**RESEARCH ARTICLE**

# SOIL FERTILITY AND PLANT HEALTH MANAGEMENT: TECHNO-ECONOMIC SURVEY AND CONSTRAINT ANALYSIS

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**Abstract**

Intensive farming in sugarcane has resulted in high nutrient turnover in the soil-plant system and this has to be restocked through an efficient nutrient supply approach involving organic, inorganic and bio-fertilizers. However, such management practices have largely been overlooked by cane growers. This paper deals with the various sociological and economic issues concerned with soil fertility and plant health management practices in sugarcane. Technology mapping revealed that farm yard manure/bio-compost, green manure and chemical fertilizer as basal and top dressing, and bio-fertilizers, micronutrient mixture and trash mulching were some key soil fertility and plant health practices adopted by the sample growers. Consequently, the respondents seemed to realize increased net returns through improved cane productivity. The reasons for adopting nutrient management practices included reduction of weeds, improved soil health with reduction in fertilizer cost, high cane yield and better returns which varied with individual grower. In spite of the constraints of high fertilizer cost and lack of timely availability of fertilizers, growers still favoured the adoption of this technology. The study gave a better understanding of the performance of nutrient management practices in farmers' fields and their apprehensions about this technology.

**Keywords :** Sugarcane, soil fertility, integrated nutrient management, constraints, perception analysis, economics

## Introduction

Sugarcane production can be sustained only if profitability can be ensured through reduction in cost of cultivation and improvement in productivity. The technologies that can minimize cost of cultivation and ensure enhanced returns in sugarcane include wider row spacing, bio-fertilizers, bud chip settlings, integrated nutrient management (INM), etc. (Bokhtiar et al. 2002; RajulaShanthy 2012). Continuous cultivation invariably removes plant nutrients from the soil which need to be replenished. While recycling and transfer of nutrients from non-crop areas, crop residues and animal manures can partially make up for the export of mineral nutrients by harvested products, application of mineral fertilizers is essential to meet crop requirements and increase crop production in many farming situations. Nutrient management is one of the major issues of concern for farmers throughout the world. Sugarcane growers, in particular, need to pay attention to this issue as few other crops exert such heavy demand on soil resources as sugarcane (Hartemink and Wood 2000).

The concept of integrated soil fertility and plant health (SFPH) implies practices such as appropriate crop rotations, cover crops, use of manure, crop residues and fertilizers, conservation and no-tillage, moisture management, etc. A blend of organic manure and inorganic fertilizers is known to improve cane production besides maintaining soil health (Bokhtiar et al. 2002).

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This approach improves and sustains soil fertility, and provides a sound basis for crop production systems to meet the changing needs through optimization of the benefits from all possible sources of plant nutrients in an integrated manner (Feder et al. 1985).

Yield decline has been noticed in sugarcane in most parts of the country in the recent pastdue to monocropping. Scientific studies indicate that integrated soil fertility and plant health management help to enrich the soil thereby leading to a healthy crop and high cane yield. Although nutrient management is an issue of concern for cane growers due to the huge nutrient demand and biomass production, adoption of an integrated approach is yet to percolate in a significant manner and the present study attempts to gain insights into the constraints in the adoption of this fast spreading technology.

## Materials and methods

In the descriptive type of research design applying ex-post facto approach followed for the study, respondents were selected among farmers adopting SFPH management practices. The study was carried out in M/s Chamundeswari Sugars, Mandya district, Karnataka State, during 2012-14 as the mill has been recommending SFPH management practices and supplying micronutrients, green manure seeds, compost and bio-fertilizers at subsidized rates to the registered cane growers. The operational area of the mill spreads over Mandya (Maddur and Makavalli taluks) and Ramanagara (parts of Channapatna taluk) districts with three zones of operation, namely Maddur, Makavalli and Mill site from each of which 20 cane growers were selected randomly making a total of 60 respondents for the study.

Yield data were recorded from individual farms through an interview schedule and the sociological appraisal was done through focus group discussions/observations. The data collected were tabulated and analyzed using descriptive statistics. Paired t test was used to analyze the test of significance of the yield data. For the perception analysis, 18 statements were developed regarding SFPH practices using a 5-point Likert – type scale responses (0 - 5 score). The statements were assessed by Cronbach's alpha coefficient as a measure of instrument reliability/ internal consistency to analyze interval data in psychometric test score and say how closely related a set of items are as a group (Cronbach 1951). The Cronbach's alpha coefficient used for the statements (Bhagwat 2012) on the perception of farmers about SFPH was 0.79 indicating the reliability of the test.

## Results and discussion

The present study focused on the profile of farmers adopting SFPH management practices, technology mapping in soil and plant health practices, perception of farmers about the technology and its advantages, constraints faced by farmers and the economics involved.

## Demographic profile of farmers

Demographic profile of the participants of the study indicated that they were mostly old-aged (> 50 years: 50.0%) to middle-aged (35-50 years: 33.3%) and literates with up to secondary education (55.0%). Agriculture was the main occupation of 83.3% respondents and 56.3% of them had more than 20 years of experience in sugarcane farming; majority of them (66.7%) owned more than 2 ha of land. Only 20.0% of

the farmers were self-sufficient in implement possession whereas the rest possessed some farm implement or the other and partially depend on hiring. One fourth of the respondents owned livestock such as cows, buffaloes, draught animals and poultry for their additional source of income, apart from their own use. Mass media channels used by the respondents were radio, television and newspaper; 96.7% of them owned radio/ television and tend to watch agricultural programmes. The source of information about various nutrient management measures was sugar factory officials as expressed by 53.3% of the respondents followed by Agricultural Department officials and input dealers. Majority of the respondents (56.8%) had grown the variety Co 62175, of which 41.4% was ratoon crop; 30.2% cultivated Co 86032 and the rest opted for the older varieties such as Co 8371 and Co 419.

**Technology mapping in soil and plant health management**

Generally, a variety with high cane yield, high sucrose and good ratooning potential is a prerequisite for profitable sugarcane agriculture (Ellis and Mery 2004). This has to be combined with rationalized INM practices involving organic manures, fertilizers and bio-fertilizers (Kumaraswamy 2011).There is always a difference between 'what is' and 'what ought to be'. Farmers in the study area were quite adept in technology adoption. The various components of SFPH as adopted by the respondents included application of farm yard manure (FYM), green manure, fertilizer application (basal and top dressing), bio-fertilizer application, trash mulching in alternate rows, soil application of additional potash and application of micronutrient mixture (Table 1).

*Application of FYM/compost*: FYM or compost are traditional inputs and the average response of sugarcane to 25 t/ha of FYM was about 8 t/ha of cane. Enriched pressmud with fungal cultures, Fe and Zn can also be used. Application of organic manure enhances microbial activity, reduces the leaching loss of N, regulates the supply of P, and improves soil tilth, water holding capacity and cation exchange capacity (Kailasam 1999). All the farmers applied FYM / bio-compost (8-10 t/ha) before planting at the time of last ploughing. FYM

**Table 1. Adoption levels of nutrient management practices followed by the respondents**

| Practice adopted | No. of respondents | Adoption percentage |
|---|---|---|
| Application of FYM/compost | 60 | 100.0 |
| Green leaf manuring (*Dhaincha* / Sunnhemp) | 32 | 53.3 |
| Application of fertilizer | 60 | 100.0 |
| Bio-fertilizer (*Azospirillum* & Phosphobacteria) | 32 | 53.3 |
| Trash mulching in alternate rows | 48 | 68.3 |
| Soil application of additional potash | 39 | 65.0 |
| Micronutrient mixture | 37 | 61.7 |

was obtained from own farms and rarely procured from nearby farms. Chamundeswari bio-compost was supplied by the mill @ Rs. 2200 per tonne.

*Green manuring*: Nearly 53.33% of the respondents applied green manures like sunnhemp/*dhaincha* as in situ application. The seeds of green manure (10 kg) are sown before planting and allowed to grow up to 40 days in the field and incorporated by using gauge wheel or rotavator. This increases the nitrogen content of the soil and makes the crop grow lush green. Farmers who practiced green manuring reduced up to 10% of nitrogenous fertilizer application during top dressing. This also helps to sustain the physical condition of the soil. Kailasam (1999) observed that crops like sunnhemp, *dhaincha* or pulses can be grown as intercrops or in sequence and incorporated into the soil. This can add 3-8 t/ha of organic matter with narrow C:N ratio and prevent leaching of nitrate N.

*Application of fertilizer:* All the respondents were applying chemical fertilizers and the average quantities were: DAP/SSP (250/500 kg/ha) as basal; urea(250-375 kg/ha), MoP (125-275 kg/ha) and complex fertilizer 10:26:26(250-375 kg/ha) as top dressing. Soil testing and tissue analysis help in fine-tuning fertilizer recommendation. Fertilizers should be placed close to root zone for immediate benefits. Band placement increases fertilizer use efficiency especially in ratoon crop (Wood 1990; Singh and Yadav 1996).

*Application of bio-fertilizer*: More than half (53.33%) of the respondents applied bio-fertilizers like *Azospirillum* and *Phosphobacteria* along with FYM. Bio-fertilizer (6 kg/ha each) was mixed with 500 kg of FYM and applied twice, i.e. at 30-35 days and 60-65 days at the base of the clumps and irrigated. *Azospirillum / Gluconacetobacter* helps in biological fixation of atmospheric nitrogen and phosphobacteria enhances P availability to the crop, and together they save up to 25% fertilizers. Increased use of organic matter and withdrawal of phosphatic fertilizers help to enhance VAM status of the soil (Shankaraiah et al. 2000).

*Micronutrient application*: Nearly 62% of the respondents applied ~ 75 kg/ha micronutrient mixture (20 kg $FeSO_4$, 5 kg $ZnSO_4$ and 5 kg S) as basal dose at planting. Farmers felt that micronutrients give a balanced supply of all the nutrients for the germinating bud and enhances the vigour of the crop. Bhaskaran et al. (2014) observed that the micronutrients required for sugarcane are Fe, Zn, Cu, Mn, B and Mo. No linear response to cane yield has been observed with application of micronutrients but yield gets reduced if the level of micronutrients in the soil is below critical limits.

*Trash mulching:* Trash disposal is an important task soon after the harvest of the plant crop. Trash is removed to the bunds and then applied to the fields after the initial ratooning operations are completed. Nearly 70% of the respondents detrashed the crop during 5$^{th}$ month and the trash was applied in alternate furrows under normal irrigation; in drip irrigated fields, trash was left in all the furrows. Few farmers applied urea (25-30 kg/ha) and cow dung mixture to facilitate decomposition. Dahiya et al. (2003) suggested that trash may be put in one furrow and the alternate furrow can be used for irrigation. Trash can also be aligned in situ in the furrows with the help of rakes and compressed either by stamping or decomposed by adding microbial culture.

**Advantages of adopting SFPH management practices**

When the respondents were asked to enlist the advantages of SFPH management with an open ended schedule (Table 2), the following trends emerged with regard to the advantages expressed.

*Increase in cane yield and net profit*: All the respondents indicated that due to adoption of nutrient management practices, the cane yield and thereby net profit increased. When the farmers had FYM from their own farms, the cost incurred was less. In case of non-availability from their own farms, they purchased it at a cost of Rs.1300 per tonne.

*Increase in cane length/weight*: The increase in cane yield was mainly due to the increase in cane weight and cane length, as expressed by 93.3% and 83.3% respectively. Increased cane length gives the crop a better field stand and adds to the cane weight.

*Improvement in soil health*: Application of FYM, bio-compost and bio-fertilizers creates conducive environment for the development of soil flora and fauna, and makes the soil healthy which was expressed by 80% of the respondents. This in turn leads to increased nutrient uptake and thereby a healthy crop. Three fourths (73.3%) of the respondents indicated that due to adoption of healthy crop management practices, soil microbial population increases.

*Reduction in fertilizer cost:* About 67% of the respondents indicated reduction in fertilizer cost due to adoption of SFPH practices. In fields where FYM and bio-fertilizers were applied, the farmers reduced urea application by 10-15% resulting in considerable reduction in the cost of fertilizers.

*Reduction of weeds*: Practices like green manuring and trash mulching resulted in decreased weed population due to smothering effect and this was reported by 80% of the respondents.

**Table 2. Perception levels of the advantages of soil fertility and nutrient management practices**

| Advantages | No. of respondents | Adoption percentage |
|---|---|---|
| Increase in cane yield and net profit | 60 | 100.00 |
| Increase in cane weight | 56 | 93.33 |
| Increase in cane length | 50 | 83.33 |
| Improvement in soil health | 48 | 80.00 |
| Reduction of weeds | 48 | 80.00 |
| Possibility of multiratooning | 46 | 76.67 |
| Organics improve microbial population | 44 | 73.33 |
| Good crop stand | 43 | 71.67 |
| Reduction in fertilizer cost | 40 | 66.67 |
| Stabilization of productivity | 35 | 58.33 |
| Additional income due to intercropping | 21 | 36.67 |

*Possibility of multi-ratooning:* Due to the adoption of nutrient management practices, fertilizer use efficiency increased. Moreover, due to addition of more organics, soil health was maintained and there was a possibility of multi-ratooning without much reduction in the cane yield of ratoon crop. The high adoption level of 76.7% endorsed the realization of these advantages among the respondents.

**Perception analysis of farmers about soil fertility and plant health management**

It is a known fact that perception of farmers about technology attributes influences adoption decisions (Polson and Spencer 1991; Strauss et al. 1991). Farmers' perceptions on the different statements about SFPH practices were measured on a 1-5 rating. Ranking was given on mean rating for individual perception parameters and mean and standard deviation of the rating were computed (Table 3).

Due to dwindling cattle population in rural areas, farmers face scarcity of FYM and hence are forced to forego its application and rely more on inorganic fertilizers. The fact that this parameter attained first rank indicated that almost all the farmers are aware of this constraint.

In most of the areas, sugarcane crop is grown year after year in the same field leading to a sharp decline in soil fertility. The situation is better in areas where crop rotation is being practiced. The perception that monocropping of sugarcane decreased soil fertility has received second rank. Decline in cane yield and build-up of pests, diseases and weeds have occurred in several regions where monocropping of sugarcane is practiced (Sundara 2008).

The practices, viz. trash mulching, green manuring, application of organic matter/enriched pressmud were perceived to be essential in their order of importance for restoring soil fertility. The same has been reiterated in earlier studies to conserve soil fertility (Manimaran et al. 2009; Gopalasundaram et al. 2012).

**Constraints in adopting nutrient management practices**

The constraints faced by farmers in adopting SFPH practices are discussed hereunder in the order of importance.

*High fertilizer cost*: Rising fertilizer cost with every passing year has been expressed as a major constraint by 90% of the respondents.

*Timely application is not possible*: Nearly 76.6% of the respondents faced the problem with timely application of fertilizer, primarily due to non-availability of inputs at the right time.

*Application of green manure in situ is cumbersome***:** Application of green manure in situ is cumbersome because it needs to be sown before planting and incorporated into the soil 45 days later which involve additional labour.

*Low awareness about micronutrients*: Around 86.6% of the respondents had low awareness about micronutrients and their composition and function. There is a need to intensify extension efforts to popularize such technologies.

*Lack of knowledge about bio-fertilizer and labour involved*: Around 76% of the respondents did not have knowledge about bio-fertilizer usage and function and they also felt that the work was laborious. Although bio-fertilizers are in vogue for quite some time, the application of this technology

**Table 3. Perception of farmers about soil fertility and plant health management**

| Rank | Perception parameter | Mean rating*@ | SD |
|---|---|---|---|
| 1 | Adequate amount of FYM is not available | 4.74 | 0.78 |
| 2 | Monocropping of sugarcane has decreased soil fertility | 4.28 | 0.64 |
| 3 | Trash mulching helps to conserve soil moisture | 3.79 | 1.12 |
| 4 | Cultivation of green manure crops is cumbersome | 3.62 | 1.09 |
| 5 | Soil organic matter has profound impact on water holding capacity | 3.54 | 1.73 |
| 6 | Enriched pressmud is a good source of organic matter and is easily available | 3.39 | 1.37 |
| 7 | Iron and zinc fertilizers have no impact on cane yield; they rather constitute wastage of money | 2.97 | 1.12 |
| 8 | Bio-fertilizers like *Azospirillum* and *Phosphobacteria* make the crop lush green and increase cane production | 2.73 | 1.38 |
| 9 | Chemical fertilizers play a major role in managing soil fertility | 2.63 | 1.09 |
| 10 | Sugarcane being a long duration crop needs enormous amount of fertilizer | 2.61 | 1.03 |
| 11 | Sugarcane crop responds to fertilizer till the grand growth phase | 2.59 | 1.16 |
| 12 | Application of gypsum helps to amend sodic soils | 2.47 | 1.47 |
| 13 | Sugarcane can be grown in all types of soil | 2.37 | 1.62 |
| 14 | Intercropping in sugarcane with legumes reduces weed infestation | 2.36 | 1.08 |
| 15 | Legume intercropping has minimum impact upon incorporating organic matter and nitrogen to the soil | 1.97 | 1.21 |
| 16 | Roots of sugarcane penetrates 1 foot horizontally and vertically and deplete the soil nutrient completely | 1.96 | 1.35 |
| 17 | Crop rotation with paddy helps to maintain soil fertility and control weeds, pests and diseases | 1.89 | 1.07 |
| 18 | Integrated soil fertility and nutrient management system in sugarcane is costly and labour intensive | 1.87 | 1.43 |

*Scale: 1-strongly disagree, 2-disagree, 3-undecided, 4-agree, 5-strongly disagree for positive statements and reverse scoring for negative statements

@ Mean of 60 respondents

is yet to gain momentum. Farmers have not yet realized the full benefit of this technology.

*Lack of availability of FYM*: At least 73% of the respondents faced the problem of non-availability of FYM but managed with bio-compost. Decline in population of cattle in rural areas is the reason for the non-availability of FYM.

*Non-availability of good quality bio-fertilizer*: Although bio-fertilizer is a promising technology, there is a paucity of production centres. About 43.3% of respondents felt that good quality bio-fertilizer was not available in time.

*Yield not up to expected level*: Nearly one fifth (20%) of the respondents reported that there was not much increase in cane yield due to application of various nutrient formulations.

*Lack of knowledge*: Trash composting is yet another fast spreading technology; however, the respondents lack comprehensive knowledge about the procedure of trash composting.

**Economics involved**

Any new technology is adopted by the clientele only if the relative economic advantage is higher than the idea it supersedes. The yield increase in farms where proper nutrient management practices were adopted was compared with the yield obtained by following conventional practices.

It is evident that 18.3% of the respondents could realize additional cane yield of up to 6 t/ha due to adoption of SFPH management practices compared to normal practice of chemical fertilizers alone. Nearly 44.0% of the respondents obtained 6-12 t/ha additional cane yield and 13.33% realized 12.0 - 15.0 t/ha enhanced cane yield in comparison to the average yield obtained from normal practices. One fourth of the respondents achieved more than 15 t/ha additional yield due to adoption of healthy nutrient management practices.

**Overall yield analysis**

The average yield obtained by the respondents through conventional practices was 100.23 t/ha as opposed to the average yield achieved by adopting SFPH practices (130.43 t/ha) amounting to an increase of 30.20 t/ha (30.13%).The highly significant difference observed in the yield levels before and after adopting SFPH practices by two-tailed paired *t* test ($t$=9.41; df=59; $P$<0.0001) indicated the superiority of the improved practices.

In our earlier experiments conducted in farmers' fields as part of Institute Village Linkage Programme, yield improvement of 7.74% with a BC ratio of 2.4 due to application of phosphobacteria and *Azospirillum*, and 5.95% higher yield with a BC ratio of 2.63 over farmers' practices were observed (Thiagarajan and Rajula Shanthy 2004). Further, in frontline demonstrations on INM in Coimbatore, Erode and Tirupur districts of Tamil Nadu state, considerable improvement in yield was noticed in demonstration plots over that obtained with farmers' practices. The factors contributing to higher crop production and field constraints of production were also examined to obtain feedback information. These demonstrations conducted in farmers' fields serve as a motivation for other growers in the neighborhood (Rajula Shanthy, 2012). In another study (2011-12) in Tamil Nadu with 150 cane growers, the respondents could obtain up to 21.5% increase in cane yield with an additional income of Rs. 20,500/ha due to the adoption of INM practices as compared to that obtained by normal practices (Rajula Shanthy and Subramanian 2015).

Modern agriculture is shifting towards low external input and sustainable agricultural systems with high resource use efficiency. In the present study, it was noticed that adoption of SFPH practices like application of FYM/ compost, green leaf manuring, trash mulching and application of adequate amount of fertilizers restores soil health, increases productivity thereby sustaining sugarcane production in the long run. Farmers realized a considerable increase in cane yield due to the adoption of improved soil health management practices.

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