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Integrated nutrient management in sorghum: A review

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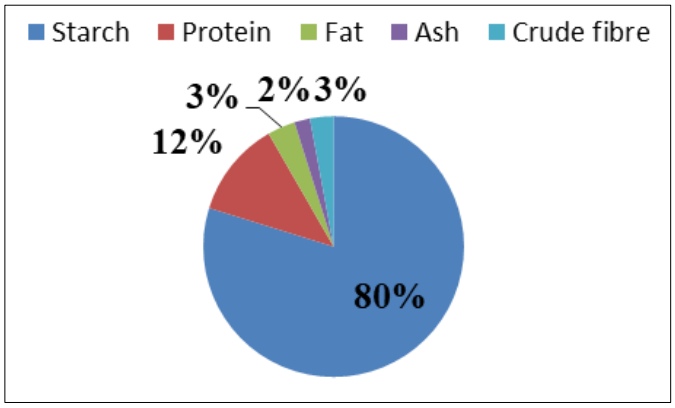
Abstract
Sorghum is major millet of India also coming under coarse cereal group. It is also used as fodder for the animals. Sorghum is a exhaustive crop and uptakes more nutrients from the soil. Supplement of recommended dose of fertilizers only through inorganic sources deteriorates soil health, induces environmental pollution and also increases the cost of production. Application of only organic sources to meet the demand of plant nutrient is also difficult because a huge amount of organic manure is required, which will be not available. So, the concept of integrated nutrient management (INM) in sorghum will be suitable in every aspect. INM includes judicious application of organic, inorganic, biofertilizer to crop for achieving optimum yield without harming ecosystem. INM improves the factors like water holding capacity, soil fertility and microbial population etc. INM increases the grain quality, stover yield, NPK uptake, yield, soil fertility, B: C ratio, net returns of sorghum.

Keywords: INM, sorghum, fodder, growth, yield, soil health, grain quality, economics

Introduction
Sorghum (*Sorghum bicolor*) is the major millet of India. It belongs to the poaceae family; sorghum genus is having 25 species of flowering plants as grass. It is domesticated in Africa and spread throughout the world. Sorghum being a cereal crop exhausts more nutrients than other forage crops and it requires high amount of nitrogen (Crawford *et al.*, 2018) [8]. According to Anonmyouys (2018) [1] it is grown for the human consumption and pastures for the cattles. Sorghum is popular as *kharif* fodder crop and the area under cultivation in India is 2.70 lakh ha and remains green for more number of days than maize fooders and bajra. It is used as the animal fodder, production of alcoholic beverages and biofuels. At present, the country faces 21.9 percent of dry fooder and shortfall of 61.1 percent of green fodder and the above situation indicates to grow 3.2% of green forage to meet the demand gap (Kumar and Faruqui, 2010) [21]. Sorghum production is low but yield potential is higher than other forage crops (Singh, *et al.*, 2016) [31]. Sorghum is rich in nutrients (fig.1). Donald (2006) [12] reported that sorghum is very hard to maintain the milk production and health of the livestock without supply of green fodder and the key to success of diary enterprises is availability of green forage. In India, sorghum covers an region of 7.38 million ha approximately with a yearly production of 7.0 million tonnes and sorghum has an average productivity of 949 kg/ha (DAC, 2012) [9]. However, Kumar *et al.* (2007) [23] mentioned that integrated nutrient management is an approach in which the combined application of inorganic fertilizers and organic manure has gained awareness in past with desire of meeting the farmers profitable needs on long term basis as well as maintaining favorable ecological conditions. INM helps to improve the fertilizer use efficiency and maintains the productivity of soil. It influence the yield of crop by economizes the chemical fertilizers (Bejbaruha *et al.*, 2009) [5]. Combined application of inorganic fertilizers in addition to different natural sources of nutrients and biofertilizer can help in continuing yield levels (Roy, 1992) [27]. Biofertilizers like *Azospirillum* and phosphate solubilizing bacteria (PSB). Azospirillium has the capacity to increase the dry fooder and green fodder yield from 7.8 to11.3 percent (Kumar and Sharma, 2002) [22]. Sharma *et al.*, 2007 [30] said that in case, the nutrient requirement will not fulfilled by these sources then inorganic fertilizers were applied to the crops. Appropriate application of chemical fertilizers with FYM improves the soil biological, chemical and physical properties and improves the soil productivity. In this article focus has given on effect of nutrient management on different aspects of sorghum crop growth and development including soil health.



***Source*:** Chandra *et al.* (2016) [11].

Fig 1: Nutritional value of sorghum

Influence of Integrated Nutrient Management on sorghum Growth

Bhuriya *et al.*, (2015) [6] carried out a field experiment at forage research station, Anand agricultural university, Gujarat and stated that the treatment 100kg N and 40 kg P ha^{-1} + Azospirillium recorded highest plant height at 30 DAS (74.67 cm) and harvest (162.33cm) while the lowest plant height recorded under treatment 60kg N and 40kg P ha^{-1}. Yadav *et al.*, (2013) [3] found that there was impact of tillage and INM on sorghum yield. According to them traditional tillage reported higher dry matter accumulation, plant height, yield parameters, net returns, gross, yield, and B.C. ratio then minimum tillage. It is found significantly superior when RDF was applied with conventional tillage over minimum tillage and reduced tillage in respect of grain yield. An experiment was conducted at Rahuri, Maharashtra, in the year 2001-02 and 2002-03 by Gawai and Pawar, (2004) [15] and they evaluated the effect of INM in sorghum-chickpea cropping sequence under irrigated condition. Application of FYM + Biofertilizers (Azospirillium and PSB) + 75% of RDF showed remarkably higher dry matter, yield parameters, plant height, fooder and grain yields of sorghum, that was at par with the treatment 100% RDF (through inorganic fertilizer) and 25% less nutrient is required. Because of FYM + 75% RDF + biofertilizer supplied to sorghum and 100% recommended dose of fertilizer applied to chickpea higher nutrient balance was recorded. Kuldeep *et al.*, (2015) [20] found that 25% of FYM + 75% RDN (through inorganic sources) improved the fooder quality, productivity and growth over control. By application of 25% of N through vermicompost + 75% RDN (through inorganic sources) in both the years increased the dry matter yield (13.5t/ha), total crude protein (0.92t/ha), green fodder yield (52.8t/ha), digestible dry matter (6.6t/ha), sugar yield (0.91t/ha), ethanol yield (2,762 kilo litre/ha), and juice yield (0.91t/ha). Available phosphorus and nitrogen content didn't vary due to different treatments at harvesting of crop.

Yield parameters and yield

Duhan (2013) [13] found that significantly higher fodder yield of sorghum obtained due to application of RDN (recommended dose of nitrogen) and RDP (recommended dose of phosphorous) from 41.11 to 108.54 q ha^{-1} over all other treatments and absolute control. Supply of 100% recommended dose of N in the form of FYM increase the intake of N,P,K by sorghum from 62.25-77.48 kg N, 7.40 - 10.82 kg P, and 53.44-85.46 kg K by per ha over absolute control. Kugedera *et al.*, (2018) [19] stated that highest grain yield of 4.40t/ha of sorghum showed by planting with cattle manure compared to tier ridges and conventional tillage. The use of rainwater harvesting such as planting pits with cattle manure increases crop production. Recommended not to use rainwater harvesting alone. Tamboli, *et al.* (2013) [32] founded that application of 5t/ha of FYM with RDF of (N-50kg + P2O5 -25kg/ha) + (Zn@ 10 kg/ha) recorded highest grain and stover yield of 13.04 and 35.0 q/ha. Experiment done for long period of time on sorghum (CSH-9) and Greengram (ML-267) as test crops at Hayathanagar, Research Farm of Central Research Institute of Dryland Agriculture, Hyderabad. Sharma *et al.*, (2004) [29] reported that 2 INM treatments 2 ton Gliricidia loppings+ N-20 kg, 4t compost+ N-20 kg effectively increase the sorghum grain yield by 84.62 and 77.7% then control respectively. The results indicate 50% of N demand of sorghum and Greengram met through farm based materials like Gliricida maculate or compost. Experiment carried out in Karnataka, Main Research Station of University of Agricultural Sciences, and Dharwad. Kalibhavi *et al.*, (2001) [18] mentioned that inorganic RDF of 100% produced the higher grain yield of 3482 kg/ha. While the organics, application of vermicompost of 1.5 ton/ha, Azospirillium@ 10 kg/ha, FYM 2.5 ton/ha of soil application recorded highest yield grain (3477 kg/ha) over individual application of each above organic sources. Patil (2013) found that in sorghum block, application of 20kg N through urea and treatment with 15kg N through leucaena loppings were recorded higher grain yield in sorghum by 64% during 2005-2006 (2200 kg.ha) and in pooled data (1468 kg.ha) over control. Patel *et al.*, (2018) [26] conducted experiment on the year 2016 Kharif season at agronomy farm of C.P. College of Agriculture, Gujarat, Sardarkrushinagar. To study about the INM of nutrient uptake, quality and green forage yield of fodder sorghum. Experiment consists of 16 treatment combinations with four organic manures. Application of 2.0t castor cake/ha can increase the stem diameter, number of nodes, leaf area per plant, leaf stem ratio, length of internode and it also significantly increases the dry and green fodder with 15.0 tonnes FYM/ha as compared to low levels. 100% RDF along with PSB+ Azotobacter improves yield attributes and growth compared to 50% RDF along with Azotobacter+ PSB. Castor cake 2.0t/ha application was recorded higher nutrient uptake (N and P), protein content, nutrients available to the soil and lower the crude fiber content. Nemade *et al.*, (2017) [28] studied ideal combinations of inorganic and organic nutrient sources on rabi chickpea and Kharif sorghum sequence for getting high yield in the year 2013-2015 on Kharif season at sorghum research unit (CRS) farm, Dr. PDKV, Akola. Experiment was done in Randomized Block Design with number of treatments i.e. nine, of Kharif sorghum as nutrient management treatments. The Rabi chickpea gone randomization without fertilizer application. It is concluded that integrated treatments are superior to inorganic treatments from three years of experiment. Application of RDN 25% through FYM + RDN of 75% through chemical fertilizer + Azospirillium + seed treatment with PSB to rabi chickpea and Kharif sorghum without RDF is superior treatment for getting yield, productivity attributes, and growth of individual crop as well as system.

Soil properties

Nandapure *et al.*, (2010) [24] stated that combined use of farm yard manure@ 10t/ha with inorganic fertilizers (100% NPK) improved the total capacity of (sorghum + wheat) found to be

correlated positively with these properties like electrical conductivity, water stable aggregates, bulk density, available water capacity, and coefficient of linear extensibility of yield and soil of the crops. Experiment conducted on field by Bhuriya *et al.*, (2019) [7] at main forage research station, Anand agricultural university reported that application of (N-100, P-40 kg.ha+ *Azospirillum*) reported highest HCN content of forage sorghum variety (GFS-4) at harvest under Gujarat conditions with sustaining soil fertility. Long term experiment conducted on the cropping sequence of sorghum (*Sorghum vulgare*) and wheat (*Triticum aestivum*) with objective of assessing continuous application of inorganic fertilizers and manures by properties of soil and the key indicators are soil quality and yield sustainability. Katkar *et al*., (2012) stated that higher soil quality index was observed under integrated nutrient management of FYM (2.45) + 100% NPK followed by 150% NPK of recommended dose of fertilizer (2.15) and FYM (2.16). Lowest was in control (1.14) by 50% NPK of recommended dose of fertilizer (1.45) indicating enhancement in soil quality due to integrated nutrient management. Deshmukh *et al.*, (2014) [10] experimented on the effect of INM in Kharif sorghum genotypes on parameters of yield and soil fertility in the year 2007-08. Experiment is conducted in RBD with SPH-840 and SPH-669 genotypes. The treatments consist of two genotypes have 100% RDF (80 kg N, 40 kg P_2O_5 and 40 kg K_2O per ha) and 50% RDF (inorganic fertilizers) and in combination with Azotobacter and FYM used as seed inoculation. Results indicate that higher grain and fodder yield reported with genotypes SPH- 840 and SPV-669. By application of 100% RDF higher fodder and grain yield were recorded. Application of 50% RDF + 7t/ha^{-1} FYM was found effective followed by RDF 100% with respect to available N, P, K status of soil and fodder and grain yield.

Nutrient uptake and quality

One experiment was conducted by Jat *et al.*, (2013) [16] on Kharif season sorghum at Rajasthan Agriculture College, Udaipur. Observed that application of two levels of FYM (0 and 10 tones/ha) four levels of soil test recommendation (0, 50, 70,100) and four Biofertilizer (no inoculation, Azotobacter, phosphate solubilizing bacter (PSB) and dual inoculation of Azotobacter+ PSB) increase the uptake of NPK (nutrient content) grain and stover. Experiment conducted at field of instruction farm, Rajasthan college of Agriculture, Udaipur. Arvind kumar Yadav and P. Singh (2016) [3, 31] stated that RDF reported higher nitrogen, phosphorous and potassium uptake and content in grain and stover of grain than the other treatment combinations. Significantly, highest protein yield- 4.31.86 kg/ha, biological yield- 13688 kg/ha, protein content- 11.06%, harvest index- 28.56%, grain- 3910 kg/ha, stover- 9978 kg/ha were recorded under RDF than other treatments of combination.

Economics

Bhagat, *et al.* (2020) [14] reported that influence of INM on productivity, growth and economics of legumes and sorghum based intercropping systems. Experiment conducted in split plot design method having eight treatments as intercropping as main plots and three treatments as integrated nutrient management as sub-plots three times replicated. Results revealed that intercropping of sorghum+ pigeon pea has recorded higher grain equivalent yield, gross return, net return, yield attributes and benefit: cost ratio of sorghum over other treatments. Biological yield, straw and grain were highest with sole sorghum which is superior to other treatments. Sorghum + pigeon pea intercropping and sole sorghum recorded more total grain productivity over other treatments. Application of 5t/ha of FYM with Biofertilizer and 50% RDF recorded highest grain, straw, yield attributes, and biological yield per ha of sorghum and also total grain productivity, gross return, grain equivalent weight, net return over other treatments. Benefit: Cost ratio was maximum with application of 5t/ha of FYM, Biofertilizer and 50% RDF (F3) and application of RDF for respective crops (F_1). Patil *et al.*, (2017) [25] conducted an experiment at Field of college Farm, Navsari (Gujarat), Navsari Agricultural University to study direct effect of RDF and residual effect of INM on clayey soil on parameters of economics, yield, and growth of Greengram in sorghum- Greengram cropping during year 2015-2016 and 2016-2017. Seven treatments consist of integrated nitrogen management of sorghum as main plot treatment in RBD in Rabi season. In summer season three levels of RDF to green gram in split-plot design and each main plot treatment was splited into three subplot treatments. Residual effect of preceding sorghum crop was fertilized with T_1-100% by biocompost @ 10t/ha + RDF through inorganic fertilizer recorded higher stover yield of (23.64q/ha) and grain yield (9.84q/ha) of succeeding green gram. Stastically, same values of stover yield, seed yield of green gram was obtained due to use of 75% RDF and 100% RDF but superior to control. Maximum net return of sorghum (RS.59146/ha), residual effect of crop sequence (Rs 94694/ha) and summer Greengram (Rs 35548/ha) with higher B:C ratio (2.42) were recorded in treatments receiving biocompost @ 10t/ha + 100% RDF through inorganic fertilizers. Regarding to economics of treatments combination of cropping sequence, T1S1 with Rs 99659/ha and T2S2 with Rs 99601/ha recorded maximum net monitory return with benefit: cost ratio 2.48 and 2.49 respectively.

Conclusion

Sorghum (jowar) is a cereal crop which require more nutrients than the other fodder crops. Application of the chemical fertilizers to the crop will not fulfill its nutrient requirement and it is damaging the soil fertility and soil health. INM is good approach for the economical benefit of the farmer and increases the soil fertility and nutrient availability to the crops. By application of three sources of fertilizers like organic, inorganic and biofertilizers will increase the growth and development of the crop. Combined application of FYM+ recommended dose of NPK fertilizers, FYM+ *Azospirillium*, and the other combinations were increases the grain yield, protein content, nutrient uptake of the soil in the sorghum. Practicing the INM on sorghum gives good yield and the productivity to the crop.

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