

Leaf Potassium Content Influences Photosynthesis Activity, Yield, and Fruit Quality of Litchi

By P.K. Pathak, K. Majumdar, and S.K. Mitra

Application of 600 and 800 g K_2O /plant/year in two equal splits at 15 days after fruit set and 60 days before flowering increased leaf K content in litchi. Increased leaf K content improved photosynthesis rate, water use efficiency, and stomatal conductance of litchi plants and led to increased yield and improved fruit quality.



Most fruit crops are heavy feeders of K and they usually carry high amounts of K in marketable parts. Among the several factors affecting fruit quality, adequate K application is considered to be of utmost importance. Potassium is known to influence fruit yield in general and fruit quality in particular (Tandon and Sekhon, 1988). Fruit size, appearance, color, soluble solids, acidity, vitamin content, and taste, as well as shelf-life are all significantly influenced by adequate supply of K. These characteristics are in turn affected by photosynthesis, translocation of photosynthates, regulation of stomata, activation of enzymes, and many other processes (Tiwari, 2005). Shortage of K supply adversely affects most of the metabolic processes mentioned above (Marschner, 1995; Mengel, 1997).

Like other crops, K affects photosynthesis in litchi (Deng et al., 1994). Potassium influences the photosynthesis process at many levels namely, synthesis of ATP, activation of enzymes involved in photosynthesis, CO_2 uptake, balance of electric charges needed for photophosphorylation in chloroplasts and is the counterion to the light-induced H^+ flux across the thylakoid membranes (Marschner, 1995). Photosynthesis requires adequate K levels in leaf tissue and lower K levels have been found to decrease photosynthesis rate sharply in corn (Smid and Peaslee, 1976). Debnath (2005) observed that net CO_2 assimilation in litchi, under high irradiance and high ambient CO_2 concentrations, increased at high application rates of K. The present study explores the effect of varying rates of applied K on leaf K content, photosynthesis activity, stomatal conductance, water use efficiency, yield, and fruit quality of litchi.

The experiment was conducted in 2004-2006 at the Horticulture Research Station, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, West Bengal, using 27-year-old litchi plants of the variety Bombai. The experiment was laid out in randomized block design having nine treatments with three replications. The nine combinations consisted of three different levels of K...400 (S_1), 600 (S_2), and 800 g/plant/year (S_3)...and three application timings...15 days after fruit set and 15 days after harvesting (T_1), 15 days after fruit set and 30 days before flowering (T_2), and 15 days after fruit set and 60 days before flowering (T_3). Applications of N at 600 g and P_2O_5 at 400 g plant/year were provided 15 days after fruit set and 15 days after harvesting. Potassium was applied in two equal splits at time intervals mentioned above. The field was irrigated regularly during fruit growth as well as after fertiliser application, except when fertiliser was applied before flowering. Plant protection measures were taken as and when necessary. Leaf K content was



Grading of harvested litchi in the experimental orchard.

estimated by standard procedure (Piper, 1944) after randomly collecting 3rd and 4th pairs of leaves from the tip at the time of panicle initiation. Photosynthesis, stomatal conductance, and transpiration rate were measured weekly after fruit set for two leaves per leaf position on three trees at 1400 hours using a portable photosynthesis system (CI-310, CID, Inc. USA). The water use efficiency was calculated as photosynthetic activity ($\mu\text{mol } CO_2/\text{sq. meter/second}$) \div transpiration ($\text{Mmol } H_2O/\text{sq. meter/second}$) and was expressed in mmol/mol (Veberic et al., 2005). The total soluble solids (TSS) were measured by hand refractometer and titratable acid content was estimated by the method described in AOAC (1990).

The average K content of leaf varied between 0.88 and 1.00% due to different levels and timings of K application (**Table 1**). Plants provided with 600 and 800 g K_2O at 15 days after fruit set and 60 days before flowering showed maximum (1.00%) accumulation of K within the leaf (treatments S_2T_3 and S_3T_3 , respectively). This was followed by K accumulation of 0.95% in treatments S_2T_1 and S_3T_1 . The lowest leaf K content was recorded with 400 g K_2O applied in two equal splits at 15 days after fruit set and 60 days before flowering. In general, higher levels of K application increased leaf K content. Menzel et al. (1995) from Australia reported that leaf K content of litchi was linearly related to K application rate. Higher accumulation of leaf K due to increased K application in litchi was also reported by Lal et al. (1999).

The average photosynthesis activity of leaves (**Table 1**) was

Abbreviations and notes for this article: K = potassium; ATP = adenosine triphosphate; H^+ = hydrogen ion; CO_2 = carbon dioxide.

Table 1. Effect of treatment on average leaf K content, photosynthesis rate, stomatal conductance, water use efficiency of leaves, yield, and fruit quality of litchi.

	Leaf K content, %	Photosynthesis, $\mu\text{mol CO}_2/\text{sq. meter/second}$	Stomatal conductance, $\text{mmol}/\text{sq. meter/second}$	Water use efficiency, mmol/mol	Yield, kg/tree	Fruit weight, g	Aril recovery, %	TSS/acid ratio
S_1T_1	0.93	5.87	17.45	15.33	54.82	20.27	55.89	33.21
S_1T_2	0.93	6.02	18.62	16.34	71.50	23.47	62.21	46.13
S_1T_3	0.88	6.81	20.03	18.01	64.30	23.37	63.63	50.97
S_2T_1	0.95	8.70	21.22	20.43	77.28	20.94	60.46	38.70
S_2T_2	0.89	5.86	16.50	17.47	79.58	23.71	60.98	48.24
S_2T_3	1.00	12.19	27.86	26.45	78.91	24.03	62.42	62.07
S_3T_1	0.95	9.20	22.74	25.21	51.91	21.68	56.46	46.50
S_3T_2	0.92	7.71	22.01	20.78	78.69	22.50	59.56	52.22
S_3T_3	1.00	11.50	25.08	25.62	58.83	22.49	59.58	57.19
Std. Dev.	0.042	2.395	3.65	4.23	11.15	1.30	2.61	8.80
Std. Error	0.014	0.798	1.22	1.41	3.72	0.43	0.87	2.93
S_1 - 400g K_2O /tree/year		T_1 - 15 days after fruit set and 15 days after harvest						
S_2 - 600g K_2O /tree/year		T_2 - 15 days after fruit set and 30 days before flowering						
S_3 - 800g K_2O /tree/year		T_3 - 15 days after fruit set and 60 days before flowering						
N at 600g and P_2O_5 at 400g/tree/year (fixed) were applied 15 days after fruit set and 15 days after harvest.								

$\text{CO}_2/\text{sq. meter/second}$) was found with 1.02% leaf K content (S_3T_3) in the 1st week after fruit set (**Figure 1**). Photosynthesis activity of leaves was highest during the first two weeks after fruit set and declined thereafter until harvest. Treatment S_2T_3 sustained the highest photosynthetic activity until the 4th week after fruit set.

The average stomatal conductance of leaves varied between 16.50 and 27.86 $\text{mmol}/\text{sq. meter/second}$, and it appears that stomatal conductance also increased along with leaf K content (**Table 1**). Highest stomatal conductance corresponded with highest leaf K content (S_2T_3). Average conductance was lowest under S_2T_2 where leaf K

highest (12.19 and 11.50 $\mu\text{mol CO}_2/\text{sq. meter/second}$) when the average leaf K content was 1.00% compared to 6.81 and 5.86 $\mu\text{mol CO}_2/\text{sq. meter/second}$ when leaf K content was lowest at 0.89 and 0.88%, respectively. Thus, higher leaf K content corresponded with increased photosynthetic activity. The highest photosynthesis activity recorded among treatments (17.30 μmol

content was 0.89%. In general, stomatal conductance was high during the first three weeks after fruit set, then it decreased until weeks 5 and 6, and increased once again at the later stages of fruit growth (**Figure 2**). Highest stomatal conductance was 35.20, 35.86, and 27.80 $\text{mmol}/\text{sq. meter/second}$ in the 1st, 2nd, and 3rd week, respectively, under S_3T_3 . This treatment

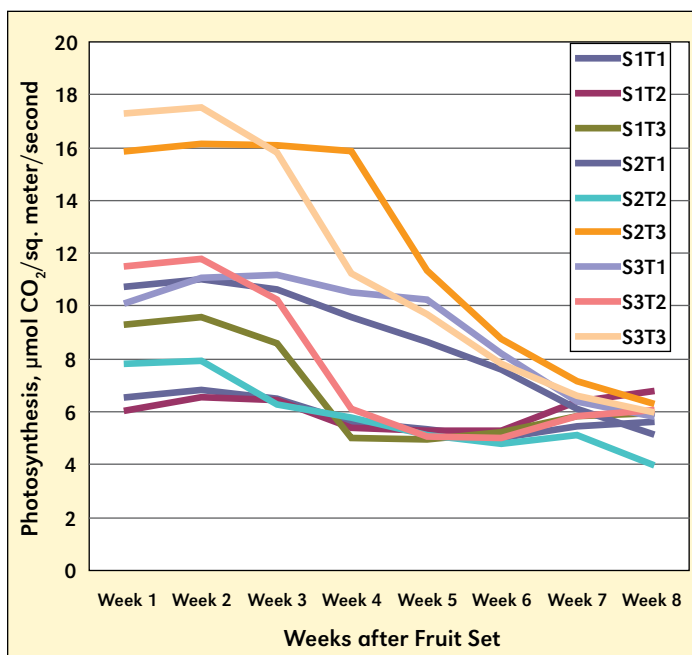


Figure 1. Leaf photosynthesis rate due to different treatments.

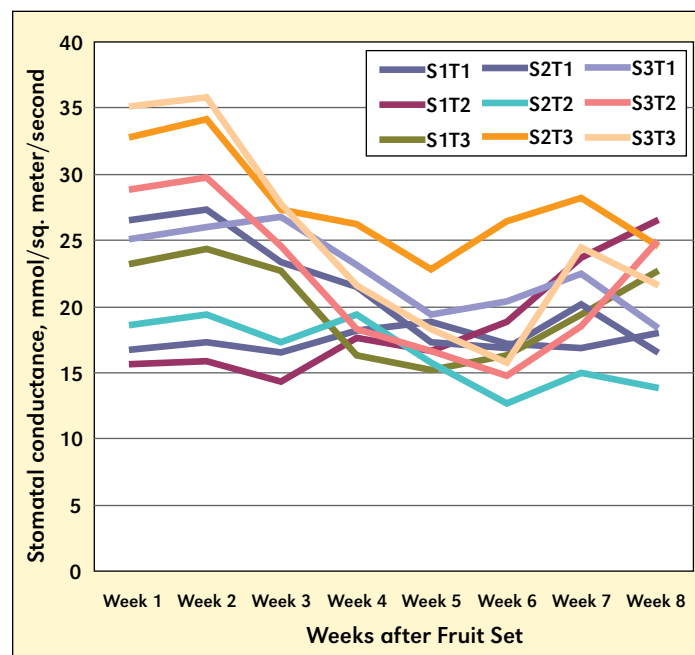


Figure 2. Leaf stomatal conductance rate due to different treatments.



Potassium is important for many key factors in litchi and other crops.

was followed by S_2T_3 (leaf K content was 0.99% and 1.04% in the month of April and May) which continued to have high conductance in the rest of the fruit growth period.

Average water use efficiency was also found to be higher under S_2T_3 and S_3T_3 and was positively influenced by leaf K content (**Table 1**). Water use efficiency was higher in all treatments during the first two weeks after fruit set and gradually decreased up to the 8th week.

Maximum average fruit weight (24.03g), TSS/acid ratio (62.07), and aril recovery (62.42%) were recorded under S_2T_3 . Maximum yield (79.58 kg/tree) was noted for the S_2T_2 treatment, which, however, was statistically at par with the yield achieved under S_2T_3 .

Potassium not only promotes the translocation of newly synthesized photosynthates, but also has a beneficial effect on the mobilization of stored material (Mengel and Kirkby, 1987). We observed higher yield, fruit weight, aril recovery, and TSS/acid ratio of fruit with higher leaf K content. These characteristics are affected by photosynthesis, translocation of photosynthates, regulation of stomata, activation of enzymes and many other processes. Plants require K for the production of high-energy molecules (Wallingford, 1973). This energy is required for all synthetic processes involved in plant metabolism, resulting in production of carbohydrates, proteins, and lipids, which express the quality of the crops. **IC-INDIA**

Dr. Pathak is Subject Matter Specialist (Horticulture) at Krishi Vigyan Kendra Ashokenagar, West Bengal. Dr. Majumdar (e-mail: kmajumdar@ipni.net) is Deputy Director, IPNI India Programme (East Zone). Dr. Mitra (e-mail: sisirm@vsnl.net) is Professor, Department of Fruits and Orchard Management, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, West Bengal.



Increased leaf K content in litchi increased yield and improved quality of fruit.

Acknowledgments

The authors gratefully acknowledge the funding provided by the IPNI India Programme.

References

- A.O.A.C. 1990. Official Methods of Analysis, 14th ed. Association of Official Agricultural Chemist. Washington, D.C.
- Debnath, S. 2005. Optimizing nutrition programme and irrigation for sustainable litchi production. Ph.D. Thesis submitted to Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal.
- Deng, Y.C., et al. 1994. J. South China Agric. Univ., 15: 80-84.
- Lal, R.L., et al. 1999. Prog. Hort., 31:79-83.
- Marschner, H. 1995. Mineral Nutrition of Higher Plants. 2nd Ed. Academic Press. London.
- Mengel, K. 1997. In Food Security in the WANA region, the essential need for balance fertilization (ed: A.E. Johnston). Proceedings of the Regional Workshop of the International Potash Institute, Bornova, Izmir, Turkey, 26-30 May 1997. IPI Bern, Switzerland. pp. 157-174.
- Mengel, K. and E.A. Kirkby. 1987. Principles of Plant Nutrition. 4th Ed. International Potash Institute, IPI, Bern, Switzerland. p. 685
- Menzel, C.M., et al. 1995. J. South African Soc. Hort. Sci., 5: 97-99.
- Piper, C.S. 1944. Soil and Plant Analysis. International Science Publications. Inc. New York.
- Smid, A.E. and D.E. Peaslee. 1976. Agron. J., 68: 904-908
- Tandon, H.L.S. and G.S. Sekhon. 1988. Potassium research and agricultural production in India Fer. Dev. Consult Org., New Delhi.
- Tiwari, K.N. 2005. Better Crops with Plant Food, 89(4): 29-31
- Veberic, R., et al. 2005. Acta Agriculturae Slovenica, 85: 143-155.
- Wallingford, W. 1973. In Potassium for agriculture. Potash & Phosphate Institute, Atlanta, GA. pp. 10-27.