conformity with **Abdelmoaty et al.,(2022)**.

Fruit yield/ha(q)

The data Fruit yield/ha(q) of strawberry as influenced by *Trichoderma asperelloides* are summarized in Table number 2.

The data reveals that the Fruit yield/ha (q) of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum Fruit yield/ha (q) of (61.46) was recorded with treatments 9 (TA-80ml/15L) in recorded, while the minimum (10.68) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount or water required for foliar sprays significantly influenced the Fruit yield/ha (q).

The maximum increase in fruit yield/plant following use of *Trichoderma asperelloides* might be due to its effect in cell division and cell elongation. The beneficial effect of *Trichoderma asperelloides* on fruit set and reducing fruit drop might be due to the higher availability of photosynthates. These chemicals are also associated with hormone metabolism which promotes synthesis of auxin, These results are in conformity with **Mandalet al.,(2021)**

QUALITY PARAMETER

TSS °Brix

The data TSS °Brix of strawberry as influenced by *Trichoderma asperelloides* are summarized in Table number 3

The data reveals that the TSS °Brix of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum TSS °Brix of (11.55) was recorded with treatments 9 (TA41-80ml/L) in recorded, while the minimum (10.05) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount or water required for foliar spray significantly influenced the TSS °Brix.

Maximum TSS in treatment- *Trichoderma asperelloides* might be attributed to rapid mobilization of sugars and other soluble solids to developing fruits **Mandal et al., (2021)**.

It may be due to fact that *Trichoderma asperelloides* increases palatability of fruit by influencing blend of TSS, total sugar, vitamin C and juice content as observed by, **Sharma et al. (2016b)**

Titrate acidity

The data Titrate acidity of strawberry as influenced by *Trichoderma asperelloides* are summarized in Table number 3.

The data reveals that the Titrate acidity of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The minimum Titrate acidity of (1.96) was recorded with treatments 9 (TA-80ml/L) in recorded, while the maximum (1.12) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount or water required for foliar spray significantly influenced the Titrate acidity.

The interaction effect of *Trichoderma asperelloides* significantly influenced the titrate acidity percent in strawberry. **Kumar (2010)** reported promontory effect of *Trichoderma asperelloides* on quality parameters in guava. The decrease in acidity in *Trichoderma asperelloides* treated plants might be due to their better utilization in respiration and rapid metabolic transformation of organic acids into sugars **Sharma et al. (2016b)**.

Vitamin C(mg/100ml)

The data Vitamin C(mg/100ml) of strawberry as influenced by *Trichoderma asperelloides* are summarized in Table number 3.

The data reveals that the Vitamin C (mg/100 ml) of strawberry increased significantly by the application of *Trichoderma asperelloides* essence under experiment over the control. The maximum Vitamin C (mg/100 ml) of (52.76) was recorded with treatments 9 (TA41-80ml/L) in recorded, while the minimum (40.01) was recorded under control. Further, the interaction effect of *Trichoderma asperelloides* to the amount of water required for foliar spray significantly influenced the Vitamin C(mg/100 ml).

The maximum Vitamin C content in treatment *Trichoderma asperelloides* was closely observed by **Kumar (2010)**. Higher levels of sugar due to *Trichoderma* application might be explained behind increase in ascorbic acid content which is synthesized from sugar **Bhupesh Chandra Kabdwalet et al.(2018)**.

ECONOMICS

The data on economics of strawberry as influenced by growth regulator are summarized in Table number 4

The data reveals that the economics bitter melon increased significantly by the application of growth regulator under experimentation over the control.

The maximum cost of cultivation (154000Rs.) was recorded with treatments 9 (TA41-80ml/15L) while the minimum cost of cultivation (74000Rs.) was recorded under control.

The maximum gross return (860472 Rs.) was recorded with treatments 9 (TA41-80ml/15L) while the minimum gross return (149558Rs.) was recorded under control.

The maximum net return (706472Rs.) was recorded with treatments 9 (TA41-80ml/15L) while the minimum net return (75558Rs.) was recorded under control.

The maximum B:C ratio (4.59) was recorded with treatments 9 (TA41-80ml/15L) while the minimum B:C ratio (1.02) was recorded under control.

CONCLUSION

Based on the results of the present study, it is concluded that, overall treatment T₈(TA41-80ml/15L) performed best in terms of growth, yield and quality of the strawberry was also obtained from this treatment.

The maximum benefit cost ratio was observed in T₈(TA41-80ml/15L) followed by T₇(TA41-60ml/15L) while the minimum benefit cost ratio was observed in T₀(Control).

Table 1 Effect of application of *Trichoderma asperelloides* on growth of strawberry

Treatment	Treatment combinations	Numbers of	Plant Spread	Plant Spread
Symbol		leaves/plant 120DAT	E-W (cm) 120D AT	N-S (cm) 120DAT
T ₀	(RDN)+Control (Water Spray) N,P,K (100:50:5 0Kg/h)	25.41	27.39	23.39
T ₁	TA41-10ml/15L	27.33	28.31	24.31
T ₂	TA41-20ml/15L	28.08	29.35	25.35
T ₃	TA41-30ml/15L	28.36	30.62	26.62
T ₄	TA41-40ml/15L	29.33	31.29	27.29
T ₅	TA41-50ml/15L	29.48	32.22	28.22
T ₆	TA41-60ml/15L	30.60	33.49	29.49
T ₇	TA41-70ml/15L	30.08	34.06	30.06
T ₈	TA41-80ml/15L	30.72	35.31	31.31
	F-test	S	S	S
	SEm(±)	1.22	0.91	0.91

CD(p=0.05)

3.65

2.72

2.72

UNDER PEER REVIEW

UNDER PEER REVIEW

Table 2 Effect of application of *Trichoderma asperelloides* on yield of strawberry

Treatment Symbol	Treatment combinations	Fruit length	Fruit width	Fruit weight	Number of fruit plant	Fruit yield	Fruit yield
		(mm)	(mm)	(g)	⁻¹	plant ⁻¹ (g)	/hac (q)
T ₀	(RDN)+Control(Water Spary)N,P,K(100:50:50Kg/h)	37.98	30.42	13.49	8.38	118.70	10.68
T ₁	TA41-10ml/15L	39.56	31.25	16.56	9.36	154.95	13.95
T ₂	TA41-20ml/15L	41.46	32.56	19.46	10.46	203.62	18.33
T ₃	TA41-30ml/15L	41.98	33.18	21.85	11.84	258.79	23.29
T ₄	TA41-40ml/15L	43.56	34.29	23.63	12.94	305.82	27.52
T ₅	TA41-50ml/15L	45.78	35.77	27.75	13.82	383.49	34.51
T ₆	TA41-60ml/15L	49.46	36.95	31.46	14.58	458.42	41.26
T ₇	TA41-70ml/15L	51.31	37.98	39.56	15.76	623.50	56.12
T ₈	TA41-80ml/15L	55.46	38.89	40.36	16.92	682.91	61.46
	F-test	S	S	S	S	S	S
	SEm(±)	1.71	1.02	0.80	0.48	14.53	1.31
	CD(p=0.05)	5.12	3.07	2.39	1.44	43.54	3.92

Table 3 Effect of application of *Trichoderma asperelloides* on quality of strawberry

Treatment Symbol	Treatment combinations			
		TSS°Brix	Titrate acidity	Vitamin C (mg/100ml)
T ₀	(RDN)+Control(Water Spary)N,P,K(100:50:50Kg/h)	10.05	1.12	40.01
T ₁	TA41-10ml/15L	10.18	1.23	42.13
T ₂	TA41-20ml/15L	10.31	1.34	42.46
T ₃	TA41-30ml/15L	10.38	1.45	44.58
T ₄	TA41-40ml/15L	10.65	1.56	46.49
T ₅	TA41-50ml/15L	10.88	1.67	46.56
T ₆	TA41-60ml/15L	10.98	1.77	48.63
T ₇	TA41-70ml/15L	11.21	1.89	49.94
T ₈	TA41-80ml/15L	11.55	1.96	52.76
	F-test	S	S	S
	SEm(±)	0.22	0.05	1.13
	CD(p=0.05)	0.67	0.15	3.39

Table 4 Effect of application of *Trichoderma asperelloides* on economics of strawberry

Treatment Symbol	Treatment Combination	Cost of cultivation/ha	Gross Return/ha	Net Return/ha	B:C Ratio
T₀	(RDN)+Control(Water Spary)N,P,K(100:50:50Kg/h)	74000	149558	75558	1.02
T₁	TA41-10ml/15L	84000	195242	111242	1.32
T₂	TA41-20ml/15L	94000	256560	162560	1.73
T₃	TA41-30ml/15L	104000	326077	222077	2.14
T₄	TA41-40ml/15L	114000	385333	271333	2.38
T₅	TA41-50ml/15L	124000	483196	359196	2.90
T₆	TA41-60ml/15L	134000	577613	443613	3.31
T₇	TA41-70ml/15L	144000	785613	641613	4.46
T₈	TA41-80ml/15L	154000	860472	706472	4.59

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