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Effect of lime and zinc on quality of strawberry in rice-fallow soil of Jorhat, Assam, India

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Abstract
A field experiment was carried out to study the effect of lime and zinc on quality of strawberry fruit in rice fallow soil. The experiment was carried out at ICR Farm, Assam Agricultural University, Jorhat, during 2022-23. Five treatments *viz.*, control, N:P:K @ 10:7:7 g sq m^{-1} (RDF), RDF with Zn @1.0 kg ha^{-1}, RDF with Zn @ 2.0 kg ha^{-1} and RDF with Zn 0.1% foliar spray were applied in both limed (500 kg ha^{-1}) and unlimed plots at 30, 45, 60 and 75 days after planting with four replications of each treatment. The study revealed that application of lime and RDF + Zn 0.1% foliar spray significantly enhanced total Zn content of strawberry fruit. Strawberry quality parameters like total soluble solid, titratable acidity, ascorbic acid, reducing sugar, non-reducing sugar and total sugar was highly significant in limed plot. Maximum total soluble solid, minimum titratable acidity, maximum ascorbic acid, reducing sugar, non-reducing sugar and total sugar was observed in the application of RDF + Zn 0.1% foliar spray.

Keywords: Strawberry, lime, zinc, reducing sugar, ascorbic acid

Introduction
Strawberry (*Fragaria x ananassa*), being a delicious and nutritious fruit, has high demand in fruit market. It gives the quickest return among all berries in shortest time (Boriss *et al*., 2006) [1]. In Assam, generally monocropping system of rice dominates and the fallow land after harvesting of the crop can be better utilized for growing strawberry crop for relatively short duration, high market price and less requirement of irrigation water. But emphasis should be given in proper nutrient management and liming as high yielding and hybrid variety of rice may exhaust soil nutrient (Zhang and Wang, 2005) [2], and soils of Assam are mostly acidic in reaction (Sen *et al.*, 1997, Barooah *et al.*, 2023) [3, 4].
Strawberry prefers slightly acidic soil in the pH range of 5.3 to 6.5 (Dixon *et al.*, 2019) [5]. It can also be grown in extremely acidic soil but yield potential and fruit quality is seriously hampered in pH less than 5.3 (Milosevic *et al.*, 2009) [6]. Therefore, liming acid soil is essential to get enhanced quality yield of strawberry. In acid soil with pH less than 5.0, basal application of lime is beneficial for strawberry cultivation (Cutcliffe *et al*., 1984) [7]. Liming maintains the pH balance of soil and supplies calcium need of strawberry plants (Sahin *et al*., 2018) [8]. Strawberry plant is very sensitive to nutritional balance (Mohamed *et al*., 2011) [9] and optimal fertilization of both macro and micronutrients enhance the quality and yield of strawberry. Application of micronutrients at proper stage may improve fruit yield and physiochemical characteristics of strawberry (Bairwa *et al.*, 2020) [10]. Zinc is one of the essential micro-nutrients which improves vegetative growth, flowering, yield, quality and shelf life of strawberry fruit (Chaturvedi *et al.*, 2005; Rehman *et al.*, 2019) [11, 12]. Foliar spray of micronutrients in strawberry can be recommended (Farid *et al.*, 2020) [13] for easy translocation of nutrients to obtain better growth, yield and quality of strawberry.

Materials and Methods
A field experiment was carried out in 2022-2023 at ICR farm of Assam Agricultural University (26°44′N, 94°10′E and 91m above MSL), Jorhat to study the effect of lime and zinc on quality of strawberry fruit with five treatments and four replications laid out in split plot design.

After harvesting of winter rice, thorough land preparation followed by ploughing and harrowing was done in a plot size of 1.5 m x 2.5 m and strawberry saplings (variety: Winter dawn) were planted at a spacing of 45 cm x 45 cm in both limed (M1) and unlimed (M2) plots. The treatments were applied in both limed (M1) and unlimed (M2) plots as T_1-Control, T_2- N:P:K @ 10:7:7 g per sqm (RDF), T_3-RDF + Zn 1.0 kg/ha (basal), T_4-RDF + Zn 2.0 kg/ha (basal) and T_5-RDF + Zn 0.1% foliar spray at 30,45,60,75 DAP. The fertilizers N, P_2O_5 and K_2O were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) respectively. After planting, required irrigation was provided until fruiting begins. The complete harvesting of strawberry was over by mid-March of 2023. Various quality parameters were recorded and the data were statistically analysed calculating the respective F values. Total soluble solid (TSS) of the fruits was measured by using Zeiss hand juice Brix refractometer. sugars (reducing, non-reducing and total) were determined by Fehling 'A' and 'B' solution method of Ranganna (1977) [14]. Titratable acidity was estimated by standard method (Anonymous, 1980) [15] and ascorbic acid content of the strawberry fruits was evaluated by using the volumetric method (Sadasivam and Manickam, 2018) [16]. Total nutrient contents in the fruits were also determined by using standard methods. Total nitrogen content was estimated by modified Kjeldahl method (Jackson, 1973) [17], total phosphorus was determined colorimetrically by Vanado-molybdate phosphoric yellow colour method (Jackson, 1973) [17], total potassium content was determined by flame photometer (Jackson, 1973) [17] and total Zn was estimated by AAS.

Results and Discussion

Quality parameters of strawberry

The data presented in Table 1 revealed that liming significantly increased total soluble solid, ascorbic acid, reducing sugar, non-reducing sugar and total sugar and decreased titratable acidity of strawberry fruits. Increased total soluble solid (TSS) and ascorbic acid in fruits grown in limed soil might be due to uptake of more calcium from exchange site of limed soil and thereby increased total soluble solid and ascorbic acid of fruit. Similar findings were observed by Zhang *et al.*, (2021) [18] in pomelo.

Among the nutrient management, strawberry fruits treated with RDF + Zn 0.1% foliar spray reported the highest total soluble solid (8.81 ^oBrix), lowest titratable acidity (0.63%) and highest ascorbic acid 76.6 mg $100g^{-1}$). This might be due to foliar application of zinc sulphate enhanced uptake of zinc and thereby enhanced photosynthesis and regulates the enzymatic activity to mobilize the carbon compounds into glucose (Chaturvedi *et al.*, 2005) [19]. Song *et al*. (2015) [20] reported increased TSS in *Vitis vitifera* crop due to foliar spray of zinc sulfate. Rath *et al*., [21] reported that foliar application of zinc sulphate increased Vit. C. These results are in confirmation with the findings of Kumar *et al*., (2010) [22]. The highest reducing sugar (4.98%), non-reducing sugar (1.03%) and total sugar (6.06%) was observed in fruits grown on RDF + Zn 0.1% foliar spray treated soil and minimum sugars were found in strawberry fruits grown in unfertilized soil. Similar result was reported by Kumar *et al*., (2010) [22] and Patel *et al*., (2013) [23] in guava.

Table 1: Quality parameters of strawberry as influenced by the treatments

Treatments	TSS (°Brix)	Titratable acidity (%)	Ascorbic acid (mg 100 g^{-1})	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
Main plot (Liming)						
Limed	9.23	0.57	80.5	5.16	1.02	6.20
Unlimed	8.00	0.75	66.3	4.42	0.90	5.35
CD (5%)	0.22	0.04	3.8	0.11	0.06	0.08
Sub-plot (Nutrient management)						
T_1-Control	8.25	0.72	66.2	4.56	0.91	5.45
T_2-N:P:K (RDF)	8.52	0.67	72.7	4.63	0.92	5.60
T_3-RDF + Zn @ 1.0 kg/ha (basal)	8.70	0.63	74.6	4.86	0.96	5.86
T_4-RDF+ Zn @ 2.0 kg/ha (basal)	8.80	0.64	75.9	4.91	0.99	5.96
T_5-RDF+ Zn 0.1% foliar spray	8.81	0.63	76.6	4.98	1.03	6.06
CD (5%)	4.10	10.48	8.3	0.11	0.04	0.10
CV (%)	9.23	0.57	80.5	9.66	9.72	6.7

Nutrient contents of strawberry

Data on the nutrient content of strawberry fruit as affected by application of lime and nutrient management is presented in table 2. Results showed that liming significantly decreased zinc content of the fruit might be due to lime induced zinc deficiency in soil which in turn affected the uptake of zinc by strawberry. The total nitrogen, total phosphorus and total potassium content in strawberry fruit was non-significantly affected by liming. Similar result was reported by Bhindhu *et al*., (2018) [24]. Among the nutrient management practices, application of RDF + Zn 0.1% foliar spray reported the significantly highest zinc content (25.9 mg kg^{-1}) in strawberry fruit which is at par with basal application of Zn @1.0 kg/ha (22.4 mg kg^{-1}) and 2.0 kg/ha with RDF (23.8 mg kg^{-1}). This might be due to higher mobility of foliar application of zinc influencing more nutrient uptake by strawberry. Similar result was reported by Bhatti *et al*., (2021) [25].

Table 2: Nutrient concentration of strawberry fruit as influenced by the treatments

Treatments	Total N (%)	Total P (%)	Total K (%)	Total Zn (mg kg^{-1})
Main plot (Liming)				
Limed	3.38	0.48	2.30	20.8
Unlimed	3.34	0.45	2.26	24.9
CD (5%)	NS	NS	NS	2.9
Sub-plot (Nutrient management)				
T_1-Control	3.25	0.41	2.10	18.8
T_2-N:P:K (RDF)	3.33	0.50	2.22	20.0
T_3-RDF + Zn @ 1.0 kg/ha (basal)	3.37	0.45	2.31	22.4
T_4-RDF+ Zn @ 2.0 kg/ha (basal)	3.41	0.47	2.34	23.8
T_5-RDF+ Zn 0.1% foliar spray	3.43	0.47	2.36	25.9
CD (5%)	NS	NS	NS	3.5
CV (%)	12.9	7.17	8.11	8.09

Conclusion

Application of lime followed by recommended dose of fertilizer with four application of 0.1% Zn as foliar spray at 15 days interval from 30 DAP significantly increased yield and quality parameters like TSS, titratable acidity, ascorbic acid, reducing sugar, non-reducing sugar and total sugar of strawberry fruit in rice-fallow soil.

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