4R Nutrient Stewardship for Sugarcane

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Practicing 4R principles of Nutrient Stewardship can help achieve higher productivity and sustainability of sugarcane cultivation.

Right timing of N at ratoon initiation is essential to ensure adequate soil available N, while foliar fertilization and fertigation proved to be the emerging right methods of fertilizer application for increased productivity of sugarcane.

Sugarcane is one of the major commercial crops of India. It is cultivated on 5.3 million (M) ha, with an annual production of 352 M t of cane and an average productivity of 70.5 t/ha (FAI, 2015). Currently, India consumes about 18.5 M t of sugar, but projections suggest that demand could reach 28 M t by 2020. Hence, sugarcane production systems are facing significant motivation to meet a growing demand for higher production. The major concern of cane growers, and the sugar industry, is the ability to achieve higher sugarcane productivity and high sugar recovery that supports maximum economic returns. Integrated nutrient management through 4R Nutrient Stewardship holds great promise in meeting the nutrient demands of intensive sugarcane systems—maintaining productivity at higher levels while sustaining soil health.

Farmer's choice of right sources of fertilizer application in sugarcane.

Right Source

For sugarcane, N, P, K, micro, and secondary nutrients are all commonly required. Gopalasundaram et al. (2012) has explained the roles of these nutrients in cane production. Nitrogen influences the yield and quality of cane, and the response to applied N is universal. It also increases the source capacity of the leaf due to its role in increasing the leaf area, and the rate of photosynthesis. Phosphorus is essential to hasten the formation of shoot roots and to increase tillering. Improved yield following P application is attributed to an increase in tiller production, weight per cane, and final stalk population. At the optimum level of P application, sugar content and purity of juice are also enhanced. Potassium plays an important role in plant growth and metabolism. It helps in regulating the uptake of water and leaf stomatal opening, maintenance of cell turgidity, and formation of proline during moisture stress. Potassium is also essential for the synthesis and translocation of proteins and carbohydrates, and accumulation of sucrose. Agronomic value of K rests with increased cane volume, girth and weight per cane, drought and disease resistance, and reduced lodging. Potassium application often increases the percentage of sugar in the cane and juice recovery, particularly when harvest is delayed.

The right source of fertilizer for sugarcane should include all these nutrients, in a balanced quantity essential for cane production. The right source could be a proportionate application of fertilizers, farmyard manure (FYM), and compost to supply these nutrients. Different forms of manure have traditionally been important inputs for maintaining soil fertility and crop yield stability. Long-term studies have indicated the necessity for basal application of FYM or compost to maintain optimum soil fertility status. Integrated use of fertilizers with manures also helps to prevent the decline in cane yield. Several experiments have been conducted in the majority of the sugarcane-growing states to study the response to the application of 25 t FYM/ha. The mean response ranged from 3.7 t/ha in Bihar and Gujarat to 11.7 t/ha in Andhra Pradesh. The overall average response was 8 t/ha of cane. During the three years of experimentation, diammonium phosphate (DAP) yielding 97.9 t/ha proved to be superior over single superphosphate (SSP) yielding 95.8 t/ha. This could be due to a higher percent of germination and initial vigor of the cane plants that led to an even higher number of millable canes at harvest with the application of DAP as a source of P (Devi et al., 2012).

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; S = sulfur; Mg = magnesium; Cu = copper; Mn = manganese; C = carbon.

Right Rate

Sugarcane is a long duration crop with C_4 metabolism that produces a very heavy biomass and demands large amounts of moisture, nutrients, and sunlight for its optimum productivity (Gopalasundaram et al., 2012). It has been estimated that a 100 t cane/ha crop removes an average of 208 kg N, 53 kg P, 280 kg K, 30 kg S, 3.4 kg Fe, 1.2 kg Mn, and 0.2 kg Cu (Singh and Yadav, 1996). Nutrient requirement varies with varietal differences in nutrient use efficiency (Gopalasundaram et al., 2012).

Besides common farmer fertilization practice, other less common practices can be based on a state recommendation, a soil test-based recommendation, a recommendation based on tissue analysis, and a determination via site-specific nutrient management through omission plot techniques. The state fertilizer recommendations for sugarcane in the major sugarcane-growing states of India vary from across states depending on the soil type, crop duration, yield level, and irrigated or rain-fed conditions. The recommended rates range from 70 to 400 kg N, 0 to 80 kg P_2O_5, and 0 to 141 kg K_2O/ha (Singh and Yadav, 1996). The fertilizer rates recommended are generally higher

Farmer weighing exact amount for arriving at the right rate of application.

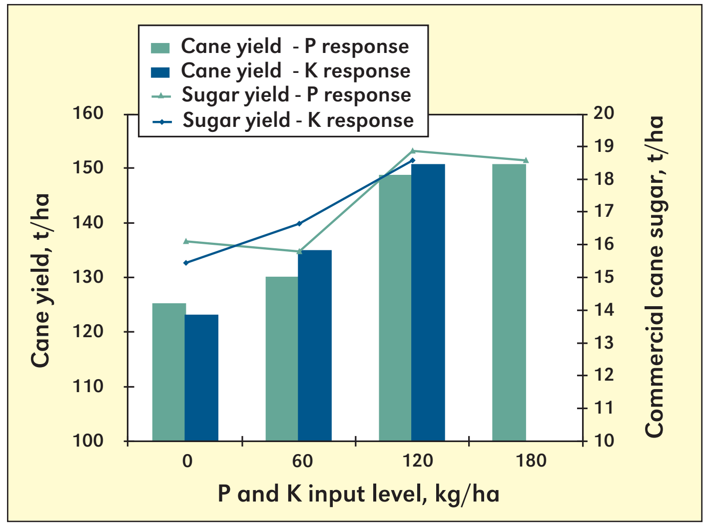

Figure 1. Effect of P and K levels on cane and sugar yield (Source: Phonde et al., 2005).

in tropical states compared to subtropical states. Saini et al. (2006) also reported that application of nutrients up to 400 kg N, 170 kg P_2O_5, and 180 to 190 kg K_2O/ha is recommended for sugarcane depending upon its duration and fertility status of the soil. In several experiments, applied P did not influence yield or quality of sugarcane ratoon to an appreciable extent. This was due to the fact that in most of the cases the soils were high in available P status (Gopalasundaram et al., 2012). However, the need for phosphate application ranging from 30 to 100 kg P_2O_5/ha has been reported to maintain productivity.

In general, and as observed at Mandya (Karnataka), pockets of Haryana, and Jalandhar and Kheri in Punjab, a ratoon crop is relatively more responsive to P application than a planted crop, (Gopalasundaram et al., 2012). Based on a critical review of the response of sugarcane to K fertilizers, Verma (2004) recommended application of 50 to 200 kg K_2O/ha in tropical states where significant response is observed, but responses were very limited in subtropical states. However, application of 66 kg K_2O/ha with irrigation water in standing, subtropical planted cane improved bud sprouting, dry matter accumulation, and nutrient uptake in following ratoon crop (Shukla et al., 2009).

Phonde et al. (2005) reported that site-specific nutrient management produced significantly higher yields compared to a generalized state recommendation, a state lab soil test-based recommendation, and farmer practice. Cane yield was significantly influenced by both P and K. A yield of 150.6 t cane/ha was recorded with 180 kg P_2O_5/ha, but this was statistically equal to the 148.6 t/ha produced with 120 kg P_2O_5/ha (**Figure 1**). Yields produced with 0 and 60 kg P_2O_5/ha were 125 and 130 t/ha, respectively. The cane yield response to 0, 60, and 120 kg K_2O/ha appeared to be linear, suggesting that even greater productivity may be achieved under K application rates beyond 120 kg K_2O/ha. Singh et al. (2008) studied balanced fertilization for sugarcane and reported that application of 200 kg N, 100 kg P_2O_5, and 150 kg K_2O along with 60 kg S/ha and 30 kg Mg/ha together have produced cane yields of 112 t/ha in the Meerut district of western Uttar Pradesh.

Right Time

The timing of fertilizer application assumes great significance in maximizing the benefits. The nutrient application timing should match the nutrient demand throughout the season by high-yielding varieties. In Belguam district of Karnataka, a study was conducted to understand the effect of fertigation on yield and quality of sugarcane in a medium-black soil. The study showed that application of N and K at a recommended rate in six day intervals through drip irrigation, starting from 30 days after planting (DAP) to 240 DAP produced a 25% higher yield and saved 46% of the water applied. This was compared to the recommended fertilizer rate applied with surface irrigation. In this study, N and K were applied at recommended rates of 250 and 185 kg/ha, respectively (Rajanna and Patil, 2003). Another study conducted at Coimbatore, Tamil Nadu, found that an application of urea under a fertigation schedule starting from day 15 to day 180 in a fortnightly interval, reduced volatilization and leaching losses and increased N use efficiency (Hemalatha and Chellamuthu, 2013).

Ratoon crops follow a planted crop, or the preceding ratoons, on the same soil. Due to the impoverished physical soil conditions and relatively poor root system development, absorption of nutrients by the ratoon cane may be negatively affected. Therefore, it is necessary that ratoons are given adequate quantities of manures and fertilizers to result in high yields. Several experiments have proved the need for early fertilizer application to ratoon sugarcane (Gopalasundaram et al., 2012). For ratoon crop, N fertilizers may be applied in two or three splits. Even in cases of split application, a third to half of the N dose should be applied immediately at the time of ratoon initiation to ensure the adequate amount of available N in the soil to overcome the temporary immobilization of N due to microbial activity on the decomposing stubbles. A full dose of P should be applied at the same time as the first dose of N application at ratoon initiation. Compared to a planted crop, a ratoon crop requires more N to produce 1 t of cane.

Nutrient use efficiency (NUE) is also reported to be the highest in planted cane as it decreases with each successive ratoon. Reduced NUE in ratoons is a result of an imbalance in the shoot-to-root ratio at the juvenile stage, delayed shoot-to-root development, and relatively inefficient stubble roots. Response to a higher level of N application in the ratoon crop has been reported from all the sugarcane-growing states. It has been found that ratoon crops generally need 25 to 50% more

N than the planted cane. Application of 25% more N at five to seven days after the ratoon initiation operation produced the highest cane and sugar yields in Tamil Nadu (Mahendran et al., 1995). The yield response to applied N, at the recommended dose for ratoon sugarcane, was reported to be 254 kg of cane/kg N at Anakapalle, 215 kg at Kanpur, 160 kg at Shahjahanpur, 160 kg at Muzaffarnagar, 136 kg at Mandya, 120 kg at Lucknow, and 119 kg at Jalandhar (Verma, 2002).

Right Place

The adoption of the proper method of fertilizer application is essential to minimize the loss of nutrients from the soil and to increase fertilizer use efficiency. Besides increasing cane yield, proper placement also reduces volatilization loss of nitrogenous fertilizers and lowers fixation of phosphatic fertilizers. Placement can occur at 8 to 10 cm deep furrows on either side of the cane rows using implements, placing the fertilizers in the furrows, and then covering them.

Nitrogen flux pathways in the soil are beneficially influenced by management techniques such as mounding of the rows, subsurface banding in narrow fertilizer bands, reduced fertilizer rates, and trash retention along with the timing of fertilizer application. These techniques help to coincide with the optimum uptake by the plant (Reghenzani et al., 1996).

Foliar feeding of N for sugarcane is a well-recognized technique. Foliar application is best used when there are adverse soil moisture conditions, such as waterlogging and limited water supply situations. The use efficiency of foliar applied N could be as high as 90 to 95% (Singh and Yadav, 1996). Foliar application of urea with potash during the formative phase (2.5% each of urea and KCl at 60, 90, and 120 DAP) was found to be beneficial when moisture was limiting. This method can increase cane yield by 19% over control. Soil application of 75% K and foliar application of the remaining 25% at 90 DAP was found beneficial in Kerala where soils are K deficient (Mathew et al., 2004).

Fertigation is another method of nutrient application, considered very effective for sugarcane. The efficiency of nutrient use can be improved when it is applied by fertigation to most of the crops. Fertigation enables adequate supplies of water and nutrients with precise timing and uniform distribution to meet the crop nutrient demand. Fertigation can be a more efficient means of applying crop nutrients, particularly N and K as compared to surface application (Bharadwaj et al., 2007; Hemalatha and Chellamuthu, 2013). Studies have reported that drip irrigation can increase the sugarcane yield from 111 to 150 t/ha in Tamil Nadu, while keeping the fertilizer application rates the same (Bharadwaj et al., 2007). Bangar and Chaudhuri (2004) also reported that application of fertilizers through drip irrigation resulted in significant increase in cane yield (28%) and water use efficiency (114%) over surface irrigation method. Pawar et al. (2013) reported that 100% drip fertigation showed 42% increase in yield. Yield increased up to 25% (about 166 t/ha) by applying only N through drip against the conventional method (133 t/ha). Fertigation also resulted in saving 40% of the fertilizer (Hemalatha and Chellamuthu, 2013).

Summary

This article provides general guidelines for 4R Nutrient Stewardship of sugarcane under varied agro-climatic situations. The review highlights that a general nutrient management recommendation may not be ideal for optimum return and the 4R concept needs to be adapted for different growing conditions to achieve higher productivity and increased profits from sugarcane growing. BC-SA

Fertilizer application in the furrow at planting is the right place for sugarcane compared to broadcasting.

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