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EVALUATION OF PLANT GROWTH REGULATORS AND COW URINE ON VEGETATIVE VIGOUR, REPRODUCTIVE TRAITS, AND YIELD OF STRAWBERRY (*FRAGARIA* × *ANANASSA* DUCH.) CV. WINTER DAWN

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ABSTRACT
The study was conducted at Horticultural Research Center, College of Horticulture, SVPUAT to assess the vegetative parameters, reproductive parameters and yield of strawberry cultivar Winter Dawn to evaluate the exogenous application of PGR's and cow urine. The experimental trial was carried out using the randomized block design (RBD) with three replications and nineteen treatments. Foliar application of plant growth regulators (GA_3 and NAA) and cow urine was done with concentration (GA_3 75 and 100 ppm), NAA (20 and 30 ppm) and cow urine (5 and 10 %). The results showed that both individual and combined application of foliar spray had shown big impact on the vegetative parameters, reproductive parameters and yield of strawberry plant. The pooled results had shown variation among the treatments for the studied characters. The treatment T_{18} GA_3 100 ppm + NAA 20 ppm + Cow urine 10 % recorded maximum pooled number of leaves (20.23 at 90 DAP), petiole length (12.77 cm at 90 DAP) and maximum canopy spread (E-W 27.51 cm and N-S 24.17 cm). For reproductive and yield parameters, treatment T_{17} – GA_3 75 ppm + NAA 30 ppm + Cow urine 5% significantly advanced the flowering duration taking minimum number of days to flowering (41.76 DAP), maximum number of fruits per plant (20.24) and recording maximum yield per plant (472.98 gm). The treatment effect for days taken to fruit set was non-significant (CD-NS). The findings demonstrate the combined application of synthetic growth regulators and cow urine enhance the vegetative vigor and reproductive traits in strawberry.

KEYWORDS: Strawberry, Plant growth regulators, GA_3, NAA, Cow urine,

INTRODUCTION

Strawberries are soft, luscious, tasty and nutrition rich fruit grown in temperate climatic conditions. It is a small perennial herb which can also be grown in subtropical climatic conditions whose plants behave like an annual belonging to the family Rosaceae with a basic chromosome number n=7. (Roussos et al. 2009, Villarreal et al. 2009). The cultivated Strawberry *Fragaria × ananassa* Duch. has chromosome 2n=56 is a monoecious octoploid of two largely dioecious octoploid species. It is assumed that the hybridization between *Fragaria chiloensis* and *Fragaria virginiana* occurred spontaneously in Europe at the beginning of the 17th century, when females of Chilean *Fragaria chiloensis* were grown close to male of *Fragaria* plants of north American origin (Salentijn 2003, Galletta and Bringhurst 1990).It is a short day plant with antioxidant, anti-inflammatory, anti-neurodegenerative and anti-cancer component called ellagic acid and is rich in vitamin, minerals such as -calcium, potassium and iron (Roussos et al., 2009). Propagation of strawberry is done through runners, and the red color is due to the presence of anthocyanin, pelargonidin, 3- monoglucoside, and traces of cyanidin (Srivastav et al., 2018).

Among all the aspects that contributed on growth, development and quality of strawberry, plant growth regulators (PGR's) are one of the most important factor for crop production (Kender et al. 1971, Sharma and Singh 2009). Exogenous application of plant growth regulators play a pivotal role in crop growth and development (Singh et. al. 2022, Tehranifar and Battey 2002). Different types of PGR's are used like auxin, gibberellin and cytokinin's to increase plant growth, fruit size, quality and other attributes. Among them auxin (NAA) is used to enlarge fruit size and delay fruit ripening while gibberellin is used to inhibit abscisic acid development and develops fruit color (Sharma and Singh 2009, Singh et al. 2022 , Katel et al. 2022).

In recent years, integrating eco-friendly bio stimulants and bioenhancers with conventional plant growth regulators has gained traction for improving crop productivity (Devakumar et al. 2014, Kumar et al. 2025, Pathak and Ram 2013) In

ancient ayurvedic medicine, cow urine has been highly referred to because of its pharmacological significance. Cow urine is one of the components of Panchagavaya (urine, milk, curd, dung and ghee). It also contains 95 %, water, 2.5% urea, a mixture of salts and minerals (e.g. Nitrogen, sulphur, iron, copper), enzymes like (lyase, lipase) and hormones like auxins, cytokinins and trace amount of gibberellins that are known to stimulate meristematic activity (Ghosh et al. 2018 , Kgasudi and Mantswe 2020). Mixing it with synthetic PGR's like GA_3 and NAA can create a powerful synergy, where the natural bio stimulant boosts the hormones effects, provides essential nutrients and cuts down on chemical use.
Although there is standalone application of GA_3, NAA, Organic manures, biofertilizers and micronutrients have been studied in strawberry (Katel et al. 2022, Tripathi and Shukla 2007, Gulzar et al. 2025, Vishal et al. 2016) but there is a little research on how different concentration of GA_3, NAA and cow urine affect the winter dawn cultivar, this study systematically tested nineteen different combinations and goal was to determine their impact on the plant's growth, and reproductive traits.

MATERIALS AND METHOD

Experimental site and planting material-The present investigation entitled "Evaluation of Plant growth regulators and Cow urine on vegetative Vigor, reproductive traits, and yield of Strawberry (*Fragaria × ananassa* Duch.) cv. Winter dawn." was carried out at Horticulture Research Center and Post harvest technology laboratory, College of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India (29.7˚ N,77.71˚E) for two consecutive winter seasons 2024-25 and 2025-26. The data recorded during both experimental years were pooled for statistical analysis.
This study evaluated the effects of plant growth regulators and cow urine on the winter dawn strawberry, a high yielding, day neutral cultivar well suited for lowland cultivation. Healthy, uniform, and disease-free runners were chosen and transplanted on the raised beds (80 cm ×240 cm) with planting distance of 40 × 40 centimeters. Standard agronomic practices were followed to manage irrigation, weeding and pest control throughout the experiment.

Cow urine source and handling- Fresh cow urine was collected by the early morning hours from healthy cows from university livestock farm. Collected urine was filtered through muslin cloth prior to the spray solution preparations. Foliar concentrations of 5% and 10% v/v were prepared fresh by diluting the measured volume of filter cow urine with water.

Experimental design and treatments- The experiment was laid out in Randomized Block Design (RBD) with nineteen treatments replicated thrice. The treatments comprised: T_0 – Control (water spray); T_1 – GA_3 75 ppm; T_2 – GA_3 100 ppm; T_3 – NAA 20 ppm; T_4 – NAA 30 ppm; T_5 – Cow urine 5%; T_6 – Cow urine 10%; T_7 – GA_3 75 ppm + Cow urine 5%; T_8 – GA_3 100 ppm + Cow urine 5%; T_9 – GA_3 75 ppm + Cow urine 10%; T_{10} – GA_3 100 ppm + Cow urine 10%; T_{11} – NAA 20 ppm + Cow urine 5%; T_{12} – NAA 30 ppm + Cow urine 5%; T_{13} – NAA 20 ppm + Cow urine 10%; T_{14} – NAA 30 ppm + Cow urine 10%; T_{15} – GA_3 75 ppm + NAA 20 ppm; T_{16} – GA_3 100 ppm + NAA 30 ppm; T_{17} – GA_3 75 ppm + NAA 30 ppm + Cow urine 5%; and T_{18} – GA_3 100 ppm + NAA 20 ppm + Cow urine 10%. Foliar sprays were applied at fortnightly intervals from the establishment of the runner plants until flower initiation, ensuring uniform and thorough wetting of the foliage.

Observations recorded- Vegetative parameters, viz., plant height (cm), number of leaves per plant, petiole length and plant spread in E-W and N-S were recorded at 30,60,90 days after planting (DAP). Flowering and fruiting behavior was assessed in terms of days taken to first flowering, days taken to initial fruit set. Number of fruits per plants and yield per plant was also recorded during the harvest.
Statistical analysis- The data recorded for each parameter was statistically analyzed following the analysis of variance techniques appropriate for randomized block design. The standard error mean (SE±) and critical difference (CD) at 5 % probability level were computed to determine significance of differences among the treatment means; parameters for which the treatment effect was non-significant were indicated as NS.

RESULT AND DISCUSSION

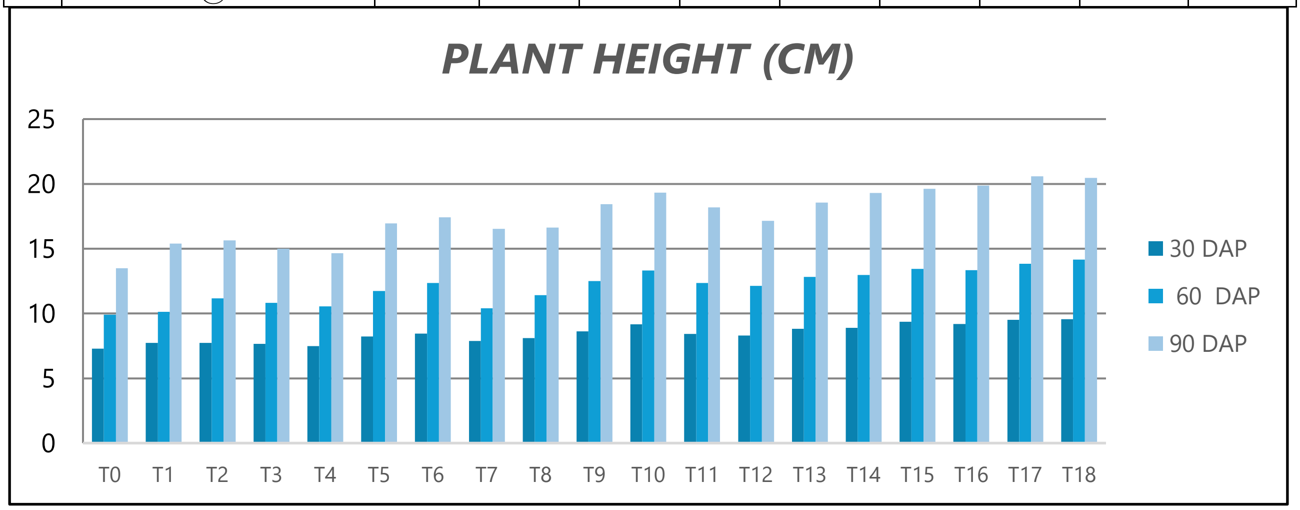
Vegetative growth parameters- As shown in table 1 and table 2, the treatments showed significant differences among treatment for plant height, number of leaves per plant, petiole length, plants spread E-W, and plant spread N-S except petiole length at 30 DAP, which remain non-significant (CD=NS). The Treatment T_{18} (GA_3 100 ppm + NAA 20ppm + cow urine 10%) produced the greatest plant height at 30 and 60 DAP measuring 9.55 cm and 14.15 cm respectively. By 90 DAP, maximum plant height was observed in the T_{17} (GA3 75 ppm + NAA 30 ppm + Cow urine 5%) at 20.59 cm, with the T_{18} performing comparably (20.47 cm). Both treatments significantly outperformed T_0 control (13.49 cm). Furthermore, T_{18} consistently maximized leaf proliferation (7.76, 15.55, and 20.23 leaves per plant at 30, 60, and 90 DAP respectively) and petiole length (10.07 cm and 12.77 cm at 60 and 90 DAP). Plant spread expanded continuously over time, peaking at 90 DAP. The widest canopies were recorded in T_{18} (27.51 cm E-W and 24.17 cm N-S), establishing a clear positive impact of this treatment on lateral vegetative growth. Conversely, the untreated control T_0 exhibited the poorest performance across all measured vegetative traits.
The enhanced efficacy of ternary formulations Relative to individual applications of GA_3, NAA or cow urine maybe ascribed to synergistic physiological mechanisms. GA_3 drive cell elongation and mitotic divisions within the sub apical meristem by mediating starch hydrolysis into the soluble sugars and enhancing cell wall extensibility, which manifests as increased plant height, internodal expansion and leaf area (Rajbhar et al. 2015, Vishal et al. 2016). Concurrently cow urine provides a source of essential macronutrients like nitrogen and potassium and micronutrients complimented by

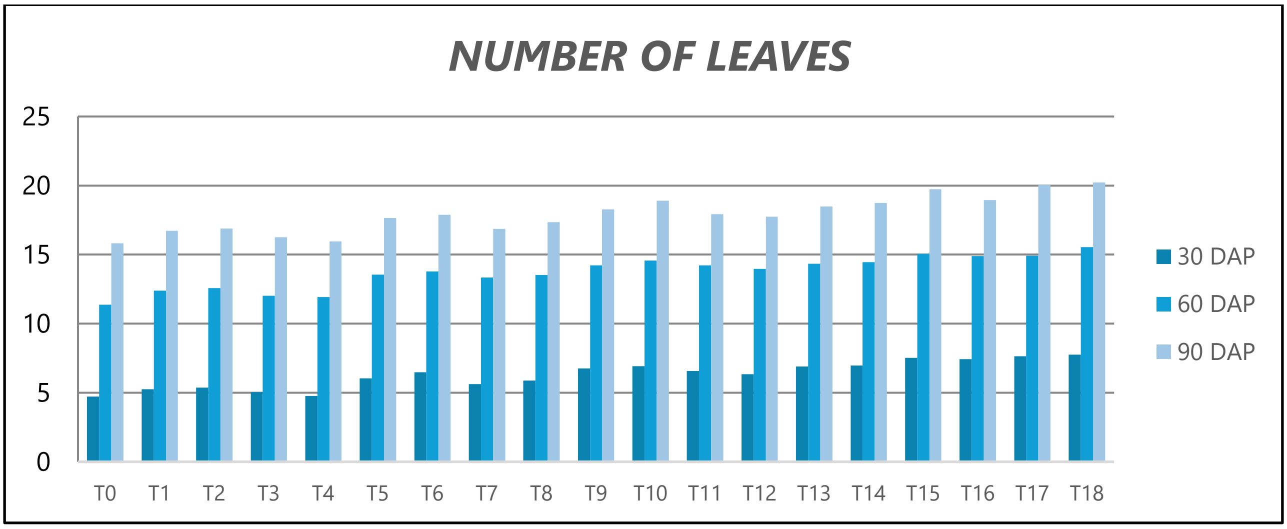
endogenous auxin and cytokinin like compounds that stimulant meristematic activity, cellular proliferation, and chlorophyll biosynthesis, optimizing canopy architecture and petiole development (Kgasudi and Mantswe 2020). These observations align closely with Singh et.al. 2022 who documented that solitary or combined application of GA_3 and NAA significantly increased plant height, foliage count and canopy spread in strawberry (*Fragaria × ananassa* cv. Chandler). Similarly, Tehranifar and Battey (2002) established that GA_3 substantially enhances petiole elongation and laminar area across diverse photoperiodic thermal environments. Furthermore the additive influence of cow urine on plant spread corroborates the findings of Kumar et al. (2025) and Kgasudi and Mantswe (2020), who linked its bio stimulatory properties to a rich matrix of elemental nutrients, endogenous phytohormones and metabolic enzymes.

Reproductive and yield parameters- Because accelerated flowering is a critical economic trait in strawberry production, floral initiation intervals were evaluated. Foliar treatment applications significantly increased durations to the first flowering and fruit count per plant. While fruit set remained non-significant (CD=NS).
As shown in table 3 Earliest floral initiation occurred under treatment T_{17} (GA_3 75 ppm + NAA 30 ppm + Cow urine 5%) at 41.76 days. This was followed by T_{18} (GA_3 100 ppm + NAA 20ppm + cow urine 10%) at 42.08 days and T16 (GA_3 100ppm + NAA 30 ppm) at 42.64 days. Though mean initial days to fruit set ranged from 5 (T_{17}) to 6.52 days (T_{12}) but ANOVA confirmed these variations were non-significant. Furthermore, T_{17} (GA_3 75 ppm + NAA 30 ppm + Cow urine 5%) maximized reproductive yield with 20.24 fruits per plant closely followed by T_{18} (GA_3 100 ppm + NAA 20ppm + cow urine 10%) with 20.18 fruits both treatments yielded a statistically significant increase of over 55% in fruit quantity relative to control with 13.03 fruits.
Maximum yield per plant was observed in T_{17} (GA_3 75 ppm + NAA 30 ppm + Cow urine 5%) which has observed 472.98 gm which was closely followed by T_{18} (GA_3 100 ppm + NAA 20ppm + cow urine 10%) which recorded 470.49 gm per plant.
The accelerated flowering and increased fruit yield observed with combined application of GA_3, NAA and cow urine can be attributed to the synergistic action of these components. Specifically, GA_3 may substitute for the natural photoperiodic or chilling requirements necessary for strawberry floral induction, there by advancing the flowering timeline (Tehranifar and Battey 2002). Concurrently the synthetic auxin NAA enhances cell division, elongated cells, prevents premature abscission and improves fertilization efficiency by promoting pollen tube growth. This hormonal framework is further augmented by cow urine which supplies crucial micronutrients and phytohormones to boost plant vigor and maximize fruit set. These findings align with previous studies; for instance, Paikra et al. 2018 noted shortened flowering durations and elevated fruit numbers using graded dose of GA_3 and NAA in Sabrina cultivar. Furthermore, Paroussi et al. (2002) confirmed that GA_3 increased the flower bud in different three varieties of strawberry (Laguna, Seascape and Camarosa).
The significant yield enhancement also observed under these treatments can be attributed to complementary mechanisms of synthetic hormones and natural bio enhancers. Exogenous GA_3 stimulates cell division and cell elongation in developing receptacle, increasing fruit weight while synthetic auxin (NAA) acts as a strong sink activator accelerating the translocation and mobilization of photosynthesized carbohydrates directly to the developing berries (Katel et al. 2022, Singh et al. 2022). Cow urine serves as an organic bio stimulant rich in macronutrients, micronutrients and enzymes which enhance chlorophyll biosynthesis and expand canopy spread thereby providing a large photosynthetic apparatus to synthesize and supply sugars required for heavy fruit load (Ghosh et al.2018).

Table 1- Effect of plant growth regulators and cow urine on plant height, number of leaves and petiole length of strawberry cv. Winter Dawn at 30, 60 and 90 days after planting (DAP

	Treatment	Plant height (cm)			Number of leaves			Petiole length (cm)		
		30DAP	60DAP	90DAP	30DAP	60DAP	90DAP	30DAP	60DAP	90DAP
T_0	Control	7.29	9.90	13.49	4.71	11.38	15.82	5.86	7.34	10.06
T_1	GA_3 75 ppm	7.72	10.12	15.39	5.25	12.39	16.72	5.55	7.97	10.34
T_2	GA_3 100 ppm	7.73	11.17	15.65	5.36	12.58	16.89	5.88	8.07	10.44
T_3	NAA 20 ppm	7.66	10.81	15.00	5.04	12.01	16.25	5.83	7.68	10.27
T_4	NAA 30 ppm	7.48	10.56	14.66	4.77	11.92	15.96	5.79	7.47	10.15
T_5	Cow urine 5%	8.23	11.74	16.95	6.05	13.56	17.66	6.09	8.67	11.53
T_6	Cow urine 10 %	8.45	12.35	17.41	6.48	13.78	17.89	6.03	8.78	10.96
T_7	GA_3 75 ppm +Cow urine 5%	7.87	10.39	16.54	5.62	13.34	16.86	5.93	8.39	10.90
T_8	GA_3 100 ppm +Cow urine 5%	8.10	11.42	16.62	5.89	13.53	17.36	5.76	8.51	11.07
T_9	GA_3 75 ppm + Cow urine 10 %	8.61	12.50	18.43	6.76	14.23	18.28	5.86	9.03	11.64
T_{10}	GA_3 100 ppm +Cow urine 10 %	9.16	13.33	19.32	6.92	14.56	18.91	5.96	9.59	12.05
T_{11}	NAA 20 ppm +Cow urine 5%	8.43	12.36	18.19	6.58	14.21	17.93	5.68	8.94	11.44
T_{12}	NAA 30 ppm +Cow urine 5%	8.29	12.12	17.16	6.35	13.97	17.75	5.81	8.77	11.38
T_{13}	NAA 20 ppm +Cow urine 10 %	8.83	12.83	18.56	6.90	14.34	18.49	5.89	9.28	12.04
T_{14}	NAA 30 ppm +Cow urine 10 %	8.89	12.98	19.30	6.96	14.45	18.75	5.47	9.48	12.09
T_{15}	GA_3 75 ppm + NAA 20 ppm	9.36	13.44	19.62	7.53	15.06	19.73	6.01	9.86	12.19
T_{16}	GA_3 100 ppm + NAA 30 ppm	9.20	13.34	19.87	7.43	14.89	18.94	5.67	9.71	12.20
T_{17}	GA_3 75 ppm + NAA 30 ppm + Cow urine 5%	9.51	13.84	20.59	7.65	14.92	20.06	5.75	10.00	12.53
T_{18}	GA_3 100 ppm+ NAA 20 ppm + Cow urine 10 %	9.55	14.15	20.47	7.76	15.55	20.23	5.54	10.07	12.77
	SE±	**0.151**	**0.222**	**0.533**	**0.380**	**0.397**	**0.395**	**-**	**0.343**	**0.382**
	CD@ 5%	**0.433**	**0.637**	**1.529**	**1.090**	**1.138**	**1.133**	**NS**	**0.983**	**1.095**





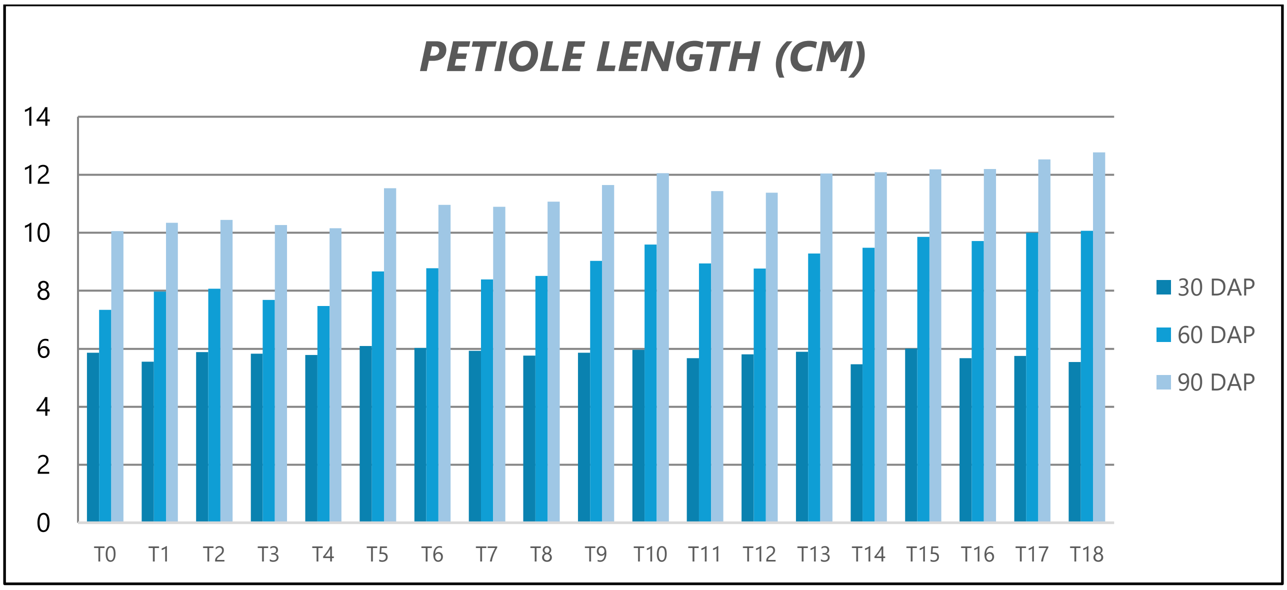
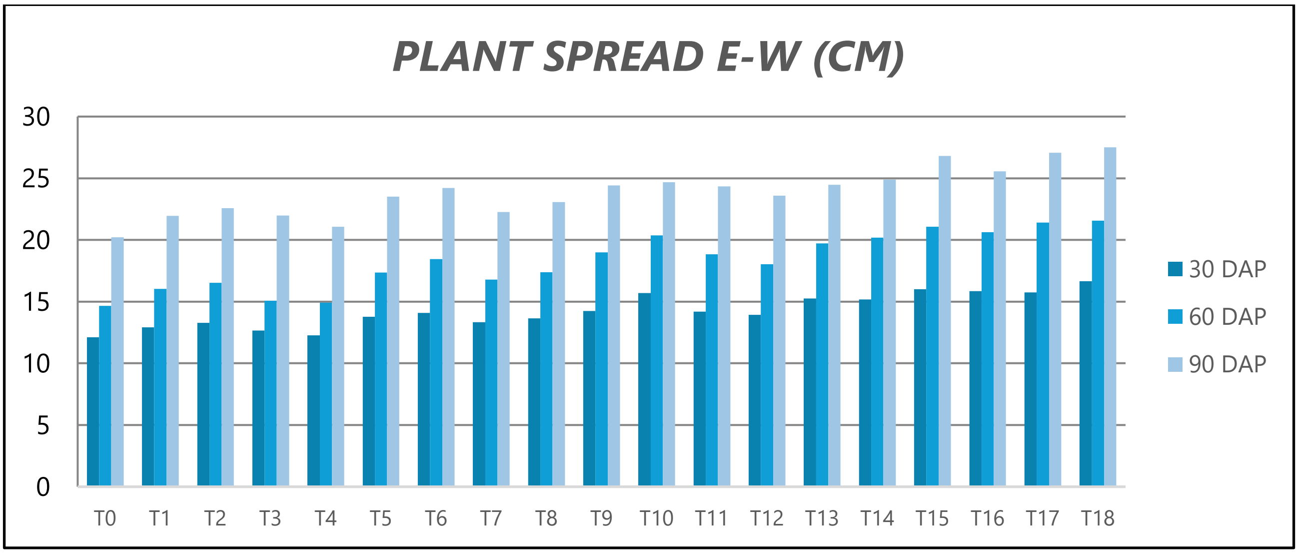


Table 2 - Effect of plant growth regulators and cow urine on plant spread E-W and plant spread N-S of strawberry cv. Winter Dawn at 30, 60 and 90 days after planting (DAP)

	Treatment	Plant spread E-W (Cm)			Plant spread N-S (Cm)		
		30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T0	Control	12.11	14.65	20.22	11.48	13.81	17.47
T1	GA_3 75 ppm	12.92	16.04	21.95	12.11	14.97	18.31
T2	GA_3 100 ppm	13.28	16.53	22.58	12.42	15.89	18.51
T3	NAA 20 ppm	12.67	15.08	21.99	11.89	15.20	18.23
T4	NAA 30 ppm	12.27	14.93	21.07	11.51	14.64	17.10
T5	Cow urine 5%	13.78	17.37	23.50	13.02	16.19	19.76
T6	Cow urine 10 %	14.10	18.46	24.22	13.50	17.13	20.72
T7	GA_3 75 ppm +Cow urine 5%	13.33	16.80	22.27	12.52	15.93	19.12
T8	GA_3 100 ppm +Cow urine 5%	13.65	17.38	23.07	12.80	16.27	19.17
T9	GA_3 75 ppm + Cow urine 10 %	14.25	18.99	24.42	14.23	17.50	21.97
T10	GA_3 100 ppm +Cow urine 10%	15.69	20.38	24.69	14.56	18.50	22.87

T11	NAA 20 ppm +Cow urine 5%	14.18	18.84	24.35	13.56	17.19	21.28
T12	NAA 30 ppm +Cow urine 5%	13.93	18.03	23.60	12.81	16.83	20.22
T13	NAA 20 ppm +Cow urine 10 %	15.26	19.73	24.48	14.18	17.72	22.07
T14	NAA 30 ppm +Cow urine 10 %	15.19	20.20	24.88	14.47	18.13	22.38
T15	GA_3 75 ppm + NAA 20 ppm	16.02	21.08	26.82	15.07	19.06	23.41
T16	GA_3 100 ppm + NAA 30 ppm	15.85	20.62	25.56	14.82	18.91	23.05
T17	GA_3 75 ppm + NAA 30 ppm + Cow urine 5%	15.74	21.40	27.07	15.18	19.41	23.74
T18	GA_3 100 ppm+ NAA 20 ppm + Cow urine 10 %	16.67	21.57	27.51	15.50	19.23	24.17
	SE±	**0.436**	**0.409**	**0.589**	**0.595**	**0.592**	**0.721**
	CD@ 5%	**1.252**	**1.174**	**1.690**	**1.706**	**1.698**	**2.067**



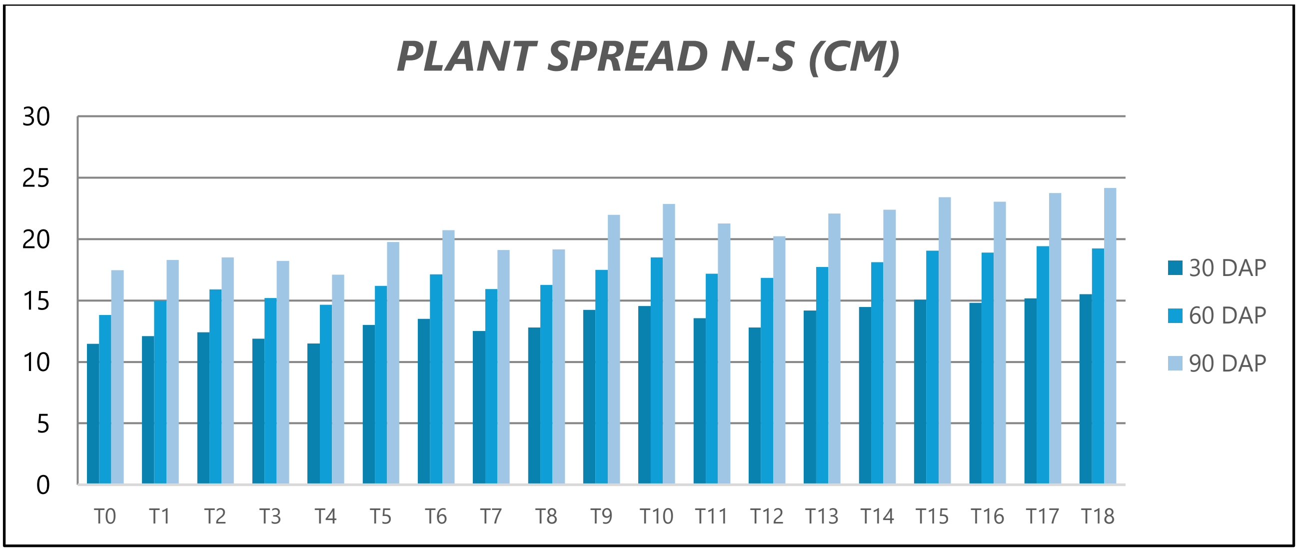
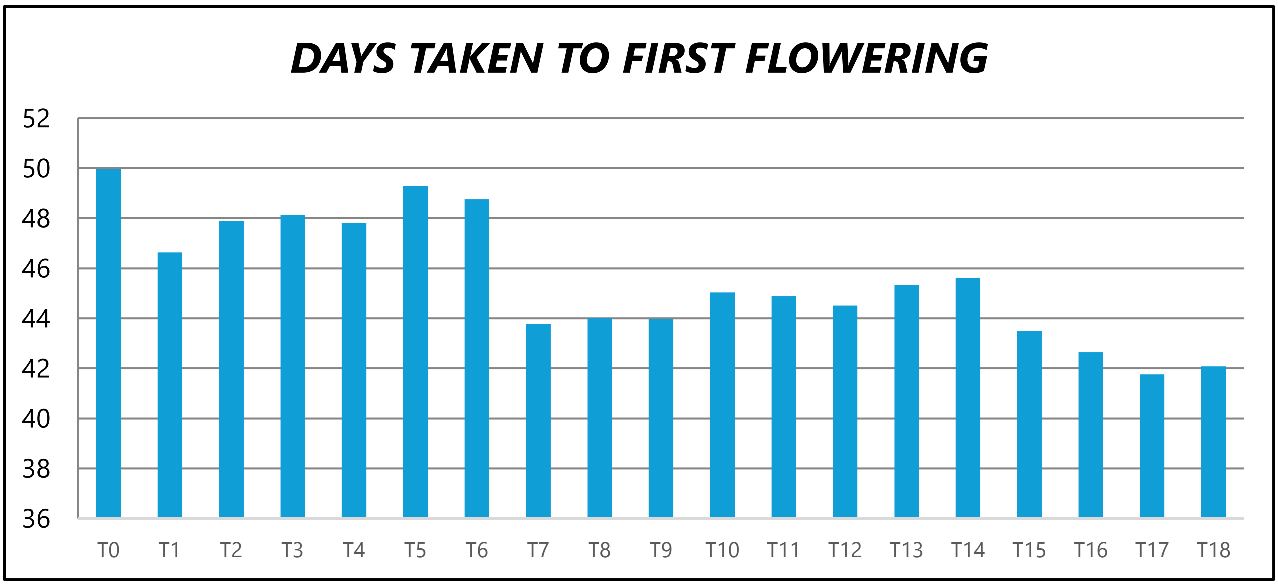
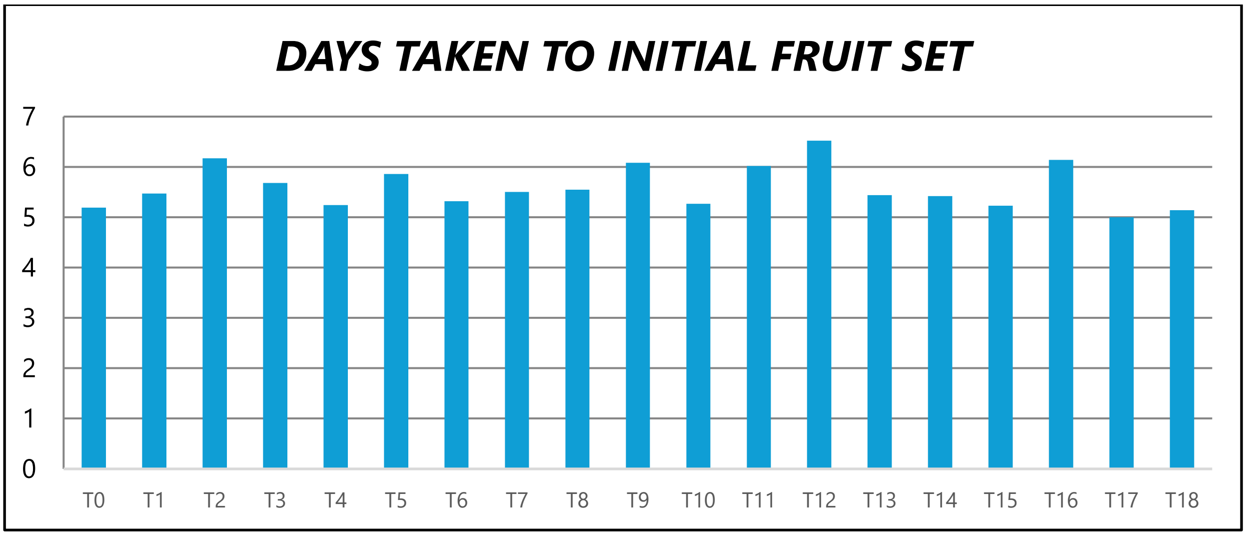
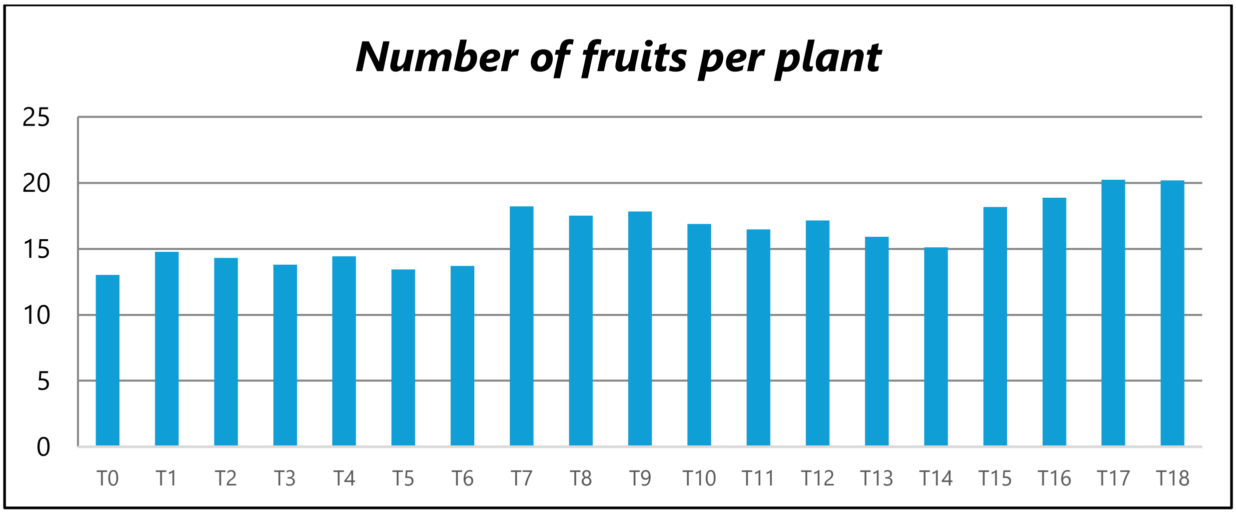


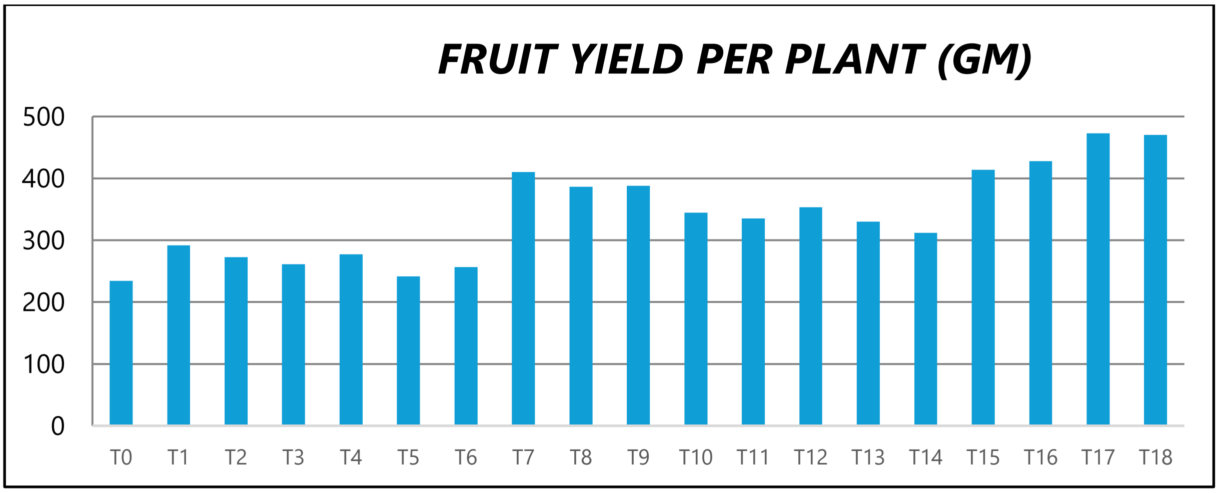
Table 3 - Effect of plant growth regulators and cow urine on days taken to first flowering, days taken to initial fruit set, number of fruits per plant and fruit yield per plant of strawberry cv. Winter Dawn at 30, 60 and 90 days after planting (DAP)

	Treatment	Days taken to first flowering	Days taken to initial fruit set	Number of fruits per plant	Fruit yield per plant
T_0	Control	49.97	5.19	13.03	234.51
T_1	GA_3 75 ppm	46.64	5.47	14.78	291.68
T_2	$GA_3$100 ppm	47.89	6.17	14.32	272.36
T_3	NAA 20 ppm	48.14	5.68	13.81	261.38
T_4	NAA 30 ppm	47.82	5.24	14.44	277.50
T_5	Cow urine 5%	49.29	5.86	13.43	241.79
T_6	Cow urine 10 %	48.76	5.32	13.70	256.33
T_7	GA_3 75 ppm +Cow urine 5%	43.79	5.50	18.21	410.18
T_8	GA_3 100 ppm +Cow urine 5%	44.00	5.55	17.52	386.18
T_9	GA_3 75 ppm + Cow urine 10 %	43.97	6.08	17.83	387.99
T_{10}	GA_3 100 ppm +Cow urine 10%	45.04	5.27	16.89	344.51
T_{11}	NAA 20 ppm +Cow urine 5%	44.89	6.02	16.47	335.07
T_{12}	NAA 30 ppm +Cow urine 5%	44.51	6.52	17.16	353.35
T_{13}	NAA 20 ppm +Cow urine 10 %	45.34	5.44	15.90	330.13
T_{14}	NAA 30 ppm +Cow urine 10 %	45.61	5.42	15.12	312.02
T_{15}	GA_3 75 ppm + NAA 20 ppm	43.49	5.23	18.16	414.08
T_{16}	GA_3 100 ppm + NAA 30 ppm	42.64	6.14	18.87	428.01
T_{17}	GA_3 75 ppm + NAA 30 ppm + Cow urine 5%	41.76	5.00	20.24	472.98
T_{18}	GA_3 100 ppm+ NAA 20 ppm + Cow urine 10 %	42.08	5.14	20.18	470.49
	SE±	**0.912**	**0.360**	**0.652**	**16.197**
	CD@ 5%	2.165	NS	1.870	46.456









CONCLUSION

This study demonstrates that combining foliar plant regulators with cow urine significantly enhances the vegetative growth, flowering dynamics and yield metrics of the strawberry cultivar winter dawn compared to individual applications or untreated control. The ternary treatment T_{17} (GA_3 75 ppm + NAA 30 ppm + Cow urine 5%) proves to be the most promising for recording the earliest flowering, and total number of fruits per plant while treatment T_{18} (GA_3 100 ppm+ NAA 20 ppm + Cow urine 10 %) increased the vegetative growth of the plant. These Findings suggest that integrating low dose synthetics PGR's with an ecofriendly, low-cost organic input like cow urine offers growers a practical and sustainable strategy to enhance strawberry productivity.

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