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Efficacy of different Potassium Sources on Quantitative and Qualitative Character of Litchi cv. Bombai grown in Indo-Gangetic Plain of West Bengal

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ABSTRACT

A field experiment was carried out at Regional Research Station, New Alluvial Zone, Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal, India during September 2014 to July 2017 to study the effect of different sources of potassium on fruit growth, yield and quality of Litchi cv. Bombai grown in Indo-gangetic plain of West Bengal. The experiment was laid out in Randomized Block Design consisting of seven treatments with three replications. All the plants were uniform in growth, 12 years of age and healthy spaced at 10×10 m^2. The results revealed that the application of different sources of potassium significantly improved the physico-chemical qualities and leaf mineral content of litchi. Among the different sources of potassium in the study, application of KNO_3 @ 2% along with fixed doses of N @ 1000 g and P_2O_5 @ 500 g^{-1} $plant^{-1}$ $year^{-1}$ showed maximum vegetative growth in terms of plant height (5.00 m), spread (N-S and E-W) while application of K_2SO_4@ 2% along with fixed doses of N @ 1000 g and P_2O_5 @ 500 g $plant^{-1}$ $year^{-1}$ showed highest fruit retention m^{-2} (32.50 no), yield (72.60 kg $plant^{-1}$), fruit weight (23.03 g), fruit length (4.08 cm), breadth (3.30 cm), aril weight (15.99 g), TSS (19.17 ˚Brix), total sugar (14.98 %), lowest reducing sugar (11.19%) with highest Vitamin C (32.83 mg 100 g^{-1}), Anthocyanin content (38.02 mg 100 g^{-1})and highest mineral content (N, P, K, Ca, B and Zn) of the leaf.

KEYWORDS: Bombai, growth, litchi, leaf minerals, potassium, quality, yield

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1. INTRODUCTION

Litchi (*Litchi chinensis* Sonn.), an indigenous crop of South-East Asia, also recognized as "Queen of the fruits" is an important subtropical evergreen fruit tree belonging to the family Sapindaceae which produces sweet arillate fruits that are very succulent, juicy, aromatic and rich in vitamins and minerals.The major producing countries are China, India, Taiwan, Thailand, Myanmar, South Africa, Mauritius, Hawaii, Madagascar, Brazil, Vietnam, Pakistan, Australia, Israel and Florida (Ghosh, 2001). It was introduced in India by end of 17th century to explore the possibilities of litchi cultivation due to the availability of convenient temperature and climatic conditions in some states of the country (Priyadarshi et al., 2018). Litchi fruits are rich in sugar contents 6.74–18.0%, acid content 0.20 to 0.64% (malic acid, citric acid, levulinic acid, phosphoric acid, glutamic acid). It also contains 40-90 mg vitamin-C^{-1}100 g edible portion, 0.9% protein, 0.3% fat, 0.42% pectin and 0.7% minerals (Ca, P, Fe). Its skin also contains free radical scavenging compounds like ascorbic acid, carotenoids, polysaccharides (Yang et al., 2006) and phenolic substances flavonoids (flavonols and anthocyanins).

India ranks 2nd in the world from the production point of view with cultivated area expansion of 30% in the last fifteen years, it occupies about 92 thousand hectares of land with 600 thousand metric tonnes of production and productivity of 6 mt ha^{-1} (Anonymous, 2018). Still, Litchi suffers from widespread problem of low and irregular bearing habits, poor fruit set, heavy fruit drop, fruit cracking and poor quality (Priyadarshi et al., 2018; Stern et al., 2000). Litchi has been identified as one of the potential fruit for export in India but the yield from the litchi orchards is often low and variable (Mandal et al., 2017). Hence, the production of quality fruit of international standard is of utmost importance. Fertilizer is one of the most important inputs for improving productivity and production of litchi orchards. Proper nutrient management is the key to achieving a higher yield and production of quality fruits. Inadequate nutrition often attributes to low yields in litchi (Menzel and Simpson, 1987) and poor quality of litchi fruit. It has been also observed that leaves and fruit absorbed most of the nutrients within 24–72 hours after spray and thereafter depletion of leaf nutrients content was noted due to translocation of N, P and K to the active developing organs in the plant system (Singh et al., 2007). The supply of potassium in a balanced manner is very important for improving soil health and plant nutrition. The quality of the fruits, especially coloration of the skin, aroma, size, and shelf life, is improved when there is adequate K (Pathak and Mitra, 2010). Potassium is an important mineral for the proper function of all cells, tissues, and organs in the plant and also regulates other physiological processes such as photosynthesis, protein synthesis, phosphorylation, transportation of photo assimilates from source tissues via the phloem to sink tissues, enzyme activation, turgor pressure, transpiration, and stress tolerance. The magnificent role of K as a quality builder is also well established in many fruit crops. In West Bengal, Bombai is the choicest cultivar of litchi but very scanty information regarding the effect of potassium is available in literature. Thus, considering the importance of this mineral on fruit crops the present investigation was carried out to find the effect of different sources of potassium on plant morphological characters, yield and qualitative characters of litchi cv. Bombai in West Bengal.

2. MATERIALS AND METHODS

2.1. Experimental site

The present investigation was carried out at Regional Research Station, New Alluvial Zone, Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal, India (22.57 °N, 89.34 °E, and 9.75 m above mean sea level) for three consecutive years from September 2014 to July 2017. The climate of the region is humid sub-tropical with hot-humid summers and cool winters. The mean annual rainfall is 1,750 mm, out of which 80–90% is normally received from June to September. The soil at the experiment site was alluvial in nature and sandy loam in texture (sand 64.8%, silt 10.4%, and clay 24.8%) with a pH of 6.6 and contained organic carbon of 0.68%, available nitrogen 178.59 kg ha^{-1}, phosphorus 48.50 kg ha^{-1} and potassium 273.12 kg ha^{-1}. Twelve years old healthy litchi plants cv. Bombai spaced at 10×10 m^{2} apart having uniform growth and vigour were selected for the present study.

2.2. Experimental design and crop husbandry

The experiment was laid out in aRandomized Block Designcomprising of seven treatments with threereplications having two plants per replication. Various treatments of different sources of potassium in different concentrations were applied viz. T_1Potassium Nitrate (KNO_3 @ 1%), T_2 Potassium Nitrate (KNO_3 @ 2%), T_3 Potassium sulphate (K_2SO_4 @ 1%), T_4 Potassium sulphate (K_2SO_4 @ 2%), T_5 Potassium chloride (KCl @ 1%), T_6 (Potassium chloride (KCl @ 2%), and T_7 Control (water spray).The above treatments were applied separately along with fixed doses of N @ 1000 g and P_2O_5 @ 500 g plant^{-1} year^{-1} as soil application in two split doses once after fruit set and remaining after harvest of fruit (June-July). The different sources of potassium were applied as foliar spray thrice starting from September, October and November through a foot sprayer. A standard package of practiceswas followed for growing plants and plant protection measureswere taken accordingly through chemical means.

2.3. Methods of data collection

The physicochemical analysis was made following all standard methods as described by Ranganna (2003). The best yield indicator in fruit crops i.e. fruit retention was measuredby the formula given by Sau et al., 2016.

Fruit retention % =No. of retained fruits (at harvest)/No. of settled fruits initially×100

Observations of fruit physical parameters like fruit size (lengthand diameter) were done with the help of Vernier Calipers. Fruit weight, Pulp and aril weight with the help of digital weighing balance wasbased on random ten fruit samples. Biochemical fruit quality wasdetermined from the juice extracted from 10 fruit. The Total Soluble Solid (TSS) was estimated using a digital refractometer (ATAGO, RX 5000, Tokyo, Japan) and was expressed as °Brix. Titratable acidity was determined by titrating 5 ml of juice against 0.1 N NaOH and expressed as % (Anonymous, 2000). Ascorbicacid (mg 100 g^{-1}) content of the guava fruit was estimated by using 2, 6-dichlorophenolindophenol dye titration method (Casanas et al., 2002). Total sugar (%), reducing sugar (%) and non-reducing sugar (%) were determined as per the guidelines of Anonymous (2000).

2.4. Leaf nutrient content determination

For the determination of leaf mineral contents (N, P and K), fiftyrecently mature 3rd pair leaves from the apexwere selected from a non-fruitingshoot at random. Three months old leaf samples in the month of October were taken from the middle portion of the lamina to the width of about 15 cm on both sides of the midrib for leaf mineral analysis. Leaf samples were washed with ordinary detergent, rinsed well with distilled water and dried in the oven at 70°C for 48 h. After drying, leaves were grinded into fine powder using an electric grinder. Then the powder samples were used for analysing total N by micro-kjeldhal steam distillation method (Anonymous, 2000). The samples were further digested in di-acid (nitric acid, perchloric acid in 9:4 v/v ratio) mixture and used for analysing phosphorus using Vanadomolybdo phosphoric acid method, K using flame photometer Murray (1960). For micronutrient content the samples were further digested in the di-acid mixture (HNO_3:$HClO_4$ 10:4) and analyzed for micronutrient (Fe, Mn, Zn and Cu) content following the methods as described by Lindsay and Norvell (1978) by using Atomic Absorption Spectrophotometer and Ca, Mg, S and B by following the methods described by Jackson (1967).

3. RESULTS AND DISCUSSION

3.1. Effect of different sources of potassium on physical growth parameters of litchi

Data on the effect of different sources of potassium on different physical parameters of litchi plant cv. Bombai has been presented in Table 1.

Table 1: Effect of different sources of potassium on physical parameters of litchi plant cv. Bombai

Treat-ments	Plant height (m)	Plant spread (N-S in m)	Plant spread (E-W in m)	Plant girth (cm)	Fruit retention m^{-2} (%)
T_1	4.77^{ab}	6.30^{cd}	6.11^{ab}	66.84^{ab}	29.00^{ab}
T_2	5.00^{b}	6.42^{d}	7.20^{c}	67.00^{ab}	29.67^{ab}
T_3	4.60^{a}	5.83^{bcd}	6.12^{ab}	68.00^{ab}	28.84^{ab}
T_4	4.76^{ab}	5.85^{bcd}	6.29^{b}	72.83^{b}	32.50^{b}
T_5	4.52^{a}	5.78^{bc}	6.23^{b}	67.67^{ab}	29.33^{ab}
T_6	4.68^{ab}	5.45^{ab}	5.70^{a}	68.00^{ab}	31.34^{b}
T_7	4.44^{a}	5.18^{a}	5.59^{a}	64.34^{a}	26.17^{a}
SEm±	0.12	0.20	0.17	2.05	1.08
DMRT p=0.05	S	S	S	S	S

T_1: KNO_3 1%; T_2: KNO_3 2%; T_3: K_2SO_4 1%; T_4: K_2SO_4 2%; T_5: KCl 1%; T_6: KCl 2%; T_7: Control

The different sources of potassium significantly influenced the different physical growth parameters of litchi plant cv. Bombai by increasing the plant height, canopy spread in both direction (N-S; E-W), plant girth and fruit retention m^{-2} as presented in Table 1. Polled data of two years suggested that among the different sources of potassium maximum plant height 5.00 m was obtained for T_2 (KNO_3 @ 2%) application along with a fixed dose of Nitrogen and Phosphorus followed by (4.77 m) in T_1 (KNO_3 @ 1%) and 4.76 m in T_4 (K_2SO_4 2%), while the control plants recorded the minimum (4.44 m) plant height. Like plant height, canopy spread in both the direction, plant girth and fruit retention m^{-2} was also affected by different sources of potassium. From the pooled analysis, as observed it was found that the canopy spread in the North-South direction showed a maximum of 6.42 m in T_2 (KNO_3 2%) followed by 6.30 m in T_1 (KNO_3 1%) which was at par with $T_1$and the least spread 5.18 m was found in T_7 (control) while polled data for canopy spread in East-West direction also recorded similar trends with the maximum 7.20 m spread in T_2 (KNO_3 2%) followed by 6.29 m in T_4 (K_2SO_4 2%) and the minimum 5.59 m was found from T_7 (control) plants. A perusal of pooled data regarding girth of plant in litchi showed a maximum of 72.83 cm in T_4 (K_2SO_4 2%) application followed by 68.00 cm in both T_3 (K_2SO_4 1%) and T_6 (KCl 2%) while the least plant girth 64.34 cm was found in control plants. Pooled data for fruit retention m^{-2} of the plant also showed similar trends with the maximum percentage of 32.50 was observed in T_4 (K_2SO_4 2%) application followed by 31.34% in T_6 (KCl 2%), which was at par with T_4 while the least fruit retention m^{-2} 26.17 was found from control plants (T_7).

Application of KNO_3 @ 2% showed a marked effect on plant height and spread while K_2SO_4 @ 2% showed maximum plant girth and fruit retention m^{-2} at harvest. Improvement in plant characters was more marked with a higher concentration of different sources of potassium than their respective lower concentration. This might be due to the effect of potassium on plant physical characters. A similar observation was obtained by Yang et al. (2015a) in litchi cv. Feizixiao. The increase in the number and size of fruits due to the application of potassium may be attributed to the improvement in vegetative growth of the plant as well as the efficient transfer of photosynthates to the economic part of the plant. According to Nijjar (1990), potassium might have acted as activation for a number of complex enzyme systems and these enzymes catalyze metabolic reactions related to the carbohydrates, nucleic acid and nucleotides, amino acids, protein and folic acid. Foliar spray of potassium might improve leaf photosynthetic CO_2 assimilation; assimilate translocation from leaves to fruits, increased enzyme activation and substrate availability (Hopkins, 1963 and Gross, 1991).The application of potassium can accelerate fibre compounding and epidermal tissue development, thicken the cell wall, and improve the mechanical resistance of collenchymas against bacterial parasites Yang et al. (2015a).

3.2. Effect of different sources of potassium on various yield attributes of mature litchi fruits cv. Bombai

Data on the effect of different sources of potassium on different yield attributes of mature litchi fruits cv. Bombai has been presented in Table 2.

Table 2: Effect of different sources of potassium on various yields attributes of mature litchi fruits

Treatments	Yield (kg plant^{-1})	Fruit wt (g)	Fruit length (cm)	Fruit breadth (cm)	Aril wt (g)	Seed wt (g)
T_1	56.86^{ab}	19.16^{ab}	3.60^{b}	3.04	14.06^{abc}	3.26^{ab}
T_2	61.35^{b}	20.27^{bc}	3.70^{b}	3.13	14.20^{bcd}	3.15^{ab}
T_3	60.79^{b}	20.56^{bc}	3.68^{b}	3.07	15.11^{bcd}	3.28^{ab}
T_4	72.60^{d}	23.03^{d}	4.08^{c}	3.30	15.99^{d}	3.18^{ab}
T_5	64.25^{bc}	21.40^{cd}	3.71^{b}	3.15	13.26^{ab}	3.10^{ab}
T_6	71.24^{cd}	21.73^{cd}	3.91^{bc}	3.16	15.82^{cd}	2.97^{a}
T_7	51.08^{a}	17.76^{a}	3.17^{a}	2.84	13.1^{2a}	3.32^{b}
SEm±	2.72	0.27	0.12	0.14	0.50	0.10
DMRT p=0.05	S	S	S	NS	S	S

T_1: KNO_3 1%; T_2: KNO_3 2%; T_3: K_2SO_4 1%; T_4: K_2SO_4 2%; T_5: KCl 1%; T_6: KCl 2%; T_7: Control

A perusal of data from Table 2 clearly indicated that different sources of potassium significantly influenced the physicochemical composition of mature litchi fruit in terms of yield, fruit weight, fruit length, fruit breadth, aril weight, seed weight and aril: seed ratio. Pooled analysis of two years regarding yield data clearly suggested that statistically significant variation was observed in litchi plants with the highest yield 72.60 kg plant^{-1} was obtained from application in T_4 (K_2SO_4 2%) followed by 71.24 kg plant^{-1} in T_6 (KCl 2%) which was statistically at par with T_4 while the lowest yield 51.08 kg plant^{-1} was obtained from the control plants (T_7). This clearly indicated that by spraying potassium sulphate (K_2SO_4) @ 2% in T_4 the yield of litchi fruit in kg plant^{-1} was increased by 21.52 kg over control plants. In the same way, the fruit weight and fruit length were found statistically significant with the application of different potassium sources and the maximum fruit weight 23.03g was obtained from T_4 (K_2SO_4 2%) followed by 21.73 g from T_6 (KCl 2%) while minimum fruit weight 17.76 g was recorded from control plant. Significantly differences among fruit length were observed due to different treatment of K. Maximum (4.08 cm) length of individual fruit was noted from T_4 followed by (3.91 cm) in T_6 while the least was recorded from control plants. Like fruit length, breadth of fruit was also influenced by the application of different sources of potassium with T_4 (K_2SO_4 @ 2%) recording maximum (3.30 cm) breadth of fruit which is at par with T_6 (3.16 cm) while control fruit recorded minimum (2.84 cm). Application of different sources of potassium significantly increased the aril weight and decreases the seed weight of fruits per plant as compared to the control plant. T_4 (K_2SO_4 @ 2%) treated plants recorded maximum aril weight (15.99 g) followed by (15.82 g) in T_6 (KCl 2%) while minimum (13.16 g) was obtained from control plants.The seed weight was found maximum in control plants T_7 (3.32 g) while the least 2.97 g was obtained in KCl @ 2% treated plants.

The pooled data regarding aril: seed ratio showed to be statistically significant in all the years with the maximum value 5.10 was found with the application of K_2SO_4 2% while the lowest 4.12 was obtained from T_6 (KCl 2%) treated plants as shown in Figure 1.

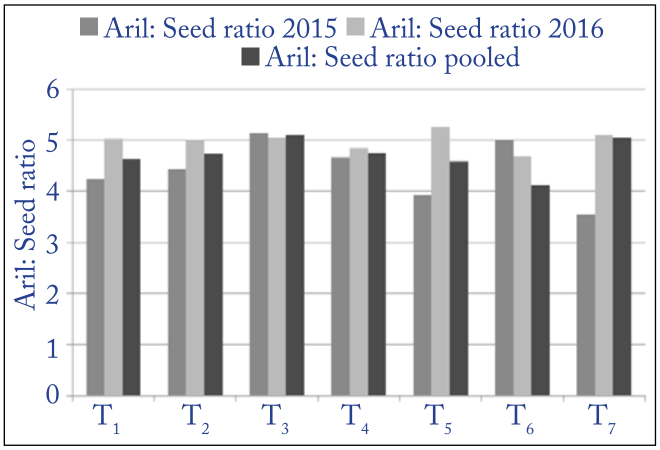

Figure 1: Effect of different sources of potassium on Aril: Seed ratio of litchi fruit cv. Bombai

Application of potassium as foliar spray from different sources viz, K_2SO_4 and KCl showed marked effect on plant characters, fruit weight and yield and other yield attributes of the crop. Foliar spray of the different sources of potassium showed a significant effect on fruit weight, fruit length and breadth, aril weight and yield tree^{-1}. K_2SO_4 @ 2% recorded maximum fruit weight and yield per tree. Cline and Bradt (1980) also observed a greater increase in berry yield with K_2SO_4 or KCl treatments than with KNO_3. Cohen (1976) observed that potassium application not only increased the fruit size but also improved the rind thickness in citrus fruit. Thus it was found K_2SO_4 @ 2% showed more beneficial in increasing individual fruit weight and yield. The improvement in fruit weight with potassium spray might be due to increased photosynthesis which results in the supply of more carbohydrates to the fruits. Potassium is an important nutrient for fruit weight and improvement in fruit quality and it is required for the production and transport of plant sugars which in turn intend to increase the fruit weight (Menzel, 1983). These results are in conformity with the finding of Pathak and Mitra (2010) who observed an improvement in fruit weight with higher leaf K content in litchi cultivar. The results also find support by Gill et al. (2012) in Patharnakh pear, Dutta et al. (2011) and Das et al. (2017) in mango cv. Himsagar.

3.3. Effect of different sources of potassium on bio-chemical composition of mature litchi fruits cv. Bombai

Data on the effect of different sources of potassium on the different biochemical compositions of mature litchi fruits cv. Bombai has been presented in Table 3.

Table 3: Effect of different sources of potassium on qualitative characters of mature litchi fruits cv. Bombai

Treatments	TSS (°Brix)	Total sugar (%)	Reducing sugar (%)	Ascorbic acid (mg 100 g^{-1})	Anthocyanin content (mg 100 g^{-1})	Titratable acidity (%)
T_1	18.12^{ab}	13.52^{a}	11.19^{a}	31.27^{b}	26.64^{ab}	0.36^{a}
T_2	17.42^{ab}	13.48^{a}	11.40^{a}	31.53^{b}	32.62^{b}	0.44^{b}
T_3	18.50^{a}	13.36^{a}	11.36^{a}	29.27^{ab}	31.19^{b}	0.38^{ab}
T_4	19.17^{c}	14.98^{b}	11.05^{a}	32.83^{b}	38.02^{c}	0.38^{ab}
T_5	18.33^{bc}	14.62^{a}	11.88^{a}	31.58^{b}	31.61^{b}	0.42^{ab}
T_6	18.38^{abc}	14.06^{a}	11.67^{a}	30.62^{b}	35.20^{bc}	0.41^{ab}
T_7	16.62^{a}	13.12^{a}	13.03^{b}	25.73^{a}	26.29^{a}	0.51^{c}
SEm±	0.40	0.34	0.34	2.78	1.50	0.02
DMRT p=0.05	S	S	S	S	S	S

T_1: KNO_3 1%; T_2: KNO_3 2%; T_3: K_2SO_4 1%; T_4: K_2SO_4 2%; T_5: KCl 1%; T_6: KCl 2%; T_7: Control

Bio-chemical compositions of fruits were also influenced by the application of different sources of potassiumas evident in Table 3. The different treatments of K showed statistically significant variation and increased the total soluble solids content of fruits. Maximum (19.17 °Brix) TSS content was measured in T_4 (K_2SO_4 2%) followed by (18.50 ^{0}Brix) in T_3 (K_2SO_4 1%), while the minimum (16.62 °Brix) was noted in T_7 (control) plants. Statistically significant influence was also observed in the case of total sugar and reducing sugar by the application of different sources of potassium. Pooled analysis of data in both years revealed a maximum sugar percentage of 14.98% in T_4 (K_2SO_4 2%) followed by 14.62% in T_5 (KCl 1%) which was statistically at par with T_4 while the minimum total sugar 13.12% was found from control fruits (T_7). Pooled data analysis also revealed the lowest reducing sugar 11.19% from T_4 (K_2SO_4 2%)

while the highest reducing sugar (13.03%) was obtained from control T_7. Other quality parameters like ascorbic acid, anthocyanin content and titrable acidity of fruit were statistically significantly influenced by different treatments of potassium. Among the different sources, here also application of K_2SO_4 @ 2% (T_4) pooled data recorded maximum ascorbic acid (32.83 mg 100 g^{-1}) and anthocyanin content (38.02 mg 100 g^{-1}) of fruit while the minimum (25.73 mg 100 g^{-1}) ascorbic acid and anthocyanin content (26.29 mg 100 g^{-1}) was obtained from T_7 (control) plants. Application of different sources of potassium significantly decreased the titratable acid content of fruit with minimum acidity 0.36% obtained from the application of KNO_3 1% in (T_1) which is at par with 0.38% in T_4 and T_3, while the maximum acidity of 0.51% was obtained from control plants (T_7). Graphical representation on TSS: acid ratio of litchi fruits as influenced by application by different sources of potassium has been presented in which it was observed that pooled analysis of data in both years showed maximum value 51.45 in T_4 (K_2SO_4 2%) while the minimum TSS: acid ratio (33.23) was obtained from T_7 (control) plants as observed in Figure 2.

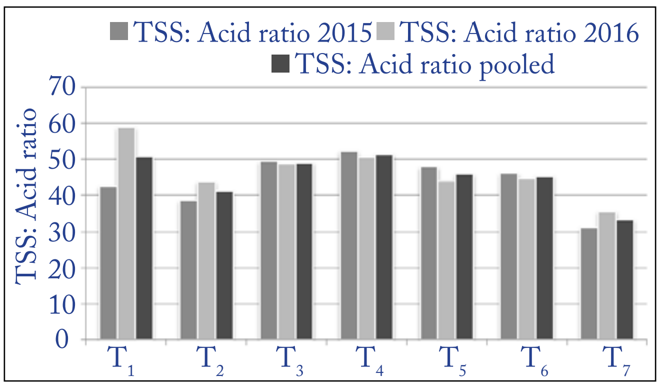

Figure 2: Effect of different sources of potassium on TSS: Acid ratio of litchi cv. Bombai

Considerable improvement in fruit quality with potassium application has been observed which increased TSS, total sugar, reducing sugar, ascorbic acid and anthocyanin content of fruit. Among the different treatments under study application of K_2SO_4 @ 2% proved most effective in improving the quality of fruits. Higher fruit quality especially higher sugar content can be explained by the role of potassium in carbohydrate synthesis, breakdown and translocation along with the synthesis of protein and neutralization of physiologically important organic acids (Tisdale and Nelson, 1966). Potassium is responsible for energy production in the form of ATP and NADH in chloroplast by maintaining a balance in electric charges in the plant system. Beside this, potassium is also involved in phloem loading and unloading of sucrose and amino acids and storage in the form of starch in developing fruits by activating the enzyme starch synthase (Mengel and Kirkby, 1987). Plants require potassium for the production of high-energy molecules (Wallingford, 1973). This energy is required for all synthetic processes involved in plant metabolism, resulting in the production of carbohydrates, protein and lipids, which express the quality of the crops. Potassium supply can increases the sugar: acid ratio because of an increase in sugars as well as a decrease in acidity (Vadivelu and Shanmugavelu, 1978). Potassium application also favors the conversion of starch into simple sugar during ripening by activating the sucrose system enzyme. Neutralization of organic acids due to high potassium levels in tissues could have also resulted in a reduction of acidity (Tisdale and Nelson, 1966). Beneficial effects of K_2SO_4 and other sources were also observed by Dutta et al. (2011) in mango. Das et al. (2017) opined that the beneficial effect of K_2SO_4 may be due to the fact that K_2SO_4 contains considerably more SO_4^{-2} than other sources. An increased amount of anthocyanin in litchi fruit due to potassium application may be due to activation of enzymes that are responsible for anthocyanin synthesis. Similar results were also obtained by Yao et al. (2014) in litchi cv. 'Feizixiao'

3.4. Effect of different sources of potassium on leaf mineral content of litchi plant cv. Bombai

Data on the effect of different sources of potassium on different leaf mineral content of litchi plant cv. Bombai has been presented in Table 4.

The leaf nutrient content of the litchi plant both macro and micronutrients showed statistically significant variation with the application of different sources of potassium. A perusal of pooled data in Table 4 revealed that application of K_2SO_4 @ 2% (T_4) showed a maximum of 1.90% leaf N content followed by 1.86% in T_6 (KCl 2%) while the minimum leaf nitrogen content of 1.59% was found in T_7 (control) plants. The application of different K salts significantly increased the phosphorus content of the leaf. Maximum leaf phosphorus content 0.28% was obtained with application of T_4 followed by 0.24% in T_3 (K_2SO_4 1%) and T_2 (KNO_3 2%) while control plant recorded minimum (0.19%) content. Leaf K nutrient content varied between 0.89 and 0.78% with the highest 0.89% was recorded from T_4 at par with 0.87% in T_2 (KNO_3 2%) while the minimum leaf potassium content of 0.78% was found in T_7 (control) plants. Pooled data also revealed that maximum leaf calcium content of 0.77% was obtained from T_4 (K_2SO_4 2%) followed by 0.67% in T_6 (KCl 2%) which was at par with T_4 while the minimum leaf calcium content of 0.58% was found from control plants.The leaf micronutrient content was also significantly influenced by the application of different sources of potassium. Among them here also application of K_2SO_4 @ 2% (T_4) pooled data recorded maximum leaf zinc

Table 4: Effect of different sources of potassium on leaf mineral content of litchi plant cv. Bombai

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Zn (ppm)	B (ppm)
T_1	1.77^{ab}	0.22^{ab}	0.83^{ab}	0.60^{a}	49.45^{ab}	16.57^{bc}
T_2	1.82^{ab}	0.24^{bc}	0.87^{b}	0.60^{bc}	61.98^{bc}	17.30^{bc}
T_3	1.85^{ab}	0.24^{bc}	0.85^{b}	0.63^{bc}	52.00^{abc}	16.31^{b}
T_4	1.90^{b}	0.28^{c}	0.89^{b}	0.77^{d}	67.17^{c}	19.57^{d}
T_5	1.76^{b}	0.23^{b}	0.84^{b}	0.63^{bc}	51.17^{abc}	17.39^{bc}
T_6	1.86^{b}	0.23^{b}	0.86^{b}	0.67^{c}	61.83^{bc}	18.21^{cd}
T_7	1.59^{a}	0.19^{a}	0.78^{a}	0.58^{ab}	43.68^{a}	13.10^{a}
SEm±	0.06	0.01	0.02	0.03	4.33	0.59
DMRT p=0.05	S	S	S	S	S	S

T_1: KNO_3 1%; T_2: KNO_3 2%; T_3: K_2SO_4 1%; T_4: K_2SO_4 2%; T_5: KCl 1%; T_6: KCl 2%; T_7: Control

content (67.17 ppm) followed by (61.98 ppm) in T_2 (KNO_3 2%) and maximum leaf boron content (19.57 ppm) followed by 18.21 ppm from T_6 (KCl 2%) while the minimum zinc content 43.68 ppm and boron content (13.10 ppm) was obtained from T_7 (control) plants.

The effect of improved soil nutrient availability coupled with better physical conditions of soil was reflected in increased uptake of macronutrients under different sources of potassium significantly improving the Nitrogen, Phosphorus, Potassium, Calcium, Zincand Boron content of the leaf. Application of Potassium sulphate (K_2SO_4) at 2% recorded the maximum Nitrogen, Phosphorus and Potassium and other micro-nutrient content (Zn, B) of the leaf while minimum value was recorded from control plants. Dutta and Dhua (2005) recorded similar observation in Mango cv. Himsagar. They opined that different sources of potassium significantly increased the Nitrogen, Phosphorus and Potassium and other micronutrient content of mango leaf. Studies have also indicated that K can enhance litchi leaf photosynthesis and nutrient accumulation, which are necessary for the following year's production (Yang et al., 2015b). It has been also reported that the addition of K fertilizer as foliar spray may extend the functional period of leaves, thus improving the photosynthetic rate and stimulating the crops (Zheng et al., 2002). Thus this observation collaborates with the present study.

4. CONCLUSION

Among the different sources of potassium application of K_2SO_4 @ 2% showed the highest plant girth, fruit retention m^{-2}, yield and other yield attributes. TSS, total sugar, and lowest reducing sugar with highest ascorbic acid, anthocyanin content and maximum mineral content of leaf. Finally, it can be concluded that K_2SO_4 @ 2% was most effective in improving the plant character, yield, physico-chemical properties and leaf nutrient content in Indo-Gangetic plain of West Bengal.

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