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Effect of nutrients and organic substances on growth and quality attributes of apple (*Malus* × *domestica*) cv. Anna in semi-arid region of Haryana

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ABSTRACT

An experiment was conducted during 2020–21 and 2021–22 at Horticulture farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana to study the effect of different plant nutrients and organic substances on growth, flowering, quality and yield attributes of the apple (*Malus* × *domestica* Borkh) cultivar Anna. The experiment consists of 19 treatments laid out in a randomized block design. Among the various treatments used, T_{12} (2.0% nitrogen plus 15% cow urine) was found superior for the growth characteristics of plants, viz. plant height (2.87 m) and plant spread (3.02 m). However, the number of days taken for flowering (70.83), fruit set (19.72 %), fruit weight (177.68 g), fruit diameter (6.40 cm), yield (11.25 kg/plant), TSS (11.45 °Brix), acidity (0.51%), total sugars (10.01%), total phenol (70.72 mg GAE/g), total anthocyanin (19.11 mg/100 g) and total carbohydrate (155.55 mg/g) content were significantly influenced by treatment T_6 (400 ppm Boron + 4% Humic acid) during both the years.

Keywords: Anna apple, Cow urine, Growth, Humic acid, Quality, Yield

The cultivated apple (*Malus* × *domestica* Borkh) belongs to the family Rosaceae is one of the most important and widely grown fruits in temperate regions of the world because of its high acreage, production, economic returns, nutritional value and popularity. Anna is a low-chill cultivar of domesticated apples that is cultivated for a dual purpose, ripens early and suitable warm climate. The Anna apple cultivated in warm climates since it blossoms even with fewer chilling hours nearly 300 h than a conventional apple, which requires more than 500 h (Babita 2015). Nutrient supplies for the trees are essential factors for quality fruit production. The appropriately stated nutrient requirements for fruit trees and type of fertilizer use can significantly affect growth and development of fruit tree. Therefore, a balanced nutrient supply is essential for quality production. Foliar fertilization offers several benefits. Furthermore, foliar nutrients application to leaves prevents nutrient loss as compared to soil application (Suman *et al.* 2017). Foliar sprays of fertilizers and organic mixtures containing macro and microelements such as nitrogen, boron, zinc, humic acid and cow urine are good for crop production, perform well with quick plant response (Fernandez *et al.* 2013, Nihad *et al.* 2023).

Plant nutrients such as nitrogen influence tree growth, flower bud formation, yield and fruit quality (Raese *et al.* 2007). Boron is a non-metal micronutrient that significantly affects plant growth and development, essential for cell wall lignifications and stability and carbohydrate, phenol, indole acetic acid and ribose nucleic acid metabolism (Ahmad *et al.* 2009). Zinc is also an essential trace element plays important role in various enzymatic processes. Humic acid also improves plant growth in response to their interactions with membrane transporters that are in charge of nutrient uptake as well as membrane associated signal transduction cascades that control growth and development (Jindo *et al.* 2020). Cow urine contains macro and micronutrients and influence plant growth and fruit quality (Sharma *et al.* 2023). Therefore, this investigation was conducted to study the coupled effect of foliar application of nutrients and organic substances on growth, flowering, yield and fruit quality attributes of apple cultivar Anna in semi-arid region of Haryana, India.

MATERIALS AND METHODS

The experiment was conducted during 2020–21 and 2021–22 at the Horticulture farm (Precision Farming

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Development Centre, PFDC) of Chaudhary Charan Singh Haryana Agricultural University, Hisar, (29º 10´ N and 75º 46´ E and 215.2 m amsl) Haryana on Anna apple. The soil of the study area belongs to the order Entisol a series of sandy loam soils with a *p*H range of 6.5 to 7.2 with high organic matter and good water holding capacity. The plants were planted at 5 m × 5 m spacing. The experiment consisted of 19 treatments, viz. T_0, Control; T_1, 1% Urea (N) + 2% Humic acid; T_2, 1.5% Urea (N) + 3% Humic acid; T_3, 2.0% Urea (N) + 4% Humic acid; T_4, 200 ppm Boron 2% Humic acid; T_5, 300 ppm Boron + 3% Humic acid; T_6, 400 ppm Boron + 4% Humic acid; T_7, 200 ppm Zinc + 2% Humic acid; T_8, 400 ppm Zinc + 3% Humic acid; T_9, 600 ppm Zinc + 4% Humic acid; T_{10}, 1.0% Urea (N) + 5% Cow urine; T_{11}, 1.5% Urea (N) + 10% Cow urine; T_{12}, 2.0% Urea (N) + 15% Cow urine; T_{13}, 200 ppm Boron + 5% Cow urine; T_{14}, 300 ppm Boron + 10% Cow urine; T_{15}, 400 ppm Boron + 15% Cow urine; T_{16}, 200 ppm Zinc + 5% Cow urine; T_{17}, 400 ppm Zinc + 10% Cow urine; T_{18}, 600 ppm Zinc + 15% Cow urine in randomized block design replicated thrice. The foliar application of nitrogen, zinc and boron were applied in the form of urea, borax and zinc monohydrate, respectively, and humic acid and cow urine were applied in liquid form. Foliar spray was done 3 times; at last week of November, 2^{nd} week of February and 3^{rd} week of March.

The growth parameters i.e. plant height (m) and spread (m) were taken during 3^{rd} week to 4^{th} week of November and June, respectively. Whereas, the flowering parameters, days taken for flowering after spray and fruit set percentage were observed during the period of February to April and fruit parameters, viz. fruit diameter (cm), weight (g) and yield (kg/plant) were observed after harvesting from last week of June to 2nd week of July.

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

Fruit firmness was measured with the help of Effegi hand-held penetrometer (Facchini, Alfonsine, Italy) driving an Effegi probe with a convex tip into whole fruit and expressed in kg/cm^2.

Total soluble solids of the fruit juice were estimated with Erma- Hand refractometer (0 to 32°Brix). Acidity was estimated based on neutralization (NaOH 0.1 N) to *p*H 8.1 using phenolphthalein (1–2 drops) as an indicator and values were expressed as per cent malic acid (Ranganna 1986). Total sugars content of fruit juice was determined as per the Lane and Eynon method (Ranganna 1986). The total phenol content (TPC) was quantified according to the Folin-Ciocalteu method and expressed in mg GAE/g fresh weight (Singleton *et al.* 1999) and total anthocyanin content (TAC) in fruits analysed using UV–visible spectrophotometer Cary 300 UV/Vis spectrophotometer. Total carbohydrate content (TCC) was determined colorimetrically by using phenol-sulphuric acid reagent (Herbert *et al.* 1971).

All parameters were analysed based on the pooled data of both the years. Data were examined by analysis of variance using Microsoft Excel software (Microsoft Corporation, Roselle, IL, USA). Wherever, Fisher's LSD test was used to separate the mean effects and significance was defined at $P \leq 0.05$. Correlations among different parameters were processed using Pearson's coefficient (r) by using R correplot package.

RESULTS AND DISCUSSION

Growth and flowering parameters: Foliar application of nutrients and organic substances caused a significant effect on growth and flowering parameters (Table 1). After harvesting of fruits, treatment T_{12} recorded higher plant height (2.87 m) and spread (3.02 m) followed by T_{11}, T_3 and T_{18}. While, lower plant height (1.96 m) and spread (1.98 m) were recorded in T_0 (control). The minimum days taken for flowering after spray (70.83 days) and maximum fruit set (19.72%) were recorded with treatment T_6 followed by T_5 for days taken for flowering and T_{15} for fruit set.

Spray of nitrogen in the form of urea was positively associated with growth characteristics because nitrogen is the primary structural component of proteins, enzymes and photosynthetic systems, plays a crucial role in plant growth. Plant height and spread were enhanced by the foliar application of cow urine because cow urine is a source of macronutrients and other essential elements (Gopal and Gurusiddappa 2022). Foliar applications of these treatments help in quick absorption of nutrients by the plant. The different enzymes and hormones present in cow urine also led to better plant growth. The present findings are supported with the results of Singh *et al.* (2012) in apricot cv. New Castle and Banyal and Banyal (2019) in apple cv. Red Delicious.

Flowering characteristics were positively affected by boron due to its multiple functions in pollination and improving flowering (Alloway *et al.* 2008). Humic acid was also increased floral stimulus synthesis in an inductive cycle due to its florigenic activity (Bhatt and Singh *et al.* 2022). The similar results found with mango cv. Kesar by Ngullie *et al.* (2014).

Fruit and yield attributes: The fruit and yield attributes of apple were highly influenced by different foliar applications of nutrients and organic substances (Table 2). Treatment T_6 significantly recorded higher fruit diameter (6.40 cm), weight (177.68 g), firmness (12.06 kg/cm^2) and yield (11.25 kg/tree) at harvest stage followed by T_5 and T_9 and lowest were observed in T_0.

Fruit weight and diameter increased with foliar application of micronutrients and organic substances due to increase in cell size and intercellular space. The similar findings reported in Florida Prince and Desert Red peach by El-Shewy and Abdel-Khalek (2014). Fruit firmness was significantly affected because boron helps in lignification and maintenance of membrane integrity (Matas *et al.* 2009). The increase in fruit weight and diameter as a consequence of humic acid application after fruit set was probably attributed to the uptake of mineral nutrients by the plant, however, the possible hormone-like activity of the HA-S in the humic

Table 1 Effect of different nutrients and organic substances on plant growth and flowering attributes of apple cv. Anna

Treatment	Plant height (m)	Plant spread (m)	Days taken for flowering after spray	Fruit set (%)
T_0	1.96 ± 0.04^{e*}	1.98 ± 0.03^{j*}	97.00 ± 00^{p}	12.92 ± 0.04^{i}
T_1	2.55 ± 0.25^{bcd}	2.70 ± 0.02^{de}	86.17 ± 1.59^{jkl}	16.26 ± 0.27^{e}
T_2	2.78 ± 0.15^{bc}	2.86 ± 0.02^{bc}	87.67 ± 0.88^{klm}	14.90 ± 0.15^{fg}
T_3	2.83 ± 0.06^{ab}	2.95 ± 0.01^{ab}	88.33 ± 0.60^{lm}	14.57 ±0.11^{gh}
T_4	2.22 ± 0.24^{de}	2.33 ± 0.01^{i}	79.50 ± 1.00^{efg}	16.93 ± 0.24^{cd}
T_5	2.24 ± 0.17^{de}	2.40 ± 0.02^{hi}	73.00 ± 0.76^{ab}	19.57 ± 0.24^{a}
T_6	2.33 ± 0.14^{cde}	2.45 ± 0.03^{h}	70.83 ± 1.01^{a}	19.72 ± 0.15^{a}
T_7	2.37 ± 0.10^{cde}	2.56 ± 0.01^{g}	82.67 ± 1.16^{ghi}	16.50 ± 0.24^{de}
T_8	2.66 ± 0.15^{bcd}	2.79 ± 0.04^{cd}	75.83 ± 1.20^{bcd}	17.08 ± 0.26^{c}
T_9	2.69 ± 0.02^{bcd}	2.78 ± 0.03^{cd}	74.33 ± 1.01^{bc}	18.37 ± 0.26^{b}
T_{10}	2.57 ± 0.03^{bcd}	2.76 ± 0.04^{de}	90.67 ± 1.36^{mn}	14.22 ± 0.17^{h}
T_{11}	2.85 ± 0.11^{a}	3.00 ± 0.04^{a}	93.17 ± 0.60^{no}	14.17 ± 0.06^{h}
T_{12}	2.87 ± 0.13^{a}	3.02 ± 0.04^{a}	95.17 ± 1.96^{op}	14.08 ± 0.00^{h}
T_{13}	2.26 ± 0.04^{de}	2.38 ± 0.02^{hi}	81.00 ± 1.04^{fgh}	17.30 ± 0.00^{c}
T_{14}	2.39 ± 00^{cde}	2.58 ± 0.02^{fg}	77.33 ± 1.16^{cde}	17.20 ± 0.19^{c}
T_{15}	2.41 ± 0.12^{cde}	2.59 ± 0.01^{fg}	74.16 ± 0.72^{bc}	19.20 ± 0.16^{a}
T_{16}	2.47 ± 0.11^{cd}	2.67 ± 0.03^{ef}	84.83 ± 0.83^{ijk}	15.17 ± 0.07^{f}
T_{17}	2.77 ± 0.35^{bc}	2.86 ± 0.02^{bc}	83.67 ± 1.59^{hij}	15.43 ± 0.14^{f}
T_{18}	2.81 ± 0.04^{ab}	2.93 ± 0.04^{ab}	78.33 ± 0.88^{def}	16.80 ± 0.31^{e}
CD (P=0.05)	0.07	0.09	3.25	0.55

Treatment details are given under Materials and Methods. *Within each column, values followed by same letter do not differ significantly at P≤0.05 by LSD test. Data are the mean ± standard error for 2020 and 2021.

Table 2 Effect of different nutrients and organic substances on fruit physical properties and yield of apple cv. Anna

Treatment	Fruit diameter (cm)	Fruit weight (g)	Fruit firmness (kg/cm^2)	Yield (kg/plant)
T_0	5.06 ± 0.10^{h*}	140.15 ± 1.04^{m}	8.30 ± 0.05^{j}	6.65 ± 0.22^{j}
T_1	5.35 ± 0.17^{fgh}	149.83 ± 2.18^{j}	9.43 ± 0.24^{hi}	8.22 ± 0.10^{ghi}
T_2	5.33 ± 0.05^{fgh}	147.45 ± 0.19^{jk}	9.99 ± 0.02^{fgh}	8.16 ± 0.15^{hi}
T_3	5.26 ± 0.14^{fgh}	144.74 ± 1.15^{klm}	10.26 ± 0.08^{efg}	8.03 ± 0.00^{hi}
T_4	5.54 ± 0.18^{defg}	167.07 ± 1.59^{efg}	11.18 ± 0.10^{bcd}	9.66 ± 0.00^{cde}
T_5	6.35 ± 0.08^{a}	176.17 ± 0.73^{ab}	11.82 ± 0.17^{ab}	11.04 ± 0.68^{a}
T_6	6.40 ± 0.16^{a}	177.68 ± 1.49^{a}	12.06 ± 0.09^{a}	11.25 ± 0.01^{a}
T_7	5.47 ± 0.03^{efg}	162.73 ± 3.65^{gh}	11.02 ± 0.09^{cde}	9.25 ± 0.21^{ef}
T_8	5.96 ± 0.09^{bc}	172.76 ± 0.73^{bcd}	11.38 ± 0.06^{abc}	10.17 ± 0.22^{bcd}
T_9	6.20 ± 0.03^{ab}	173.76 ± 1.62^{abc}	11.40 ± 0.90^{abc}	10.70 ± 0.13^{ab}
T_{10}	5.22 ± 0.05^{gh}	146.17 ± 0.55^{jkl}	8.34 ± 0.42^{j}	7.96 ± 0.03^{hi}
T_{11}	5.19 ± 0.16^{gh}	144.33 ± 1.50^{klm}	8.35 ± 0.05^{j}	7.59 ± 0.11^{i}
T_{12}	5.18 ± 0.06^{gh}	142.32 ± 2.01^{lm}	8.42 ± 0.05^{j}	7.37 ± 0.06^{ij}
T_{13}	5.51 ± 0.12^{defg}	164.57 ± 1.05^{fg}	10.40 ± 0.03^{def}	9.46 ± 0.52^{def}
T_{14}	5.78 ± 0.17^{cde}	169.55 ± 1.15^{cde}	10.79 ± 0.01^{cde}	9.92 ± 0.21^{bcde}
T_{15}	5.85 ± 0.09^{cd}	170.76 ± 1.62^{cde}	11.11 ± 0.15^{bcd}	10.47 ± 0.51^{abc}
T_{16}	5.38 ± 0.06^{fgh}	156.74 ± 0.46^{i}	9.08 ± 0.08^{j}	8.78 ± 0.17^{fgh}
T_{17}	5.40 ± 0.05^{fgh}	159.79 ± 1.29^{hi}	9.57 ± 0.09^{ghi}	9.05 ± 0.21^{efg}
T_{18}	5.62 ± 0.15^{cdef}	168.40 ± 0.28^{def}	9.92 ± 0.09^{fgh}	9.80 ± 0.34^{cde}
CD (P=0.05)	0.32	4.38	0.72	0.80

Treatment details are given under Materials and Methods. *Within each column, values followed by same letter do not differ significantly at P≤0.05 by LSD test. Data are the mean ± standard error for 2020 and 2021.

Table 3 Effect of different nutrients and organic substances on biochemical attributes of apple cv. Anna

Treatment	TSS content (°Brix)	Acidity (%)	Total sugars (%)	TPC (mg GAE/g FW)	TAC (mg/100 g)	TCC (mg/g FW)
T_0	9.40 ± 0.07[k*]	0.72 ± 0.01[l]	7.76 ± 0.08[m]	60.05 ± 0.75[i*]	13.70 ± 0.20[k]	135.99 ± 0.13[l]
T_1	10.36 ± 0.04[g]	0.68 ± 0.01[hij]	8.10 ± 0.07[ij]	63.36 ± 0.14[fgh]	15.76 ± 0.37[hi]	141.84 ± 0.76[hi]
T_2	10.59 ± 0.16[ef]	0.62 ± 0.01[f]	8.34 ± 0.04[gh]	64.31 ± 0.67[ef]	16.10 ± 0.06[gh]	143.19 ± 1.21[ghi]
T_3	10.76 ± 0.06[de]	0.61 ± 0.01[f]	8.44 ± 0.05[gh]	64.61 ± 0.57[e]	16.53 ± 0.08[fg]	143.77 ± 1.06[fgh]
T_4	10.93 ± 0.07[cd]	0.56 ± 0.01[cd]	9.31 ± 0.04[c]	68.85 ± 0.19[abc]	17.95 ± 0.25[cd]	149.55 ± 1.36[bcd]
T_5	11.27 ± 0.01[ab]	0.53 ± 0.01[ab]	9.84 ± 0.06[ab]	69.96 ± 0.46[ab]	18.83 ± 0.10[ab]	152.12 ± 0.45[ab]
T_6	11.45 ± 0.03[a]	0.51 ± 0.003[a]	10.01 ± 0.04[a]	70.72 ± 0.97[a]	19.11 ± 0.17[a]	155.55 ± 0.37[a]
T_7	10.81 ± 0.10[d]	0.60 ± 0.004[f]	8.87 ± 0.06[de]	67.16 ± 0.22[bcd]	17.42 ± 0.17[de]	146.88 ± 0.30[de]
T_8	11.08 ± 0.02[bc]	0.55 ± 0.003[bc]	9.65 ± 0.08[b]	68.55 ± 1.10[bcd]	18.43 ± 0.28[bc]	151.29 ± 1.33[bc]
T_9	11.18 ± 0.03[b]	0.53 ± 0.01[ab]	9.78 ± 0.10[b]	69.65 ± 0.58[ab]	18.69 ± 0.05[ab]	151.54 ± 0.86[bc]
T_{10}	9.65 ± 0.09[j]	0.72 ± 0.01[l]	7.81 ± 0.06[lm]	60.57 ± 0.06[hi]	14.34 ± 0.06[j]	136.69 ± 0.98[kl]
T_{11}	9.75 ± 0.05[j]	0.71 ± 0.01[jkl]	7.87 ± 0.05[klm]	61.78 ± 0.42[ghi]	14.44 ± 0.17[j]	137.86 ± 0.32[kl]
T_{12}	9.96 ± 0.06[i]	0.70 ± 0.02[ijk]	7.99 ± 0.05[jkl]	62.35 ± 0.66[fgh]	15.16 ± 0.17[i]	138.77 ± 0.56[jk]
T_{13}	10.78 ± 0.01[de]	0.61 ± 0.01[f]	8.54 ± 0.12[fg]	63.82 ± 1.55[efg]	16.81 ± 0.08[f]	144.86 ± 1.14[efg]
T_{14}	10.83 ± 0.03[d]	0.60 ± 0.00[f]	8.72 ± 0.03[ef]	66.72 ± 0.51[d]	17.13 ± 0.26[ef]	146.18 ± 1.50[ef]
T_{15}	10.95 ± 0.05[cd]	0.58 ± 0.01[de]	9.01 ± 0.06[d]	67.99 ± 0.38[bcd]	17.97 ± 0.23[cd]	148.96 ± 0.59[cd]
T_{16}	10.15 ± 0.10[h]	0.68 ± 0.02[hij]	8.06 ± 0.08[ijk]	62.92 ± 0.27[efg]	15.69 ± 0.11[hi]	140.74 ± 1.08[ij]
T_{17}	10.45 ± 0.01[fg]	0.66 ± 0.01[gh]	8.02 ± 0.06[jk]	63.43 ± 00[efg]	15.84 ± 0.31[h]	142.99 ± 0.70[ghi]
T_{18}	10.52 ± 0.02[fg]	0.65 ± 0.01[g]	8.25 ± 0.09[hi]	63.60 ± 0.46[efg]	15.89 ± 0.22[h]	143.17 ± 0.14[ghi]
CD (P=0.05)	0.20	0.02	0.20	1.85	0.56	2.34

Treatment details are given under Materials and Methods.

*Within each column, values followed by same letter do not differ significantly at P≤0.05 by LSD test. Data are the mean ± standard error for 2020 and 2021. TSS, total soluble solids; TPC, total phenol content; TAC, total anthocyanin content; TCC, total carbohydrate content.

substances could be responsible for the increase in fruit weight and diameter (auxin, gibberellins and cytokinin-like activity) (Nardi *et al.* 2021). These findings supported with Somaa (2007) on apple trees.

Quality attributes: The biochemical attributes of apple under foliar application of nutrients and organic formulations were significantly affected during the experimentation (Table 3). The maximum TSS and total sugars content (11.45 °Brix and 10.01%, respectively) were recorded with T_6 followed by T_5 and minimum were (9.40°Brix and 7.76%, respectively) in T_0. The lower acidity (0.51%) was observed in T_6 followed by T_5 and T_9. Whereas, higher acidity (0.72%) was observed in T_0.

Different nutrients and organic formulations significantly affected the secondary metabolites in fruit (Table 3). Treatment T_6 recorded significantly higher total phenol (70.72 mg GAE/g FW), total anthocyanin (19.11 mg 100/g) and total carbohydrate (155.55 mg/g FW) content followed by T_5 and T_9. Whereas, the lower total phenol (60.05 mg GAE/g FW), total anthocyanin (13.70 mg 100/g) and total carbohydrate (135.99 mg/g FW) content recorded with T_0. It might be due to the fact that the role of boron in carbohydrate metabolism is focused on the synthesis of cell wall material and the transport of sugars (Marschner 1995). The positive effect of humic acid and boron are consistent with previous findings on Kesar mango by Ngullie *et al.* (2014).

The increase in total sugars seen after the application of humic acid (Hermans *et al.* 2006) owing to the accumulation of more carbohydrates in leaf and fruit tissues, which turned into glucose and sucrose in the end, as well as the breakdown of starch into sugars during ripening. Total phenol and anthocyanin content also increased due to humic acid. Similarly, foliar spray of B and Zn increased fruit quality of mango (Sohnika *et al.* 2017).

Correlations among growth and fruit quality attributes: Fruit set (0.961), diameter (0.941), weight (0.983), firmness (0.902), TSS (0.895), total sugars (0.872), total phenol (0.889), anthocyanin (0.914) and carbohydrate content (0.921) of apple showed a significant positive correlation with fruit yield (Fig. 1). The highest significant positive correlation was observed between total carbohydrate and total anthocyanin content (0.989), plant spread and plant height (0.985), total phenol and total anthocyanin content (0.983), and total phenol and total carbohydrate content (0.982). Similarly, good positive correlation was found between TSS and total anthocyanin content (0.973), total carbohydrate content and total sugars (0.970), total sugars and total phenol content (0.971), and fruit set and fruit weight (0.930). Whereas, significant negative correlation was recorded between total carbohydrate content and

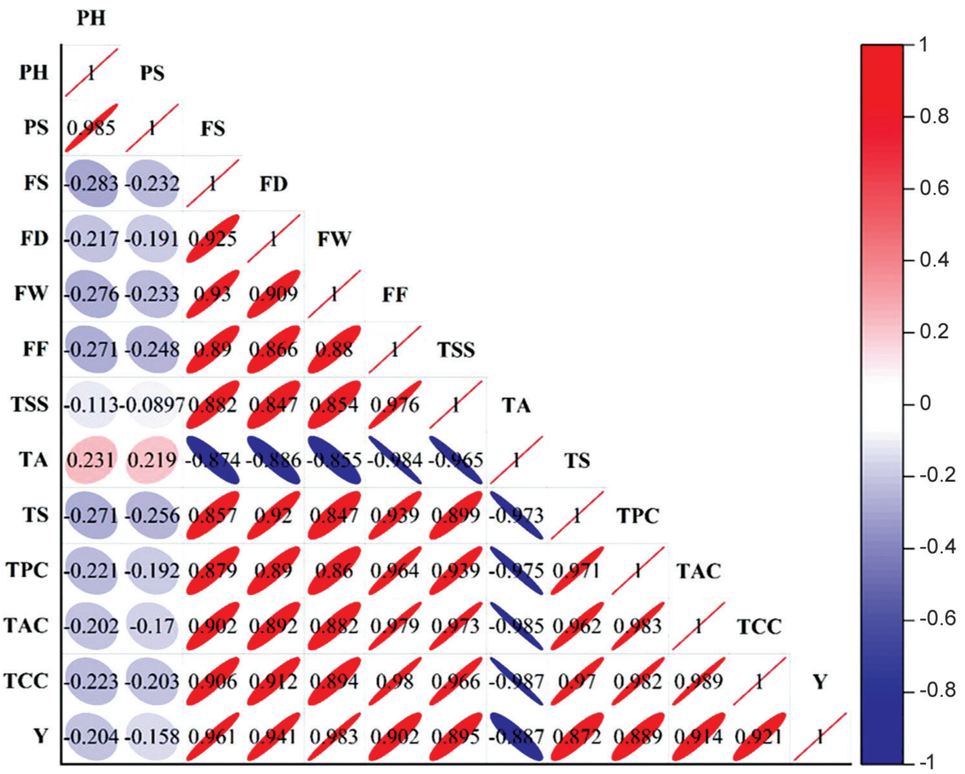

Fig. 1 Pearson's correlation matrix between the growth and fruit quality attributes of apple cv. Anna.

PH, Plant height; PS, Plant spread; FS, Fruit set; FD, Fruit diameter; FW, Fruit weight; FF, Fruit firmness; TSS, Total soluble solids; TA, Titratable acidity; TS, Total sugars; TPC, Total phenol content; TAC, Total anthocyanin content; TCC, Total carbohydrate content Y, Yield.

titratable acidity (-0.987) followed by titratable acidity and total anthocyanin content (-0.985), titratable acidity and fruit set (-0.984), titratable acidity and total phenol content (-0.975), and titratable acidity and total sugars (-0.973). The nutrient combinations accelerate the metabolic activities of the plant. The increase in fruit weight, fruit diameter and fruit volume owing to an increase in cell size and intercellular space (Baker and Davis 1951). Favourable effects of the foliar application of boron might be due to its role in cell division, cell elongation, sugar metabolism and accumulation of carbohydrates (Sourour 2000). Similar findings were reported by Asad (2014) in Anna apple. Humic acid and boron are consistent with previous findings on Kesar mango by Ngullie *et al.* (2014) and Frantoio olive by Hegazi *et al.* (2018).

Our study concluded that the foliar spray of various nutrients and organic formulations had a significant effect on vegetative growth, flowering behaviour, yield and quality of apple cv. Anna and treatment T_{12} was found (2.0% Nitrogen + 15% Cow urine) most effective for enhancing plant growth. Treatment T_6 (400 ppm Boron + 4% Humic acid) found superior for flowering, high yield and quality of apple cv. Anna fruit under semi-arid conditions of Haryana.

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