BIOLOGICAL NUTRIENT MANAGEMENT FOR ENHANCING YIELD AND QUALITY OF SEEDCANE

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M.Sc. (Ag.)

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(AGRONOMY)

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BIOLOGICAL NUTRIENT MANAGEMENT FOR ENHANCING YIELD AND QUALITY OF SEEDCANE

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DECLARATION

I, **PODAPATI VINAYA LAKSHMI,** hereby declare that the thesis entitled **"BIOLOGICAL NUTRIENT MANAGEMENT FOR ENHANCING YIELD AND QUALITY OF SEEDCANE"** submitted to the Acharya N.G. Ranga Agricultural University for the degree of Doctor of Philosophy in Agriculture in the major field of Agronomy is the result of original research work done by me. Part of thesis has been published by me as P. Vinaya Lakshmi, M. Martin Luther, M. Bharatha Lakshmi, Ch. Sujani Rao and V. Srinivasa Rao, 2021. **Growth and Yield of Sugarcane Seed Crop as Influenced by Fertilizer Rates and Timing in Anakapalle, Andhra Pradesh, India**. *International Journal of Plant and Soil Science.* 33 (20): 8-19.

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CERTIFICATE

Ms. PODAPATI VINAYA LAKSHMI has satisfactorily prosecuted the course of research and that thesis entitled **"BIOLOGICAL NUTRIENT MANAGEMENT FOR ENHANCING YIELD AND QUALITY OF SEEDCANE"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

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CERTIFICATE

This is to certify that the thesis entitled **“BIOLOGICAL NUTRIENT MANAGEMENT FOR ENHANCING YIELD AND QUALITY OF SEEDCANE”** submitted in partial fulfilment of the requirements for the degree of ‘Doctor of Philosophy in Agriculture’ of the Acharya N.G. Ranga Agricultural University, Lam, Guntur is a record of the bonafide original research work carried out by **Ms. PODAPATI VINAYA LAKSHMI** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all the assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

&	:	And
@	:	At the rate of
A.N.	:	After noon
AMF	:	Arbuscular Mycorrhizal Fungi
BCR or B:C ratio	:	Benefit Cost Ratio
BF	:	Biofertilizers
CD (P = 0.05)	:	Critical Difference at 5 per cent probability level
cm	:	Centimetre
CV	:	Coefficient of Variance
DAP	:	Days After Planting
DAR	:	Days After Ratooning
dS m^{-1}	:	Deci Siemen per metre
^{0}C	:	Degree Celsius
EC	:	Electrical Conductivity
et al.	:	and others
etc.	:	and so on; and other people/ things
Fig.	:	Figure
F.N.	:	Fore noon
FYM	:	Farm Yard Manure
g	:	Gram
g l^{-1}	:	Gram per litre
GM	:	Green Manure
g m^{-2}	:	Grams per square metre
GR	:	Gross Returns
ha^{-1}	:	Per hectare
$hill^{-1}$	:	Per hill
i.e.,	:	Which is to say, in other words, That is
K	:	Potassium
K_2O	:	Potassium Oxide
kg	:	Kilogram
kg^{-1}	:	Per Kilogram
kg ha^{-1}	:	Kilograms per hectare
km	:	Kilometre
KRB	:	Potassium Releasing Bacteria
l	:	Litre
l^{-1}	:	Per litre
l ha^{-1}	:	Litre per hectare
m	:	Metre
m^{-2}	:	Per square metre

Max.	:	Maximum
Min.	:	Minimum
mg	:	Milligram
ml	:	Millilitre
ml l^{-1}	:	Millilitre per litre
mm	:	Millimetre
MOP	:	Muriate of Potash
Mt	:	Million tonne
N	:	Nitrogen
NR	:	Net Returns
No.	:	Number
NS	:	Non-Significant
OC	:	Organic Carbon
P	:	Phosphorus
P_2O_5	:	Phosphorus pentoxide
%	:	Per cent
PSB	:	Phosphorus Solubilizing Bacteria
PM	:	Poultry Manure
pH	:	Potential of hydrogen ion concentration
RDF	:	Recommended Dose of Fertilizers
RDN	:	Recommended Dose of Nitrogen
RH	:	Relative Humidity
Rs.	:	Rupees
SCW	:	Single cane weight
SEm $\pm$	:	Standard error of mean
SSP	:	Single Superphosphate
STB	:	Soil test based
t	:	Tonne
t^{-1}	:	Per tonne
T_{max}	:	Maximum Temperature
T_{min}	:	Minimum Temperature
t ha^{-1}	:	Tonnes per hectare
VAM	:	Vesicular Arbuscular Mycorrhiza
viz.,	:	Namely

ABSTRACT

Name of the Author	:	**PODAPATI VINAYA LAKSHMI**
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A field experiment titled "**Biological nutrient management for enhancing yield and quality of seedcane**" was conducted during 2019-20 and 2020-21 on sandy clay soil at the Regional Agricultural Research Station, Anakapalle.

The experiment was laid out in split-plot design with the treatments consists of three main plot treatments *viz.*, a control and two organic sources- biofertilizer mixture (*Azospirillum*, Phosphorus Solubilizing Bacteria, Potassium Releasing Bacteria each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1}) and trash mulching with bio-decomposers and six sub plot treatments *viz.*, S_1-75% STBNK (Soil Test Based Nitrogen and Potassium) at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting, S_2-75% STBNK at planting, 45, 90, 135 and 180 DAP, S_3-100% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting, S_4-100% STBNK at planting, 45, 90, 135 and 180 DAP, S_5-125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting, S_6-125% STBNK at planting, 45, 90, 135 and 180 DAP, in three replications. A high yielding commercial cane variety CoA 92081 (87A 298) was used.

Germination percentage was not significantly influenced either by organic sources or time and dose of N and K given to seed crop of sugarcane. The growth parameters *viz.*, plant height, number of tillers and shoots and drymatter production were influenced with application of biofertilizer mixture and it was comparable with trash mulching (M_3) and both found to be

significantly superior to control. Among sub plot treatments, 125% STBNK + additional 25% RDK (S_5) resulted in taller plants with more tiller and shoot population and drymatter production and found at par with 100% STBNK + additional 25% RDK (S_3). A significant interaction between organic sources and different doses and time of N-K application was observed for drymatter production at 180 DAP during both the years of study and in pooled data.

Yield attributes *viz*., stalk population, cane length, diameter, single cane weight, weight of 100 three bud setts and cane yield were maximum with application of biofertilizers (M_2) and trash mulching (M_3) and found significantly superior to control. Among different sub plot treatments, significantly higher yield attributing characters were recorded with application of 125% STBNK + additional 25% RDK (S_5), but it was found statistically comparable with 125% STBNK (S_6), 100% STBNK + additional 25% RDK (S_3) and found superior to S_1 and S_2 treatments. Seedcane yield showed significant interaction between organic sources and different rates and timing of N-K application. Application of less fertilizer dose along with biofertilizers (M_2S_1) and with trash mulching (M_3S_1) was found on a par with that of M_1S_5.

Quality parameters of seedcane were not influenced by the organic sources, however the sub plot treatments showed significant influence on moisture per cent, reducing sugars per cent, germinability of setts and seedling vigour index. Application of 125% STBNK (S_6) significantly improved quality parameters of seedcane over S_1 and S_2 and was at par with S_3 and S_4 treatments.

Combined application of biofertilizers or trash mulching along with 125% STBNK or 100% STBNK applied at 30 days interval + additional 25% RDK one month before harvesting recorded higher N, P and K content, uptake and availability in soil after harvest. A significant interaction between organic sources and different rates and timing of N-K application was observed with N uptake at 180 DAP and P uptake at harvest. The higher N and P uptake were registered with M_2S_5 whereas, lower were with M_1S_2 and M_1S_1 treatments.

Gross returns, net returns and BC ratio were higher with application of biofertilizers or trash mulching along with 125% STBNK + additional 25% RDK (S_5) and it was comparable with 100% STBNK + additional 25% RDK (S_3). A significant interaction between organic sources and different rates and timing of N-K application was observed with net returns. The higher net returns were recorded with M_2S_5 treatment. Whereas, lower net returns were observed with M_1S_2 and M_1S_1 treatments.

From the experiment conducted for two consecutive years, with organic sources and different rates and timing of N-K application, it can be concluded that combined application of biofertilizer mixture or trash mulching with bio-decomposers and 100% STBNK at 30 days interval + additional dose of 25% recommended potassium one month prior to harvest was found to be optimum and profitable for improving yield and quality of sugarcane seed crop on sandy clay soils of North Coastal Zone.

Chapter – I

Introduction

Chapter I

INTRODUCTION

Sugarcane is the most important commercial crop of India and plays a vital role in the agricultural as well as industrial economy. Sugarcane is a multipurpose crop that provides sugar, bio-fuel, fibre and manure apart from many by-products. It constitutes the major raw material for sugar production and for making gur and khandasari. Bagasse and molasses are considered as the main byproducts of the sugar industry. Bagasse is the chiefly used by product for fuel purpose and also for the production of compressed fiber board, paper, plastics and furfural. In distilleries, molasses is used for the manufacture of ethyl alcohol, butyl alcohol, citric acid *etc.* Sugarcane is having a unique character among the commercial crops as several succeeding cane crops are raised from a single planting which is an integral component of the sugarcane production system.

In India, sugarcane is grown under diverse agro-climatic conditions with an area of about 48.67 lakh ha^{-1} with an annual production and average productivity of 377.77 million tonnes and 77.61 t ha^{-1}, respectively. In Andhra Pradesh, it is cultivated in an area of 1.26 lakh ha with production and productivity of 9.59 million tonnes and 76.14 t ha^{-1}, respectively (Cooperative Sugar, 2020**).**

Due to a slump in factor productivity, the yield of sugarcane has reached a plateau in recent years. Cane and sugar per unit area can be enhanced through the intensification of cultural and agronomic related production factors. The production potential of sugarcane crop depends on the quality of planting material and the use of fertilizer, which are costlier inputs. Hebert (1956) stated that planting the considerable pieces, having high germination capacity is very crucial to maintain a uniform stand of sugarcane that eventually produces high cane and sugar yield.

As sugarcane is vegetatively propagated by stem cuttings, the intrinsic stalk characteristics are important factors influencing sprouting and tillering and the stage of growth depends largely on the reserve food in the sett (Singh and Ali, 1973). The findings of Kakde (1985) and Clements (1980) revealed that the condition of buds, nutrient reserves in setts, size and age of stalk will affect sprouting and shoot development.

Seedcane production, which is an essential component of sugarcane production, often receives less priority than commercial crop plants (Smith, 1978 and Koeheler, 1984). A good seed crop can be raised through special cultural management such as fertilization, irrigation, crop protection measures *etc*. Among different cultural practices, balanced nutrition through organic and inorganic fertilizers is one of the essential inputs for optimising seedcane yield and maintains soil fertility.

Satisfactory crop stand establishment plays an important role in improving seedcane production. Germination constitutes to be a critical stage for establishment of a satisfactory crop stand in the life of sugarcane crop (Dellewijin, 1952). Well treated and nourished seedcanes put on a base to have a good germination capacity and vigour for the subsequent good crop. According to Kakde (1985) fresh succulent condition of a bud enhances rapid multiplication of cells and quicker sprouting of buds. Dellewijin (1952) reported that the sprouting ability of buds seems to be positively correlated with the moisture, N and glucose content of bud tissue. A well-nourished short crop may help in realizing higher yields from the succeeding commercial crop. However, the paucity of appropriate cultural practices in particular the nutrient management on seedcane fields is one of the major constraints of sugarcane production.

The fertilizers should be applied according to soil and crop characteristics so that there will be increased nutrient use efficiency and crop yield levels (Tiwari, 2002). The excess usage of chemical fertilizers lead to deterioration of soil quality and fertility and might drive to accumulation of heavy metals in plant tissues, results in affecting the nutritional value and edibility (Farnia and Hasanpoor, 2015).

Integrated application of FYM, biofertilizers, trash incorporation with inorganic fertilizers gave better economic output; improve soil health and higher microbial activity in the sugarcane plant-ratoon system Tyagi *et al*. (2011). Increasing and extending the role of microorganisms by way of inoculation or application of biofertilizers may reduce the need for chemical fertilizers and thereby decrease adverse environmental effects (Govindarajan *et al*., 2008).

Being an alternative for cost-effective sustainable agriculture, liquid biofertilizers facilitate long shelf life, minimum contamination, carrier-free activity, handling comfort, storage and transport convenience, easy quality control and enhanced export potentials these were preferred by the farming community as well as manufacturers (Pindi and Satyanarayana, 2012). *Azotobacter*, *Azospirillum*, PSB & VAM have been extensively used as biofertilizers among several beneficial bacterial genera reported with sugarcane. They will enhance the nutrients fixation in the rhizosphere, produce plant growth stimulants, effective in soil stability, biodegrade substances, nutrient recycling, support mycorrhiza symbiosis and unfold the bioremediation processes in soils contaminated with toxic, xenobiotic and recalcitrant substances. The biofertilizers supply also enhances the productivity per area in a comparatively short time, consume smaller amounts of energy, increase soil fertility, encourage antagonism and biological control of phytopathogenic organisms.

To explore the benefits of biofertilizer application, the bacterial culture must be used in combination with a suitable level of fertilizer. Amongst the major nutrient elements, nitrogen, which is scarce in most Indian soils, plays an important role in enhancing the productivity of sugarcane crop. However, its indiscriminate management such as inappropriate rate, time and placement may lead to poor crop performance and yield besides escalating the cost of production. Potassium, one of the major nutrients play a key role in energy transfer and carbohydrates metabolism activating more than 60 enzymes which is basis for the synthesis and accumulation of sugar. At present farmers apply potassium only as basal dose, where some quantity may be fixed by clay colloid and some may be lost leading to insufficient availability during later crop growth stages. So, it is necessary to recommend optimum rate and time of N & K application for improving the quality of seedcane setts.

Sugarcane trash is one of the most commonly available farm wastes in sugarcane growing areas and most essential for maintaining soil fertility and better crop growth over a longer period of time. About 6-8 t of trash can be obtained from one ha of sugarcane and contains about 5.4 kg N, 1.3 kg P_2O_5 and 3.1 kg K_2O t^{-1} of trash and small quantities of micronutrients, which is either removed or burnt in the field, causes loss of natural and sustainable source for the potential to improve soil organic carbon. Trash mulching in sugarcane is an important practice generally followed by farmers for moisture conservation, moderating soil temperature extremes, checking weed growth and adding organic matter to soils.

The slow decomposition factor discourages the sugarcane growers from not employing the trash even though its benefits are massive. Use of bio-decomposer culture appears to be a viable option to overcome this lacuna which enhances the process of decomposition and adds organic matter to soil besides delivering the benefits of much at initial stages of application. It is a consortium of 10 beneficial microorganisms (Decompostion A and B) developed by Agricultural Research Station, Amaravathi, ANGRAU which decomposes trash in 55 days by decreasing C:N ratio. It also works as bio control as well as soil reviver. Harman (2000) stated that legitimate decomposition of sugarcane trash will be accelerated with the use of *Trichoderma* sp., inhabitants of the rhizosphere, besides hastening the decomposition of organic residues which also act as biocontrol agents of soil-borne plant pathogens.

Therefore the seedcane plants should be fertilized in the same way as that of commercial cane fields for maintenance of soil fertility and crop productivity in a sustainable manner which is possible through an appropriate combination of organics, inorganics and bio-fertilizers in an integrated manner to harness their complementary advantage.

Considering the role of organic, inorganic and biofertilizers in mineral nutrition of sugarcane seed crop an experiment titled "**Biological Nutrient Management for Enhancing Yield and Quality of Seedcane**" is proposed with the following objectives:

1. To evaluate the nutrient requirement through biological nutrient management for enhancement of seedcane yield.
2. To audit the scheduling of nitrogen and potassium application on yield and quality of seedcane.
3. To study the influence of trash mulching and bio-fertilizers on nutrient uptake by seedcane.
4. To assess the influence of biological nutrient management on sprouting of cane setts.
5. To work out the profitability.

Chapter – II

Review of Literature

Chapter II

REVIEW OF LITERATURE

Sugarcane is the most ancient crop used by human being and play prominent role as a commercial cash crop in the world economy. India enjoys a pride place in sugarcane production but the average productivity is low as compared to other sugarcane growing countries. Nearly 10-12 per cent of cane grown is being utilized for seed purpose. In general, farmers use matured cane, cut into two or three budded setts and used as seed material which results in reduced germination percentage and low crop stand establishment leads to less yields. Well treated and nourished seedcanes have been found to have good germination capacity and vigour of the subsequent crop. Therefore, quality seed production is the essential requisite of sugarcane farmer for elevating cane yield. Accordingly, seedcane plants should undergo special cultural management like fertilization, irrigation, crop protection measures *etc*. Apart from other cultural practices, mineral nutrition has a prominent role in enhancing the cane yield. N and K are the major nutrients crucial for plant growth and development which contribute for increasing sugarcane productivity besides, its late application improves the quality of seedcane. However, application of these nutrients in chemical forms subjected to leaching and other losses which elicit low availability to plants. The addition of organic sources of nutrients can reduce nutrient losses and enhance fertilizer use efficiency. Thus, proper amalgamation of organic and biological sources of nutrients along with chemical fertilizers is a key to formulate sustainable production technology besides to apprehend maximum cane yield. Keeping this in view a field experiment titled **"Biological Nutrient Management for Enhancing Yield and Quality of Seedcane"** was conducted during 2019-20 and 2020-21 at the Regional Agricultural Research Station, Anakapalle. The available literature is reviewed in this chapter and presented under different sub heads.

2.1 EFFECT OF BIOFERTILIZERS ON GERMINATION, GROWTH, YIELD ATTRIBUTING CHARACTERS AND YIELD OF SEEDCANE

2.1.1 Germination Percentage

An experiment conducted at the research farm of U.P. Council of Sugarcane Research, Shahjahanpur revealed that the germination per cent and number of shoots per hectare did not differ significantly due to different organic and inorganic treatments in sugarcane on silty loam soils (Singh *et al.*, 2011b).

Mohanty *et al*. (2013) stated that significantly higher germination percentage of 65.40 at 45 days after planting was recorded in sugarcane with the combined application of 100% recommended dose of fertilizers along with additional 25% N through FYM and soil application of *Azotobacter* @ 5 kg ha^{-1} + PSB @ 4 kg ha^{-1} on sandy loam soils at Sugarcane Research Station, Panipoilla, Odisha.

Singh *et al*. (2016) proved that the combined application of 100% RDF through inorganics and 25% N through organic manures along with biofertilizers (*Azotobacter* + PSB @ 10 kg ha^{-1}each) gave higher germination percentage in sugarcane on sandy loam soils of Sugarcane Research Institute, Shahjahanpur.

The combined application of 75% RDN through inorganic + 25% RDN through FYM + *Azotobacter* + *Azospirillum* (T_7) registered the higher germination percentage in sugarcane on loamy soils of West Bengal (Banerjee *et al*., 2018).

Patel and Chaudhari (2018) stated that germination percentage was higher with application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + soil test based NPK application over no organic + 50% RDF on black clayey soils at Sugarcane Research Station, Navsari.

An experiment carried out at Sugarcane Research Institute, Shahjahanpur revealed that the germination percentage in sugarcane did not differ significantly with the integrated use of organic and inorganic nutrient sources along with biofertilizers on sandy loam soils (Yadav *et al*., 2018).

Kumar *et al*. (2019) found that germination percentage, cane weight and cane yield recorded with application of FYM @10 t ha^{-1} + BF + 100% RD NPK, FYM @ 10 t ha^{-1} + BF + soil test based NPK was significantly superior over control in sugarcane on clay loam soils of research farm of Regional Research Station, Karnal.

Ranjan *et al*. (2020) observed that at 45 DAP, higher germination percentage (47.5%) was recorded with 75% N as inorganic + 25% N as organic fertilizer (bio-compost + neem cake) along with biofertilizer among all the treatments in sugarcane on sandy loam soils of Crop Research Centre, Pusa farm, Dr. Rajendra Prasad Central Agricultural University, Bihar.

2.1.2 Growth, Yield Attributes and Yield

Shankaraiah and Hunsigi (2000) reported 10-15 per cent increase in cane yield with the soil inoculation of nitrogen fixers *viz.*, *Azotobacter* in plant crop and *Azospirillum* in ratoon crop on sandy clay loam soils of Regional Research Station, Visveswaraya Canal Farm, Mandya, Karnataka.

Lokhande and Ghatge (2001) observed 30 per cent higher cane yield with the inoculation of combined culture of *Azotobacter* + *Azospirillum* or *Acetobacter* + P-solubilizing bacteria with 75% of N and P along with full dose of K.

Integrated application of 75% NPK + enriched pressmud with *Pleurotus* sp. registered higher cane yield of 86.7 t ha^{-1} followed by 75% NPK + biocompost, 75% NPK + enriched pressmud with *T*. viride, 100% NPK and *Acetobactor* and phosphobacterium on sandy loam soils at the Research Farm of M/s. Rajshree Sugars and Chemicals Ltd., Theni (Rakkiyappan *et al*., 2001).

Ramesh *et al*. (2002) stated that the application of recommended level of phosphorus as rock phosphate + *Phosphobacterium* at planting and intercropped dhaincha incorporation at 45 DAP gave higher cane yield on sandy clay loam soils of TNAU, Coimbatore.

Ramesh *et al*. (2004) observed 5-10 per cent increase in cane yield with the inclusion of biofertilizers in the nutrient management programme, besides increasing the nutrient use efficiency.

Hari and Srinivasan (2005) reported that combined application of biofertilizers along with N @ 200 kg ha^{-1} gave higher cane yield of 116.7 t ha^{-1} on sandy loam soils at Sugarcane Breeding Institute, Coimbatore.

Mathew and Varughese (2005) noticed higher cane girth, length, weight and cane yield with the application of pressmud and was closely followed by application of *Azospirillum* @ 10 kg ha^{-1} on entisols of Sugarcane Research Station, Thiruvalla.

Application of pressmud cake @ 10 t ha^{-1} + fly ash @ 10 t ha^{-1} + PSB along with 75% RDF significantly increased cane yield over chemical fertilizers alone (Saini *et al.*, 2006).

Studies conducted by Shankaraiah (2007) on sandy clay loam soils of Zonal Agricultural Research Station, Mandya revealed that inoculation of *Azotobactor chroococcum* increased drymatter, cane height, weight and cane yield against no inoculation.

Soundarrajan *et al*. (2007) opined that application of 100% recommended dose of NPK along with bio-earth @ 6 t ha^{-1} found to be superior in increasing yield and was comparable with 75% NPK fertilizers + bio-earth @ 6 t ha^{-1} + *Acetobacter* on clay loam soils at EID Parry command area, Pattambakkam.

Srivastava *et al*. (2008) inferred that application of SPM (Sulphitation Pressmud) + FYM @ 10 t ha^{-1} each resulted in the higher cane yield of autumn (79.4 t ha^{-1}) and spring (68.8 t ha^{-1}) planted crops and it was closely followed by SPM 10 t ha^{-1} + *Azotobacter* on sandy loam soils of Indian Institute of Sugarcane Research, Lucknow.

Manimaran *et al*. (2009) stated that significantly higher single cane weight (1.41 kg) and cane yield (141.97 t ha^{-1}) were obtained with the addition of recommended fertilizers along with *Acetobacter* @ 10 kg ha^{-1} and foliar spraying of micronutrient mixture on sandy loam soils in sugarcane at Tamil Nadu.

Experiment conducted by Babu (2009a) observed that higher cane yield was recorded with application of 100% N + 75% P_2O_5 + 8 kg *Phosphobacteria* ha^{-1} on clay loam soils at Sugarcane Research Station, Vuyyuru.

Studies conducted by Nazirkar *et al*. (2010) on sugarcane at Mahatma Phule Krishi Vidyapeeth, Rahuri revealed that higher number of tillers, plant height, cane girth, number of internodes and cane yield were noticed with the application of RDF + trash + PSB + *Azotobacter* + *Azospirillum*.

Cock *et al*. (2011) stated that inoculation of sugarcane with *Azospirillum brasilense* significantly increased stem length on clay soils of Colombia.

Singh and Srivastava (2011) reported that application of 75% N through organics + biofertilizers + 25% NPK through fertilizers resulted in higher cane yield (82.6 t ha^{-1} for plant cane and 78.5 t ha^{-1} for ratoon) on sandy loam soils of Indian Institute of Sugarcane Research, Lucknow.

Singh *et al*. (2011b) proved that soil inoculation with *Azospirillum brasilense* @ 5 kg ha^{-1} along with various sources of nitrogen improved cane yield on silty loam soils at the research farm of U.P. Council of Sugarcane Research, Shahjahanpur.

Experiment conducted at Regional Research Station of Gurdaspur and Faridkot Sugarcane farm, Ladhowal, Punjab Agricultural University (PAU) on sandy loam soils of sugarcane indicated increased growth, yield attributing characters and cane yield with the inoculation of *Azotobacter* (Gosal *et al*., 2012).

The combined use of 100% recommended dose of fertilizers along with additional 25% N through FYM and soil application of *Azotobacter* @ 5 kg ha^{-1} + PSB @ 4 kg ha^{-1} produced significantly higher tillers at 120 DAP, cane length, girth, internodes per cane, single cane weight and cane yield as compared to 100% NPK through inorganics on sandy loam soils of sugarcane at the farm area of Sugarcane Research Station, Panipoilla, Odisha (Mohanty *et al*., 2013).

Surendran and Vani (2013) reported significantly higher tiller count, cane length, single cane weight and cane yield with the combined application of 100% phosphorous + 18.75 kg ha^{-1} arbuscular mycorrhizal fungi on sandy loam soils at Research and Development farm, Tamil Nadu.

Singh *et al.,* (2014a) reported that integrated use of inorganic + organic fertilizer along with dual biofertilizers (*Azotobacter* + PSB) significantly improved number of shoots and cane yield as compared to conventional fertilizer application on alluvial soils of sugarcane at the research farm of U.P. council of Sugarcane Research, Shahjahanpur.

Singh *et al*. (2014b) noticed that treatment receiving 75% recommended NPK through inorganic fertilizers + 25% through farm yard manure along with biofertilizers (*Azotobacter* + PSB) + trash mulching and green manure of legumes (*Sesbania*) inoculated with *Rhizobium* produced significantly higher cane length, cane weight and cane yield on loamy soils of Pantnagar, Uttarakhand.

Kuri and Chandrashekar (2015) found higher growth and yield components in sugarcane with the recommended package of practice consisting of fertilizers @ 250: 75: 190 kg N: P_2O_5: K_2O ha^{-1}, respectively, $ZnSO_4$ and $FeSO_4$ @ 25 kg ha^{-1} each, coupled with organic manures (FYM @ 25 t ha^{-1} and biofertilizers: *Azospirillum* and phosphorus solubilizing bacteria @ 10 kg ha^{-1}) on black soils of Sankeshawar.

Shridevi and Chandrashekhar (2015) reported that significantly higher cane yield (153.55 t ha^{-1}) was recorded with the application of RDF (250:75:190 kg N:P_2O_5:K_2O ha^{-1}) along with FYM @ 25 t ha^{-1}, $FeSO_4$ and $ZnSO_4$ @ 25 kg ha^{-1} and biofertilizers like *Azospirillum* and PSB @ 10 kg ha^{-1} than 100% fully organic (102.34 t ha^{-1}) and inorganic (115.09 t ha^{-1}) treatments in sugarcane on Vertisols of Agricultural Research Station, Sankeshwar.

Kumar *et al*. (2015b) stated that application of 75% RDF (112.5 kg N ha^{-1} + 37.5 kg P_2O_5 ha^{-1} for plant and 168.75 kg N ha^{-1} + 37.5 kg P_2O_5 ha^{-1} for ratoon) along with biofertilizers (*Azotobacter* + PSB + bio control agent) gave similar yield attributing characters viz., cane length, diameter and cane yield compared to the RDF on clay loam soils of CCS Haryna Agricultural University (HAU), Regional Research Station, Karnal.

Mahatma *et al*. (2016) carried out experiment at Sugarcane Research Station, Navsari Agricultural University, Navsari and noticed that yield attributing characters of sugarcane (number of tillers, cane length, weight and number of nodes) and cane yield increased significantly with *Aceotobacter* + PSB sett treatment each @ 1000 ml ha^{-1} and also soil application both @ 2000 ml ha^{-1} two times first at planting and second at the time of final earthing up along with 125: 62.5: 125 NPK kg ha^{-1} over recommended dose of chemical fertilizers alone.

Combined application of recommended dose of fertilizers @ 250:75:190 kg N:P_2O_5:K_2O ha^{-1} along with FYM @ 25 t ha^{-1}, $FeSO_4$ and $ZnSO_4$ @ 25 kg ha^{-1} and biofertilizers like *Azospirrillum* and PSB @ 10 kg ha^{-1} produced significantly higher plant height (276.9 and 298.6 cm), number of tillers (0.96 and 1.73 lakh ha^{-1} at 90 and 120 DAP, respectively) and cane yield (153.55 t ha^{-1}) on Vertisols of Karnataka (Shridevi *et al*., 2016).

Singh *et al*. (2016) conducted experiment at research farm of Sugarcane Research Institute, Shahjahanpur and reported that significantly higher number of shoots and cane yield were registered with the application of 100% RDF through inorganics and 25% N through organic manures along with biofertilizers (*Azotobacter* + PSB @ 10 kg ha^{-1} each).

Maximum individual cane weight and yield were observed with liquid biofertilizers (LBF) combined with 75% recommended NPK through chemical fertilizers (Chelvi, 2017).

Higher cane yield (113 t ha^{-1}) was noticed with the application of 10 t ha^{-1} FYM/compost + inorganic NPK fertilizers on soil test basis + biofertilizers (*Azotobacter* + PSB) @ 10 kg ha^{-1} each (Yadav *et. al*., 2017).

Banerjee *et al*. (2018) carried out experiment on loamy soils of West Bengal and found that combined application of 75% RDN through inorganic + 25% RDN through FYM + *Azotobacter* + *Azospirillum* recorded higher drymatter production, single cane weight and cane yield.

Application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + soil test based NPK application produced significantly higher numbers of tillers and cane yield on black clayey soils at Sugarcane Research Station, Navsari (Patel and Chaudhari, 2018).

Shanthy and Venkatesaperumal (2018) carried out research at Rajshree Sugars and Chemicals Ltd., Villupuram taluk, Tamil Nadu and found that the application of biofertilizers increased cane yield to the tune of 15 t ha^{-1}.

Combined application of FYM @ 10 t ha^{-1} + soil test-based RDF + biofertilizers (*Azotobacter* + PSB) @ 12.5 kg ha^{-1} each recorded significantly higher number of mother shoots (39,580 ha^{-1}), shoots (165,790 ha^{-1}), cane length (2.36 m) and cane yield (98.84 t ha^{-1}) in sugarcane on sandy loam soils of Sugarcane Research Institute, Shahjahanpur (Yadav *et al*., 2018).

Studies conducted by Jha *et al*. (2019) revealed that application of 50% N+ 100% PK + 50% N (vermicompost + castor cake + neem cake) 1/3 each+ biofertilizer was significantly superior to rest of the treatments in influencing cane yield on sandy loam soils of crop research centre, Dr. Rajendra Prasad Central Agricultural University, Pusa Bihar.

Application of 100% recommended dose of NPK + liquid *Azospirillum* + liquid PSB produced significantly higher cane population at different growth stages and cane yield in sugarcane at Regional Agricultural Research Station, Anakapalle (Lakshmi *et al*., 2019).

Viana *et al*. (2019) concluded that the application of *Azospirillum brasilense* at 200 ml ha^{-1} into planting furrow at 7 and 21 DAP increased plant height in sugarcane when compared to control on loamy soils at College of Agricultural and Technological Sciences, Brazil.

Djajadi *et al*. (2020) opined that application of 100% recommended fertilizer along with biofertilizer gave maximum number of sugarcane stalks (17.55 stalks m^{-1}) on silty clay soils at Karangploso Research Station of Indonesian Sweetener and Fiber Crops Research Institute.

Jyothi and Rao (2020) reported that shoot population at different stages of crop growth and cane yield were more with 50% N through urea and 50% N through castor cake along with recommended doses of P and K and was on par with 50% N through urea + *Azospirillum* @ 5kg ha^{-1} + 25% N through green manure + RDP and K at Sugarcane Research Station, Vuyyuru.

Higher number of tillers and single cane weight were obtained with 75% N as inorganic + 25% N as organic fertilizer (biocompost + neem cake) along with biofertilizer at 120 DAP in sugarcane on sandy loam soils at Crop Research Centre, Pusa farm, Dr. Rajendra Prasad Central Agricultural University, Bihar (Ranjan *et al*., 2020).

2.2 EFFECT OF BIOFERTILIZERS ON QUALITY PARAMETERS OF SEEDCANE

Rakkiyappan *et al.* (2001) revealed that combined application of inorganics as well as organics not significantly influenced brix and sucrose percentage in cane juice at the Research Farm of M/s. Rajshree Sugars and Chemicals Ltd., Vaigai dam, Theni on sandy loam soils.

Nazirkar *et al.* (2010) found that application of RDF + trash + PSB + *Azotobacter* + *Azospirillum* markedly increased quality parameters of sugarcane such as brix and sucrose percentage at Mahatma Phule Krishi Vidyapeeth, Rahuri.

Mohanty *et al.* (2013) opined that juice quality parameters of sugarcane viz., brix and polarity percentage did not vary significantly with various combinations of organic manures and biofertilizers along with graded doses of inorganic fertilizers on sandy loam soils at Sugracane Research Station, Panipoilla, Odisha.

Kumar *et al.* (2015b) reported that significantly lower juice quality was observed in sugarcane by applying 75% RDF alone or 50% RDF with or without biofertilizers or 100% recommended N + P as rock phosphate, 100% recommended N or 50% N + 50% P as rock phosphate + biofertilizers on clay loam soils of CCS HAU Regional Research Station, Karnal.

Results of experiment conducted at Sugarcane Research Station, Navsari Agricultural University, Navsari revealed that application of different doses of chemical fertilizers along with biofertilizers could not affect the quality parameters of sugarcane significantly (Mahatma *et al*., 2016).

Shridevi *et al.* (2016) found that sugarcane juice quality parameters like brix, pol and reducing sugars values were not significantly influenced by different nutrient management practices on Vertisols of Karnataka.

Patel and Chaudhari (2018) found that application of organic and inorganic nutrients did not influence juice quality parameters on black clayey soils. Similar observations were also reported by Bautista *et al*. (2019), Lakshmi *et al*. (2019) and Ranjan *et al*. (2020).

2.3 EFFECT OF BIOFERTILIZERS ON NUTRIENT AVAILABILITY AND UPTAKE

Shankaraiah and Hunsigi (2000) found that higher N uptake and availability of N in soil were registered with the soil inoculation of nitrogen fixers *viz.*, *Azotobacter* in plant crop and *Azospirillum* in ratoon crop on sandy clay loam soils of Regional Research Station, Visveswaraya Canal Farm, Mandya, Karnataka.

The available P content in the soil increased significantly by the application of P fertilizer along with PSB over P alone on Vertisols of Sugarcane Breeding Institute, Coimbatore (Sundara *et al*., 2002).

An experiment conducted at Sugarcane Breeding Institute, Coimbatore revealed that inoculation of biofertilizers did not influence the soil available nitrogen status in sugarcane on sandy loam soils (Hari and Srinivasan, 2005).

Mathew and Varughese (2005) recorded that higher NPK uptake by sugarcane was noticed with the integrated application of pressmud with 100% RDF which was closely followed by application of *Azospirillum* @ 10 kg ha^{-1} with 100% RDF on Entisols of Sugarcane Research Station, Thiruvalla.

The combined application of 100% NPK and 25% N through FYM along with biofertilizer (*Azotobacter* + PSB) resulted in higher NPK uptake as compared to other levels on silty clay loam soils of sugarcane at Crop Research Centre of G.B. Pant University of Agriculture and Technology (Saini *et al*., 2006).

Significantly higher N uptake of 297 kg ha^{-1} and 377 kg ha^{-1} at 6^{th} month and at harvest stages respectively were recorded with the inoculation of *Azotobactor chroococcum* on sandy clay loam soils of sugarcane at Zonal Agricultural Research Station, Mandya (Shankaraiah, 2007).

Results of the experiment revealed that higher N, P and K availability noticed with the combined application of 100% recommended dose of NPK along with bio-earth @ 6 t ha^{-1} followed by 75% NPK fertilizers + bio-earth @ 6 t ha^{-1} + *Acetobacter* on clay loam soils at EID Parry command area, Pattambakkam (Soundarrajan *et al*., 2007).

Studies conducted by Kanjana and James (2009) noticed that higher available nutrients at different stages of crop growth were observed with the application of higher dose (340, 80, 140 kg N, P, K ha^{-1}) of N, P, K in combination with micronutrients (37.5 kg $ZnSO_4$ and 100 kg $FeSO_4$ ha^{-1}), vermicompost @ 5 t ha^{-1} and *Azophos* @ 2.4 kg ha^{-1} in sugarcane on sandy clay loam soils of Vayalpatti village of Theni, Tamil Nadu.

Babu (2009b) reported higher leaf N and P contents and N, P, K uptake by sugarcane at different growth stages with 75% RDN + 100% RDP along with *Azotobacter* @ 5 kg ha^{-1} followed by 75% RDN + 75% RDP also with *Azotobacter* @ 5 kg ha^{-1} and *Phosphobacteria* @ 8 kg ha^{-1} on clay loam soils at Sugarcane Research Station, Vuyyuru.

Significantly higher nitrogen (463.05 kg ha^{-1}) and phosphorus (34.26 kg ha^{-1}) uptake at harvest stage and potassium uptake (239.34 kg ha^{-1}) at 6 months stage were recorded with recommended package of practices (250 kg N: 100 kg P_2O_5: 125 kg K_2O ha^{-1} + farmyard manure @ 25 t ha^{-1}) followed by 50% N applied through press mud + 50% N through fertilizers + biofertilizers in sugarcane on sandy clay loams soils of Dharwad (Keshavaiah *et al*., 2012).

Surendran and Vani (2013) revealed that application of 100% phosphorous + 18.75 kg ha^{-1} arbuscular mycorrhizal fungi improved N, P and K availability in soil on sandy loam soils of sugarcane at Research and Development farm, Tamil Nadu.

Mulyani *et al*. (2017) stated that application of biofertilizer can increase total N in soil from 1.5-18.01 per cent over control in sugarcane at sugarcane plantation, Purwadada Subang Bandung.

Oliveira *et al*. (2017) conducted an experiment on sandy loam soils of Pernambuco, Brazil and found that application of biofertilizers influenced nutrient uptake and increased availability of nutrients in the soil, especially total N, nitrate-N, ammonical-N and available P and K.

Banerjee *et al*. (2018) concluded that application of 25% RDN through FYM along with *Azotobacter* and *Azospirillum* inoculation and 75% RDN through inorganic fertilizer resulted in maximum uptake of N, P, K nutrients by sugarcane at tillering, grand growth and maturity stages and also available N, P_2O_5 and K_2O content in soil after harvest of crop in loamy soils at West Bengal.

Patel and Chaudhari (2018) inferred that combined application of organics and inorganics in sugarcane on black clayey soils did not influence available N, P, K at Sugarcane Research Station, Navsari.

Jha *et al*. (2019) opined that higher available N, P and K in soil was observed with the application of 50% N through inorganic and 50% N through organic nutrient combinations along with *Azotobacter* and PSB applied @ 4.0 kg ha^{-1} each on sandy loam soils of crop research centre, Dr. Rajendra Prasad Central Agricultural University, Pusa Bihar.

Lakshmi *et al*. (2019) conducted an experiment at Regional Agricultural Research Station, Anakapalle and revealed that buildup of available nitrogen and phosphorus were significantly superior in all the biofertilizer treated plots to chemical fertilizers alone in sugarcane.

Higher uptake of N (41.16 g $plant^{-1}$) was recorded with the application of 100% recommended fertilizer + biofertilizer + sunnhemp on silty clay soils of Karangploso Research Station of Indonesian Sweetener and Fiber Crops Research Institute (Djajadi *et al*., 2020).

Jyothi and Rao (2020) opined that uptake of K by sugarcane did not differ significantly due to integrated application of various organic and inorganic nitrogenous fertilizers at Sugarcane Research Station, Vuyyuru.

Ranjan *et al*. (2020) reported that significantly higher nitrogen, phosphorus and potassium uptake and nitrogen and phosphorus content of soil were recorded with application of 50% N as inorganic + 50% N as organic fertilizer (bio compost + neem cake) along with biofertilizer in sugarcane on sandy loam soils of Crop Research Centre, Pusa farm, Dr. Rajendra Prasad Central Agricultural University, Bihar.

2.4 EFFECT OF BIOFERTILIZERS ON ECONOMICS OF SEEDCANE

Experiment carried out on sandy clay loam soils of Regional Research Station, Visveswaraya Canal Farm, Mandya, Karnataka revealed that higher net returns and benefit cost ratio were obtained with the inoculation of *Azotobacter* in sugarcane plant crop and *Azospirillum* in ratoon crop (Shankaraiah and Hunsigi, 2000).

Results of experiment conducted on sandy clay loam soils of Tamil Nadu Agricultural University (TNAU), Coimbatore proved that combined application of phosphorus bacterium with dhaincha incorporation and recommended level of phosphorus as rock phosphate resulted in maximum net returns as well as returns per rupee investment in sugarcane (Ramesh *et al*., 2002).

Singh *et al*. (2014b) stated that the higher net returns and BC ratio were recorded with the application of 75% recommended NPK through inorganic + 25% through organic manure (FYM) + biofertilizers (*Azotobactor* + PSB) + trash mulching and green manure of legumes (*Sesbania*) inoculated with *Rhizobium* + biopesticide on loamy soils of sugarcane at Pantnagar, Uttarakhand.

Mahatma *et al*. (2016) reported that maximum cost benefit ratio of 1: 4.86 was recorded with the treatment receiving *Acetobacter* and PSB as sett treatment @ 1000 ml ha^{-1} each + soil application of *Acetobacter* and PSB @ 2000 ml ha^{-1} each two times (at planting and final earthing up) and 50% reduction of chemical N and K in sugarcane at Sugarcane Research Station, Navsari Agricultural University, Navsari.

Studies conducted on sandy loam soils of Shahjahanpur revealed that maximum benefit cost ratio was observed with the application of 100% RDF through inorganics and 25% N through organic manures along with biofertilizers (*Azotobacter* + PSB @ 10 kg ha^{-1} each) in sugarcane (Singh *et al*., 2016).

Application of 100% recommended dose of fertilizers through inorganics and 25% N through organic manures along with biofertilizers (*Azotobacter* + PSB @ 10 kg ha^{-1}) treated plots gave significantly higher gross returns, net returns and B: C ratio (1.44) in sugarcane at research farm of Genda Singh Sugarcane Breeding and Research Institute, Seorahi, Kushinagar (Kumar *et al*., 2018).

An experiment conducted on black clayey soils at Sugarcane Research Station, Navsari revealed that the application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + soil test based NPK resulted in higher net returns of Rs. 2,98,938/- with BCR of 3.50 (Patel and Chaudhari, 2018).

Yadav *et al*. (2018) reported that higher BC ratio (2.66) was obtained with the application of FYM @ 10 t ha^{-1} + soil test-based RDF + biofertilizers (*Azotobacter* + PSB) @ 12.5 kg ha^{-1} each on sandy loam soils of sugarcane at Sugarcane Research Institute, Shahjahanpur.

2.5 EFFECT OF TIME AND DOSE OF N AND K APPLICATION ON GERMINATION PERCENTAGE OF SEEDCANE

Selvan (2000) stated that, application of 281 kg N ha^{-1} in four splits significantly increased establishment per cent in sugarcane compared to N applied at 225 kg ha^{-1} on sandy clay loam soils of Sugarcane Research Station, Melalathur.

Pratap *et al*. (2006) inferred that lower germination percentage was recorded with the heavy basal application of urea nitrogen compared to no nitrogen application in sugarcane on silty loam soils of G. B. Pant university of Agriculture and Technology, Pantnagar.

Srivastava *et al.* (2007) proved that germination percentage was unaffected by different fertilizer levels in sugarcane on loamy soils at Regional Research Station, Karnal.

Experimental results indicated that germination percentage was not influenced by the application of various levels of nitrogen in sugarcane on sandy loam soils at G.S. Sugarcane breeding and Research Institute, Seorahi, Uttar Pradesh (Singh *et al.*, 2008).

Singh *et al.* (2011a) conducted experiment on clay loam soils of Indian Institute of Sugarcane Research, Lucknow and found that germination percentage was unaffected by row spacing and N levels in sugarcane. Similar results were reported by Kumar *et al.* (2012) and Sarala *et al.* (2012).

The experiment carried out at Sugarcane Research Institute, Faisalabad revealed that germination percentage was not statistically affected by different fertilizer rates in sugarcane (Wains *et al.*, 2012).

Sime (2013) reported that higher sprouting percentage was recorded with plants grown from seedcane treated with application of 92 kg N ha^{-1} in two equal split doses at five and seven and half months and single application of 138kg N ha^{-1} applied at seven and half month, respectively on Luvisols of Finchaa.

Singh and Uppal (2013) opined that germination percentage, number of internodes per cane, cane length and diameter were not influenced with the application of various levels of nitrogen on sandy loam soils of sugarcane at Punjab Agricultural University, Ludhiana.

Meena and Kumar (2015) concluded that application of various levels of NPK had significant effect on tillers and cane yield while the impact on germination percentage, cane length and single cane weight were non-significant on clay loam soils of sugarcane at Agricultural Research Station, Ummedganj, Kota.

Tayade *et al*. (2017a) reported that germination count in sugarcane was not significantly influenced by various fertilizer levels on sandy clay soils of ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu.

Results of experiment conducted at Amhara regional state, Awi revealed that maximum sprouting percentage of buds with planting material obtained from seedcane crop grown with single dose of 195 kg N ha^{-1} at 5 months of cane age (Wubale and Girma, 2018).

Singh *et al*. (2019b) stated that germination percentage in sugarcane did not differ significantly due to various nitrogen levels on clay loam soils at Regional Research Station, Karnal.

Lakshmi *et al*. (2020) reported that split application of N and K did not show any significant difference on seedling survival percentage in sugarcane on sandy loam soils of Regional Agricultural Research Station, Anakapalle.

2.6 EFFECT OF TIME AND DOSE OF N AND K APPLICATION ON GROWTH AND YIELD OF SEEDCANE

Akhtar *et al*. (2000) studied that application of NPK @ 200:150:150 kg ha^{-1} gave maximum cane yield than lower levels of phosphorus and potassium at the National Agricultural Research Centre, Islamabad.

Results of experiment conducted on sugarcane revealed that application of 200-150-150 kg NPK ha^{-1} gave significantly higher yield at Sugarcane Research Institute, Faisalabad (Ali and Afghan, 2000).

Selvan (2000) inferred that application of 281 kg N ha^{-1} in four splits markedly increased number of tillers, cane length, diameter, internodes per cane, single cane weight and cane yield over N applied at 225 kg ha^{-1} on sandy clay loam soils of Sugarcane Research Station, Melalathur.

Tiwari *et al*. (2000) observed that higher cane yield was observed with the application of potassium in splits rather than entire dose as basal application and among various levels of potassium application, higher cane yield was recorded with the application of 100.8 kg K ha^{-1} on clay loam soils at Sugar Research Station, Sehore, Madhya Pradesh.

Choudhary and Sinha (2001) reported higher tiller count, plant height, cane diameter, cane weight and cane yield with the application of nitrogen @ 150 and 200 kg ha^{-1} than application of 50 and 100 kg N ha^{-1} on sandy loam soils of Sugarcane Research Institute Farm, Pusa.

Pandey and Shukla (2001) reported significantly higher cane length, cane weight and cane yield with the application of 187.5 kg N ha^{-1} compared to 112.5 and 150 kg N ha^{-1} on clay loam soils of sugarcane at the experimental farm of Indian Institute of Sugarcane Research (IISR), Lucknow.

Singh *et al*. (2001) found that higher cane yield was observed with the higher level of nitrogen application i.e., 180 kg ha^{-1} as compared to other levels on sandy loam soils of Lakhaoti.

Alexander *et al*. (2002) observed number of tillers and 1000 three budded sett weight in sugarcane was not influenced significantly due to mineral nutrition and split application of N on Entisols of Sugarcane Research Station, Thiruvalla.

Pandey and Shukla (2003) recorded increasing trend of tillers, cane length, diameter, weight and cane yield with increase in N dose from 112.5 kg ha^{-1} to 187.5 kg ha^{-1} but the increase was significant upto 150 kg ha^{-1} on loamy soils at Indian Institute of Sugarcane Research, Lucknow.

Asokan *et al*. (2005) observed increased cane yield with increase in nitrogen application up to 300 kg ha^{-1} in sugarcane varieties Co 86032 and Co 86027 on sandy loam soils at Sugarcane Breeding Institute, Coimbatore.

Khan *et al*. (2005) observed higher cane yield with application of 300 N kg ha^{-1}, 200 P_2O_5 kg ha^{-1} and 250 K_2O kg ha^{-1} than at lower levels of application at the Experimental Farm, Nuclear Institute of Agriculture (NIA), Tando Jam.

Balaji *et al*. (2006) reported higher cane yield of 138.12 t ha^{-1} with treatment receiving combined application of fertilizer nutrients $N_3P_2K_2$ Zn each @ 387.5, 160, 250, 31 and 72 kg ha^{-1} on sandy clay loam soils of P.C. Patty, Rajashree sugar mill area of Theni, Tamil Nadu.

Gupta *et al*. (2006) observed that time of application of N and K did not show any significant effect on seedcane yield however, maximum yield was recorded with the application of N in three splits and K in two splits on sandy loam soils of Sugarcane Research Institute Farm under Rajendra Agricultural University, Pusa.

Lakshmi *et al*. (2006) stated that higher seedcane yield was realized with the application of 100% recommended N in two equal splits at 45 and 90 DAP than 75% level on loamy sand soils of Regional Agricultural Research Station, Anakapalle.

Experiment conducted at G. B. Pant university of Agriculture and Technology, Pantnagar on silty loam soils revealed that significantly higher drymatter accumulation and cane yield were observed with application of 120 kg N ha^{-1} through FYM as basal + 60 kg N ha^{-1} through urea as top dressing (Pratap *et al*., 2006).

Shankaraiah (2007) concluded that cane height, weight and cane yield were increased with increase in N level from 150 to 250 kg ha^{-1} and higher cane height, weight and cane yield were recorded with the application of 250 kg N ha^{-1} on sandy clay loam soils at Zonal Agricultural Research Station, Mandya.

Shukla (2007) conducted experiment at Lucknow and proved that increasing nitrogen dose from 150 to 200 kg ha^{-1} resulted in significant increase in tiller production, cane length, cane weight and cane yield on loamy soils.

There was significant increase in production of tillers and cane yield of early maturing varieties due to increasing doses of nitrogen and phosphorus from 75% to 125% of recommendation in sugarcane on loamy soils at Regional Research Station, Karnal (Srivastava *et al*., 2007).

Bahrani *et al*. (2008) proved that cane yield was increased with increase in N application upto 172 kg ha^{-1} on clay loam soils at Khuzestan.

Devi *et al*. (2008) observed significantly higher cane yield with the application of three split doses of P (0, 60 and 120 DAP/DAR) and K (0, 60 and 120 DAP/DAR) over application of entire dose of P and K as basal during both the years and it was comparable with two split doses of P and K at planting and 45 DAP/DAR on sandy loam soils at Regional Agricultural Research Station, Anakapalle.

Singh *et al*. (2008) observed higher number of shoots, cane length, girth, single cane weight and cane yield with the application of 200 kg N ha^{-1} over 150 kg N ha^{-1} on sandy loam soils at G.S. Sugarcane breeding and Research Institute, Seorahi, U.P.

Kanjana and James (2009) reported that application of N @ 340 kg ha^{-1} along with recommended dose of P, K, $ZnSO_4$, $FeSO_4$, vermicompost and Azophos resulted in higher cane length and cane yield as compared to other N levels on sandy clay loam soils of Vayalpatti village of Theni, Tamil Nadu.

Significantly higher number of tillers, cane girth and cane yield were produced with the application of 150 kg potash ha^{-1} than 50 kg on sandy loam soils at Mohan farm and Regional Sugarcane Research Station (RSRS) farm under Thakurgaon Sugar mills Ltd. (Rahman *et al*., 2009).

Application of 250-150-150 kg NPK ha^{-1} produced significantly higher number of tillers and cane yield over remaining fertilizer levels at Sugarcane Research Institute, AARI, Faisalabad, Pakistan (Chattha *et al*., 2010).

A study conducted at Sugarcane Research Institute, Ayub Agricultiural Research Institute (AARI), Faisalabad on loamy soils, revealed maximum stripped cane yield was observed with the treatment receiving K_2O @ 168 kg ha^{-1} in two splits; half at planting + half at 90 DAP (Ghaffar *et al*., 2010).

Dev *et al*. (2011) conducted experiment in sugarcane on sandy clay loam soils at Research Farm, Banaras Hindu University, Varanasi and reported significantly higher number of tillers ha^{-1}, cane length, number of internodes $cane^{-1}$, cane girth and cane yield were recorded with the application of 210 kg N ha^{-1} as compared to lower doses of nitrogen.

Indirajith and Natarajan (2011) conducted experiment on seedcane at the cane farm of NPKRR Cooperative sugar mills and revealed higher mean shoot population, cane length, weight and seedcane yield with application of recommended dose of N and K on 30, 60, 90, 120 and 150 DAP along with recommended dose of P applied in two splits 50% as basal and 50% as top dress at 30 DAP.

Experiment conducted by Madhuri *et al*. (2011) revealed that taller canes and higher cane yield with application of nitrogen @ 150% RDN over 100 and 75% in sugarcane on sandy loam soils of Agricultural Research Station, Perumallapalle.

Patel *et al*. (2011) reported that application of 125% RDN in four splits at 45, 90, 120 and 135 DAP + extra 25 kg K_2O ha^{-1} gave higher weight of 1000 two eye bud setts and cane yield than other levels on clay soils of seedcane at Regional Sugarcane Research Station, Navsari.

Shukla and Singh (2011) carried out research work at Indian Institute of Sugarcane Research, Lucknow and revealed that higher cane length, diameter and cane weight with application of 150-60-60 kg N, P_2O_5 and K_2O ha^{-1} in sugarcane on sandy loam soils.

Application of nitrogen at 225 kg N ha^{-1} produced significantly higher tiller count and cane yield in sugarcane on clay loam soils of Indian Institute of Sugarcane Research, Lucknow (Singh *et al*., 2011a).

Kumar (2012) recorded that crop receiving 200, 54.6, 99.6 kg N, P, K ha^{-1} gave significantly higher tillers, cane length, drymatter and cane diameter which was statistically at par with 200 + 43.6 + 83.0 kg NPK ha^{-1} on sandy loam soils at Sugarcane Research Institute, Rajendra Agricultural University, Pusa, Bihar.

Results of experiment conducted by Kumar *et al*. (2012) proved that higher number of shoots at 120 DAP, cane length, weight and cane yield were observed with the application of 125% RDF over 75% RDF on sandy loam soils at Research Farm of Chaudhary Chhotu Ram Post-Graduate College, Muzaffarnagar.

Saleem *et al*. (2012) inferred higher cane length, cane girth and stripped cane yield with the treatment receiving N @ 252 kg ha^{-1} in two equal splits *i.e*., half at planting and half at 90 DAP in sugarcane on loamy soils at Sugarcane Research Institute, Ayub Agricultural Research Institute, Faisalabad.

Sarala *et al*. (2012) reported that taller and thicker canes with application of 150% RDN and 125% RDN than lower levels on sandy loam soils of Agricultural Research Station, Perumallapalle.

Wains *et al*. (2012) observed that fertilizer dose of 68-112-112 NPK kg ha^{-1} was found to be effective in increasing cane yield as compared to rest of the doses at Sugarcane Research Institute, Faisalabad.

Sime (2013) proved that good growth, population, stalk length as well as higher sett yield were registered with application of 138kg N ha^{-1} (300 kg urea ha^{-1}) in two doses of 92 and 46 kg N ha^{-1} at two and half and five months, respectively on Luvisols of Finchaa.

Thakur *et al*. (2013) reported that significantly higher number of tillers (156300 ha^{-1}), cane length (236 cm), single cane weight (762.2 g) and cane yield (86.1 t ha^{-1}) with application of NPK @ 250-55-99.6 kg ha^{-1} and compost as compared to other levels on sandy loam soils at Sugarcane Research Institute, Pusa, Bihar.

Bikila *et al*. (2014) reported both stalk height and weight were unaffected with the application of different levels of precutting nitrogen at the time of harvest in seedcane on sandy clay soils of Finchaa Sugar Estate.

The results of experiment conducted at Pusa, Bihar concluded that significant improvement in growth, yield attributes in terms of tillers, plant height and cane yield with application of 100% RDN through chemical fertilizer + 25% RDN through press mud, however it was comparable with treatment 125% RDN through chemical fertilizer (Rathore *et al*., 2014).

Results of experiment conducted at Regional Agricultural Research station, Anakapalle revealed that significantly higher cane yield was noticed with application of nitrogen at 175% recommended dose (196 kg ha^{-1}) as compared to other nitrogen levels on sandy loam soils (Gouri *et al.,* 2015).

Meena and Kumar (2015) reported that treatment receiving application of NPK of 200:60:40 kg NPK ha^{-1} recorded significantly higher tillers (1,40,150 ha^{-1}) and cane yield (92.86 t ha^{-1}) over 150:45:30 kg NPK ha^{-1} and on par with NPK of 250:75:50 kg ha^{-1} on clay loam soils of Kota, Rajasthan.

Shukla *et al*. (2016) from Indian Institute of Sugarcane Research, Lucknow reported that increasing N levels significantly increased cane yield in sugarcane plant crop on sandy loam soils.

Ullah *et al*. (2016) reported that higher cane yield was observed when the crop was supplied with NPK @ 300:300:300 kg ha^{-1} in sugarcane at Agriculture Research Institute, Dera Ismail Khan.

Begum *et al*. (2017) revealed significantly higher cane yield (62.91 t ha^{-1}) with the application of 125% recommended dose of NPK than 75% and 100% recommended dose of NPK on clay loam soils of Buralikson, Assam.

Hussain *et al*. (2017) proved that application of 100% P and 50% K at planting, 33% of N applied at 50 days after planting, 33% N and rest 50% K at 90 days after planting and rest 33% N applied at 130 days after planting has given higher no. of tillers, taller canes, good girth and cane yields on loamy soils of Agriculture Farm of Fatima Sugar Mills, Kot Addu.

Higher growth and yield was recorded with application of 125% recommended N + P_2O_5 + K_2O compared to other treatments in sugarcane on sandy loam soils of research farm of U.P. Council of Sugarcane Research, Shahjahanpur (Yadav *et al*., 2017).

Madhu *et al*. (2018) reported that significantly higher cane yield was observed with split application of potash (50% as basal and 50% as top dressing at earthing up) than 100% as basal application whereas among various fertilizer levels, significantly higher cane yield was noticed with application of 100% recommended dose of fertilizers than 75% and 50% recommended dose of fertilizers on medium deep black soils at the Agricultural Research Farm of S. Nijalingappa Sugar Institute (SNSI) Belagavi.

Wubale and Girma (2018) conducted experiment on seedcane at Amhara regional state, Awi and concluded that application of 195 kg N ha^{-1} in three equal split doses at 15 days after transplanting, 2.5 months after transplanting and 5 months after transplanting showed the best plant height, stalk weight, stalk length and sett yield.

Vuyyuru *et al*. (2019) found that application of 50 kg N ha^{-1} at planting and additional 50 kg N ha^{-1} (N 50+50) at 90 DAP as side-dress enhanced tillering and tons of cane per hectare in sugarcane on Histosols of Belle Glade.

Singh *et al*. (2019a) found that the treatment receiving 6 splits of nitrogen application recorded significantly higher number of tillers (165.6 thousand ha^{-1}), cane yield (154.72 t ha^{-1}), drymatter accumulation in sugarcane on sandy clay loam soils at Banaras Hindu University, Varanasi.

Singh *et al*. (2019b) revealed that taller plants at 90, 120, 150 and 180 DAP were obtained with the application of 150 kg N ha^{-1} and being statistically at par with 175 kg N ha^{-1} in sugarcane on clay loam soils at Regional Research Station, Karnal.

Kadarwati (2020) reported that application of 180 K_2O kg ha^{-1} appreciably increased stalk length, stalk weight, stalk diameter and yield in sugarcane on clay loam soils of Karangploso Experimental Station, Malang.

Application of 150% RDN registered higher plant population, cane length, drymatter production and single cane weight in sugarcane both plant and ratoon crops at Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar (Kumar and Kumar, 2020).

Experiment carried out by Lakshmi *et al*. (2020) concluded that significantly higher shoot population at 120 DAP, stalk population at 240 DAP and cane yield were produced with application of 100% recommended N and K in four splits at planting, 30, 60 and 90 days after planting of single node seedlings on sandy loam soils of Regional Agricultural Research Station, Anakapalle.

Studies conducted by Zeng *et al*. (2020) stated that increased cane yield was registered with increase in N application on red loam soils of experimental field of college of Agriculture, China.

2.7 EFFECT OF TIME AND DOSE OF N AND K APPLICATION ON QUALITY PARAMETERS OF SEEDCANE

Kakde (1985) suggested that adequate moisture content in setts is important for quicker sprouting as buds remain fresh, plump and healthy.

Reddy *et al*. (2000) inferred that sucrose value of sugarcane did not differ significantly due to application of various fertilizer treatments on clay loam soils at Sugarcane Research Station, Vuyyuru.

Choudhary and Sinha (2001) stated that sucrose percentage in juice was not influenced significantly by application of varied levels of nitrogen on sandy loam soils at Sugarcane Research Institute Farm, Pusa.

No significant difference was observed among juice quality parameters of sugarcane with respect to increasing nitrogen levels upto 187.5 kg ha^{-1} on clay loam soils at the experimental farm of Indian Institute of Sugracane Research (IISR), Lucknow (Pandey and Shukla, 2001).

Results of experiment carried out on sandy loam soils of Lakhaoti revealed that reducing sugars percentage in sugarcane shows increasing trend with increase in nitrogen level and higher reducing sugars percentage was noticed with the application of 180 kg N ha^{-1} (Singh *et al*., 2001).

Alexander *et al*. (2002) reported that application of mineral nutrition with N at 125% of recommended dose + 100% recommended dose of P and K had appreciably increased moisture percentage and reducing sugars content in sugarcane juice whereas split application of N did not show any significant effect on reducing sugar content and moisture percentage in sett on Entisols at Sugarcane Research Station, Thiruvalla.

Pandey and Shukla (2003) noticed that juice quality parameters of sugarcane viz., brix and pol percentage were not significantly influenced by application of various levels of nitrogen on loamy soils of Indian Institute of Sugarcane Research, Lucknow.

Mathew and Varughese (2005) stated that application of nitrogen in different doses could not show any significant effect on reducing sugars percentage in first plant crop on entisols of Sugarcane Research Station, Thiruvalla.

Lakshmi *et al*. (2006) noticed appreciable increase in seedcane quality with lower sucrose and higher glucose content by extending nitrogen application upto 135 days on loamy sand soils at Regional Agricultural Research Station, Anakapalle.

Studies of Pratap *et al*. (2006) revealed that there is a significant increase in reducing sugars per cent with increasing nitrogen levels during both the years of experiment in sugarcane on silty loam soils of G. B. Pant university of Agriculture and Technology, Pantnagar.

Experiment conducted by Shukla (2007) revealed that application of various fertilizer levels did not show any significant effect on quality parameters of sugarcane on loamy soils of Lucknow.

Dev *et al*. (2011) concluded that juice sucrose and purity coefficients were decreased with increasing nitrogen levels in sugarcane on sandy clay loam soils of Research Farm, Banaras Hindu University, Varanasi.

Indirajith and Natarajan (2011) noticed that application of recommended dose of N and K at 30, 60, 90, 120 and 150 DAP along with recommended dose of P applied 50% as basal and 50% as top dress at 30 DAP gave maximum mean reducing sugar content in cane juice at the cane farm of NPKRR Cooperative sugar mills.

Madhuri *et al*. (2011) from Agricultural Research Station, Perumallapalle found that quality parameters of sugarcane viz., brix and sucrose percentage did not differ significantly by increasing nitrogen levels on sandy loam soils.

Patel *et al*. (2011) reported marked increase in moisture percentage in setts, reducing sugars percentage in setts and germinability percentage of seed were noticed with the application of 125% RDN + extra 25 kg K_2O ha^{-1} and also with four splits (45, 90, 120 and 135 DAP) of N application than two and three splits on clay soils of Regional Sugarcane Research Station, Navsari.

Singh *et al*. (2011a) inferred that quality traits *viz.,* brix and pol percentage under different nitrogen levels did not undergo significant changes in sugarcane on clay loam soils at Indian Institute of Sugarcane Research, Lucknow.

Jayaramudu (2012) observed increased reducing sugars percentage and moisture content of seedcane with increase in nutrient levels from 120,75,75 to 240,150,150 kg NPK ha^{-1} on clay loam soils of Agricultural Research Station, Perumallapalle.

Sarala *et al*. (2012) stated that quality parameters of sugarcane like brix and sucrose percentage were unaffected by different nitrogen levels on sandy loam soils of Agricultural Research Station, Perumallapalle.

Singh and Uppal (2013) reported that application of graded doses of nitrogen could not show any significant effect on quality parameters of sugarcane on sandy loam soils of Punjab Agricultural University, Ludhiana.

Thakur *et al*. (2013) proved that application of different levels of fertilizers and compost did not affect brix and sucrose percentage significantly in sugarcane on sandy loam soils at Sugarcane Research Institute, Pusa, Bihar.

Bikila *et al*. (2014) reported that both N level as well as time of precutting nitrogen application and interaction of these two did not show any significant effect on pol and brix percentage of cane juice but significantly increased the reducing sugars as well as sett moisture content on sandy clay soils of Finchaa Sugar Estate. He also stated that well treated and nourished seedcanes found to have good germination capacity and vigour of subsequent crop.

Gouri *et al*. (2015) inferred that sucrose percentage of sugarcane did not vary significantly with various nitrogen levels on sandy loam soils of Regional Agricultural Research station, Anakapalle.

Meena and Kumar (2015) noticed that application of various levels of NPK did not show any significant effect on pol percentage in sugarcane on clay loam soils of Agricultural Research Station, Ummedganj, Kota.

Experiment conducted on clay loam soils of Buralikson revealed that juice quality parameters were not significantly affected due to different fertilizer levels (Begum *et al*., 2017).

Rao *et al*. (2017) observed that the treatments comprises of nitrogen in Urea, Calcium in 10 per cent lime dipping and growth substance GA3 in addition to coir pith and vermicompost favoured germination per cent and improved seedling vigour index at Regional Agricultural Research Station, Anakapalle.

An experiment conducted on sandy clay soils of ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu revealed that juice quality parameters in sugarcane did not differ significantly by graded fertilizer levels (Tayade *et al*., 2017a).

Singh *et al*. (2019a) stated that quality parameters of sugarcane like brix, juice sucrose and purity were not significantly affected due to various nitrogen scheduling treatments on sandy clay loam soils of Banaras Hindu University, Varanasi.

Kumar and Kumar (2020) stated that higher dose of nitrogen resulted in less sucrose content in juice compared to lower dose of nitrogen in sugarcane at Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar.

Lakshmi *et al*. (2020) proved that quality parameters of sugarcane viz., brix and sucrose percentage were unaffected by split application of N and K in sugarcane on sandy loam soils of Regional Agricultural Research Station, Anakapalle.

Zeng *et al*. (2020) noticed that with increase in nitrogen application there was a decreased trend in juice brix and sucrose percentage in sugarcane on red loam soils of experimental field of college of Agriculture, China.

2.8 EFFECT OF TIME AND DOSE OF N AND K APPLICATION ON NUTRIENT AVAILABILITY AND UPTAKE

Studies conducted by Tiwari *et al*. (2000) revealed that potassium uptake by crop as well as availability in soil increased with increase in level of potassium as well as split application in sugarcane on clay loam soils of Sugar Research Station, Sehore.

Results of experiment conducted at the research farm of Dr. Rajendra Agricultural University concluded that higher N uptake as well as availability were recorded with the application of 200 kg N ha^{-1} in sugarcane on sandy loam soils (Choudhary and Sinha, 2001).

Results of experiment conducted at Sugarcane Breeding Institute, Coimbatore revealed that N uptake was influenced by nitrogen dose and the progressive increase was up to 400 kg ha^{-1} in sugarcane varieties Co 86027 and Co 86032 on sandy loam soils (Asokan *et al*., 2005).

Hari and Srinivasan (2005) opined that significantly higher nitrogen content of stem in sugarcane was with the application of N @ 200 and 300 kg ha^{-1} along with biofertilizers on sandy loam soils of Sugarcane Breeding Institute, Coimbatore.

Shankaraiah (2007) noticed that there is marginal increase in N uptake with the addition of N at 6^{th} month and significant increase was observed at harvest stage. Among different N levels, higher N uptake and soil available N were observed at 250 kg ha^{-1} in sugarcane on sandy clay loam soils at Zonal Agricultural Research Station, Mandya.

Experiment carried out by Madhuri *et al*. (2011) revealed that with increase in nitrogen dose, the leaf N per cent also increased slightly at 180 DAP in sugarcane on sandy loam soils of Agricultural Research Station, Perumallapalle.

Kumar (2012) proved that increased available N, P and K content in soil as well as N, P and K uptake by crop were observed with increase in N, P and K levels from 150:37.1:49.8 to 200: 54.6:99.6 kg ha^{-1} on sandy loam soils of sugarcane at Sugarcane Research Institute, Dr. Rajendra Agricultural University, Pusa, Bihar.

Thakur *et al*. (2013) reported that higher nutrient uptake as well as availability of nutrients (NPK) were recorded by the treatment receiving higher level of NPK @ 250-55-99.6 kg ha^{-1} in sugarcane on sandy loam soils at Sugarcane Research Institute, Pusa, Bihar.

The results of experiment conducted on clay loam soils of Kota, Rajasthan revealed that uptake of NPK nutrients by sugarcane crop significantly increased up to 200:60:40 kg NPK ha^{-1} over fertility levels of NPK 150:45:30 kg ha^{-1} and was on par with that of 250:75:50 kg NPK ha^{-1} (Meena and Kumar, 2015).

An experiment conducted by Kadarwati (2020) noticed that with increase in dose of K_2O higher availability of K in the soil was observed in sugarcane on clay loam soils of Karangploso Experimental Station, Malang.

Kumar and Kumar (2020) found that higher N uptake was observed with the application of 150% recommended dose of nitrogen in sugarcane at Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar.

2.9 EFFECT OF TIME AND DOSE OF N AND K APPLICATION ON ECONOMICS OF SEEDCANE

Studies conducted by Selvan (2000) noticed that higher net returns and benefit cost ratio were registered with the application of 281 kg N ha^{-1} in four splits on sandy clay loam soils of Sugarcane Research Station, Melalathur.

Choudhary and Sinha (2001) inferred that among various nitrogen levels, application of 200 kg N ha^{-1} recorded higher net profit in sugarcane on sandy loam soils of Sugarcane Research Institute Farm, Pusa.

Experiment carried out by Gupta *et al*. (2006) on sandy loam soils of seedcane at Research Institute Farm under Dr. Rajendra Agricultural University, Pusa revealed that maximum gross returns, net returns and also benefit cost ratio were higher with application of N @ 200 kg ha^{-1} and K @ 100 kg ha^{-1}, whereas time of application of N and K did not influence the economics of seedcane significantly.

Dev *et al*. (2012) noticed that application of nitrogen @ 210 kg ha^{-1} gave significantly higher gross returns, net returns and BC ratio compared to application of 210 kg N ha^{-1} and was at par with the application of 180 kg N ha^{-1} on sandy clay loam soils of Research Farm, Institute of Agricultural Sciences, Banaras Hindu University (BHU), Varanasi.

Kumar (2012) opined that with increasing N, P and K levels from 150:37.1: 49.8 to 200:43.6:83.0 kg ha^{-1} significantly increased net returns on sandy loam soils of sugarcane at Sugarcane Research Institute, Dr. Rajendra Agricultural University, Pusa, Bihar.

The results of experiment conducted on sandy loam soils of Agricultural Research Station, Perumallapalle revealed higher benefit cost ratio and net returns with application of 125% RDN and 150% RDN in sugarcane (Sarala *et al*., 2012).

Ghaffar *et al*. (2013) stated that maximum net field benefit (NFB) of Rs. 1,29,034 ha^{-1} and benefit cost ratio (BCR) of 1.84 were obtained with the sugarcane treated with 84 kg K_2O ha^{-1} at planting and 84 kg K_2O ha^{-1} at 90 DAP at Sugarcane Research Institute, Ayub Agricultural Research Institute, Faisalabad on loamy soils.

Results of experiment on sandy loam soils at Sugarcane Research Institute, Pusa, Bihar revealed that combined application of higher level of NPK *i.e*., 250-55-99.6 kg ha^{-1} and compost gave higher net returns than other levels in sugarcane (Thakur *et al*., 2013).

Sagoo *et al*. (2014) reported that maximum benefit cost ratio of 1.64 and 1.59 was realized with the treatment receiving 200-200-100 NPK kg ha^{-1} and 30/90cm spaced paired row strip planting pattern in sugarcane on sandy loam and silty clay soils of Pakistan.

Studies conducted on clay loam soils of Kota, Rajasthan indicated that application of 200:60:40 kg NPK ha^{-1} resulted in significantly higher gross returns (Rs. 2,13,570 ha^{-1}), net returns (Rs. 1,11,770 ha^{-1}) and BC ratio (2.10) over nutrient levels of 150:45:30 kg NPK ha^{-1} and on par with 250:75:50 kg NPK ha^{-1} (Meena and Kumar, 2015).

Ullah *et al*. (2016) found that higher benefit cost ratio was obtained with the application of NPK @ 250:250:250 kg ha^{-1} in sugarcane at Agriculture Research Institute, Dera Ismail Khan.

Hussain *et al*. (2017) noticed that application of 100% P and 50% K at planting, 33% of N at 50 days after planting, 33% N and rest 50% K at 90 days after planting and rest 33% N at 130 days after planting appreciably increased gross returns, net returns and value cost ratio in sugarcane on loamy soils at Agriculture Farm of Fatima Sugar Mills, Kot Addu.

Application of nitrogen in six splits resulted in higher gross returns, net returns and benefit cost ratio as compared to other splits in sugarcane on sandy clay loam soils of Banaras Hindu University, Varanasi (Singh *et al*., 2019a).

An experiment carried out at Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar proved that with each successive increase in recommended dose of nitrogen from 0 to 125% there was a significant improvement in net returns and benefit cost ratio (Kumar and Kumar, 2020).

2.10 EFFECT OF TRASH MULCHING ON GERMINATION PERCENTAGE OF SEEDCANE

Dhanapal (2014) inferred that 36 per cent higher germination was noticed under trash mulching as compared to control when sugarcane was planted during b hot weather period in Tamil Nadu.

Suma and Savitha (2015) reported higher germination percentage with integrated sugarcane trash management compared to trash burning on clay loam soils of Mallanayakanakatte village of Mandya district, Karnataka.

Tayade *et al*. (2016) stated that germination percentage in sugarcane unaffected by in situ trash management treatments at ICAR-Sugarcane Breeding Institute, Coimbatore.

Ranjan *et al*. (2020) observed that at 45 DAP, higher germination percentage was recorded in sugarcane with the treatment receiving 100% N as inorganic fertilizer + organic mulching with sugarcane trash @ 6 t ha^{-1} + *Trichoderma* than control on sandy loam soils of Crop Research Centre, Pusa farm, Dr. Rajendra Prasad Central Agricultural University, Bihar.

2.11 EFFECT OF TRASH MULCHING ON GROWTH, YIELD ATTRIBUTES AND YIELD OF SEEDCANE

Results of experiment conducted by Anil and Sreenivasa (2000) revealed that application of 100% RDF + trash incorporation + *Phanerochaete chrysosporium* gave higher drymatter at all the growth stages except 180 DAP than no mulching on red sandy loam soils of University of Agricultural Sciences, Dharwad.

Panwar and Singh (2000) proved that the trash mulching in sugarcane increased yield by 16.6 per cent over no mulch on sandy loam soils of farmer's field near Yamuna nagar, Haryana.

Patel (2002) reported that application of trash mulch @ 10 t ha^{-1} and FYM @ 25 t ha^{-1} significantly increased single cane weight which is directly related to cane yield.

Singh (2002) conducted experiment on sandy loam soils of sugarcane and proved that application of trash mulching @ 6 t ha^{-1} gave significantly higher cane yield compared to mulching @ 3 t ha^{-1} and no mulching at Agricultural Research Station, Rajasthan.

Dahiya *et al*. (2003) inferred that trash mulching significantly increased cane yield by 11.6 per cent as compared to unmulched plots in sugarcane on loamy soils of research farm of CCS Haryana Agricultural University, Hisar.

Rana *et al*. (2003) revealed that maximum drymatter of shoot and cane weight were recorded under trash mulching along with nitrogen application over no mulching.

Studies conducted by Bhalerao *et al*. (2006) opined that application of recommended dose of NPK and trash resulted in significantly higher cane yield (107 t ha^{-1}) and it was on par with application of NPK @ 75% recommended dose + trash + biofertilizers (104 t ha^{-1}) on deep black soils of Central Sugarcane Research Station (CSRS), Padegaon.

Varghese and Massey (2006) conducted an experiment on sandy loam soils of Allahabad and stated that mulching with dead leaves significantly increased total biomass by 7.3 per cent over no mulching.

Kumar *et al*. (2008a) carried out experiment on sugarcane and observed that higher plant height, cane girth, average cane weight and cane yield were produced by the application of trash mulching @ 10 t ha^{-1} on sandy loam soils of new area farm of Dr. Rajendra Agricultural University (R.A.U.), Pusa.

Hemwong (2009) reported that plant height, stalk and tiller number per hill were not significantly influenced by sugarcane stover management methods on sandy soils of Agronomy Unit's field site at Khon Kaen University, Khon Kaen, Thailand.

Thakur *et al*. (2010) observed significantly higher number of tillers at 120 DAP, cane weight and cane yield with the application of 150 kg N + trash inoculated with *Trichoderma* + *Azotobacter* over control on sandy loam soils of Sugarcane Research Institute, Pusa, Bihar.

Studies conducted on sandy loam soils of New Area Farm of Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University (DRPCAU), Pusa, Bihar revealed that treatment receiving NPK @ 100 kg ha^{-1} along with 10 t ha^{-1} sugarcane trash gave higher yield in sugarcane (Umesh *et al*., 2013).

Studies conducted by Kumar *et al.* (2015a) proved that mulching @ 10 t ha^{-1} significantly improved plant height, cane girth and average cane weight over control on sandy loam soils of New Area Farm of R.A.U., Pusa.

A field experiment conducted at ICAR-Sugarcane Breeding Institute, Coimbatore revealed that in situ trash mulching coupled with microbial consortia application resulted in higher single cane weight and cane height over control (Tayade *et al*., 2016).

Choudhary *et al*. (2017) observed that chopping and surface retention of trash and use of multi-purpose machine for stubble shaving, offbarring, root pruning and drilling of basal doses of fertilizers and increasing the basal N to double the recommended dose recorded higher plant height, internodes per cane, internode length, cane diameter, cane length, cane weight on black soils of farmer's fields in Malegaon village and adjoining areas of Baramati tehsil, Pune.

Significantly higher number of tillers was noticed with integration of press mud, sugarcane trash and micronutrient Fe over recommended dose of fertilizers alone (Jha *et al.*, 2017).

Tayade *et al*. (2017b) reported that higher cane yield of 133.57 and 124.38 t ha^{-1} was produced with treatment receiving retention of green cane trash blanketing + 100% RDF + biofertilizer application at Thalavaipettai, Tamil Nadu.

Dhanapal *et al*. (2018) stated that setts planting at 90 cm with Composted Coir Pith (CCP) @ 10 t ha^{-1} or with sugarcane trash application @ 5 t ha^{-1} performed better and recorded significantly higher cane yield on sandy clay loam soils of ICAR-Sugarcane Breeding Institute, Coimbatore.

2.12 EFFECT OF TRASH MULCHING ON QUALITY PARAMETERS OF SEEDCANE

Anil and Sreenivasa (2000) noticed that quality parameters of sugarcane *viz.*, brix and pol percentage were not significantly influenced by any of the trash applied treatments on red sandy loam soils of University of Agricultural Sciences, Dharwad.

Singh *et al*. (2007) reported that quality parameters of sugarcane plant and ratoon crops were unaffected with the application of various organic treatments on sandy loam soils of Indian Institute of Sugarcane Research, Lucknow.

Kumar *et al*. (2008a) found that significant increase in brix and pol percentage in sugarcane juice by the application of trash mulching @ 10 t ha^{-1} than control on sandy loam soils of new area farm of R.A.U., Pusa.

Kumar *et al.*, (2015a) reported that trash mulching @ 10 t ha^{-1} significantly improved brix and pol percentage of cane juice over control on sandy loam soils of New Area Farm of R.A.U., Pusa.

Tayade *et al*. (2016) noticed that juice quality parameters in sugarcane viz., brix and sucrose percentage were unaffected by in situ trash management treatments at ICAR-Sugarcane Breeding Institute, Coimbatore.

2.13 EFFECT OF TRASH MULCHING ON NUTRIENT AVAILABILITY AND UPTAKE

Anil and Sreenivasa (2000) opined that the higher nutrient uptake and available N in soil was observed with trash incorporation + *Phanerochaete chrysosporium* on red sandy loam soils of University of Agricultural Sciences, Dharwad.

Shahi *et al*. (2003) carried out experiment at research farm of Indian Institute of Sugarcane Research, Lucknow on loamy soils of sugarcane and concluded that high concentration of potassium in sugarcane leaves was noticed with mulching.

The combined application of chemical fertilizers as well as trash resulted in increased availability of available N, P and K compared to control in sugarcane on Entisols of Sugarcane Research Station (SRS), Thiruvalla (Mathew and Varughese, 2007).

Singh *et al*. (2007) observed that availability status of major nutrients (NP) in soil was higher with application of sugarcane trash @ 10 t ha^{-1} + *Trichoderma* in sugarcane on sandy loam soils of farm of Indian Institute of Sugarcane Research, Lucknow.

Yadav *et al*. (2009) reported that increased N, P and K uptake by 15.9, 4.68 and 23.6 kg ha^{-1}, respectively with trash mulch + *Trichoderma* inoculation over uninoculated condition.

Nazirkar *et al*. (2010) noticed that application of RDF + trash + PSB + *Azotobacter* + *Azospirillum* gave maximum available N, P and K contents in soil and it was followed by other treatments of trash incorporation in sugarcane at Mahatma Phule Krishi Vidyapeeth, Rahuri.

Thakur *et al*. (2010) recorded that application of trash appreciably increased N, P and K uptake by crop as well as availability in soil over control in sugarcane on sandy loam soils of Sugarcane Research Institute, Pusa, Bihar.

Tyagi *et al*. (2011) observed that application of 100% NPK + trash + biofertilizer gave maximum uptake of N, P and K by sugarcane crop as well as available N, P and K content of soil compared to application of RDF alone on clay loam soils of G.B. Pant University of Agriculture and Technology, Pantnagar.

Umesh *et al*. (2013) found that higher N, P and K uptake by sugarcane crop were observed with application of NPK @ 100 kg ha^{-1} along with 10 t ha^{-1} sugarcane trash over inorganics alone on sandy loamy soils of New Area Farm of Sugarcane Research Institute, DRPCAU, Pusa, Bihar.

Kumar *et al*. (2014) reported that significantly increased available P and K was observed with combined application of sugarcane trash @ 3 t ha^{-1} along with N in soil over no trash.

Suma and Savitha (2015) concluded that higher N, P and K availability in soil was registered with integrated sugarcane trash management compared to trash burning on clay loam soils of Mallanayakanakatte village of Mandya district, Karnataka.

Tayade *et al.* (2017b) inferred that application of Green Cane Trash Blanketing (GCTB) + 100% RDF and GCTB + 100% RDF + microbial consortia gave higher soil available nitrogen in sugarcane at Thalavaipettai, Tamil Nadu.

2.14 EFFECT OF TRASH MULCHING ON ECONOMICS OF SEEDCANE

Singh (2002) reported that higher net returns (Rs. 42,219 ha^{-1}) and benefit cost ratio (2.68) were obtained with trash mulch applied @ 6 t ha^{-1} compared to mulching @ 3 t ha^{-1} and no mulching in sugarcane on sandy loam soils of Agricultural Research Station, Rajasthan.

Bhalerao *et al.* (2006) recorded that higher monetary returns (Rs. 1,12,350 ha^{-1}), net profit (Rs. 84,430 ha^{-1}) and BC ratio (4.02) with the application of recommended dose of NPK and trash in sugarcane on deep black soils of CSRS, Padegaon.

Experiment conducted by Virdia *et al.* (2009) revealed that treatment receiving trash incorporation @ 10 t ha^{-1} with biofertilizer inoculation + 100% NPK gave higher net income and benefit cost ratio in sugarcane ratoon crop on clay soils of Regional Sugarcane Research Station, Navsari.

Thakur *et al.* (2010) reported higher net returns and B:C ratio with the addition of *Trichoderma* inoculated sugarcane trash @ 10 t ha^{-1} + 150 kg N ha^{-1} and *Azotobacter* @ 4 kg ha^{-1} on sandy loam soils of Sugarcane Research Institute, Pusa, Bihar.

Tyagi *et al.* (2011) observed that application of 100% NPK + trash + biofertilizer gave maximum net returns and BC ratio as compared to control on clay loam soils of G.B. Pant University of Agriculture and Technology, Pantnagar.

Chapter – III

Material and Methods

Chapter III

MATERIAL AND METHODS

A field experiment entitled **"Biological Nutrient Management for Enhancing Yield and Quality of Seedcane"** was conducted during 2019-20 and 2020-21. The description with regard to the material used and the methods followed during the course of investigation has been comprehensively presented in this chapter.

3.1 LOCATION OF THE EXPERIMENTAL SITE

The experiment was conducted at Regional Agricultural Research Station, Anakapalle, Visakhapatnam district. It is located on the eastern side of the peninsular India, on 18°45' N latitude and 83°01' E longitude and at an altitude of 28.62 m above the mean sea level and about 22 km away from Bay of Bengal.

3.2 WEATHER DURING CROP PERIOD

The weather data recorded during the crop growth period in 2019-20 and 2020-21 at the Regional Agricultural Research Station, Anakapalle were summarized in Table 3.1 and depicted in Fig. 3.1a to 3.1b.

The weekly mean maximum temperature ranged from 28.4°C to 35.3°C and 27.4°C to 34.5°C during 2019-20 and 2020-21, respectively. The weekly mean minimum temperature for the corresponding period ranged from 17.2°C to 26.8°C and 15.7°C to 25.9°C, respectively while the average weekly maximum and minimum temperatures during the same period were 31.7°C and 22.5°C during 2019-20 and 31.9°C and 22.0°C during 2020-21, respectively. The weekly mean relative humidity for F. N and A. N ranged from 79.6 to 96.3 per cent and 47.3 to 82.3 per cent during 2019-20 and 82.6 to 96.3 per cent and 38.1 to 81.9 per cent during 2020-21, while the average weekly relative

Table 3.1. Average weekly weather data during crop growth period of sugarcane seed crop in 2019-20 and 2020-21

SMW*	Date and month	2019-2020						2020-2021					
		Mean temp (^{0}C)		Mean RH (%)		Rainfall (mm)	Rainy days	Mean temp (^{0}C)		Mean RH (%)		Rainfall (mm)	Rainy days
		Max.	Min.	F. N	A. N			Max.	Min.	F. N	A. N		
26	25 June-01 July	-	-	-	-	-	-	34.5	25.9	89.3	63.9	36.0	1
27	02 July -08 July	-	-	-		-	-	32.3	25.0	89.9	67.6	61.9	4
28	09 July -15 July	35.2	26.8	79.6	57.6	1.4	0	34.1	25.4	87.7	65.0	164.7	4
29	16 July -22 July	35.3	26.0	86.4	66.4	7.0	1	32.6	25.8	90.1	63.9	5.7	1
30	23 July -29 July	32.2	25.3	88.4	76.0	39.4	3	33.7	24.9	91.6	65.3	8.1	1
31	30July-05 Aug	31.7	25.3	80.1	65.4	18.4	2	34.1	25.7	90.3	68.0	52.3	3
32	06 Aug-12 Aug	32.0	25.4	90.4	68.0	65.6	3	32.4	25.5	89.0	71.4	22.4	1
33	13 Aug-19 Aug	34.6	26.1	87.9	64.3	7.9	1	29.9	24.5	94.7	73.6	52.6	4
34	20 Aug-26 Aug	34.5	25.8	91.3	61.4	39.6	4	32.7	25.8	91.0	69.1	15.2	2
35	27 Aug -02 Sep	34.4	25.6	85.4	63.7	92.6	2	34.1	25.1	88.0	65.4	5.5	1
36	03 Sep-09 Sep	30.8	25.3	92.1	72.6	23.3	4	33.9	25.4	89.1	63.4	11.3	2
37	10 Sep-16 Sep	32.0	25.4	90.9	76.1	20.5	3	33.9	25.3	91.0	70.3	64.3	5
38	17 Sep-23 Sep	32.7	25.3	93.9	77.7	96.6	5	33.0	25.4	91.9	69.0	35.6	4
39	24 Sep-30 Sep	30.9	24.5	94.4	81.1	143.1	5	33.2	24.9	90.0	67.0	35.5	3
40	01 Oct-07 Oct	33.2	24.1	94.7	71.3	40.5	2	32.3	24.5	92.6	75.3	69.0	3
41	08 Oct-14 Oct	32.8	24.0	95.4	69.3	35.4	4	31.6	24.5	93.9	81.9	277.2	5
42	15 Oct-21 Oct	30.8	24.4	94.9	76.4	34.5	3	31.8	24.5	92.0	72.6	100.4	3
43	22 Oct-28 Oct	30.1	24.4	96.3	82.3	199.6	4	32.7	23.9	90.1	54.6	0.0	0
44	29 Oct-04 Nov	32.4	24.0	93.4	62.0	5.9	2	32.7	22.1	89.9	53.1	6.2	1

Table 3.1 Cont…

SMW*	Date and month	2019-2020						2020-2021					
		Mean temp (^{0}C)		Mean RH (%)		Rainfall (mm)	Rainy days	Mean temp (^{0}C)		Mean RH (%)		Rainfall (mm)	Rainy days
		Max.	Min.	F. N	A. N			Max.	Min.	F. N	A. N		
45	05 Nov-11 Nov	32.5	21.7	85.6	48.0	0.0	0	31.8	20.2	86.1	55.9	0.0	0
46	12 Nov-18 Nov	31.8	21.9	88.6	50.3	0.0	0	30.6	19.8	82.6	51.1	28.2	1
47	19 Nov-25 Nov	31.2	20.6	91.0	53.6	0.0	0	31.5	20.2	87.7	61.0	12.4	1
48	26 Nov-02 Dec	31.0	20.5	91.4	54.4	0.0	0	27.4	16.9	89.3	64.9	86.1	3
49	03 Dec-09 Dec	29.8	18.9	89.7	49.1	0.0	0	30.5	16.1	88.7	55.1	0.0	0
50	10 Dec-16 Dec	29.9	19.5	91.4	52.6	0.2	0	30.7	16.3	93.0	53.9	0.0	0
51	17 Dec -23 Dec	30.2	19.0	93.7	51.4	0.0	0	29.8	15.9	91.6	55.4	0.0	0
52	24 Dec -31 Dec	28.4	17.8	90.6	51.9	0.0	0	29.0	15.7	91.1	48.1	0.0	0
1	01 Jan - 07 Jan	28.5	19.5	91.6	62.0	0.8	0	29.7	16.4	88.6	44.9	0.0	0
2	08 Jan - 14 Jan	29.6	17.4	94.9	49.9	0.0	0	32.2	17.2	89.4	38.1	0.0	0
3	15 Jan – 21 Jan	30.8	17.2	96.3	48.0	0.0	0	31.2	17.8	96.3	48.7	0.0	0
4	22 Jan – 28 Jan	31.7	19.4	96.0	54.7	0.0	0	31.8	19.3	95.0	53.3	0.0	0
5	29 Jan – 04 Feb	30.8	20.3	93.9	66.1	15.1	3	30.7	18.7	92.0	41.1	0.0	0
6	05 Feb – 11 Feb	29.5	20.4	92.1	56.0	1.6	0	-	-	-	-	-	-
7	12 Feb – 18 Feb	33.1	18.5	91.9	47.3	0.0	0	-	-	-	-	-	-
Total		**1014.5**	**720.2**	**2914.2**	**1987.0**	**889.0**	**51.0**	**1022.1**	**704.5**	**2893.4**	**1951.9**	**1150.6**	**53.0**
Mean		**31.7**	**22.5**	**91.1**	**62.1**	**-**	**-**	**31.9**	**22.0**	**90.4**	**61.0**	**-**	**-**

***Standard Meteorological Week**

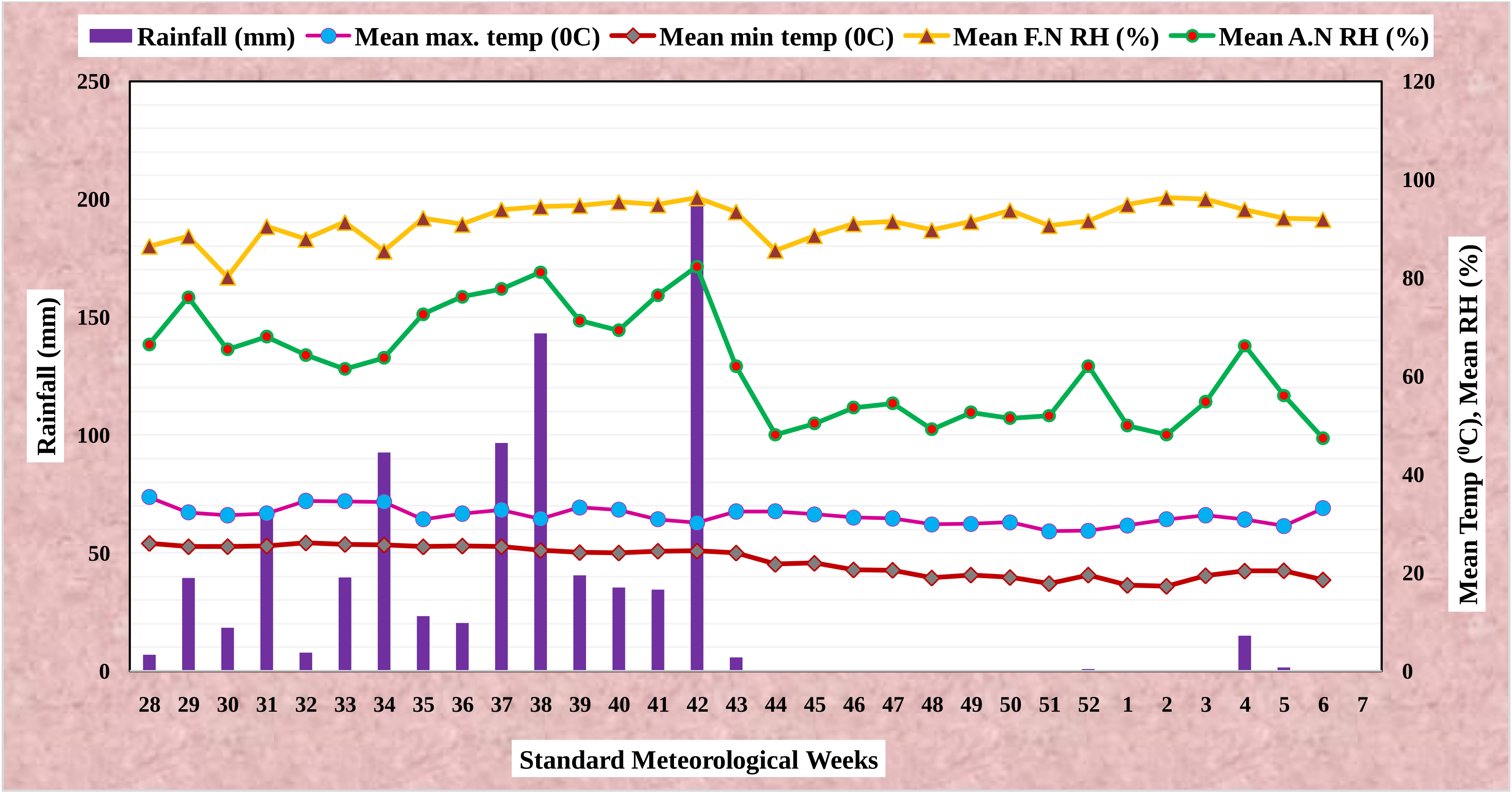

Fig. 3.1a. Weekly mean maximum, minimum temperatures, relative humidity for F.N, A.N and total weekly rainfall data for the crop growth period 2019-2020

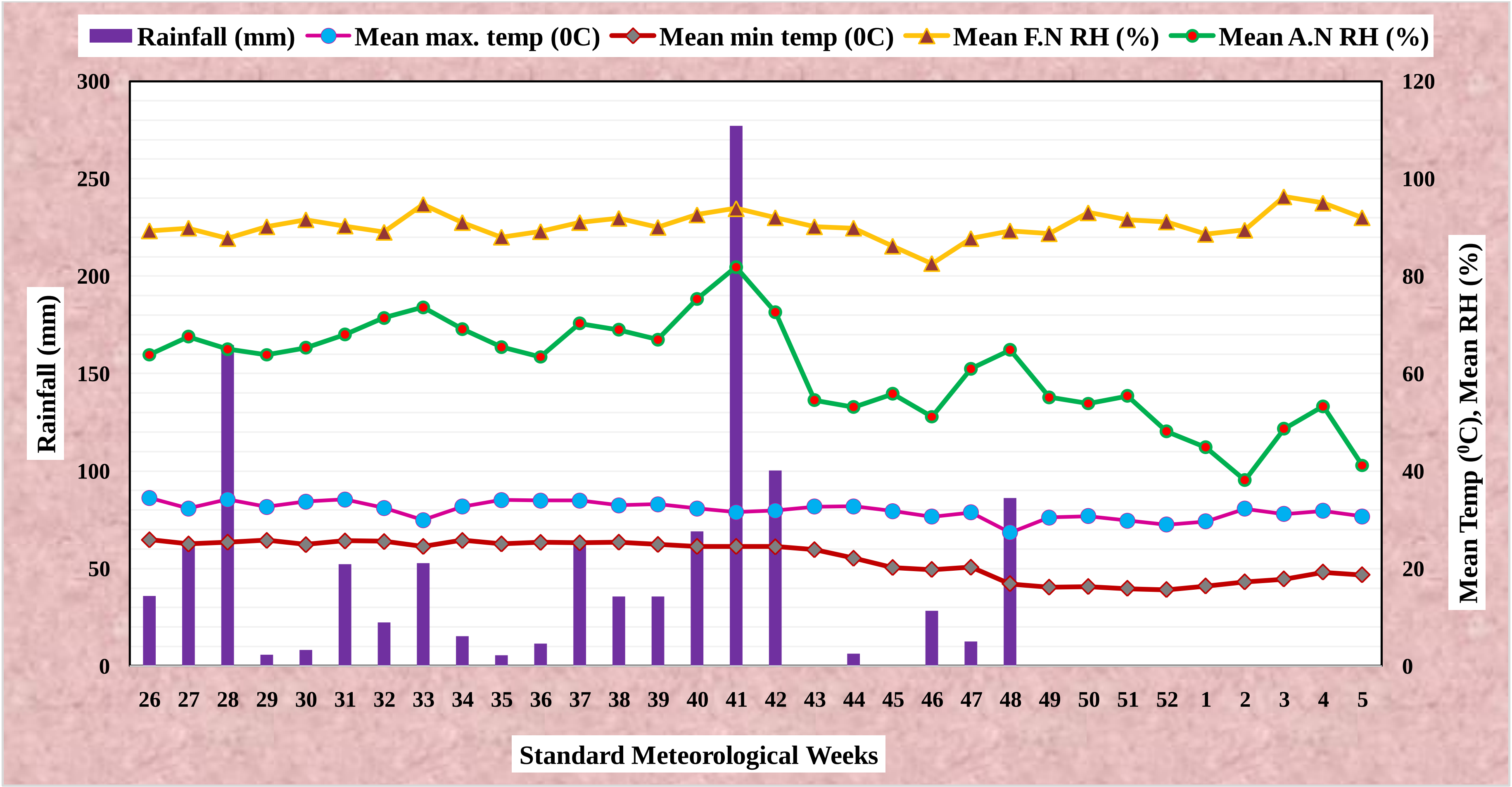

Fig. 3.1b. Weekly mean maximum, minimum temperatures, relative humidity for F.N, A.N and total weekly rainfall for the crop growth period 2020-2021

humidity for F. N and A. N were 91.1 and 62.1 per cent during 2019-20 and 90.4 and 61.0 per cent during 2020-21, respectively. A total rainfall of 889.0 mm and 1150.6 mm was received during 2019-20 and 2020-21 in 51 and 53 rainy days, respectively.

3.3 EXPERIMENTAL SOIL

Soil samples from 0-30 cm depth were collected at random from the experimental site before layout of the experiment. A composite soil sample was analyzed for physical and physico-chemical properties by following standard methods. The results of analysis indicated that the experimental soil was sandy clay in texture, neutral in reaction and medium in organic carbon, low in available nitrogen, high in available phosphorus and medium in available potassium (Table 3.2).

Table 3.2. Physical and physico-chemical properties of the experimental soil

S. No.	Properties	2019-20	2020-21	Method of analysis
I	**Physical properties**			
	Sand (%)	50.0	48.0	Bouyoucos hydrometer method (Piper, 1960)
	Silt (%)	10.0	11.0	
	Clay (%)	40.0	41.0	
	Textural class	Sandy clay	Sandy clay	
II	**Physico-chemical properties**			
	pH (1:2.5)	6.80	7.20	Glass electrode method (Jackson, 1973)
	EC (dS m^{-1} at 25°C)	0.17	0.22	Digital conductivity meter (Jackson, 1973)
III	**Chemical properties**			
	Organic carbon (%)	0.54	0.59	Modified Walkley and Black Method (Walkley and Black, 1934)
	Available N (kg ha^{-1})	232.7	244.0	Alkaline permanganate method (Subbiah and Asija, 1956)
	Available P_2O_5 (kg ha^{-1})	66.4	72.8	Olsen's method (Olsen *et al*., 1954)
	Available K_2O (kg ha^{-1})	272.8	276.0	Neutral normal ammonium acetate method (Muhr *et al.*, 1963)

3.4 CROPPING HISTORY OF THE EXPERIMENTAL FIELD

The experimental site has been under cultivation for many years. The cropping history for the five consecutive yester years is given below.

Table 3.3. Cropping history of the experimental site for past five years

Year	Crop	
	Kharif	***Rabi***
2014-2015	Fallow	Maize
2015-2016	Paddy	Fallow
2016-2017	Sugarcane	
2017-2018	Sugarcane	
2018-2019	Sugarcane	

3.5 EXPERIMENTAL DETAILS

The experiment was laid out (Fig. 3.2) in split - plot design with 18 treatments and replicated thrice.

3.5.1 Treatments :

Main plot : 3

Sub plot : 6

Replications : 3

I. Main plots

M_1: No biofertlizers

M_2: Biofertilzer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1})

M_3: Trash mulching with bio-decomposers

II. Sub plots (Time and Dose of Nitrogen & Potassium application)

S_1: 75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting

S_2: 75% STBNK at planting, 45, 90, 135 & 180 DAP

S_3: 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting

S_4: 100% STBNK at planting, 45, 90, 135 & 180 DAP

S_5: 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting

S_6: 125% STBNK at planting, 45, 90, 135 & 180 DAP

(P as basal and N & K as per treatments)

3.6 DESCRIPTION OF SEEDCANE CULTIVAR

The variety chosen was 87A 298. It is a cross between Co 7704 × Co C671. It is an early maturing variety, suitable for both irrigated and rainfed conditions and also a good ratooner. It is susceptible to smut but resistant to red rot. It is a high yielding variety with yield potential of 125 t ha^{-1} with high sucrose per cent (19.5%). At present this variety is occupying sizable area (nearly 40%) in the state of Andhra Pradesh.

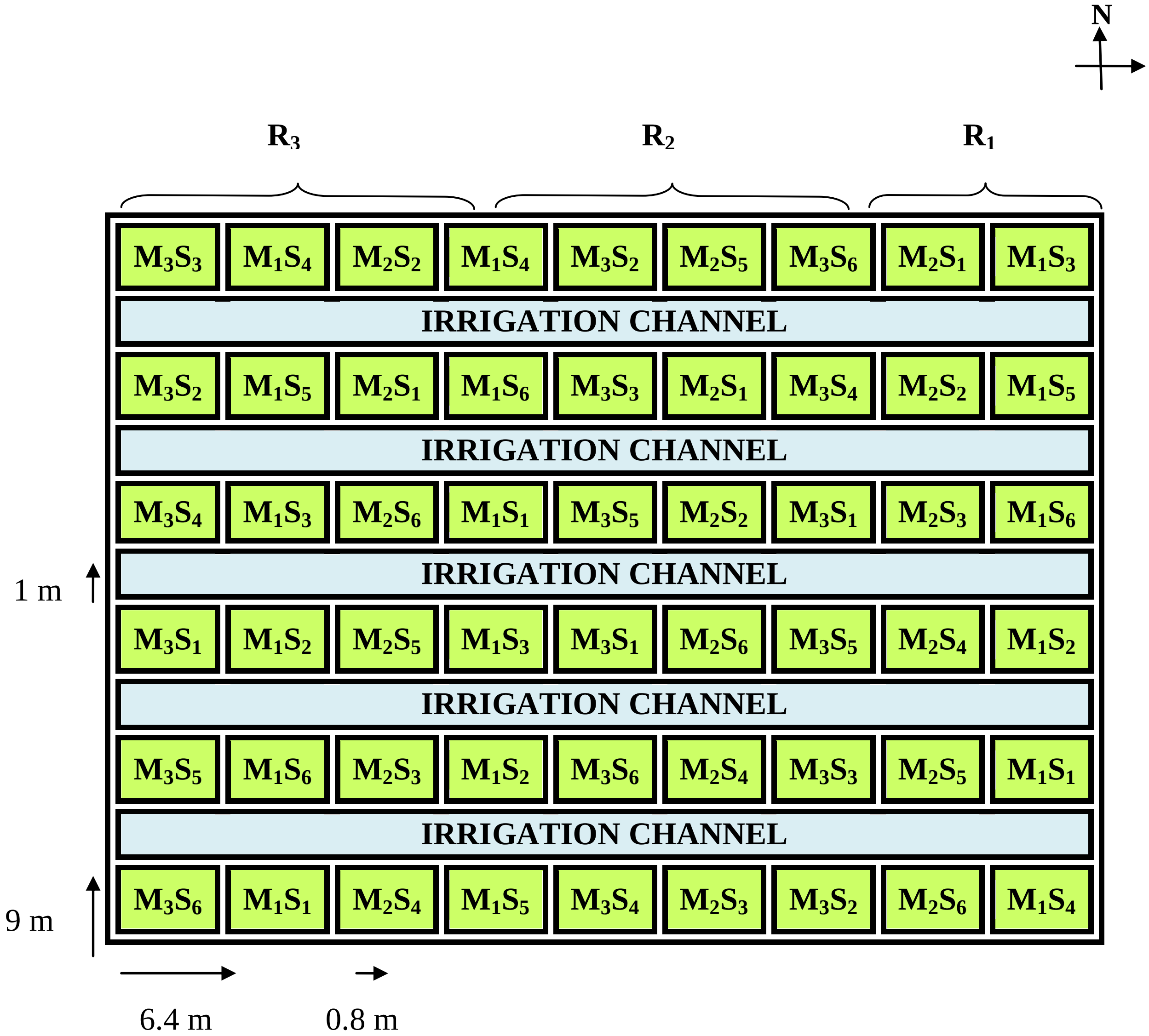

Fig. 3.2. Layout plan of experimental field during 2019-20 and 2020-21 of sugarcane seed crop

Crop	:	**Sugarcane (seed crop)**
Season	:	2019-20 and 2020-21
Treatments	:	18
Variety	:	87A 298 (Viswamitra)
Design	:	Split-plot
Replications	:	Three
Spacing	:	80 cm
Plot size	:	as per the details given below
Main plot	:	Gross : 6.4 m × 59.0 m (377.6 m^2)
Sub plot	:	Gross : 6.4 m × 9.0 m (57.6 m^2)
		Net : 3.2 m × 8.0 m (25.6 m^2)

3.7 CULTIVATION DETAILS

3.7.1 Field Preparation

The experimental field was ploughed once with mould board plough and then working with rotavator followed by cultivator in criss cross direction to get a fine tilth and later levelled by working a wooden plank. Deep furrows were formed at 80 cm apart with a tractor drawn ridge mar. The experimental plots were demarcated by forming cross channels with cattle pair at 9 m apart and rectified. These were used as irrigation channels during pre-monsoon and post-monsoon periods and as drainage channels during monsoon period whenever necessary. The field was then divided into required number of main plots and sub plots as per the layout plan (Fig. 3.2).

3.7.2 Planting

Disease free three budded setts of sugarcane variety 87A 298 from short crop seed material (40,000 three budded setts ha^{-1}) were planted in deep furrows on 14th July, 2019 and 1st July, 2020 for the first year and second year seed crops respectively.

3.7.3 Fertilizer Application

The organic manures *viz*., biofertilizer mixture *i.e*., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} were mixed in 100 kg FYM and kept for overnight and then applied in the field three days after planting of the crop as per the treatments (M_2) and trash mulching @ 3 t ha^{-1} was done on third day of planting and bio-decomposer mixed dung slurry was sprinkled on mulch for main plot M_3.

The inorganic fertilizers *viz*., N, P and K were applied as per the soil test basis (nitrogen was low in status for that additional 30% of recommended dose was applied, phosphorus status was high for that 30% of recommended dose was lowered and potassium status was medium for that normal recommended dose was applied). The recommended dose of NPK for seedcane is 112-100-

120 kg ha^{-1}. Nitrogen and potassium were applied as per the treatments (75, 100 and 125 per cent based on soil test results) in five equal splits i.e., at planting, 30, 60, 90, 120 DAP in S_1, S_3 and S_5 plots whereas to S_2, S_4 and S_6 treatments N & K were applied at planting, 45, 90, 135 and 180 DAP. An additional dose of 25 per cent recommended K was applied in S_1, S_3 and S_5 plots one month before harvesting of the seedcane crop. Entire quantity of phosphorus was applied as basal. Nitrogen, phosphorus and potassium were applied in the form of neem coated urea, SSP and MOP, respectively. The inorganic fertilizers were applied by pocketing method at 5 cm away and 7.5 cm depth nearer to the root zone. Foliar spraying of 19-19-19 and 13-0-45 was done during 4th week of October and 2nd week of November uniformly to all plots to ameliorate the detrimental effects of water logging during 2020-21.

3.7.4 Gap Filling

Gap filling was done at 25 DAP with three budded setts to ensure optimum crop stand.

3.7.5 Weed Management

2,4-D @ 2000 g ha^{-1} and metribuzin @ 1000 g ha^{-1} were sprayed at 30 DAP as post emergence spray against grass and broad leaved weeds. Manual weeding and hoeing was done at 60 and 90 DAP.

3.7.6 Irrigation

First irrigation was given immediately after planting to ensure proper germination. Subsequent irrigations were provided as and when required. A total of eight and seven irrigations during 2019-20 and 2020-21, respectively were given to supplement the rainfall during crop growth period.

3.7.7 Earthing up

Earthing up was done manually at 120 days age of the crop to provide adequate support to stalks against lodging and promote better root growth, anchorage and also suppress weeds.

3.7.8 Propping

Propping was done at 5th month age by "trash twist" method to keep the cane crop erect and prevent from lodging.

3.7.9 Plant Protection

Early shoot borer incidence was observed during the initial stages, which was controlled by spraying monocrotophos @ 1.6 ml L^{-1}. One spray of chlorpyriphos @ 2.5 ml L^{-1} was applied at 57 DAP during first year against termites. Whip smut was noticed, for that Tebuconazole + Trifloxystrobin (nativo) @ 0.5 g L^{-1} was sprayed at 69 DAP during first year. Soil drenching with copper oxychloride and streptocycline @ 3 g L^{-1} and 1 g 10 L^{-1} respectively were taken up thrice with an interval of four days at 120 DAP during second year to control bacterial wilt. Spraying of mancozeb 3 g L^{-1} and dimethoate @ 1.7 ml L^{-1} was taken up twice with an interval of 30 days at 130 DAP against rust and scales.

3.7.10 Harvesting

Plant crop was harvested in the month of February. At the time of harvest, two border rows on either side of the experimental plot were harvested first and the cane in remaining net plots were harvested separately and cane yield was recorded.

3.8 OBSERVATIONS RECORDED

For recording biometric observations, ten plants were labelled in each net plot area. All observations during the crop growth were recorded from the labelled plants at 60, 120, 180 DAP and at harvest. Plants of one meter row length in the second row from the left border row or seventh row from the right border row in each plot were sampled each time for recording drymatter production through destructive sampling.

3.8.1 Pre Harvest Observations

3.8.1.1 Germination Percentage: Germination was recorded at 40 DAP and expressed in percentage. It was calculated by the number plants established to the total number of buds originally planted.

$$\text{Germination \%} = \frac{\text{Number of buds germinated}}{\text{Total number of buds kept for germination}} \times 100$$

3.8.1.2 Plant Height: Ten labelled plants in the net plot were used for recording plant height. It is measured from the base of the plant to the top most visible dewlap leaf joint by using a linear meter scale at different crop growth stages i.e. at 60, 120 and 180 DAP and at harvest, averaged and expressed in centimeters.

3.8.1.3 Number of Tillers and Shoot Population: Number of tillers at 60 and 120 DAP and shoots at 180 DAP were counted manually in each plot of all replications. Tiller and shoot population per plot was arrived by taking the cumulative total of all rows and expressed as thousands ha^{-1}.

3.8.1.4 Stalk Population: Number of stalks at harvest was counted manually in each plot of all replications. Stalk population per plot was arrived by taking the cumulative total of all rows and expressed as thousands ha^{-1}.

3.8.1.5 Drymatter Production: Plants of one meter row length from the destructive sampling area from each plot at 60, 120, 180 DAP and at harvest were cut at the base then chopped into small pieces and fresh weight of sample was taken. The plant samples were initially shade dried followed by hot air oven drying at 70°C till a constant weight was obtained. The dry weight of each sample was determined and expressed as drymatter production in kg ha^{-1}.

3.8.2 Post-Harvest Observations

3.8.2.1 Single Cane Weight: The weight of ten randomly selected canes from each plot was recorded and the mean weight thus obtained was expressed as weight of single cane in kilograms.

3.8.2.2 Seedcane Length: The length of ten randomly selected mature canes were measured from base to the least transverse mark at the time of harvest and expressed as mean seedcane length in centimetres.

3.8.2.3 Cane Diameter: The diameter of ten randomly selected canes were measured by using vernier calipers at bottom, middle and top portion of each cane at the time of harvest and the average diameter of each cane was computed and expressed in centimetres.

3.8.2.4 Number of Internodes per Cane: The total number of internodes from each of the ten sampled canes were counted at the time of harvest and the average number of internodes per cane was calculated.

3.8.2.5 Hundred Three Bud Sett Weight: The weight of 100 three bud setts in the net plot of each treatment at the time of harvest from the three replications were recorded and mean was calculated and expressed in kilograms.

3.8.2.6 Seedcane Yield: All the canes in net plot of each treatment were harvested to ground level individually at the time of harvest and the cane weight was recorded in kg per net plot after detrashing and de-topping just below the spindle using spring balance and expressed in t ha^{-1}.

3.8.3 Quality Parameters

Ten canes from net plot of each treatment were selected randomly at harvest and crushed after detopping and detrashing by using sugarcane crusher. The extracted juice was used for determination of juice quality parameters.

3.8.3.1 Germinability of Seed Produced: Hundred single node setts were taken randomly from each plot after harvest of the seed crop and planted in portrays. Germination percentage was calculated at 30 DAP. It was computed as the number plants established to the total number of buds originally planted.

3.8.3.2 Seedling Vigour Index: Ten seedlings from the germination test were randomly selected for measurement of seedling length. The seedling length was measured from base of the plant to the tip of the leaf and expressed in centimeters. It was computed by using below formula suggested by Abdul-Baki and Anderson (1973).

$$\text{Seedling Vigour Index} = \text{Germination (\%)} \times \text{Seedling length (cm)}$$

3.8.3.3 Moisture Percentage in Sett: Moisture content of seedcane stalk for each treatment was determined by samples taken randomly and fresh weight was recorded. Then shade dried followed by oven drying and dry weight was recorded. The moisture per cent was calculated with the formula

$$\text{Moisture \%} = \frac{\text{Weight of fresh sample - weight of dry sample}}{\text{Weight of dry sample}} \times 100$$

3.8.3.4 Reducing Sugars Percentage: The reducing sugars were estimated by Lane and Eynon's volumetric method. Taken 5 ml of each Fehlings A and Fehlings B solution and boiled until clear bubbles appeared then added three to four drops of methylene blue and then titrated against filtered cane juice till solution turns to brick red colour and volume of juice consumed was recorded and expressed in per cent. The reducing sugars per cent was calculated by using the formula (Brown and Zerban, 1941).

$$\text{Reducing Sugars \%} = \frac{5}{\text{Titre value}}$$

3.8.3.5 Brix Percentage: Brix represents total soluble solids present in the juice. The extracted juice sample was clarified by adding a small quantity (3 g) of dry lead acetate and filtered through ordinary filter paper. The brix per cent at harvest was determined using Sucrolyzer.

3.8.3.6 Sucrose Percentage: The extracted juice sample was clarified by adding a small quantity (3 g) of dry lead acetate and filtered through ordinary filter paper. The sucrose per cent at harvest was determined using Sucrolyzer.

Sucrose percentage in juice was determined by using pol reading and brix per cent values by referring table values as indicated by Brown and Zerban (1941) and expressed in per cent.

3.9 SOIL ANALYSIS

Soil samples were collected initially and after harvest of the crop from 0-30 cm depth and were shade dried, ground with a wooden hammer, passed through a 2 mm sieve and finally stored in labelled airtight polythene bags for laboratory analysis (Table 3.2).

3.10 CHEMICAL ANALYSIS OF PLANT MATERIAL

3.10.1 Nutrient Content

Nitrogen, phosphorus and potassium content in whole plant at different stages of crop growth *viz.*, 60, 120, 180 DAP and at maturity were estimated by following methods detailed below (Table.3.4).

Table 3.4. Methods adopted for plant analysis

Element	Method adopted	Reference
Nitrogen	Microkjeldahl distillation method	Bremner (1965)
Phosphorus	Vanado molybdo phosphoric yellow colour method	Koeing and Johnson (1942)
Potassium	Flame photometer method	Jackson (1973)

3.10.2 Nutrient Uptake

Nutrient uptake was calculated by multiplying the nutrient content with respective drymatter yield and expressed in kg ha^{-1}.

Nutrient uptake (kg ha^{-1}) =

$$\frac{\text{Nutrient content (\%)} \times \text{Weight of drymatter (kg ha}^{-1}\text{)}}{100}$$

3.11 ECONOMICS

The gross returns from each treatment were worked out with the prevailing market prices. The net returns from each treatment were calculated by deducting the cost of cultivation from gross returns. Benefit cost ratio for all the treatments were also worked out on the basis of gross returns and cost of cultivation.

Gross returns = Value of the product

Net returns = Gross returns - Total cost of cultivation

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns}}{\text{Total cost of cultivation}}$$

3.12 STATISTICAL ANALYSIS

The data collected on growth, development, yield components and yield of crop was analysed statistically to draw a valid conclusion. The data were analysed as per the standard analysis of variance procedure for split plot design by Rangaswamy (2013). Statistical significance was tested by applying F-test at 0.05 level of probability. Critical differences at 5 per cent level was worked out for the effects, which were significant.

Chapter – IV

Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

The results of the field experiment entitled **“Biological Nutrient Management for Enhancing Yield and Quality of Seedcane”** conducted during 2019-20 and 2020-21 at Regional Agricultural Research Station, Anakapalle, are presented in this chapter under appropriate heads and subheads depicting in tables and figures. The results of the experiment are also discussed with possible reasons and correlated with relevant findings.

4.1 EXPERIMENTAL SOIL AND WEATHER CONDITIONS DURING SEEDCANE CROP

The experimental soil was sandy clay in texture, neutral in reaction, medium in organic carbon, low in available nitrogen, high in available phosphorus and medium in available potassium (Table 3.2).

The impacts of long term climatic change as well as local weather and seasonal variations have strong influence on sugarcane crop. Basically, sugarcane is an irrigated crop and depends profoundly on the amount and duration of precipitation, temperature, humidity, moisture content and soil condition (Gawander, 2007).

The weekly mean maximum temperature ranged from 28.4°C to 35.3°C and 27.4°C to 34.5°C during 2019-20 and 2020-21, respectively. The weekly mean minimum temperature for the corresponding period ranged from 17.2°C to 26.8°C and 15.7°C to 25.9°C, respectively while the average weekly maximum and minimum temperatures during the same period were 31.7°C and 22.5°C during 2019-20 and 31.9°C and 22.0°C during 2020-21, respectively. The weekly mean relative humidity for F. N and A. N ranged from 79.6 to 96.3 per cent and 47.3 to 82.3 per cent during 2019-20 and 82.6 to 96.3 per cent and 38.1 to 81.9 per cent during 2020-21, while the average weekly relative humidity for F. N and A. N were 91.1 and 62.1 per cent during 2019-20 and

90.4 and 61.0 per cent during 2020-21, respectively. A total rainfall of 889.0 mm and 1150.6 mm was received during 2019-20 and 2020-21 in 51 and 53 rainy days, respectively. The rainfall is not well assured and unevenly distributed. However, the rainfall was well distributed during the year 2019 from July to October as compared to heavy rainfall received during the corresponding period with peaks during 2nd week of July and 3rd and 4th week of October (Table 3.1 and depicted in Fig. 3.1a to 3.1b).

The crop performance was much affected due to variation in rainfall arise during the second year of experimentation. As the heavy rainfall occurred during 2nd week of July, which coincides with the germination of seedcane owing to less sprouting. Besides, the heavy rainfall again thrash the crop during 3rd and 4th week of October at that time the crop was at peak tillering stage. This leads to waterlogged conditions prevailed during formative phase which triggers various bacterial and fungal diseases and certainly causes great yield loss. Abiotic stresses on sugarcane, as a consequence of changing climate, affect soil health, growth and development of the crop, its chemical composition, accumulation and synthesis of sugar and also exacerbate other abiotic/biotic stresses which augment the losses incurred (Shrivastava *et al.*, 2016).

4.2 EFFECT OF ORGANIC SOURCES AND TIME AND DOSE OF NITROGEN AND POTASSIUM APPLICATION ON GERMINATION, GROWTH, YIELD ATTRIBUTES AND YIELD OF SEEDCANE

4.2.1 Germination Percentage

Germination is found to be a critical phase in the life cycle of the plant as good germination denotes good start of the crop which bring about adequate plant stand at harvest.

Data pertaining to germination percentage of cane setts as influenced by organic sources as well as time and dose of nitrogen and potassium application are presented in Table 4.1. The data indicated that germination percentage was not significantly influenced by organic sources during both the years of study

Table 4.1. Germination percentage of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1 - No Biofertilizers	65.2	55.0	60.1
M_2 - Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	66.5	57.3	61.9
M_3 - Trash mulching with bio-decomposer (A & B)	66.2	56.8	61.5
SEm±	1.37	1.30	1.64
CD (p = 0.05)	NS	NS	NS
CV (%)	8.8	9.8	11.4
Time and dose of N & K application			
S_1 - 75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	63.7	54.8	59.3
S_2 75% STBNK at planting, 45, 90, 135 & 180 DAP	64.1	56.0	60.0
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	67.3	56.1	61.7
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	65.9	56.4	61.1
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	67.7	58.0	62.9
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	67.0	57.0	62.0
SEm±	1.85	1.41	1.46
CD (p = 0.05)	NS	NS	NS
CV (%)	8.4	7.5	7.2
Interaction	NS	NS	NS

and also in pooled data. Similar to the organic sources, the time and dose of N and K application exhibited no significant variation in germination percentage of seedcane setts. The interaction between organic sources and time and dose of N and K application also found to be non significant in influencing germination percentage. These findings are in line with the earlier findings of Thakur *et al*. (2010), Mahatma *et al*. (2016) and Banerjee *et al*. (2018).

The non significant effect of various treatments on germination percentage of cane setts might be due to absence of absorbing and assimilatory organs of sett at germination stage. The results are in corroboration with Singh *et al*. (2008), Kumar *et al*. (2012), Sarala *et al*. (2012) and Singh and Uppal (2013).

4.2.2 Plant Height (cm)

Data on plant height recorded at different growth stages of crop *viz*., 60, 120, 180 DAP and at harvest are emboided in Table 4.2 and depicted in Fig. 4.1.

Plant height was significantly influenced by both organic sources as well as time and dose of N and K application at all the growth stages *i.e*., 60, 120, 180 DAP and at harvest while, the interaction between these two found to be non significant during both the years of experimentation and also in pooled data. Though the plant height of different treatments were higher during the first year (2019-20) of study than that of second year (2020-21), the effect of various treatments were almost similar in both the years.

The data in Table 4.2 revealed that plant height increased gradually with advancement in age of the crop from 60 DAP to till harvest.

At 60 DAP, significantly taller plants were observed (66.1, 58.2 and 62.1 cm during 2019-20, 2020-21 and in pooled data, respectively) with the application of biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1}) over control but was on a par with trash mulching with bio-decomposers.

Table 4.2. Plant height (cm) at different growth stages of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest
Organic sources												
M_1	60.4	148.3	201.9	219.0	49.6	138.6	187.3	203.0	55.0	143.4	194.6	211.0
M_2	66.1	166.6	217.8	237.3	58.2	155.4	203.5	223.9	62.1	161.0	210.7	230.6
M_3	64.7	163.8	216.9	235.8	55.2	153.1	200.7	220.6	59.9	158.5	208.8	228.2
SEm±	1.13	3.66	3.38	3.81	1.47	3.46	3.28	4.23	1.28	3.57	3.33	4.05
CD (p = 0.05)	4.4	14.4	13.3	15.0	5.8	13.6	12.9	16.6	5.0	14.0	13.1	15.9
CV (%)	7.5	9.7	6.8	7.0	11.5	9.8	7.1	8.3	9.2	9.8	6.9	7.7
Time and dose of N & K application												
S_1	60.0	150.4	196.7	217.8	51.4	139.6	188.0	204.8	55.7	145.0	192.3	211.3
S_2	58.7	145.7	194.3	214.9	50.0	137.4	185.8	202.6	54.4	141.5	190.0	208.8
S_3	65.1	163.7	220.6	237.1	56.1	154.6	201.7	222.1	60.6	159.2	211.1	229.6
S_4	62.8	160.6	210.9	231.1	54.1	149.6	198.6	215.6	58.4	155.1	204.8	223.4
S_5	68.9	170.4	228.1	244.1	58.4	159.5	205.9	226.2	63.6	164.9	217.0	235.2
S_6	66.7	166.6	222.8	239.2	55.8	153.5	203.0	223.7	61.3	160.1	212.9	231.4
SEm±	1.46	4.43	4.73	5.37	1.58	4.14	4.10	4.63	1.49	4.46	3.87	4.87
CD (p = 0.05)	4.2	12.8	13.7	15.5	4.6	11.9	11.8	13.4	4.3	12.9	11.2	14.1
CV (%)	6.9	8.3	6.7	7.0	8.7	8.3	6.2	6.4	7.6	8.7	5.7	6.5
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

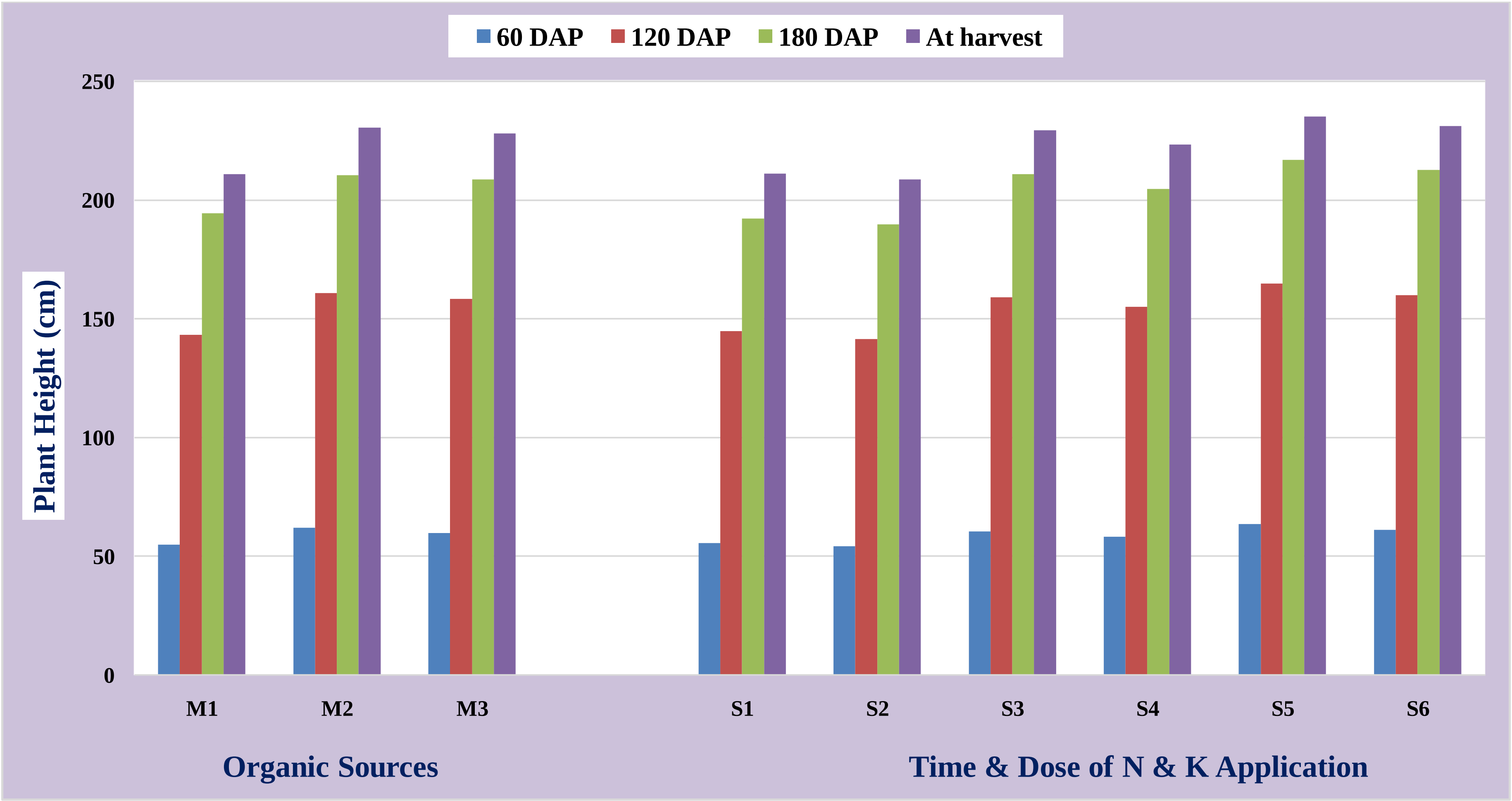

Fig. 4.1. Plant height (cm) at different growth stages of sugarcane seed crop as influenced by biological nutrient management in pooled data

At 120 DAP, though maximum plant height (166.6, 155.4 and 161.0 cm during 2019-20, 2020-21 and in pooled data, respectively) was recorded with application of biofertilizer mixture, it was on a par with trash mulching with bio-decomposers (163.8, 153.1 and 158.5 cm during 2019-20, 2020-21 and in pooled data, respectively) and both the treatments were significantly superior to control (148.3, 138.6 and 143.4 cm during 2019-20, 2020-21 and in pooled data, respectively). The differences in plant height of seedcane recorded at 180 DAP and at harvest followed a similar trend during both the years of experimentation and in pooled data.

At all the stages of crop growth, plant height increased with the addition of biofertilizers as well as trash mulching. It could be due to the fact that application of biofertilizers and trash mulching improved soil environment in respect of nutrients for crop growth at active growing stages as a result of elevated root proliferation, cell multiplication and elongation leading to increased plant height. This is in agreement with observations made by Nazirkar *et al*. (2010), Shridevi *et al*. (2016) and Viana *et al*. (2019).

Among various sub plot treatments, the data pertaining to plant height at 60, 120, 180 DAP and at maturity (Table 4.2) revealed that taller plants (68.9, 170.4, 228.1 and 244.1 cm) were recorded with 125% STBNK applied in five splits *i.e*., at planting, 30, 60, 90, 120 DAP + 25% additional dose of recommended K one month before harvesting which was on a par with 100% STBNK applied at planting, 30, 60, 90, 120 DAP + 25% additional dose of recommended K one month before harvesting (65.1, 163.7, 220.6 and 237.1 cm) and both were found significantly superior to 75% STBNK applied at planting, 30, 60, 90, 120 DAP + 25% additional dose of recommended K one month before harvesting. Lower plant height (58.7, 145.7, 194.3 and 214.9 cm) was recorded with 75% STBNK applied at planting, 45, 90, 135 and 180 DAP during 2019-20. Similar trend was observed during second year of experimentation and in pooled data.

Increased dose of fertilizers might have provided adequate nutrition to plant leading to anatomical changes like increase in cell size, intercellular spaces, thinner cell walls and lower development of epidermal tissue resulting in increased number of nodes, more elongation of internodes or both which ultimately culminated in increased plant height. Similar findings were reported by Choudhary and Sinha (2001), Rathore *et al*. (2014) and Wubale and Girma (2018).

4.2.3 Number of Tillers at Different Growth Stages and Shoot Population at 180 Days after Planting

Optimum plant population per unit area is crucial to get maximum yield. Tillering in seedcane found to be the most important parameter that contributes to number of canes per unit area.

Number of tillers per hectare was recorded at 60, 120 DAP and shoot population at 180 DAP were presented in Table 4.3 and graphically depicted in Fig. 4.2.

A perusal of the data in Table 4.3 indicates that the organic sources significantly influenced number of tillers ha^{-1} at 120 DAP and shoot population at 180 DAP during both the years of study as well as in pooled data.

At 60 DAP, tiller number was not influenced by main plot treatments. At 120 DAP, higher number of tillers (132.3, 125.9 and 129.1 '000 ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) was recorded with application of biofertilizer mixture *i*.e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} (M_2), which was on a par with trash mulching with bio-decomposers (130.6, 123.8 and 127.2 '000 ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) and both the treatments were found significantly superior to control (120.1, 110.7 and 115.4 '000 ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively).

Shoot population at 180 DAP were higher with biofertilizers and VAM application (108.9, 102.3 and 105.6 '000 ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) which was comparable to trash mulching (105.6, 100.3 and 102.9 '000 ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) and both were superior to control (98.9, 92.4 and 95.7 ‘000 ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively).

In general, application of biofertilizers increased tiller number, probably due to plant regulator hormones secreted by *Azospirillum brasilense*. Ethylene is the foremost phytohormone regulating this physiological process in sugarcane (Mishra *et al*., 2014). Moreover, application of PSB has ability to trigger release of cytokinins which will be essential for cell division in tiller buds. The results are in conformity with the findings of Thakur *et al*. (2010), Singh *et al*. (2016) and Viana *et al*. (2019).

The tiller number and shoot population were significantly affected by time and dose of nitrogen and potassium application at 120 and 180 DAP while such significant influence was not observed at 60 DAP. Number of tillers increased with increase in fertilizer dose from 75% to 125% at all the crop growth stages.

In seed crop at 60 DAP, tiller number did not differ significantly with any of the sub plot treatments. At 120 DAP, application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% recommended K one month before harvesting registered higher number of tillers (135.5 ‘000 ha^{-1} during 2019-20) due to early emergence and better photosynthetic efficiency with adequate nitrogen application. However, tiller population at S_5 was comparable with 125% STBNK applied at 45 days interval (S_6), 100% STBNK applied at 30 days interval + additional 25% RDK (S_3) and distinctly superior to 100% STBNK alone applied at 45 days interval (S_4), 75% STBNK applied at 30 days interval + additional 25% RDK (S_1) and 75% STBNK alone applied at 45 days interval (S_2) during the first year of study. Similar trend was observed in shoot population at 180 DAP during both the years of study and in pooled data.

In the second year of experimentation and in pooled data, S_5 treatment recorded maximum number of tillers (127.8 and 131.6 ‘000 ha^{-1}, respectively) at 120 DAP which was significantly superior to the rest of treatments

Table 4.3. Number of tillers ('000 ha^{-1}) at 60, 120 DAP and shoot population at 180 DAP of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20			2020-21			Pooled data		
	60 DAP	120 DAP	180 DAP	60 DAP	120 DAP	180 DAP	60 DAP	120 DAP	180 DAP
Organic sources									
M_1	87.1	120.1	98.9	76.9	110.7	92.4	82.0	115.4	95.7
M_2	90.2	132.3	108.9	83.1	125.9	102.3	86.7	129.1	105.6
M_3	90.1	130.6	105.6	81.4	123.8	100.3	85.8	127.2	102.9
SEm±	2.05	2.48	1.56	1.80	3.11	1.90	1.80	2.78	1.77
CD (p = 0.05)	NS	9.7	6.1	NS	12.2	7.5	NS	10.9	6.9
CV (%)	9.8	8.2	6.3	9.5	11.0	8.2	9.0	9.5	7.4
Time and dose of N & K application									
S_1	86.8	121.5	101.7	79.1	113.4	93.7	82.9	117.4	97.7
S_2	87.4	120.2	99.8	79.0	110.4	91.5	83.2	115.3	95.6
S_3	89.8	131.1	107.9	81.3	124.1	101.6	85.5	127.6	104.8
S_4	89.3	125.4	103.0	80.3	120.6	96.9	84.8	123.0	99.9
S_5	91.0	135.5	108.7	81.6	127.8	104.2	86.3	131.6	106.4
S_6	90.6	132.3	105.9	81.5	124.4	102.3	86.1	128.4	104.1
SEm±	2.39	3.34	1.78	2.54	4.25	2.47	1.94	3.80	2.21
CD (p = 0.05)	NS	9.6	5.2	NS	12.3	7.1	NS	11.0	6.4
CV (%)	8.0	7.8	5.1	9.5	10.6	7.5	6.9	9.2	6.5
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

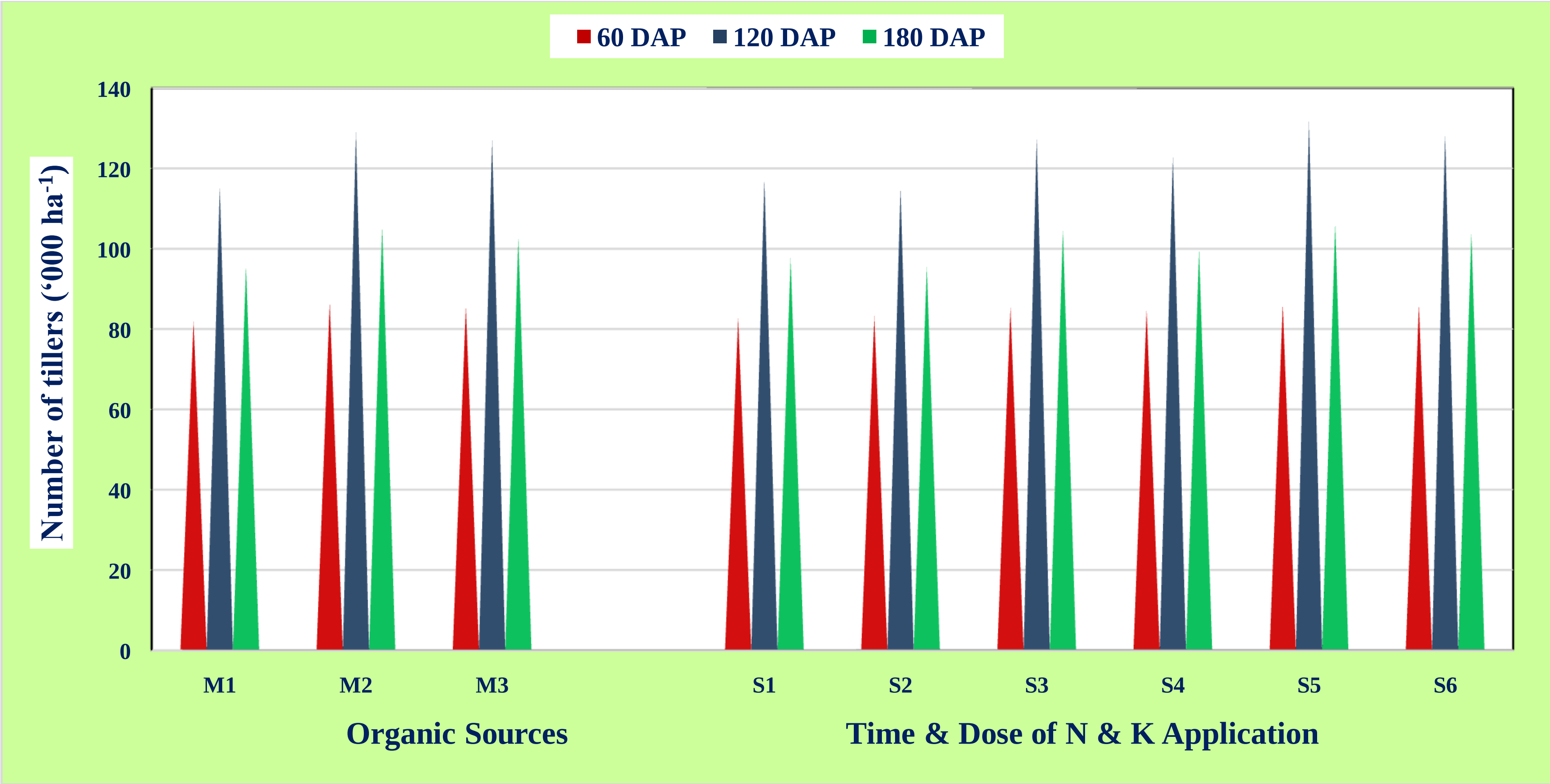

Fig. 4.2. **Number of tillers ('000 ha^{-1}) at 60, 120 DAP and shoot population at 180 DAP of sugarcane seed crop as influenced by biological nutrient management in pooled data**

but maintained parity with S_6, S_3 and S_4 treatments. The lower number of tillers (110.4 and 115.3 '000 ha^{-1}, respectively) was observed with S_2 treatment. More tiller numbers and shoot population were observed with increased rate of fertilizer due to continuous uptake of nutrients under higher level of fertilizers and implies increased rate of physiological process in plants owing to more tiller or shoot production in seed crop. The results are in agreement with the findings of Srivastava *et al*. (2007), Rahman *et al*. (2009), Dev *et al*. (2011), Singh and Uppal (2013), Rathore *et al*. (2014), Madhu *et al*. (2018) and Kumar and Kumar (2020).

The interaction between organic sources and time and dose of nitrogen and potassium was found non significant with respect to number of tillers or shoots in seedcane during all the growth stages.

4.2.4 Drymatter Production

Perusal of data pertaining to drymatter production at 60, 120, 180 DAP and at harvest was presented in Table 4.4 and illustrated in Fig. 4.3.

A linear increase in drymatter accumulation was observed throughout the growth period of seedcane. Data displayed in Table 4.4 exhibited that application of various organic sources had a significant influence on drymatter accumulation at 120, 180 DAP and at harvest. At 60 DAP, no significant differences were observed with execution of various organic sources during both the years of experimentation and in pooled data.

Obviously, the application of biofertilizer mixture *i*.e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} exhibited remarkable performance in increasing drymatter production (9134, 7317 and 8226 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) at 120 DAP and was comparable with trash mulching (M_3) and both the treatments found significantly superior to control. At 180 DAP and at harvest unaltered trend of treatmental performance continued with regard to drymatter accumulation as noticed at 120 DAP during both the years of study and also in pooled data.

The per cent increase in drymatter at harvest with biofertilizer, trash mulching over control was 18.8, 17.6 during 1st year, 15.9, 13.3 during 2nd year and 17.4, 15.5 in pooled data, respectively.

Increased drymatter accumulation with the application of biofertilizers could be attributed to strategy that they enhance growth and development in younger plants, while preserving as much relevant morphological traits as possible, such as deeper roots and a larger availability of green leaves to uptake minerals from the substantial soil depths and robustly perform photosynthesis (Viana *et al.*, 2019). The results are in line with Anil and Sreenivasa (2000), Shankaraiah and Hunsigi (2000) and Banerjee *et al.* (2018).

At all the growth stages, drymatter production was significantly influenced by different dose and time of N and K application. At 60 DAP, addition of 125% STBNK at planting, 30, 60, 90 and 120 DAP + additional dose of 25% recommended K one month before harvesting (S_5) recorded appreciable increase in drymatter production (2306 and 1988 kg ha^{-1} during 2019-20 and in pooled data, respectively) and maintained parity with 125% STBNK applied at planting, 45, 90, 135 and 180 DAP, 100% STBNK applied at planting, 30, 60, 90, 120 DAP + extra dose of 25% recommended K one month before harvesting. The application of 100% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% RDK one month before harvesting was on par with 100% STBNK alone applied at planting, 45, 90, 135 and 180 DAP. Distinctly lower drymatter production was found with 75% STBNK alone applied at planting, 45, 90, 135 and 180 DAP (1931 and 1707 kg ha^{-1} during 2019-20 and in pooled data, respectively) and 75% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting during the first year of study and in pooled data.

During the second year of study at 60 DAP, noticeable increase in drymatter accrual was recorded with S_5 treatment (1669 kg ha^{-1} during 2020-21) and was comparable with the treatments S_6, S_3 and S_4 and significantly superior to rest of the treatments.

Table 4.4. Drymatter production (kg ha^{-1}) at different growth stages of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest
Organic sources												
M_1	2087	7793	22550	25301	1554	6299	19956	24122	1820	7046	21253	24711
M_2	2169	9134	27042	30070	1608	7317	24218	27955	1889	8226	25630	29012
M_3	2155	9052	25639	29755	1588	7290	23465	27336	1871	8171	24552	28545
SEm±	42.9	242.7	391.2	913.5	36.4	220.0	396.4	494.7	34.5	248.5	394.6	625.7
CD (p = 0.05)	NS	953	1536	3587	NS	864	1556	1942	NS	976	1550	2457
CV (%)	8.5	11.9	6.6	13.7	9.8	13.4	7.5	7.9	7.9	13.5	7.0	9.7
Time and dose of N & K application												
S_1	1975	7843	22566	27052	1505	6580	19296	24330	1740	7211	20931	25691
S_2	1931	7582	20955	25717	1483	6372	17852	23361	1707	6977	19404	24539
S_3	2188	8996	26711	29495	1618	6993	24487	27803	1903	7994	25599	28649
S_4	2138	8421	25431	27652	1584	6820	23122	26526	1861	7621	24277	27089
S_5	2306	9836	27812	30694	1669	7794	25724	28691	1988	8815	26768	29693
S_6	2281	9281	26988	29642	1640	7252	24796	28114	1961	8267	25892	28878
SEm±	57.7	338.6	526.4	796.9	46.1	310.8	515.5	668.4	39.3	324.7	514.7	862.5
CD (p = 0.05)	167	978	1520	2302	133	898	1489	1930	114	938	1487	2491
CV (%)	8.1	11.7	6.3	8.4	8.7	13.4	6.9	7.6	6.3	12.5	6.5	9.4
Interaction	NS	NS	S	NS	NS	NS	S	NS	NS	NS	S	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

Table 4.4a. Interaction between organic sources, time and dose of nitrogen and potassium application on drymatter production (kg ha^{-1}) at 180 DAP of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Time and dose of nitrogen and potassium application	Organic Sources (2019-20)			Mean	Organic Sources (2020-21)			Mean	Organic Sources (Pooled data)			Mean
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	Mean
S_1	18895	25795	23010	22566	15046	21616	21226	19296	16971	23705	22118	20931
S_2	15989	24240	22636	20955	13102	20868	19587	17852	14546	22554	21111	19404
S_3	25013	28220	26900	26711	22731	25713	25016	24487	23872	26967	25958	25599
S_4	23347	26808	26139	25431	21011	24458	23898	23122	22179	25633	25018	24277
S_5	26861	28653	27921	27812	24554	26683	25937	25724	25707	27668	26929	26768
S_6	25198	28536	27229	26988	23290	25973	25125	24796	24244	27254	26177	25892
Mean	22550	27042	25639		19956	24218	23465		21253	25630	24552	
	SEm±	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**	
Organic Sources (M)	391.2	1536	6.6		396.4	1556	7.5		394.6	1550	7.0	
Time and dose of nitrogen & potassium application (S)	526.4	1520	6.3		515.5	1489	6.9		514.7	1487	6.5	
Interaction												
M*S	911.8	2633			892.9	2579			891.5	2575		
S*M	927.6	2934			919.6	2915			917.2	2907		

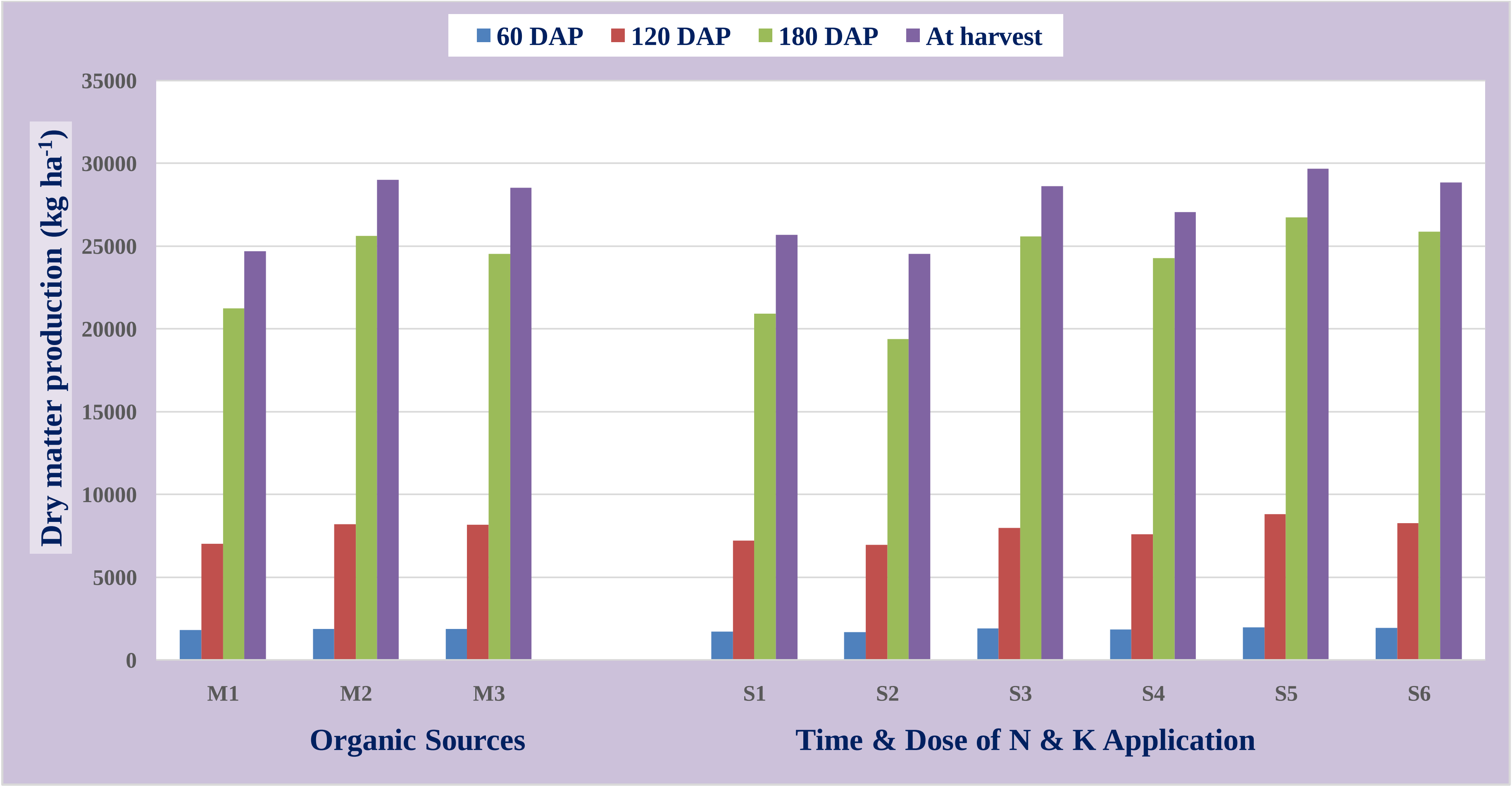

Fig. 4.3. Drymatter production (kg ha^{-1}) at different growth stages of sugarcane seed crop as influenced by biological nutrient management in pooled data

Analysis of data at 120 DAP, exhibited that the drymatter production was higher with S_5 level of fertilizers which was significantly superior to S_1 and S_2 treatments. However, the treatment S_5 showed statistical parity with S_6 and S_3 treatments. The treatment S_3 was closely followed by S_4 and was statistically on par with each other. The lower drymatter production recorded with the application of 75% STBNK at planting, 45, 90, 135 and 180 DAP could be ascribed to the fact that nutrient supply at this level was not able to meet the requirement of the crop. Similar trend was also observed at 180 DAP and at harvest during both years of study and in pooled data as well.

The per cent increase in drymatter at harvest with 125% STBNK + 25 % additional K over 75% STBNK (S_1 & S_2) was 13.5, 19.4 during 1st year, 17.9, 22.8 during 2nd year and 15.6, 21.0 in pooled data, respectively.

Contemplating the data at various stages of crop growth indicated that higher drymatter production under higher nitrogen applied treatment could be ascribed to nitrogen, being an important constituent of enzymes, nucleotides and chlorophyll, its application resulted in taller plants with robust stalks. The results projected in the present study were in consonance with Pratap *et al*. (2006), Kumar (2012) and Kumar and Kumar (2020).

The interaction between organic sources and time and dose of N and K application on drymatter accumulation was found significant only at 180 DAP during both the years of study and in pooled data (Table 4.4a).

The data on interaction between organic sources and time and dose of N and K application indicated that lower drymatter accrual was with S_2 under M_1 and found significantly inferior to all other treatments during 2019-20 while, it shows parity with S_1 during 2020-21 and in pooled data. At M_2 and M_3 treatments, S_2 exhibited statistical parity with S_1. The treatments S_5, S_6 and S_3 were comparable under M_1 treatment and S_3 inturn was comparable with S_4. The S_5, S_6, S_3 and S_4 treatments were statistically comparable among themselves under M_2 and M_3 treatments during both the years of study and also in pooled data.

During 2019-20, 2020-21 and in pooled data at S_1 and S_2 nutrient management treatments, M_2 and M_3 treatments were statistically on par and both remained significantly superior to M_1. The M_1, M_2 and M_3 treatments were comparable at S_5 treatment. The M_2 treatment maintains parity with M_3 which inturn was comparable with M_1 at S_6, S_3 and S_4 treatments.

4.2.5 Stalk Population of Seedcane at Harvest

A perusal of the data in Table 4.5 and Fig. 4.4 indicates that the organic sources significantly influenced the stalk population at harvest during both the years of study as well as in pooled data.

Stalk population at harvest during 2019-20, 2020-21 and in pooled data was higher with biofertilizers and VAM application (106.8, 100.8 and 103.8 '000 ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) which was comparable with trash mulching and were superior to control. Application of PSB, which has ability to trigger the release of cytokinins essential for cell division in tiller buds. The results are in conformity with the findings of Thakur *et al*. (2010), Singh *et al*. (2016) and Viana *et al*. (2019).

Data pertaining to stalk population at harvest was significantly influenced by time and dose of nitrogen and potassium application. The application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% recommended K one month before harvesting registered higher number of stalks (106.7 '000 ha^{-1} during 2019-20) which may be due to better photosynthetic efficiency with adequate nitrogen application. However, stalk population at S_5 was comparable with 125% STBNK applied at 45 days interval (S_6), 100% STBNK applied at 30 days interval + additional 25% RDK (S_3) and distinctly superior to 100% STBNK alone applied at 45 days interval (S_4), 75% STBNK applied at 30 days interval + additional 25% RDK (S_1) and 75% STBNK alone applied at 45 days interval (S_2) during the first year of

Table 4.5. Stalk population ('000 ha^{-1}) at harvest of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1 - No Biofertilizers	96.3	91.4	93.8
M_2 - Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	106.8	100.8	103.8
M_3 - Trash mulching with bio-decomposer (A & B)	104.1	99.2	101.7
SEm±	1.78	1.86	1.88
CD (p = 0.05)	7.0	7.3	7.4
CV (%)	7.4	8.1	8.0
Time and dose of N & K application			
S_1 - 75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	99.0	93.4	96.2
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	98.1	91.5	94.8
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	105.1	99.0	102.0
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	100.2	95.6	97.9
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	106.7	103.2	105.0
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	105.1	100.2	102.7
SEm±	2.07	2.56	2.41
CD (p = 0.05)	6.0	7.4	7.0
CV (%)	6.1	7.9	7.3
Interaction	NS	NS	NS

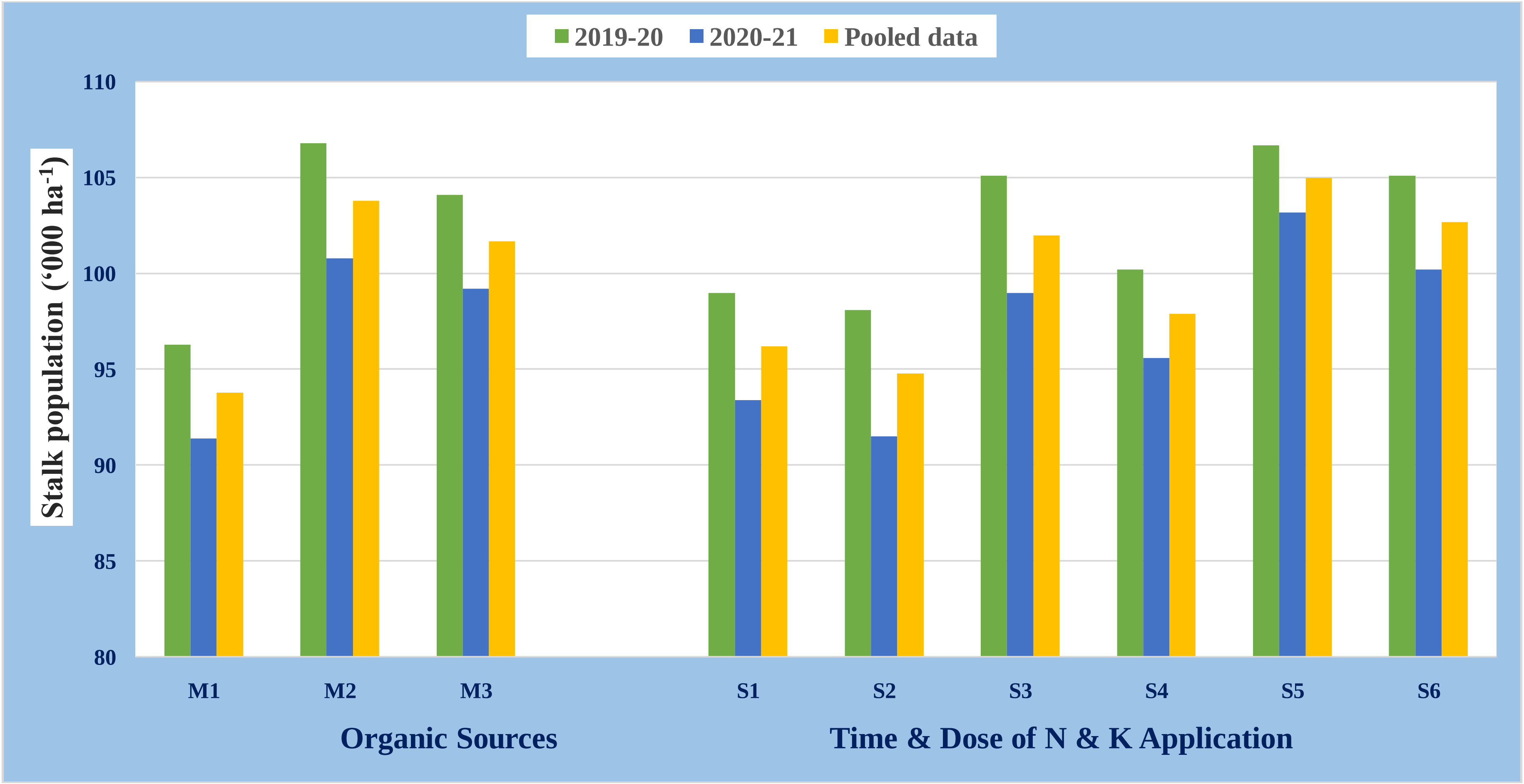

Fig. 4.4. Stalk population ('000 ha^{-1}) at harvest of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

study. Similar to the above trend was also observed during second year of study and in pooled data. More stalk population was observed with increased rate of fertilizer due to continuous uptake of nutrients under higher level of fertilizers and implies increased rate of physiological process in plants owing to more stalk production in seed crop. The results are in agreement with the findings of Srivastava *et al*. (2007), Rahman *et al*. (2009), Dev *et al*. (2011), Singh and Uppal (2013), Rathore *et al*. (2014) and Madhu *et al*. (2018).

The interaction between organic sources and time and dose of nitrogen and potassium application was found non significant with respect to stalk population in seedcane during all the growth stages.

4.2.6 Length of Seedcane

The data related to length of seedcane is presented in Table 4.6 and illustrated in Fig. 4.5. Critical perusal of the data revealed that cane length was significantly influenced by organic sources as well as time and levels of nitrogen and potassium application during both the years and in pooled data, while their interaction failed to hold a significant influence on seedcane length.

Among different organic sources studied, crop supplied with biofertilizer mixture displayed taller canes (207.7 cm) and was comparable with trash mulching with bio-decomposers (204.7 cm) and both were superior to control (189.4 cm) during the first year of study. An indistinguishable trend as exhibited above was ostentated at 2020-21 and also in pooled data.

Application of biofertilizers, trash mulching with bio-decomposers found to have significant influence on seedcane length may be attributed to both direct effect of nutrients present in organics and indirect effect on microbial activity and mineralization of native nutrients leading to lengthier canes. These findings corroborates with the results obtained by Mathew and Varughese (2005), Shankaraiah (2007) and Singh *et al*. (2014b).

With regard to various time and dose of N and K application, the higher cane length (212.8, 200.1 and 206.5 cm during 2019-20, 2020-21 and in pooled data, respectively) was documented with the application of 125% STBNK at 30

Table 4.6. Cane length (cm) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	189.4	183.4	186.4
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	207.7	199.4	203.6
M_3- Trash mulching with bio-decomposer (A & B)	204.7	197.0	200.9
SEm±	3.70	3.28	3.49
CD (p = 0.05)	14.5	12.9	13.7
CV (%)	7.8	7.2	7.5
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	189.2	185.1	187.2
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	187.8	183.8	185.8
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	206.8	197.7	202.2
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	198.9	194.6	196.8
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	212.8	200.1	206.5
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	208.2	198.4	203.3
SEm±	5.19	4.37	4.58
CD (p = 0.05)	15.0	12.6	13.2
CV (%)	7.8	6.8	7.0
Interaction	NS	NS	NS

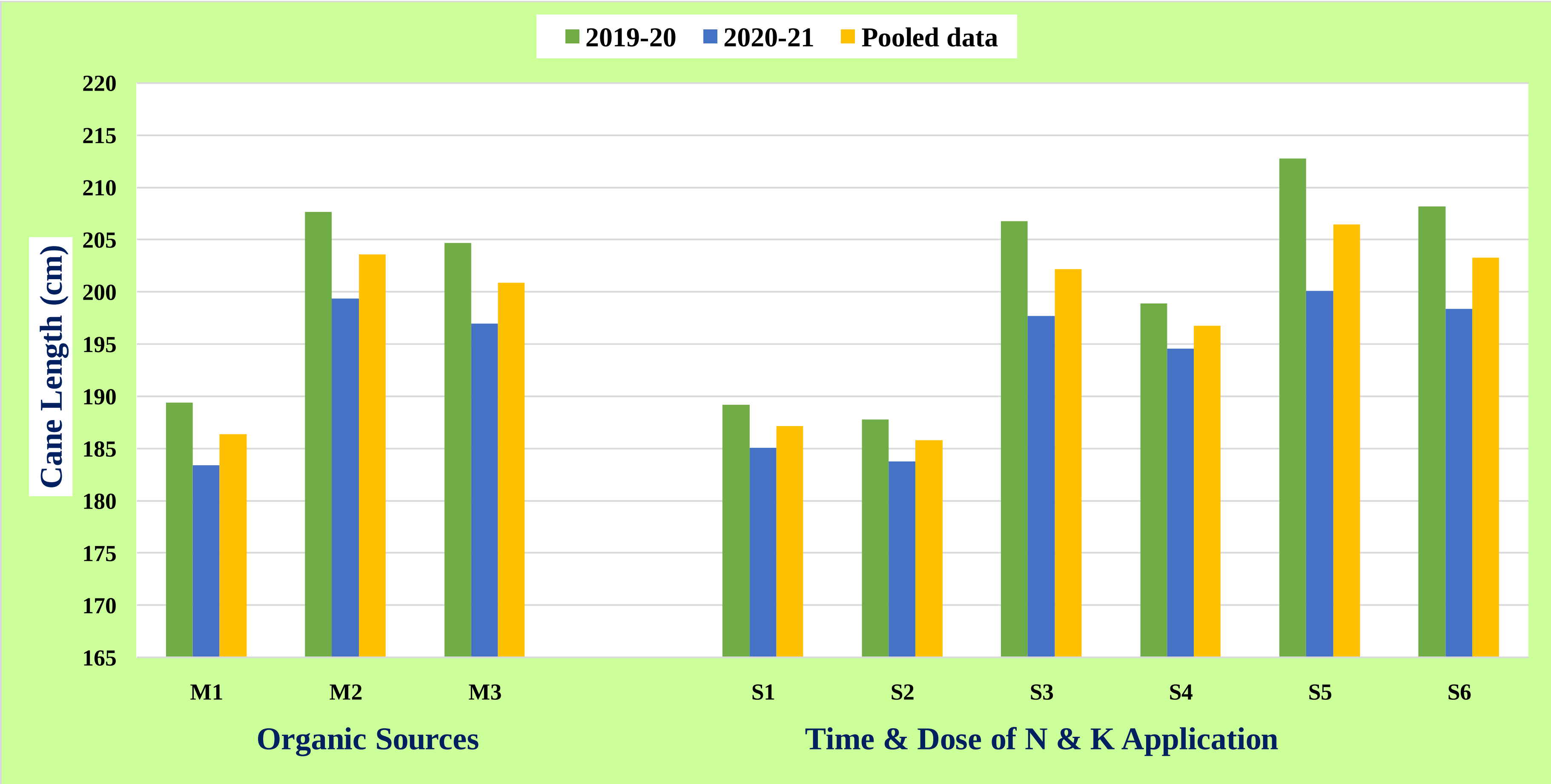

Fig. 4.5. Cane length (cm) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

days interval + additional dose of 25% recommended K one month before harvesting. Though, S_5 treatment recorded taller canes, it was found to be comparable with 125% STBNK alone at 45 days interval, application of 100% STBNK at 30 days interval + additional 25% RDK and addition of 100% STBNK alone at 45 days interval. The significantly lower cane length (187.8, 183.8 and 185.8 cm during 2019-20, 2020-21 and in pooled data, respectively) was noticed with 75% STBNK alone applied at 45 days interval over S_5, S_6 and S_3 treatments and maintained parity with application of 75% STBNK at 30 days interval + additional 25% recommended dose of K one month before harvesting and 100% STBNK applied at 45 days interval.

The increased cane growth was documented with high fertilizer level possibly due to vital role of nitrogen in chlorophyll formation and carbohydrate metabolism and there by increased growth of canes. The taller canes manifested with application of 125% STBNK may be due to steady supply of plant nutrients in sufficient quantities and resulted in increasing nutrient availability in soil and mediates congenial environment for absorption of nutrients by crop which inturn exert positive influence on growth and development of cane. The results are in conformity with the findings of Selvan (2000), Singh *et al*. (2008), Dev *et al*. (2012), Kumar (2012), Saleem *et al*. (2012) and Kumar and Kumar (2020).

4.2.7 Cane Diameter (cm)

Data on diameter of seedcane furnished under Table 4.7 and depicted in Fig. 4.6 was significantly influenced by organic sources and time and dose of nitrogen and potassium application as well during the both the years of experimentation and in pooled data. Cane diameter was not influenced by the interaction effect of organic sources and time and dose of nitrogen and potassium application.

Application of biofertilizer mixture *i.*e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} and trash mulching with bio-decomposers recorded more cane diameter and both the treatments exhibited significant superiority over control (M_1).

Table 4.7. Cane diameter (cm) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	2.2	2.0	2.1
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	2.5	2.3	2.4
M_3- Trash mulching with bio-decomposer (A & B)	2.5	2.3	2.4
SEm±	0.05	0.06	0.06
CD (p = 0.05)	0.2	0.2	0.2
CV (%)	9.1	12.1	10.6
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	2.2	2.0	2.1
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	2.2	1.9	2.1
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	2.4	2.3	2.4
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	2.4	2.2	2.3
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	2.5	2.4	2.4
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	2.5	2.3	2.4
SEm±	0.07	0.08	0.07
CD (p = 0.05)	0.2	0.2	0.2
CV (%)	8.8	11.7	9.5
Interaction	NS	NS	NS

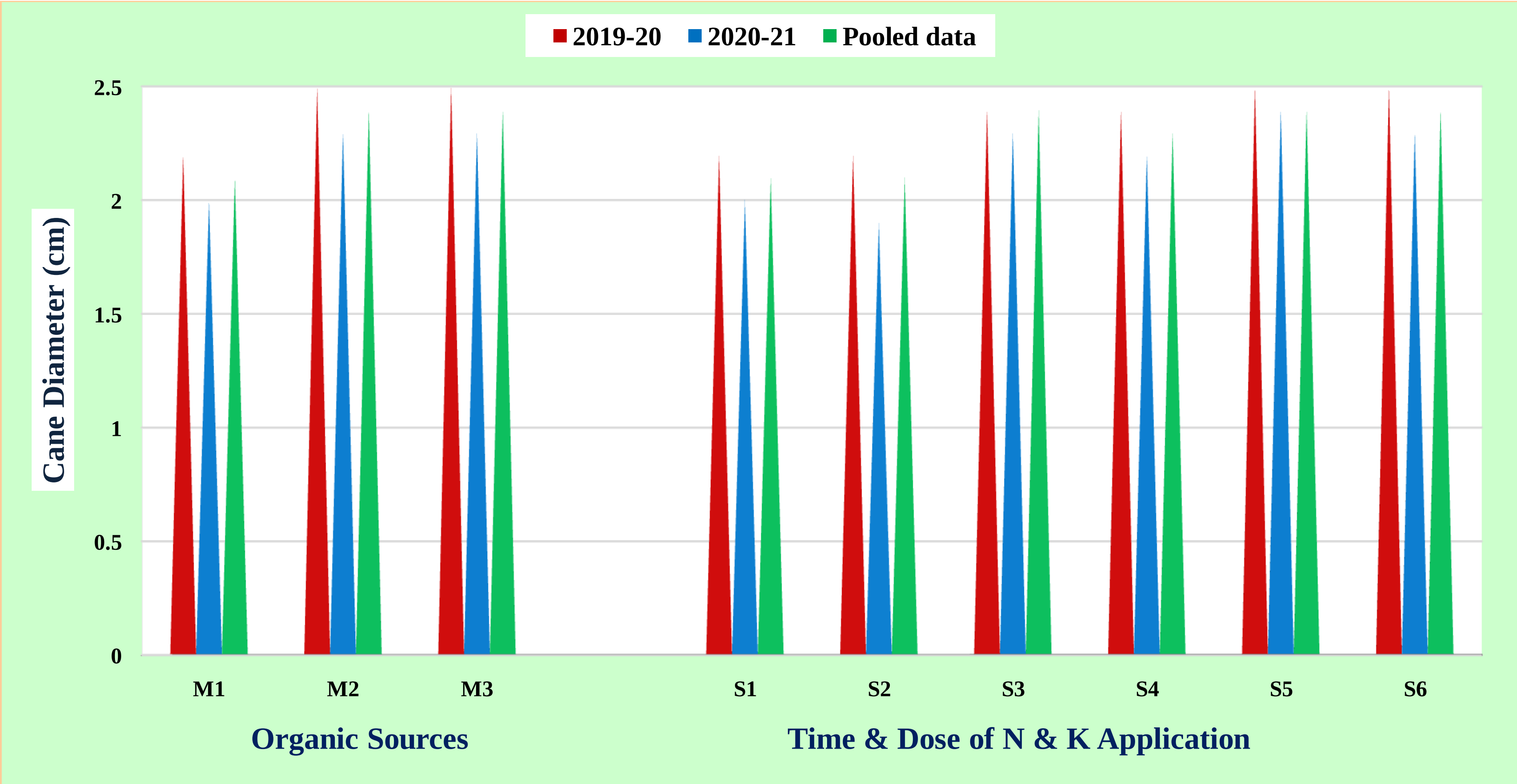

Fig. 4.6. Cane diameter (cm) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Distinctly higher cane diameter was observed with biofertilizers and trash mulching probably due to solubilising the sparingly soluble P into soluble P by PSB and by fixing atmospheric N by *Azospirillum* in soil and were made available to plants for absorption resulted in increased growth and development leading to more cane diameter. These results were in consonance with those reported by Mathew and Varughese (2005) and Singh *et al*. (2014b).

During the first year of experimentation, higher cane diameter was manifested with application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting and was followed by 125% STBNK applied at 45 days interval, addition of 100% STBNK at planting, 30, 60, 90, 120 DAP + extra 25% recommended dose of K one month before harvesting and 100% STBNK alone applied at 45 days interval. However, these four treatments were statistically comparable among themselves. Lower cane diameter was observed with application of 75% STBNK. An identical trend was displayed during 2020-21 and in pooled data. The increased nitrogen dose might have made significant translocation and storage of photosynthates from source to sink which resulted in enhanced diameter of cane (Dev *et al*., 2012). The results were in conformity with the earlier findings of Selvan (2000), Choudhary and Sinha (2001), Singh *et al*. (2008), Kanjana and James (2009), Rahman *et al*. (2009), Dev *et al*. (2012) and Wubale and Girma (2018).

4.2.8 Number of Internodes

Data pertaining to number of internodes per cane was recorded at harvest and presented in Table 4.8, which visualized that there was no significant influence of both organic sources and time and levels of nitrogen and potassium application and their interaction as well in this study. Similar results were reported by Singh and Uppal (2013), Bikila *et al*. (2014) and Wubale and Girma (2018).

Table 4.8. Number of internodes of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	17.7	16.8	17.3
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	18.4	17.3	17.8
M_3- Trash mulching with bio-decomposer (A & B)	18.3	17.0	17.7
SEm±	0.46	0.44	0.43
CD (p = 0.05)	NS	NS	NS
CV (%)	10.8	10.9	10.3
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	17.6	16.9	17.3
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	17.4	16.7	17.1
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	18.4	17.2	17.8
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	18.3	16.9	17.6
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	18.6	17.3	17.9
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	18.5	17.2	17.8
SEm±	0.55	0.46	0.58
CD (p = 0.05)	NS	NS	NS
CV (%)	9.2	8.2	10.0
Interaction	NS	NS	NS

4.2.9 Single Cane Weight

Single cane weight was distinctly altered by organic sources as well as time and dose of nitrogen and potassium application during both the years of experimentation and in pooled data (Table 4.9 and Fig. 4.7).

Higher single cane weight (0.87, 0.83 and 0.85 kg during 2019-20, 2020-21 and in pooled data, respectively) was recorded with M_2 treatment (application of biofertilizer mixture *i.*e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1}) which was significantly superior to control (M_1) and statistically on par with trash mulching (M_3).

Organic sources released nutrients through decomposition and mineralization which would have increased the nutrient availability to plants during later stages and improves the soil physical, chemical and biological properties owing to increased soil fertility and absorption of plant nutrients as well might have resulted in enhanced growth and development of cane thus lead to more cane weight. These results were in tune with the findings of Mathew and Varughese (2005), Shankaraiah (2007), Singh *et al*. (2014b) and Patel and Chaudhari (2018).

Among different doses and time of nitrogen and potassium application, application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting (S_5) recorded the higher cane weight (0.90, 0.86 and 0.88 kg during 2019-20, 2020-21 and in pooled data, respectively) and exhibited significant superiority over 75% STBNK applied at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting and 75% STBNK applied at 45 days interval. However, the treatment S_5 was statistically comparable with 125% STBNK at planting, 45, 90, 135 and 180 DAP and 100% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% recommended dose of K one month before harvesting during 2020-21 and in pooled data whereas in first year S_5 was maintained parity with 100% STBNK applied at 45 days interval in addition to

Table 4.9. Single cane weight (kg) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	0.78	0.76	0.77
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	0.87	0.83	0.85
M_3- Trash mulching with bio-decomposer (A & B)	0.86	0.82	0.84
SEm±	0.017	0.014	0.016
CD (p = 0.05)	0.07	0.06	0.06
CV (%)	8.7	7.5	8.4
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	0.77	0.75	0.76
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	0.75	0.73	0.74
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	0.87	0.83	0.85
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	0.85	0.80	0.83
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	0.90	0.86	0.88
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	0.88	0.84	0.86
SEm±	0.017	0.018	0.015
CD (p = 0.05)	0.05	0.05	0.04
CV (%)	6.2	6.8	5.7
Interaction	NS	NS	NS

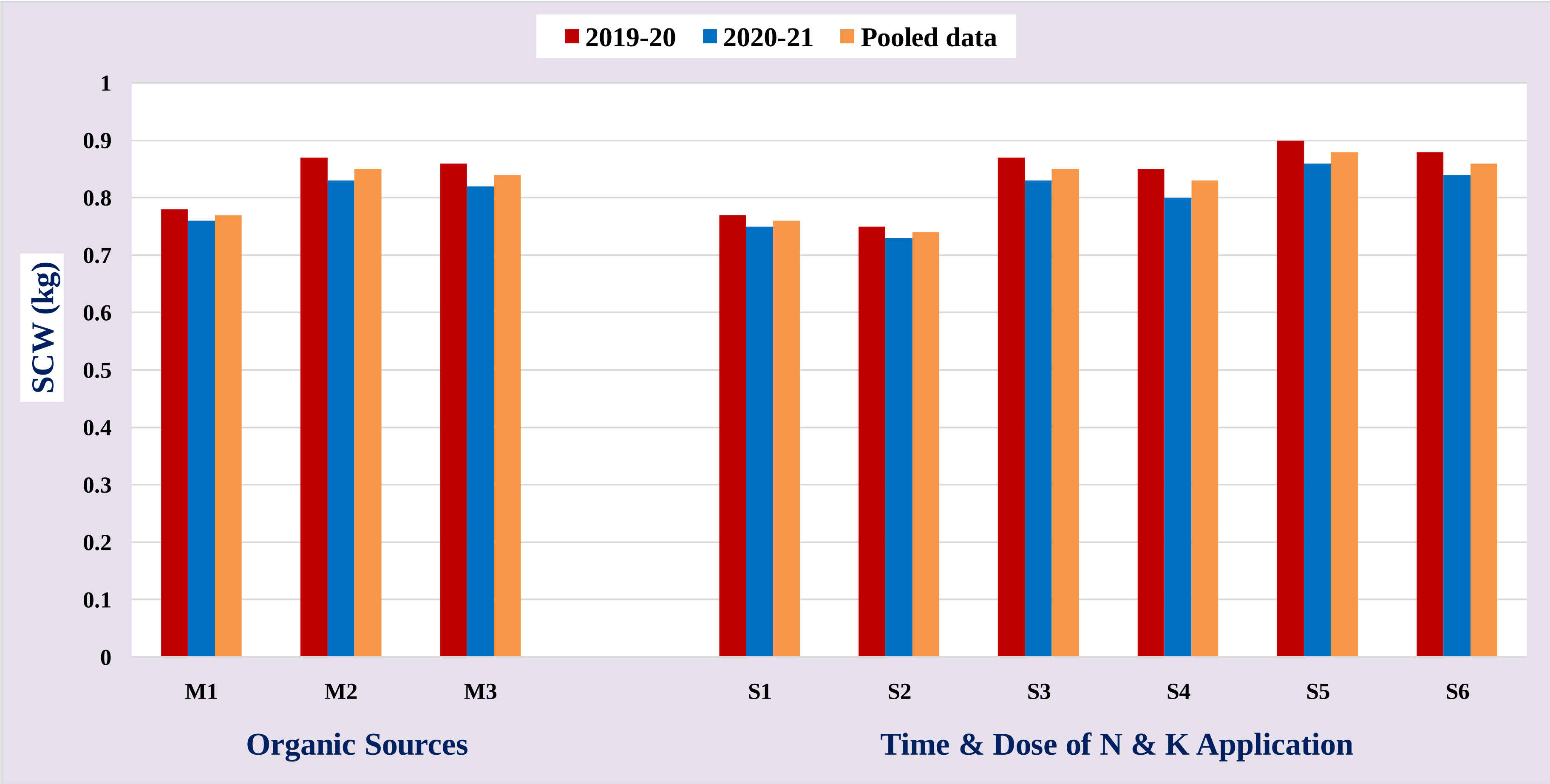

Fig. 4.7. Single cane weight (kg) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

S_6 and S_3 treatments. The treatment S_2 recorded conspicuously lower single cane weight during both the years of experimentation and in pooled data.

Higher single cane weight registered with higher fertilizer dose applied in different splits could be ascribed to split application of vital plant nutrients *viz.*, N and K in balanced proportions might have matched the nitrogen and potassium requirement of the crop at various growth stages. The experimental results of Selvan (2000), Choudhary and Sinha (2001), Pandey and Shukla (2003), Mathew and Varughese (2005), Shukla (2007), Singh *et al*. (2008), Thakur *et al*. (2010), Dev *et al*. (2012) and Kumar and Kumar (2020) lend support to the present findings.

The interaction between organic sources and different time and doses of application of nitrogen and potassium was found non significant in affecting the cane weight during 2019-20, 2020-21 and in pooled data.

4.2.10 Weight of 100 Three Bud Sett

Weight of 100 three bud sett was significantly influenced by both the organic sources and different time and dose of nitrogen and potassium application taken up in this study. The data are presented in Table 4.10 and illustrated in Fig. 4.8. Interaction between the organic sources and time and dose of N and K application was not significant in influencing the sett weight.

Among different organic sources studied, higher weight of 100 three bud sett was manifested with M_2 (application of biofertilizer mixture *i*.e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1}) and it was followed by trash mulching with bio-decomposers. However, these two treatments were statistically on a par with each other. Significantly lower sett weight was associated with control during 2019-20, 2020-21 and in pooled data.

The possible reason for significant influence of liquid biofertilizers on sett weight was that they are capable of growing beyond the depletion zones

Table 4.10. Weight of 100 three bud sett (kg) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	14.2	11.3	12.7
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	15.7	13.4	14.5
M_3- Trash mulching with bio-decomposer (A & B)	15.3	13.3	14.3
SEm±	0.27	0.37	0.34
CD (p = 0.05)	1.0	1.4	1.3
CV (%)	7.5	12.3	10.3
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	13.8	11.7	12.8
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	12.9	11.3	12.1
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	15.8	13.1	14.5
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	15.0	12.5	13.7
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	16.6	14.0	15.3
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	16.1	13.4	14.7
SEm±	0.38	0.49	0.37
CD (p = 0.05)	1.1	1.4	1.1
CV (%)	7.7	11.5	7.9
Interaction	NS	NS	NS

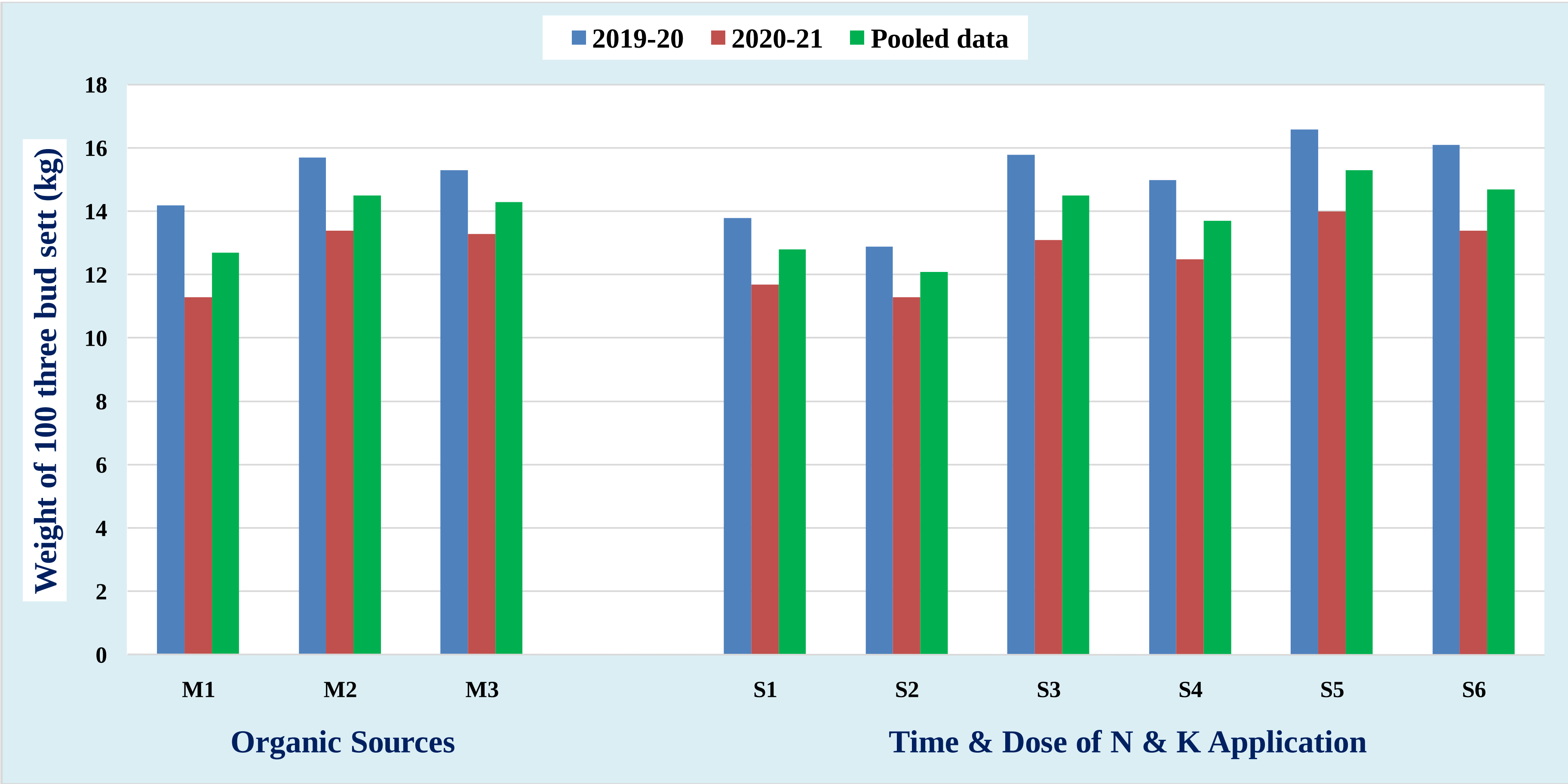

Fig. 4.8. Weight of 100 three bud sett (kg) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

around the plant roots and made plants to uptake immobile nutrients like P, K and micronutrients as well which ultimately enhanced the growth and sett weight of seedcane. The trash on decomposition supplies macro and micronutrients to plants at all stages of crop development resulted in increased sett weight.

Analysis of data on weight of 100 three bud sett displayed that with increase in fertilizer dose, the sett weight also increased gradually from 75% to 125%. During both the years of study and in pooled data, the application of 125% STBNK at 30 days interval + 25% RDK displayed higher sett weight (16.6, 14.0 and 15.3 kg during 2019-20, 2020-21 and in pooled data, respectively) which was comparable with 125% STBNK applied at 45 days interval and 100% STBNK applied at 30 days interval + additional 25% RDK during 2019-20, 2020-21 and also in pooled data and significantly differed from rest of the treatments. This was possibly due to increased photosynthetic rate with increased level of nitrogen which inturn lead to accumulation of more food materials, increased drymatter and thereby more weight of canes. Similar trend of effects has also been advocated by Patel *et al*. (2011).

Noticeably lower 100 three bud sett weight (12.9, 11.3 and 12.1 kg during 2019-20, 2020-21 and in pooled data, respectively) was registered with 75% STBNK alone applied at 45 days interval followed by addition of 75% STBNK at 30 days interval + 25% RDK one month before harvesting.

4.2.11 Seedcane Yield

Seedcane yield was recorded at harvest *i.e*., seven months age and the data is presented in Table 4.11 and graphically depicted in Fig. 4.9. Different organic sources and time and dose of nitrogen and potassium application had a significant influence on seedcane yield. Besides, the interaction between organic sources and time and levels of nitrogen and potassium application on seedcane yield was also found to be significant during both the years of study and in pooled data as well.

The application of organic and biofertilizers proved advantageous and increased the seedcane yield significantly. The higher cane yield of 81.49, 76.02 and 78.76 t ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively was registered with the application of biofertilizer mixture *i.*e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} but maintained parity with trash mulching with bio-decomposers. The lower seedcane yield of 73.07, 69.03 and 71.05 t ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively was noticed with control and found significantly inferior to rest of the treatments. Similar observations with regard to organic manures on cane yield were noticed with Panwar and Singh (2000), Singh (2002), Dahiya *et al*. (2003), Mathew and Varughese (2005) and Shankaraiah (2007).

The per cent increase in seedcane yield with biofertilizers, trash mulching over control was 11.5, 09.1 during 1st year, 10.1, 08.7 during 2nd year and 10.9, 08.9 in pooled data, respectively.

The application of biofertilizers and trash mulching exhibited significant influence on growth and seedcane yield as biofertilizers are capable of synthesizing growth hormones and or regulators in addition to nitrogen fixation which inturn along with trash constitutes favourable effect on nutrient uptake and resulted in higher cane growth and yield (Virdia *et al*., 2009).

The possible reasons for superior cane yield and quality under biofertilizer applied treatment could be ascribed to enhanced rooting and plant establishment, better uptake of low mobile ions such as P, improved nutrient cycling, improved plant tolerance to stress (biotic and abiotic) and amelioration of the quality of soil structure (Surendran and Vani, 2013).

The execution of nitrogen and potassium application @ 125% STBNK in five splits at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting documented higher seedcane yield (83.98, 79.40 and 81.69 t ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) which was significantly superior to rest of the treatments except for the treatments 125% STBNK alone applied at 45 days interval and 100% STBNK applied at 30 days interval + additional 25% RDK one month before harvesting. The treatment S_3 was followed by S_4 (100% STBNK at planting, 45, 90, 135 and 180 DAP) and both the treatments showed superiority over lower fertilizer dose (S_2 and S_1) during 2019-20, 2020-21 and in pooled data. Application of 75% STBNK at planting, 45, 90, 135 and 180 DAP displayed distinctly lower yield and found comparable with 75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting during both the years of study and in pooled data. The decreased yield could be attributed to insufficient supply of required N and K to plants. The present findings were in corroboration with Selvan (2000), Pandey and Shukla (2003), Devi *et al*. (2008), Kanjana and James (2009), Rahman *et al*. (2009), Gouri *et al*. (2015) and Lakshmi *et al*. (2019).

The per cent increase in seedcane yield with 125% STBNK + 25% additional K over 75% STBNK (S_1 & S_2) was 15.1, 20.1 during 1^{st} year, 17.6, 21.9 during 2^{nd} year and 16.3, 21.0 in pooled data, respectively.

The interaction between the organic sources and application of nitrogen and potassium at different doses and time was found significant during both the years of study and in pooled data with reference to seedcane yield. The cane yield varied between 55.13 t ha^{-1} at 75% STBNK at planting, 45, 90, 135 and 180 DAP (M_1S_2) to 86.03 t ha^{-1} and significantly higher with application of biofertilizer mixture *i*.e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} along with the application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting (M_2S_5).

During first year of the study, application of 75% STBNK at planting, 45, 90, 135 and 180 DAP (S_2) was statistically comparable with S_1 under M_1, M_2 and M_3. The seedcane yield with S_5, S_6 and S_3 was statistically on par with each other irrespective of the organic sources. The application of biofertilizers along with chemical fertilizers enhanced the yield but appreciable increase was observed particularly at lower dose of inorganic fertilizers.

Table 4.11. Seedcane yield (t ha^{-1}) as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	73.07	69.03	71.05
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	81.49	76.02	78.76
M_3- Trash mulching with bio-decomposer (A & B)	79.70	75.05	77.38
SEm±	1.364	1.065	0.954
CD (p = 0.05)	5.35	4.18	3.74
CV (%)	7.4	6.2	5.3
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	72.99	67.51	70.25
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	69.93	65.11	67.52
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	81.82	76.93	79.38
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	77.70	73.17	75.43
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	83.98	79.40	81.69
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	82.10	78.08	80.09
SEm±	1.304	1.404	1.337
CD (p = 0.05)	3.77	4.05	3.86
CV (%)	5.0	5.7	5.3
Interaction	S	S	S

Table 4.11a. Interaction between organic sources, time and dose of nitrogen and potassium application on sugarcane seed crop yield (t ha^{-1}) at harvest as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Time and dose of nitrogen and potassium application	Organic Sources (2019-20)			Mean	Organic Sources (2020-21)			Mean	Organic Sources (Pooled data)			Mean
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
S_1	63.63	79.00	76.33	72.99	58.30	72.87	71.37	67.51	60.97	75.93	73.85	70.25
S_2	60.10	76.17	73.53	69.93	55.13	70.30	69.90	65.11	57.62	73.23	71.72	67.52
S_3	80.23	83.17	82.07	81.82	75.50	78.03	77.27	76.93	77.87	80.60	79.67	79.38
S_4	72.23	80.93	79.93	77.70	70.33	74.83	74.33	73.17	71.28	77.88	77.13	75.43
S_5	81.83	86.03	84.07	83.98	78.30	80.87	79.03	79.40	80.07	83.45	81.55	81.69
S_6	80.37	83.67	82.27	82.10	76.63	79.20	78.40	78.08	78.50	81.43	80.33	80.09
Mean	73.07	81.49	79.70		69.03	76.02	75.05		71.05	78.76	77.38	
	SEm±	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**	
Organic Sources (M)	1.364	5.35	7.4		1.065	4.18	6.2		0.954	3.74	5.3	
Time and dose of nitrogen & potassium application (S)	1.304	3.77	5.0		1.404	4.05	5.7		1.337	3.86	5.3	
Interaction												
M*S	2.259	6.52			2.432	7.02			2.315	6.69		
S*M	2.668	8.64			2.492	7.89			2.322	7.32		

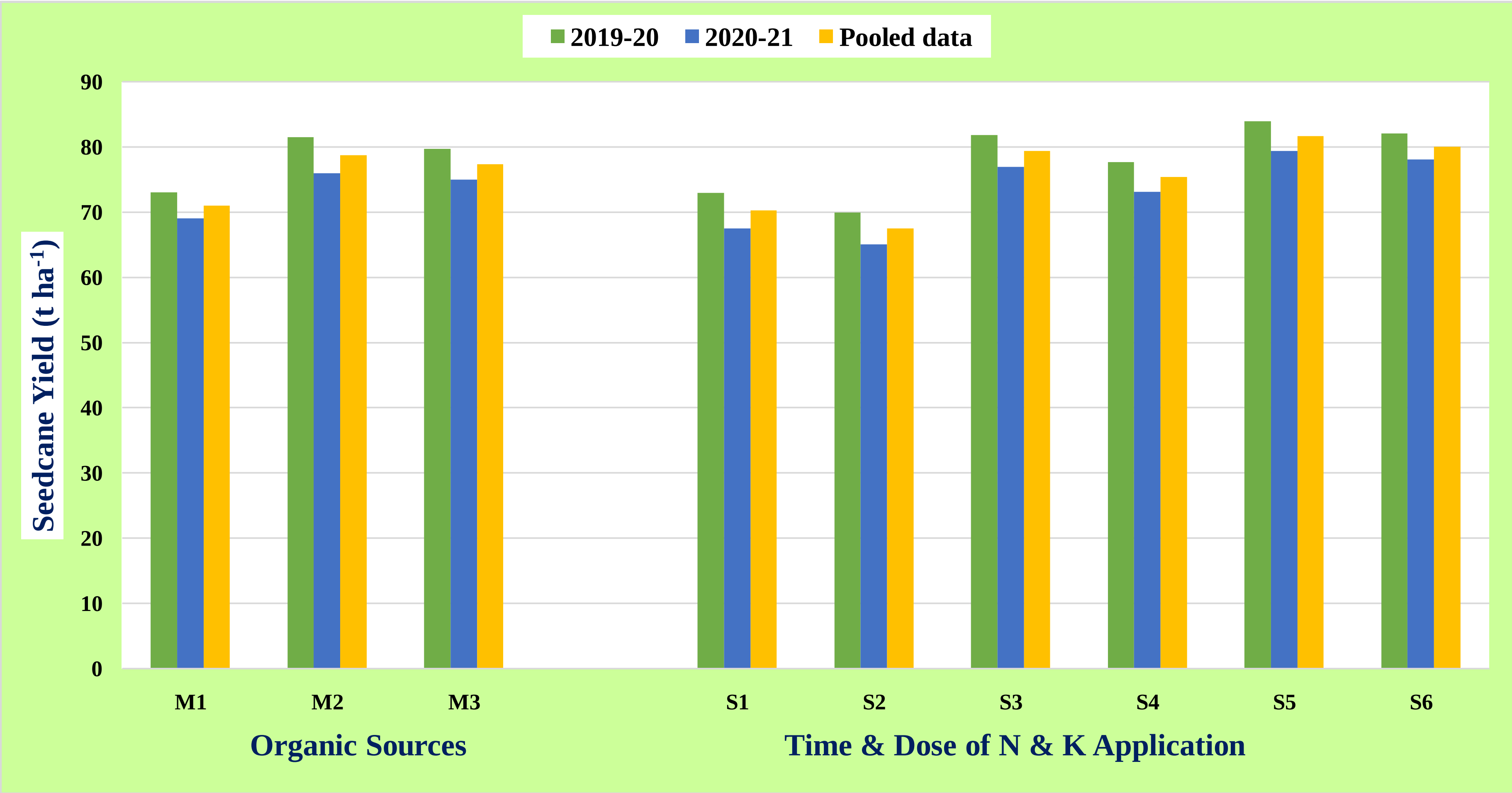

Fig. 4.9. Seedcane yield (t ha^{-1}) as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

At S_1 and S_2 nutrient management treatments, M_2 and M_3 were statistically on par and both remained significantly superior over M_1. The M_1, M_2 and M_3 treatments were comparable at S_3, S_5 and S_6 treatments. Similar trend was observed during 2020-21 and in pooled data (Table 4.11a).

The application of 100% STBNK @ 190, 60 and 50 kg ha^{-1} (Soil Test Based Fertilizer Recommendation) through chemical fertilizers and organic manure + biofertilizers registered significantly higher seedcane yield possibly due to the contribution of organic manure and biofertilizer, which increased the efficiency of applied fertilizer as organic manures are known to maintain adequate supply of different nutrients and soil microbial activity (Singh *et al.*, 2014a).

Biofertilizer mixture, trash mulching with bio-decomposers along with application of higher dose of fertilizers (125% STBNK) in different splits registered higher cane yield. Addition of substantial quantities of fertilizers to soil is not amenable to plants and a considerable portion is lost through different mechanisms operating in the soil. Proper amalgamation of organic sources with chemical fertilizers at appropriate time increased use efficiency of added inorganic nutrients through nutrient conservation, slow and steady release of nutrients and also improved nutrient availability, soil physico-chemical and biological properties which enacted better expression of yield attributes and inturn high seedcane yield. The results projected in the present study were in accordance with Mathew and Varughese (2005), Bhalerao *et al*. (2006), Thakur *et al*. (2010), Tyagi *et al*. (2011) and Singh *et al.* (2014a).

4.3 EFFECT OF ORGANIC SOURCES AND TIME AND DOSE OF NITROGEN AND POTASSIUM APPLICATION ON QUALITY OF SEEDCANE

4.3.1 Moisture Percentage in Seedcane Setts

The data pertaining to moisture per cent in cane setts was recorded at harvest of seed crop is presented in Table 4.12 and depicted in Fig. 4.10. Perusal of data shows that different organic sources, interaction between organic sources and different time, dose of N and K application did not differ the moisture per cent significantly in cane setts while, the application of nitrogen and potassium in different doses and timings had exerted significant influence during 2019-10, 2020-21 and in pooled data.

Significantly higher moisture per cent in cane setts (73.6%) was documented with 125% STBNK alone applied at 45 days interval when compared to other treatments however maintained parity with 125% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting (72.8%), 100% STBNK alone applied at 45 days interval (72.7%) and 100% STBNK applied at 30 days interval + extra 25% recommended dose of K one month before harvesting (71.4%). The 75% STBNK applied at planting, 30, 60, 90, 120 DAP + additional 25% recommended dose of K one month before harvesting recorded lower moisture per cent in cane setts and it was closely followed by S_2 treatment during the first year of experimentation. Moisture per cent in seedcane setts with different time and dose of N and K application highlighted an unaltered trend as indicated above was observed in the second year and in pooled data also. The present findings were also supported by Alexander *et al*. (2002) and Patel *et al*. (2011).

Increase in moisture percentage in sett with 125% STBNK alone over 75% STBNK (S_1 & S_2) was 07.9, 07.4% during 1st year, 11.1, 09.7% during 2nd year and 09.4, 08.5% in pooled data, respectively.

Sundara (2000) reported that additional fertilizers given to seedcane crop or pre fertilizing the nursery crop at 6 to 8 weeks prior to harvest for planting helps to obtain healthy setts with more moisture, reducing sugars and high nitrogen content as well.

Table 4.12. Moisture percentage of sugarcane seed crop sett as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	68.7	66.7	67.7
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	72.6	69.3	71.0
M_3- Trash mulching with bio-decomposer (A & B)	72.3	69.3	70.8
SEm±	1.67	1.52	1.40
CD (p = 0.05)	NS	NS	NS
CV (%)	10.0	9.4	8.5
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	68.2	64.2	66.2
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	68.5	65.0	66.7
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	71.4	69.3	70.4
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	72.7	69.9	71.3
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	72.8	70.9	71.9
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	73.6	71.3	72.4
SEm±	1.42	1.92	1.63
CD (p = 0.05)	4.1	5.5	4.7
CV (%)	6.0	8.4	7.0
Interaction	NS	NS	NS

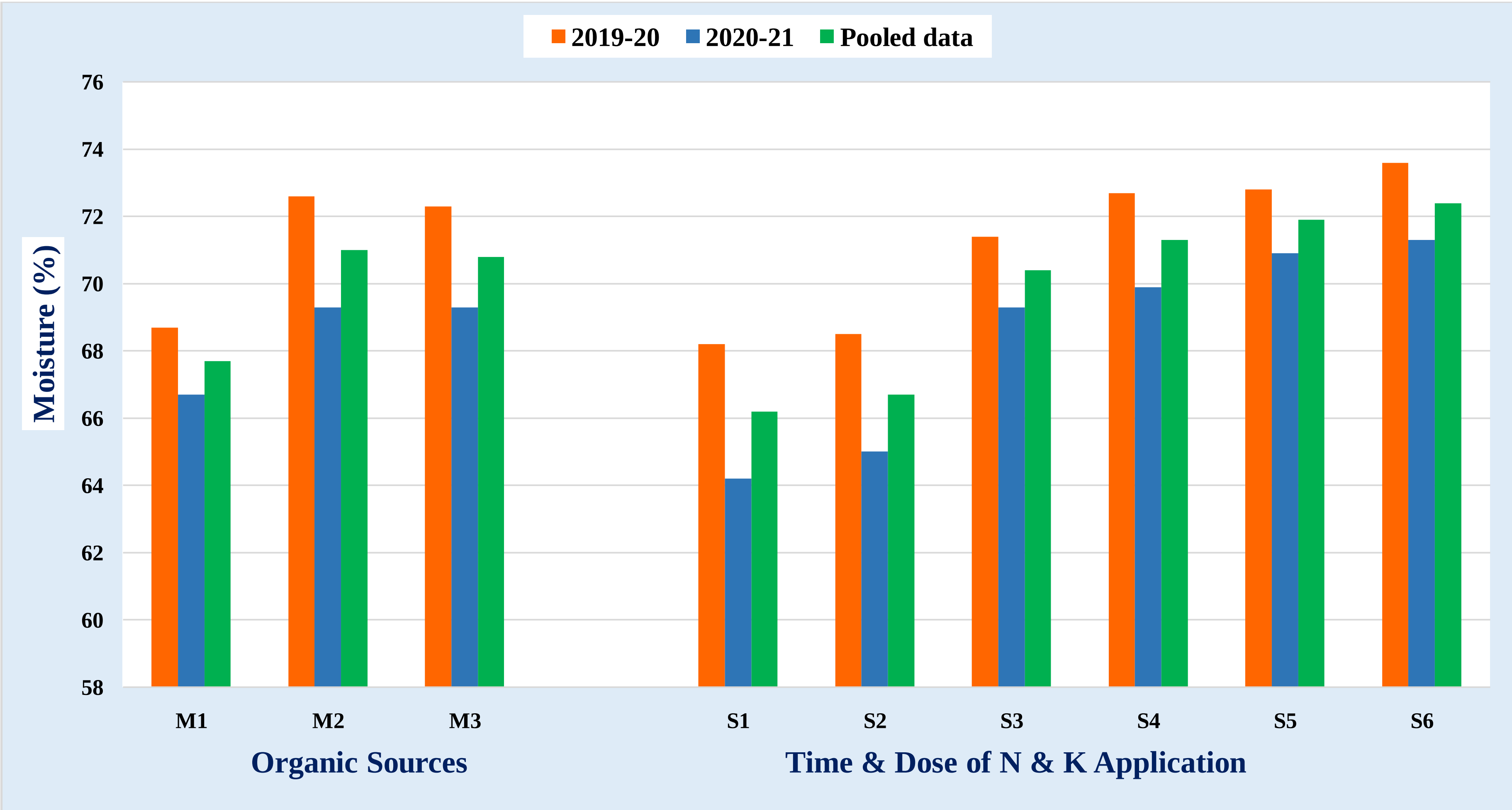

Fig. 4.10. Moisture percentage of sugarcane seed crop sett as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

4.3.2 Reducing Sugars Percentage

Reducing sugars percentage in seed crop sett as influenced by various organic sources and time and levels of nitrogen and potassium application was presented in Table 4.13 and illustrated in Fig. 4.11. The data revealed that reducing sugars per cent in cane setts was not influenced by different organic source treatments in this study during both the years of experimentation and in pooled data.

During both the years of experimentation and in pooled data, reducing sugars per cent in cane setts was altered by time and dose of N and K application. Among the different treatments, higher reducing sugars (2.04, 1.91 and 1.98%) was recorded with application of 125% STBNK alone at 45 days interval (S_6) and differed significantly over rest of the treatments. However, addition of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting, 100% STBNK at 30 days interval + additional 25% recommended dose of K one month before harvesting and 100% STBNK alone applied at 45 days interval treatments were statistically on par with S_6. Lower reducing sugars per cent (1.79, 1.69 and 1.74% during 2019-20, 2020-21 and in pooled data, respectively) was registered with application of 75% STBNK at 30 days interval + additional 25% RDK one month before harvesting might be due to less nitrogen supply. The current findings are inline with the earlier findings of Singh *et al*. (2001), Alexander *et al*. (2002), Indirajith and Natarajan (2011), Patel *et al*. (2011) and Bikila *et al*. (2014).

Richard and Irvine (1993) also noticed that the high amount of reducing sugar content was observed with young and immature canes.

The increase in reducing sugars percentage in sett with 125% STBNK alone over 75% STBNK (S_1 & S_2) was 14.0, 10.9% during 1st year, 13.0, 13.0% during 2nd year and 13.8, 11.9% in pooled data, respectively.

Table 4.13. Reducing sugars percentage of sugarcane seed crop sett as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	1.87	1.76	1.81
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	1.98	1.84	1.91
M_3- Trash mulching with bio-decomposer (A & B)	1.91	1.82	1.87
SEm±	0.052	0.046	0.049
CD (p = 0.05)	NS	NS	NS
CV (%)	11.6	10.9	11.1
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	1.79	1.69	1.74
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	1.84	1.69	1.77
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	1.89	1.81	1.85
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	1. 98	1.86	1.92
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	1.98	1.87	1.93
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	2.04	1.91	1.98
SEm±	0.058	0.049	0.058
CD (p = 0.05)	0.17	0.14	0.17
CV (%)	9.1	8.1	9.3
Interaction	NS	NS	NS

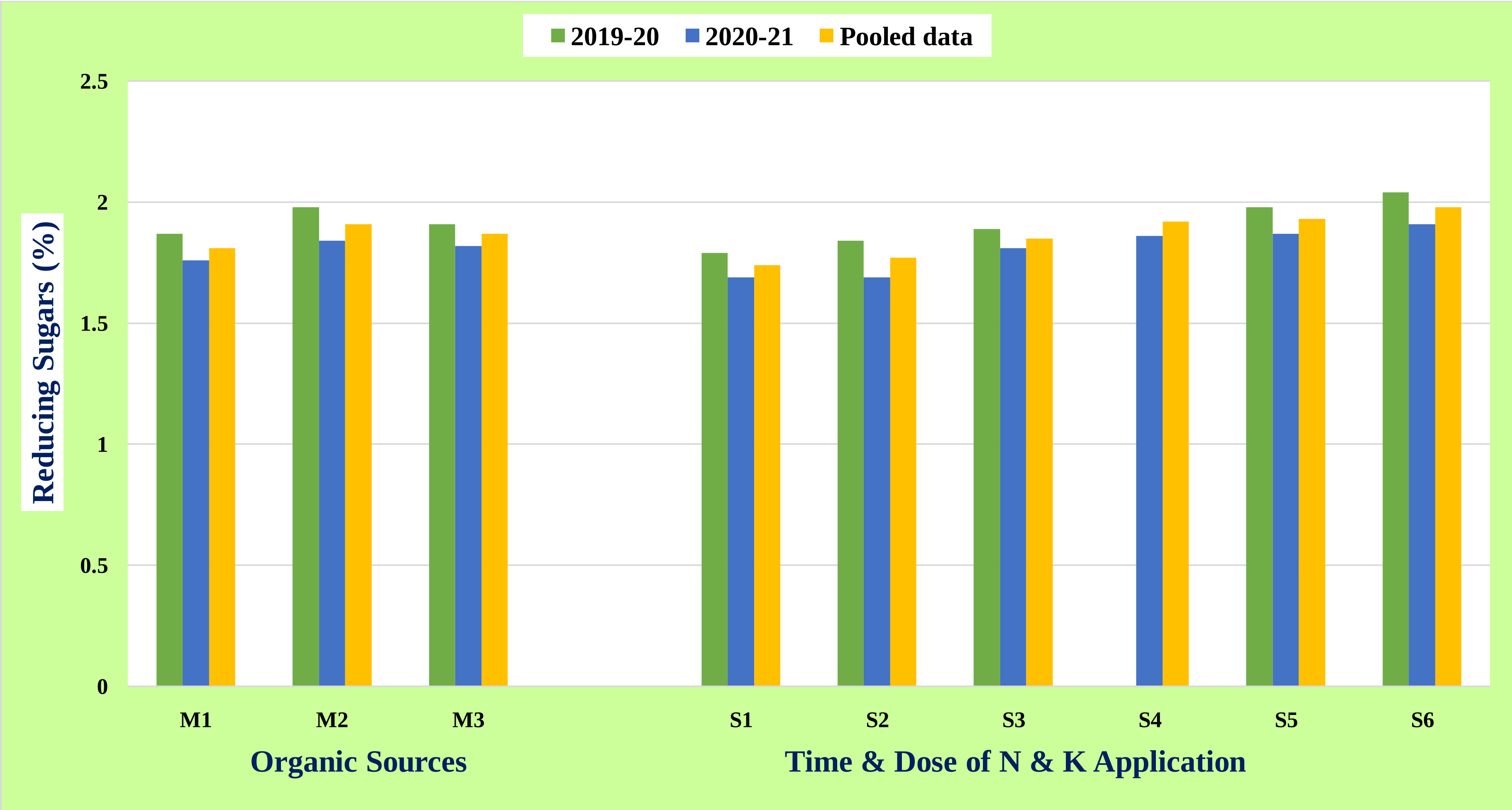

Fig. 4.11. Reducing sugars percentage of sugarcane seed crop sett as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

The interaction between organic sources and application of nitrogen and potassium in different timings and levels did not alter the reducing sugars significantly during both the years and in pooled data.

4.3.3 Brix Percentage

Brix per cent (apparent or total soluble solids in cane juice) is the second qualitative parameter used for maturity judgement in sugarcane (Sarwar *et al*., 2011).

Data pertaining to brix percentage was presented in Table 4.14. Perusal of data revealed that both organic sources as well as time and dose of nitrogen and potassium application and their interaction failed to hold significant effect on brix percentage during both the years of experimentation and in pooled data. The current findings are in agreement with, Selvan (2000), Thakur *et al*. (2010), Mohanty *et al*. (2013), Bikila *et al*. (2014), Patel and Chaudhari (2018) and Singh *et al*. (2019b), who reported non significant influence of nutrient management practices on brix percentage.

Wiedenfeld (1997) reported that late application of nitrogen resulted in poor juice quality (low brix and pol value) in matured cane but in contrary to this, it is a good quality for seedcane plants in maintaining food reserve for the germinating buds (Singh and Kanwar, 1986).

4.3.4 Sucrose Percentage

Sucrose percentage in cane juice is considered as an important qualitative parameter used for judging maturity in sugarcane. Perusal of data on sucrose percentage recorded at harvest was furnished under Table 4.15 visualized that there is no significant variation observed on sucrose percentage by either organic sources or time and dose of nitrogen and potassium application and their interaction as well during both the years of study and in pooled data. Singh *et al*. (2007), Thakur *et al*. (2010), Mohanty *et al*. (2013), Singh and Uppal (2013), Bikila *et al*. (2014), Meena and Kumar (2015) and Patel and Chaudhari (2018) also observed non significant effect of nutrient management treatments on sucrose percentage.

Table 4.14. Brix percentage of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	18.2	18.3	18.3
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	17.8	18.0	17.9
M_3- Trash mulching with bio-decomposer (A & B)	18.1	18.1	18.1
SEm±	0.40	0.51	0.45
CD (p = 0.05)	NS	NS	NS
CV (%)	9.5	11.9	10.6
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	18.2	18.2	18.2
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	18.3	18.4	18.4
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	18.0	18.1	18.1
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	17.9	18.0	18.0
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	17.9	18.1	18.0
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	17.9	18.0	17.9
SEm±	0.47	0.63	0.63
CD (p = 0.05)	NS	NS	NS
CV (%)	7.9	10.4	10.4
Interaction	NS	NS	NS

Table 4.15. Sucrose percentage of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	16.4	16.4	16.4
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	16.2	16.2	16.2
M_3- Trash mulching with bio-decomposer (A & B)	16.3	16.3	16.3
SEm±	0.45	0.46	0.41
CD (p = 0.05)	NS	NS	NS
CV (%)	11.8	11.8	10.8
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	16.6	16.5	16.6
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	16.5	16.3	16.4
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	16.3	16.3	16.3
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	16.2	16.3	16.3
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	16.3	16.3	16.3
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	16.0	16.3	16.1
SEm±	0.41	0.62	0.53
CD (p = 0.05)	NS	NS	NS
CV (%)	7.5	11.4	9.8
Interaction	NS	NS	NS

Mohammed (1989) described an inverse relationship between the increasing rate of late fertilizer application and decreasing value of sucrose per cent in seedcane.

Lower sucrose per cent of immature seedcane might be due to minimum rate of reversion of glucose and fructose to sucrose at active growth stage of the plant (Bakker, 1999).

4.3.5 Germinability of Setts Produced from Seedcane after Harvest

Germinability of setts produced from seedcane after harvest (Table 4.16 and Fig. 4.12) was differed significantly with application of nitrogen and potassium in different timings and dose. While, the effect of organic sources and the interaction among these two could not reach the level of significance during both the years of study and in pooled data.

However, among organic sources application of biofertilizer mixture (M_2) proved to be better in increasing sprouting of setts numerically and it was closely followed by trash mulching with bio-decomposers.

Higher germinability of setts (88.7, 85.6 and 87.2% during 2019-20, 2020-21 and in pooled data, respectively) was recorded with application of 125% STBNK at planting, 45, 90, 135 and 180 DAP might be due to high nutritional status of cane setts over rest of the treatments. However, it was comparable with the application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% RDK one month before harvesting, 100% STBNK applied at planting, 45, 90, 135 and 180 DAP and 100% STBNK applied at planting, 30, 60, 90, 120 DAP + additional 25% recommended dose of K one month before harvesting. The distinctly lower sprouting was noticed with lower fertilizer dose *i.e*., 75% STBNK (S_1 with 81.2, 77.1 and 79.1% and S_2 with 82.0, 77.9 and 80.0% during 2019-20, 2020-21 and in pooled data, respectively). These results corroborate with the findings of Patel *et al*. (2011) and Wubale and Girma (2018).

Table 4.16. Germinability of setts (%) produced in sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	83.3	80.3	81.8
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	86.4	83.7	85.1
M_3- Trash mulching with bio-decomposer (A & B)	86.4	82.6	84.5
SEm±	1.33	1.69	1.69
CD (p = 0.05)	NS	NS	NS
CV (%)	6.6	8.7	8.5
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	81.2	77.1	79.1
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	82.0	77.9	80.0
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	85.6	83.3	84.5
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	87.2	84.5	85.8
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	87.5	84.9	86.2
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	88.7	85.6	87.2
SEm±	1.88	2.26	2.06
CD (p = 0.05)	5.4	6.5	6.0
CV (%)	6.6	8.3	7.4
Interaction	NS	NS	NS

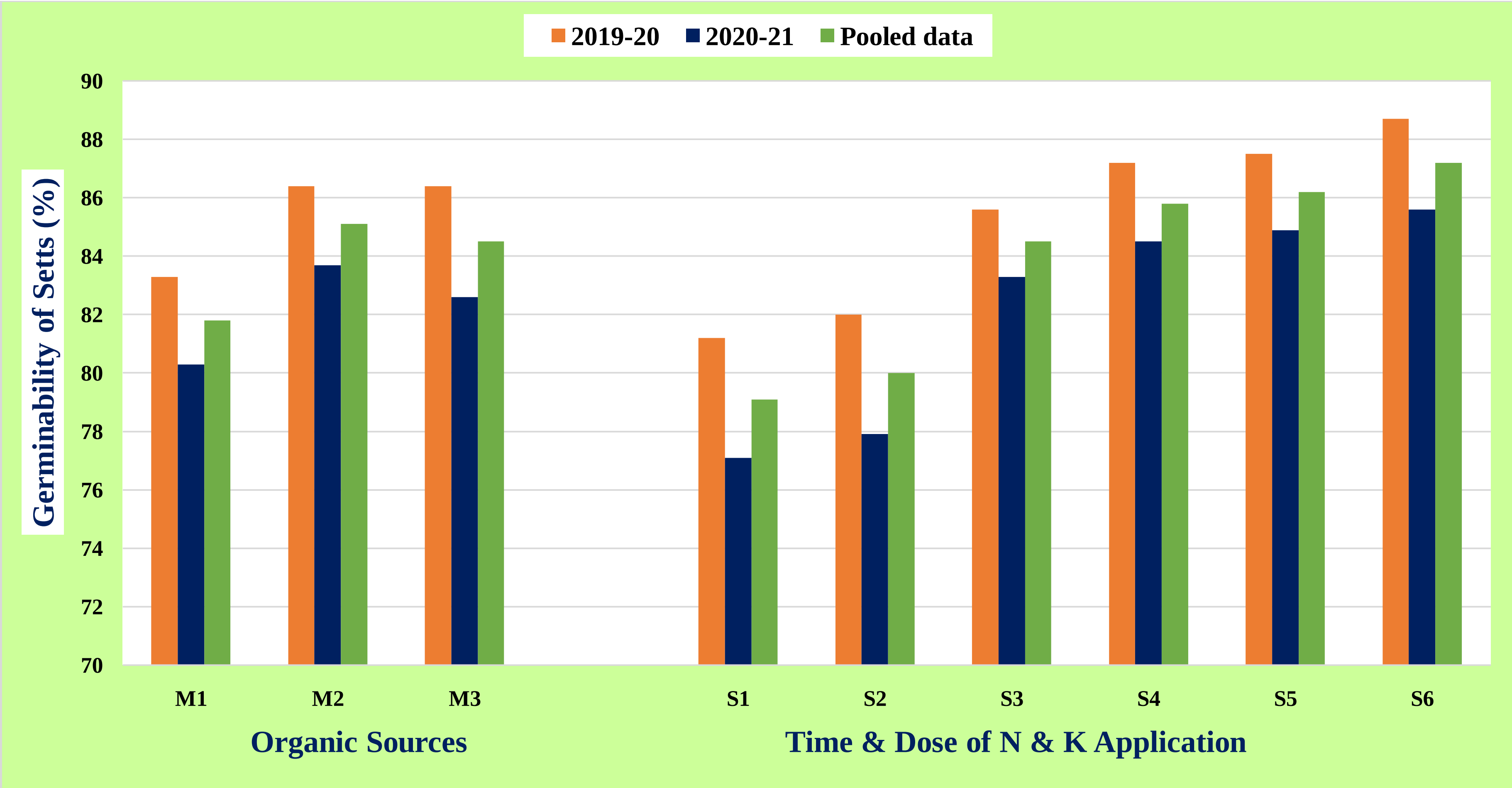

Fig. 4.12. Germinability of setts (%) produced in sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

The increase in sprouting percentage of setts produced from seedcane with 125% STBNK alone over 75% STBNK (S_1 & S_2) was 09.2, 08.2% during 1st year, 11.0, 09.9% during 2nd year and 10.2, 09.0% in pooled data, respectively.

King (1965) also reported that the plants with high nitrogen content germinate better than setts obtained from poorly fertilized crop. Dellewijin (1952) also revealed that the sprouting ability of buds seems to be positively correlated with the moisture, nitrogen and glucose content of the bud tissue.

Late application of nitrogen at higher dose gave more sprouting compared to others might be due to storage of nitrogen temporarily in the nodes just below the buds (Cornelison and Cooper, 1994) under application. Therefore, the sprouting buds might have easily utilized this nitrogen for emergence and successive growth.

4.3.6 Seedling Vigour Index of Setts Produced from Seedcane after Harvest

Data related to seedling vigour index displayed under Table 4.17 and graphically depicted in Fig. 4.13 revealed that seedling vigour index significantly differed due to time and dose of nitrogen and potassium application. While, organic sources and interaction between the main plots and sub plots was found to be non significant during both the years of study and in pooled data.

In the first year of study, among various sub plot treatments, application of 125% STBNK at 45 days interval recorded higher seedling vigour index (3811) and found significantly superior to application of 75% STBNK applied at 30 days interval + 25% RDK which displayed distinctly lower vigour (2953) and 75% STBNK alone at 45 days interval (3028). Application of 125% STBNK at 30 days interval + 25% recommended K one month before harvesting, 100% STBNK applied at 30 days interval + 25% RDK one month before harvesting and 100% STBNK alone applied at 45 days interval were

Table 4.17. Seedling vigour index of setts produced in sugar cane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20	2020-21	Pooled data
Organic sources			
M_1- No Biofertilizers	3352	3240	3296
M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}	3607	3496	3552
M_3- Trash mulching with bio-decomposer (A & B)	3533	3383	3458
SEm±	108.1	95.2	85.3
CD (p = 0.05)	NS	NS	NS
CV (%)	13.1	12.0	10.5
Time and dose of N & K application			
S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	2953	2811	2882
S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP	3028	2906	2967
S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	3686	3518	3602
S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP	3697	3631	3664
S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting	3809	3644	3726
S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP	3811	3728	3769
SEm±	118.2	121.2	103.1
CD (p = 0.05)	341	350	298
CV (%)	10.1	10.8	9.0
Interaction	NS	NS	NS

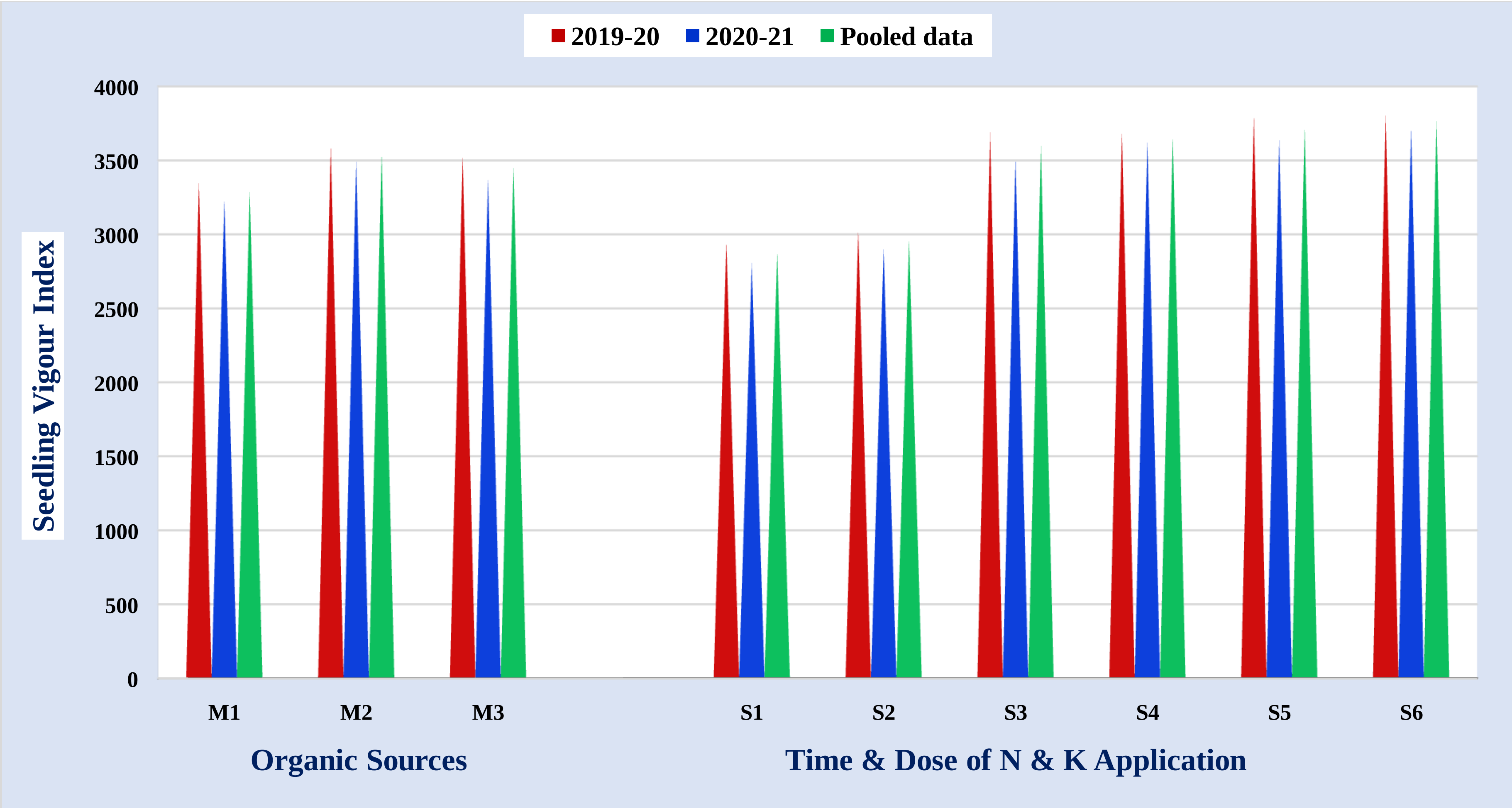

Fig. 4.13. Seedling vigour index of setts produced in sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

found to be on par with S_6 treatment. Similar trend was observed during second year of study and also with pooled data.

This result was supported by Gururaj (2001) who stated that well fertilized setts germinate rapidly with vigorous seedlings and a high proportion of roots and shoots.

Verma (2004) also reported that setts with higher moisture content give faster and higher germination and seedlings emerged from such setts establish quickly and grow vigorously.

4.4 EFFECT OF ORGANIC SOURCES AND TIME AND DOSE OF NITROGEN AND POTASSIUM APPLICATION ON NUTRIENT CONTENT AND UPTAKE BY SEEDCANE

4.4.1 Nitrogen Content (%)

The influence of organic sources and time and dose of nitrogen and potassium application on nitrogen content in seedcane whole plant recorded at different growth stages *viz*., 60, 120, 180 DAP and at harvest are presented in Table 4.18.

Nitrogen content was not influenced by organic sources at 60 and 120 DAP during both the years of study and in pooled data. While, at 180 DAP, nitrogen content was significantly influenced by organic sources (Table 4.18). Higher nitrogen content (0.65%) was observed with application of *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} (M_2) and trash mulching (M_3) and both were superior to control (M_1) during first year of the study. An identical trend was exhibited at harvest during both the years of experimentation and in pooled data as well.

In the second year of experimentation and in pooled data, higher nitrogen content (0.63 and 0.64% during 2020-21 and in pooled data, respectively) was registered with M_2 and found statistically comparable with M_3 (0.62 and 0.63% during 2020-21 and in pooled data, respectively) and both exhibited significant superiority over control (0.57% during 2020-21 and in pooled data, respectively). These results were in accordance with that of Shankaraiah and Hunsigi (2000), Babu (2009b) and Banerjee *et al*. (2018).

The build up of nitrogen content in plants might be due to greater multiplication of microbes owing to trash application which lead to more N mineralization in soil resulting in higher N availability apart from that of inoculated *Azospirillum* fixing atmospheric nitrogen in soil which inturn was taken up by plants.

Application of nitrogen and potassium at different time and levels had significant effect on nitrogen content at all the growth stages. At 60 DAP, application of 125% STBNK at 30 days interval + additional 25% recommended dose of K one month before harvesting (S_5) had perceptibly increased the nitrogen content. However, 125% STBNK applied at 45 days interval, 100% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting and 100% STBNK applied at 45 days interval were comparable. The significantly lower nitrogen content was observed with 75% STBNK alone applied at 45 days interval followed by 75% STBNK applied at 30 days interval + additional 25% recommended dose of K one month before harvesting over 125% STBNK applied plots. Similar trend was observed at 120 DAP and at harvest during both the years of study and also with pooled data.

Whereas at 180 DAP, higher nitrogen content was associated with S_5 treatment which maintains parity with S_6 and S_3 treatments and differed significantly with S_1, S_2 and S_4 treatments during 2019-20. In the second year of experimentation and in pooled data, S_5 maintained parity with S_4 treatment in addition to S_6 and S_3 treatments. The S_2 treatment recorded distinctly lower nitrogen content during both the years of study and also in pooled data. The increase in nitrogen content in response to higher fertilizer levels were in conformity with the present findings of Shankaraiah and Hunsigi (2000) and Madhuri *et al*. (2011). With increase in N supply, availability, acquisition, mobilization and influx into the plant tissues increased with balanced N supply might be the possible reason for more N content in plants.

Table 4.18. Nitrogen content (%) in whole plant at different growth stages of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest
Organic sources												
M_1	1.21	0.88	0.56	0.55	1.17	0.85	0.57	0.52	1.19	0.87	0.57	0.53
M_2	1.29	0.93	0.65	0.61	1.23	0.89	0.63	0.56	1.26	0.91	0.64	0.58
M_3	1.29	0.92	0.65	0.61	1.22	0.88	0.62	0.56	1.25	0.90	0.63	0.58
SEm±	0.044	0.029	0.019	0.012	0.041	0.024	0.010	0.007	0.040	0.029	0.014	0.009
CD (p = 0.05)	NS	NS	0.07	0.05	NS	NS	0.04	0.03	NS	NS	0.05	0.04
CV (%)	14.8	13.7	12.7	8.8	14.6	11.4	7.3	5.2	13.9	13.9	9.6	7.0
Time and dose of N & K application												
S_1	1.17	0.85	0.56	0.55	1.12	0.81	0.57	0.51	1.15	0.83	0.56	0.53
S_2	1.12	0.81	0.54	0.54	1.10	0.81	0.54	0.49	1.11	0.81	0.54	0.51
S_3	1.34	0.95	0.66	0.61	1.25	0.91	0.63	0.56	1.29	0.93	0.64	0.59
S_4	1.27	0.92	0.62	0.58	1.21	0.90	0.60	0.54	1.24	0.91	0.61	0.56
S_5	1.36	0.99	0.68	0.62	1.29	0.92	0.64	0.59	1.32	0.96	0.66	0.61
S_6	1.33	0.94	0.67	0.62	1.26	0.91	0.65	0.58	1.30	0.93	0.66	0.60
SEm±	0.057	0.037	0.015	0.022	0.050	0.032	0.016	0.016	0.046	0.030	0.019	0.017
CD (p = 0.05)	0.16	0.11	0.04	0.06	0.15	0.09	0.05	0.05	0.13	0.09	0.06	0.05
CV (%)	13.5	12.3	7.2	11.1	12.5	11.1	8.1	8.8	11.3	10.2	9.5	9.0
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

Similar results were reported by Lakshmi *et al*. (2013) that nitrogen content of 0.84 to 0.91 per cent in whole plant at formative phase and 0.55 to 0.64 per cent at grand growth phase at Regional Agricultural Research Station, Anakapalle.

The interaction between organic sources and different time and levels of nitrogen and potassium application failed to project significant effect on nitrogen content in whole plant at all the growth stages of seed crop during 2019-20, 2020-21 and in pooled data.

4.4.2 Nitrogen Uptake (kg ha^{-1})

Nitrogen uptake at different growth stages are presented in Table 4.19 and graphically depicted in Fig. 4.14. Organic sources had a significant effect on nutrient uptake at all growth stages except at 60 DAP during both the years of study and in pooled data.

At 120 DAP, the application of biofertilizer mixture *viz*., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} had appreciably increased the nitrogen uptake (85.0, 65.3 and 75.2 kg ha^{-1} during 2019-20, 2021 and in pooled data, respectively) and it was comparable with trash mulching with bio-decomposers. Lower nitrogen uptake was observed with control which was significantly inferior to M_2 and M_3 treatments. A similar trend of treatmental behaviour was observed at 180 DAP and at harvest during both the years of study and in pooled data. The present results are in close conformity with the earlier findings of Bhalerao *et al*. (2006), Shankaraiah (2007) and Tyagi *et al*. (2011).

The progressive increase in nitrogen uptake from 60 DAP to harvest might be due to increased drymatter accumulation with the advance in age of crop. The biofertilizer applied plots recorded higher nitrogen uptake could be due to *Azospirillum* inoculation that fixes the atmospheric nitrogen and also synergistic effect of inoculated *Azospirillum* and PSB (Babu, 2009b).

Contemplating the data at various stages of crop growth indicated that the nitrogen uptake was significantly altered by different time and dose of nitrogen and potassium application at all the crop growth stages during 2019-20, 2020-21 and in pooled data.

At 60 DAP, higher nitrogen uptake (31.3, 21.6 and 26.4 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) by seed crop was registered with the application of 125% STBNK at 30 days interval *i.e.*, at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting. However, it was statistically on par with 125% STBNK alone applied at 45 days interval, 100% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting during 2019-20 and in pooled data and with S_6, S_3 and S_4 during 2020-21 whereas S_5 exhibited superiority over 75% STBNK alone applied at 45 days interval (S_2) and 75% STBNK applied at 30 days interval + additional dose of 25% RDK (S_1) during 2020-21 and in addition to S_2 and S_1, S_4 also found inferior during first year and in pooled data. Lower nitrogen uptake was recorded with S_2 treatment during both the years of experimentation and pooled data.

Application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% recommended K one month before harvesting recorded remarkable performance in increasing nitrogen uptake by seedcane at 120 DAP. Even though S_5 registered significantly higher nutrient uptake over rest of the treatments, the treatment S_6 was comparable with S_5. The next best treatment was S_3 which inturn maintains parity with S_4 treatment and shows significantly superior over S_2 and S_1.

Whereas, at 180 DAP, application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% recommended K one month before harvesting (S_5) exhibited significantly higher nitrogen uptake when compared to other treatments however, it was comparable with S_6 and S_3 treatments. The next best treatment was S_4 but inferior to S_5, S_6 and S_3 while it was superior to S_2 and S_1 during 2020-21. While in first year of study and in pooled data also,

Table 4.19. Nitrogen uptake (kg ha^{-1}) at different growth stages of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest
Organic sources												
M_1	25.4	68.8	129.3	139.6	18.3	53.6	116.0	126.2	21.8	61.2	122.6	132.9
M_2	28.0	85.0	176.4	183.2	19.8	65.3	152.9	157.2	23.9	75.2	164.7	170.2
M_3	28.0	83.2	166.9	180.7	19.3	64.4	146.7	152.0	23.6	73.8	156.8	166.4
SEm±	0.86	2.68	4.30	5.91	0.69	2.15	4.11	4.55	0.61	1.93	2.82	4.91
CD (p = 0.05)	NS	10.5	16.9	23.2	NS	8.5	16.1	17.8	NS	7.6	11.1	19.3
CV (%)	13.5	14.4	11.6	14.9	15.3	15.0	12.6	13.3	11.2	11.7	8.1	13.3
Time and dose of N & K application												
S_1	23.2	66.2	126.8	149.7	16.9	53.7	110.2	124.3	20.1	60.0	118.5	137.0
S_2	21.7	61.4	116.4	142.2	16.2	50.7	98.5	114.5	19.0	56.0	107.4	128.4
S_3	29.1	85.2	176.1	178.7	20.1	63.6	155.4	156.3	24.6	74.4	165.8	167.5
S_4	27.4	77.6	157.9	161.7	19.2	61.5	140.1	142.6	23.3	69.5	149.0	152.2
S_5	31.3	96.3	188.1	192.3	21.6	71.6	165.8	170.3	26.4	84.0	176.9	181.3
S_6	30.2	87.5	179.9	182.6	20.6	65.6	161.2	162.7	25.4	76.5	170.5	172.6
SEm±	1.16	3.75	3.34	7.09	0.86	2.72	4.26	6.40	0.85	2.59	3.23	5.41
CD (p = 0.05)	3.4	10.8	9.6	20.5	2.5	7.9	12.3	18.5	2.5	7.5	9.3	15.6
CV (%)	12.8	14.2	6.4	12.7	13.5	13.4	9.2	13.2	11.1	11.1	6.5	10.4
Interaction	NS	NS	S	NS	NS	NS	S	NS	NS	NS	S	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

Table 4.19a. Interaction between organic sources, time and dose of nitrogen and potassium application on nitrogen uptake (kg ha^{-1}) by sugarcane seed crop at 180 DAP as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Time and dose of nitrogen and potassium application	**Organic Sources (2019-20)**			**Mean**	**Organic Sources (2020-21)**			**Mean**	**Organic Sources (Pooled data)**			**Mean**
	M_1	**M_2**	**M_3**		**M_1**	**M_2**	**M_3**		**M_1**	**M_2**	**M_3**	
S_1	100.2	142.6	137.6	126.8	75.8	128.0	126.9	110.2	88.0	135.3	132.2	118.5
S_2	71.1	139.2	138.9	116.4	64.4	123.0	108.1	98.5	67.8	131.1	123.5	107.4
S_3	154.8	192.6	181.1	176.1	126.5	171.9	167.9	155.4	140.6	182.3	174.5	165.8
S_4	127.6	176.1	170.0	157.9	119.6	156.7	144.0	140.1	123.6	166.4	157.0	149.0
S_5	166.5	204.4	193.4	188.1	159.4	167.3	170.6	165.8	163.0	185.9	182.0	176.9
S_6	155.4	203.6	180.7	179.9	150.6	170.5	162.5	161.2	153.0	187.0	171.6	170.5
Mean	129.3	176.4	166.9		116.0	152.9	146.7		122.6	164.7	156.8	
	SEm±	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**	
Organic Sources (M)	4.30	16.9	11.6		4.11	16.1	12.6		2.82	11.1	8.1	
Time and dose of nitrogen & potassium application (S)	3.34	9.6	6.4		4.26	12.3	9.2		3.23	9.3	6.5	
Interaction												
M*S	5.78	16.7			7.39	21.3			5.60	16.2		
S*M	7.69	25.3			8.38	27.0			6.06	19.4		

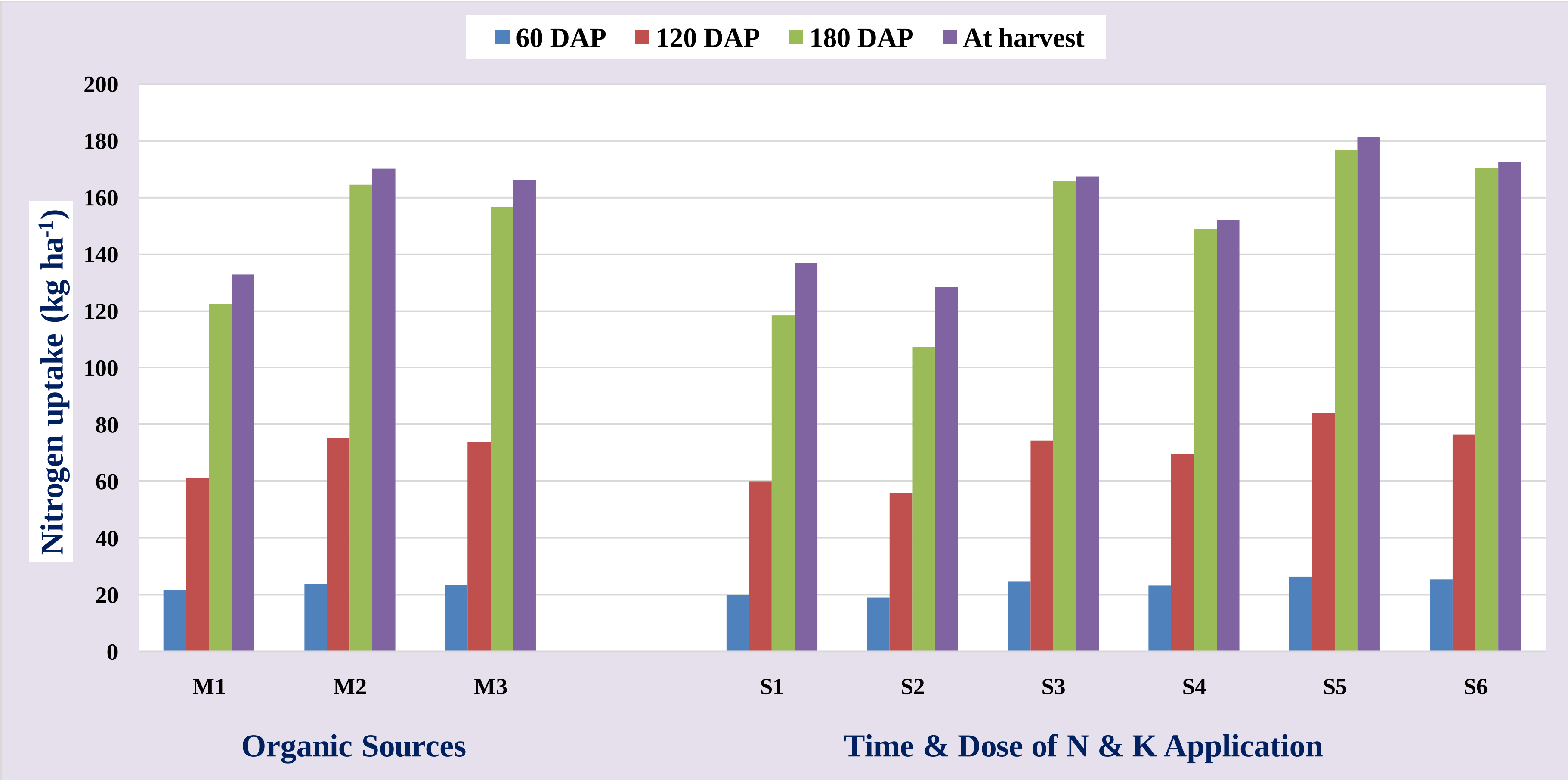

Fig. 4.14. Nitrogen uptake (kg ha^{-1}) at different growth stages of sugarcane seed crop as influenced by biological nutrient management in pooled data

obviously S_5 treatment found to increase nitrogen uptake significantly over the rest of the treatments except with S_6. However, S_3 treatment also recorded higher nitrogen uptake and found comparable with S_6. Lower nitrogen uptake was noticed with S_2 and was significantly inferior to all the treatments.

The significantly higher nitrogen uptake (192.3, 170.3 and 181.3 kg ha^{-1} during 2019-20, 2021 and in pooled data, respectively) by seed crop was recorded with the application of 125% STBNK at 30 days interval *i.e.*, at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting over rest of the treatments. However, it maintained statistical parity with S_6 and S_3 treatments at harvest during both the years and in pooled data. These results are in agreement with those of Asokan *et al*. (2005), Shankaraiah (2007), Kumar (2012) and Kumar and Kumar (2020).

A critical perusal of the data at various growth stages indicated that higher nitrogen uptake with higher fertilizer doses could be due to application of nutrients which increased the nitrogen, phosphorus and potassium content in seedcane by providing balanced nutritional environment inside the plant thereby increased photosynthetic efficiency which resulted in more drymatter accumulation which inturn lead to higher uptake of N by seed crop.

The interaction between organic sources and time and dose of nitrogen and potassium application at all the growth stages did not differ in N uptake except at 180 DAP during both the years of study and in pooled data (Table 4.19a).

At 180 DAP, application of 75% STBNK documented lower nitrogen uptake whereas application of 125% STBNK + additional 25% RDK resulted in higher nitrogen uptake with the M_1 and M_3 treatments during both the years of study and in pooled data. At M_2 level, during first year application of 75% STBNK documented lower nitrogen uptake and 125% STBNK + additional 25% RDK resulted in higher nitrogen uptake while, the higher nitrogen uptake was with S_3 treatment during 2020-21 and with S_6 treatment in pooled data.

Under S_1, S_2, S_3 and S_4 fertilizer levels, application of biofertilizers and trash mulching were comparable with each other and both showed superior nitrogen uptake over control except at S_4 during 2020-21, where M_3 was on par with M_1. At S_5 fertilizer dose, M_2 was found on par with M_3 whereas M_1 recorded the significantly lower uptake of nitrogen over M_2 during 2019-20 and in pooled data but in the second year, all the main plots were statistically on par among themselves. At S_6 fertilizer dose, all the main plot treatments were comparable during 2020-21. However, M_2 maintained parity with M_3 and found superior over M_1 during the first year and in pooled data.

4.4.3 Phosphorus Content (%)

Phosphorus content as influenced by organic sources and different doses and time of nitrogen and potassium application furnished under Table 4.20 clearly shows that phosphorus content at 180 DAP and at harvest was significantly affected by organic sources whereas, at 60 and 120 DAP it was found to be non significant.

Application of *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} and trash mulching with bio-decomposers recorded higher phosphorus content (0.18, 0.17 and 0.18% during 2019-20, 2020-21 and in pooled data, respectively) and both exhibited superiority over control at 180 DAP.

At harvest even though M_2 registered higher phosphorus content (0.17, 0.16 and 0.17% during 2019-20, 2020-21 and in pooled data, respectively), found comparable with M_3 (0.16, 0.15 and 0.16% during 2019-20, 2020-21 and in pooled data, respectively) and both found significantly superior to M_1 during 2019-20 and in pooled data whereas during 2020-21, only M_2 found superior to M_1. More P content in seedcane could be ascribed to reduced phosphorus sorption leading to greater mobilization of phosphorus in soil and also solubilisation of sparingly soluble phosphorus compounds into soluble compounds by the applied PSB thereby augmenting its availability to plants (Babu, 2009b and Banerjee *et al.*, 2018).

With reference to different doses and time of N and K application, the perceptibly increased phosphorus content in whole plant at 60 DAP was noticed with the application of 125% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting (S_5), 125% STBNK applied at 45 days interval, 100% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting and maintained parity with 100% STBNK alone applied at 45 days interval during 2019-20.

The lower phosphorus content was observed with less fertilizer applied plots of 75% STBNK at 45 days interval and 75% STBNK at 30 days interval + additional 25% recommended dose of K one month before harvesting. Similar trend was invariably observed at 120 DAP during both the years of experimentation and also in pooled data.

In the second year of experimentation, at 60 DAP the higher phosphorus content in whole plant was recorded with S_5, S_6, S_3 and S_4 treatments and showed significant superiority over S_1 and S_2 treatments. Whereas in pooled data, treatment S_5 registered more phosphorus content in whole plant and it was statistically on par with S_6, S_3 and S_4 treatments.

At 180 DAP during 2019-20, more phosphorus content (0.18%) in whole plant was recorded with S_5, S_6 and S_3 treatments and showed significant superiority over S_1 (0.16%), S_2 (0.16%) and S_4 (0.16%) treatments. While during 2020-21, treatment S_5 registered more phosphorus content in whole plant and it was statistically on par with S_6, S_3 and S_4 treatments. In pooled data, S_5, S_6 and S_3 treatments recorded equal phosphorus content and significantly superior to S_1 and S_2 treatments.

At harvest S_5, S_6 and S_3 treatments registered higher phosphorus content and exhibited significant superiority over all other treatments during 2019-20 while, during 2020-21 higher phosphorus content was noticed with S_5, S_6, S_3 and S_4 treatments. In pooled data, S_5, S_6 and S_3 treatments recorded equal phosphorus content and significantly superior to S_1 and S_2 treatments. The least

Table 4.20. Phosphorus content (%) in whole plant at different growth stages of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest
Organic sources												
M_1	0.20	0.19	0.16	0.14	0.19	0.18	0.15	0.14	0.20	0.18	0.16	0.14
M_2	0.21	0.19	0.18	0.17	0.20	0.18	0.17	0.16	0.21	0.19	0.18	0.17
M_3	0.21	0.19	0.18	0.16	0.20	0.18	0.17	0.15	0.21	0.19	0.18	0.16
SEm±	0.007	0.006	0.003	0.004	0.004	0.004	0.003	0.003	0.006	0.007	0.004	0.004
CD (p = 0.05)	NS	NS	0.01	0.01	NS	NS	0.01	0.01	NS	NS	0.01	0.01
CV (%)	13.7	13.9	8.1	10.0	9.0	8.8	8.7	7.3	11.6	15.1	8.9	9.8
Time and dose of N & K application												
S_1	0.19	0.17	0.16	0.14	0.18	0.17	0.16	0.13	0.19	0.17	0.16	0.14
S_2	0.19	0.17	0.16	0.14	0.18	0.17	0.15	0.13	0.19	0.17	0.16	0.14
S_3	0.22	0.20	0.18	0.17	0.20	0.19	0.17	0.16	0.21	0.20	0.18	0.17
S_4	0.21	0.19	0.16	0.15	0.20	0.18	0.17	0.16	0.21	0.19	0.17	0.16
S_5	0.22	0.20	0.18	0.17	0.20	0.19	0.18	0.16	0.22	0.20	0.18	0.17
S_6	0.22	0.20	0.18	0.17	0.20	0.19	0.17	0.16	0.21	0.20	0.18	0.17
SEm±	0.008	0.008	0.004	0.005	0.004	0.005	0.005	0.004	0.006	0.006	0.004	0.005
CD (p = 0.05)	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01
CV (%)	11.6	13.2	6.4	9.8	6.1	7.5	8.3	7.1	8.9	9.8	7.7	8.7
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

phosphorus content was noted with S_2 treatment during both the years of study and in pooled data.

Babu (2009b) also observed that application of high fertilizer dose *i*.e., 100% resulted in more phosphorus content in cane plants than lower dose *i*.e., 75%.

The phosphorus content of whole cane was not significantly altered by the interaction between organic sources and time and dose of nitrogen and potassium application at all the growth stages during both the years and also in pooled data.

4.4.4 Phosphorus Uptake (kg ha^{-1})

Phosphorus uptake was significantly influenced by various organic sources evaluated during both years of experiment and in pooled data at all growth stages of crop except at 60 DAP (Table 4.21 and Fig. 4.15). Phosphorus uptake increased gradually with advancement of crop age.

The appreciably increased phosphorus uptake (17.7, 13.5 and 15.6 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) at 120 DAP was associated with the application of biofertilizer mixture (M_2) and statistically on par with trash mulching with bio-decomposers (17.0, 13.2 and 15.2 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) and both were found significantly superior over control (14.6, 11.1 and 12.9 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) which recorded lower phosphorus uptake. Similar trend was noticed at 180 DAP and at harvest as that observed in 120 DAP during both the years of study and in pooled data. Bhalerao *et al*. (2006), Babu (2009b) and Jyothi and Rao (2020) also reported similar trend in seed crop of sugarcane.

Higher phosphorus uptake with the application of organics could be ascribed to the multiple properties of organic material which hinders the precipitation and fixation of phosphorus and retained it in soluble form thereby more availability of P resulting in higher absorption by plants.

The symbiotic association between AM fungi and plants can produce colonies beyond root zone thereby more uptake of water and nutrients by plant roots besides acting as agent which can improve plant-water relationship through increased stomatal resistance by adjusting plant hormonal balance (Mulyani *et al*., 2017).

With reference to time and dose of nitrogen and potassium application at all the growth stages, phosphorus uptake was significantly affected by different levels and time of nitrogen and potassium application. At 60 DAP, application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting (S_5) registered higher phosphorus uptake and was comparable with the application of 125% STBNK at planting, 45, 90, 135 and 180 DAP, 100% STBNK applied at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting and 100% STBNK applied at planting, 45, 90, 135 and 180 DAP. The significantly lower phosphorus uptake was manifested with 75% STBNK alone applied at planting, 45, 90, 135 and 180 DAP followed by 75% STBNK applied at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting over S_5, S_6 and S_3 treatments.

The phosphorus uptake in whole cane was higher (19.8 kg ha^{-1}) in S_5 treatment, which was significantly superior to other treatments and statistically on par with S_6 and S_3 treatments. The least phosphorus uptake was observed with S_2 (12.4 kg ha^{-1}) and S_1 (13.6 kg ha^{-1}) treatments at 120 DAP during the first year of study. An identical trend was exhibited at 180 DAP during both the years and in pooled data as well.

Higher phosphorus uptake (14.6 and 17.2 kg ha^{-1} during 2020-21 and in pooled data, respectively) was recorded with S_5 treatment which was significant superior to all other treatments except with S_6 treatment in pooled data and with S_6 and S_3 treatments during 2020-21 and significantly superior to S_4, S_2 and S_1 treatments.

Table 4.21. Phosphorus uptake (kg ha^{-1}) at different growth stages of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest
Organic sources												
M_1	4.2	14.6	35.5	36.2	2.9	11.1	31.3	34.7	3.6	12.9	33.4	35.5
M_2	4.6	17.7	48.0	49.9	3.2	13.5	41.9	44.8	3.9	15.6	45.0	47.3
M_3	4.6	17.0	45.3	47.5	3.2	13.2	40.6	42.3	3.9	15.2	43.0	44.9
SEm±	0.16	0.59	1.24	1.22	0.11	0.42	1.23	0.63	0.12	0.40	1.25	0.90
CD (p = 0.05)	NS	2.3	4.9	4.8	NS	1.6	4.8	2.5	NS	1.6	4.9	3.5
CV (%)	14.9	15.2	12.3	11.6	15.4	14.1	13.7	6.6	13.2	11.6	13.1	9.0
Time and dose of N & K application												
S_1	3.8	13.6	37.0	38.8	2.8	11.2	30.5	32.7	3.3	12.4	33.8	35.8
S_2	3.7	12.4	34.6	36.9	2.8	10.7	28.1	30.9	3.2	11.6	31.4	33.9
S_3	4.7	17.9	47.5	49.1	3.3	13.0	42.0	44.5	4.0	15.5	44.8	46.8
S_4	4.5	16.0	40.9	41.6	3.1	12.4	39.1	42.5	3.8	14.2	40.0	42.1
S_5	5.1	19.8	49.8	51.2	3.4	14.6	45.2	47.3	4.3	17.2	47.5	49.2
S_6	5.0	18.9	47.7	49.4	3.3	13.6	42.8	45.6	4.2	16.3	45.2	47.5
SEm±	0.22	0.80	1.77	1.16	0.12	0.58	1.65	0.87	0.17	0.54	1.39	0.96
CD (p = 0.05)	0.6	2.3	5.1	3.3	0.3	1.7	4.8	2.5	0.5	1.6	4.0	2.8
CV (%)	14.5	14.6	12.3	7.8	11.2	13.8	13.0	6.4	13.0	11.2	10.3	6.7
Interaction	NS	NS	NS	S	NS	NS	NS	S	NS	NS	NS	S

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

Table 4.21a. Interaction between organic sources, time and dose of nitrogen and potassium application on phosphorus uptake (kg ha^{-1}) by sugarcane seed crop at harvest as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Time and dose of nitrogen and potassium application	Organic Sources (2019-20)			Mean	Organic Sources (2020-21)			Mean	Organic Sources (Pooled data)			Mean
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
S_1	28.3	43.6	44.6	38.8	25.2	36.9	36.1	32.7	26.8	40.3	40.4	35.8
S_2	23.7	43.7	43.4	36.9	20.9	36.9	34.9	30.9	22.3	40.3	39.2	33.9
S_3	43.4	55.4	48.5	49.1	39.8	49.0	44.7	44.5	41.6	52.2	46.6	46.8
S_4	34.0	46.1	44.8	41.6	39.3	45.1	43.1	42.5	36.7	45.6	44.0	42.1
S_5	44.0	55.3	54.2	51.2	42.0	51.6	48.2	47.3	43.0	53.5	51.2	49.2
S_6	43.5	55.3	49.2	49.4	41.0	49.0	46.8	45.6	42.3	52.2	48.0	47.5
Mean	36.2	49.9	47.5		34.7	44.8	42.3		35.50	47.3	44.9	
	SEm±	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**	
Organic Sources (M)	1.22	4.8	11.6		0.63	2.5	6.6		0.90	3.5	9.0	
Time and dose of nitrogen & potassium application (S)	1.16	3.3	7.8		0.87	2.5	6.4		0.96	2.8	6.7	
Interaction												
M*S	2.00	5.8			1.51	4.4			1.66	4.8		
S*M	2.37	7.7			1.52	4.8			1.86	6.0		

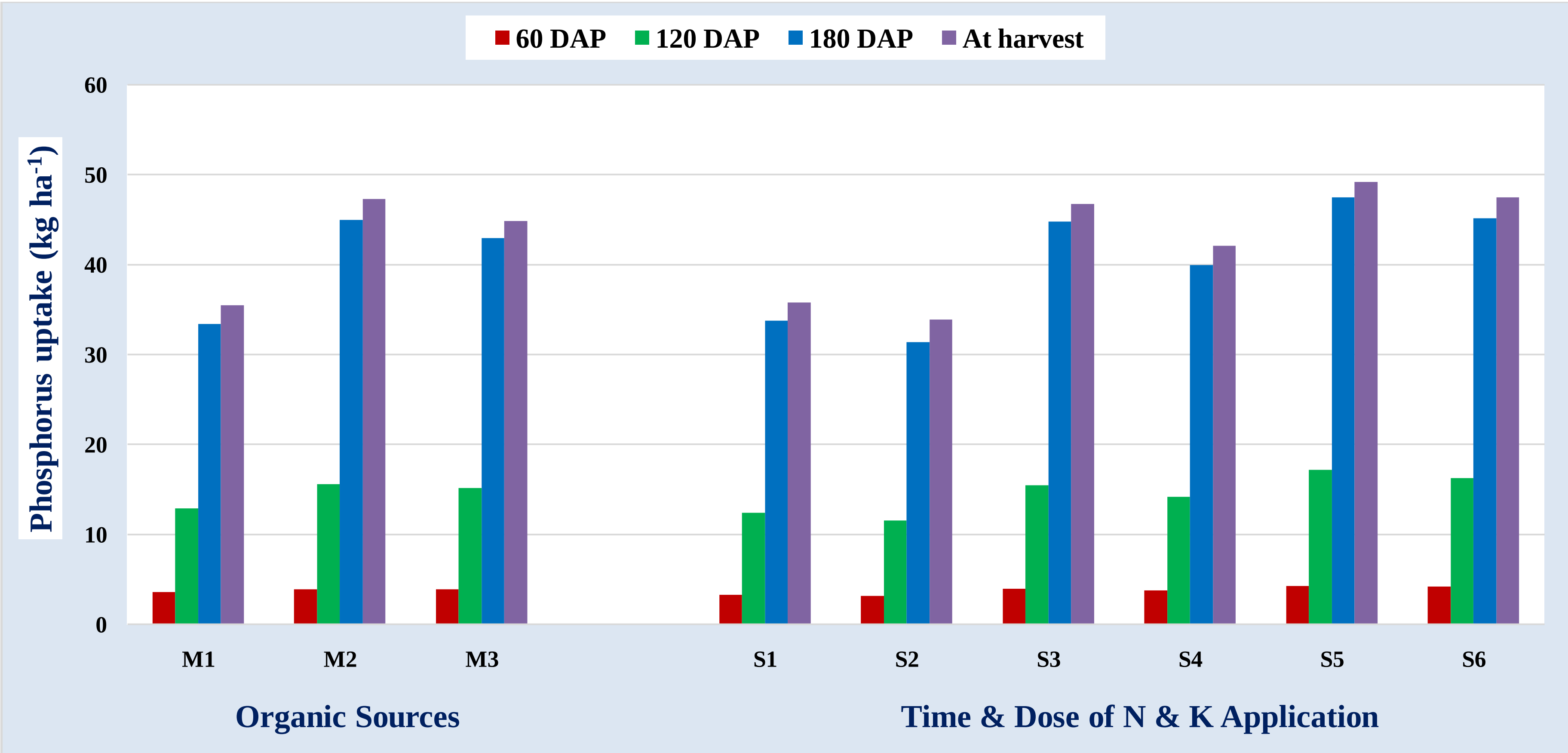

Fig. 4.15. Phosphorus uptake (kg ha^{-1}) at different growth stages of sugarcane seed crop as influenced by biological nutrient management in pooled data

At harvest, increased phosphorus uptake (51.2, 47.3 and 49.2 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) was observed with S_5 treatment and was significantly superior to all the other treatments studied in this study whereas, S_5 maintained parity with S_6 and S_3 during 2019-20 and in pooled data and with S_6 only during 2020-21. Treatment S_2 recorded lower phosphorus uptake during both the years of study and in pooled data. At all the growth stages, higher P uptake was registered with higher fertilizer dose. The possible reason for this increase could be higher drymatter accumulation as well as P availability owing to higher levels of fertilizers. The current findings are in consonance with the earlier findings of Kumar (2012), Umesh *et al*. (2013) and Meena and Kumar (2015).

The interaction effect of organic sources and time and dose of nitrogen and potassium application had failed to hold significant influence on phosphorus uptake at all growth stages except at harvest. At all the main plot treatments, S_5 recorded higher phosphorus uptake than S_2 and S_1 treatments however maintained statistical parity with S_6 treatment. The application of lower fertilizer dose along with biofertilizers (M_2S_2 and M_2S_1) and trash mulch (M_3S_2 and M_3S_1) was found on par with that of application of 125% STBNK + additional 25% RDK (M_1S_5) during the first year of study and also in pooled data (Table 4.21a).

4.4.5 Potassium Content (%)

Potassium content in whole plant at different growth stages of seedcane as influenced by organic sources and time and dose of nitrogen and potassium application during both the years and also in pooled data was presented in Table 4.22. A glance at the data on potassium content indicated that potassium content was uninfluenced by various organic sources used in this study at all growth stages except at harvest.

At harvest, higher potassium content (0.69%) was documented with M_2 treatment and M_3 treatments and both the treatments were superior to M_1 (0.62%) during 2019-20 and in pooled data. While, during 2020-21 higher

Table 4.22. Potassium content (%) in whole plant at different growth stages of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest
Organic sources												
M_1	0.90	0.84	0.67	0.62	0.88	0.78	0.67	0.61	0.89	0.81	0.67	0.62
M_2	0.94	0.88	0.76	0.69	0.92	0.85	0.75	0.69	0.94	0.87	0.76	0.69
M_3	0.94	0.88	0.75	0.69	0.92	0.83	0.73	0.68	0.93	0.86	0.74	0.69
SEm±	0.022	0.024	0.025	0.014	0.027	0.024	0.020	0.014	0.024	0.023	0.018	0.016
CD (p = 0.05)	NS	NS	NS	0.06	NS	NS	NS	0.06	NS	NS	NS	0.06
CV (%)	10.2	11.9	14.3	9.2	12.5	12.2	11.7	9.2	10.9	11.6	10.8	10.1
Time and dose of N & K application												
S_1	0.88	0.81	0.69	0.61	0.85	0.78	0.68	0.61	0.87	0.80	0.69	0.61
S_2	0.87	0.80	0.67	0.61	0.84	0.77	0.64	0.61	0.86	0.79	0.66	0.61
S_3	0.96	0.90	0.74	0.70	0.94	0.84	0.76	0.68	0.95	0.87	0.76	0.69
S_4	0.93	0.87	0.72	0.68	0.91	0.82	0.70	0.66	0.92	0.85	0.71	0.67
S_5	0.97	0.91	0.77	0.70	0.95	0.87	0.77	0.70	0.97	0.89	0.77	0.71
S_6	0.96	0.91	0.76	0.70	0.95	0.85	0.76	0.70	0.96	0.88	0.76	0.70
SEm±	0.026	0.030	0.024	0.027	0.030	0.021	0.027	0.019	0.026	0.027	0.017	0.019
CD (p = 0.05)	0.08	0.09	0.07	0.08	0.09	0.06	0.08	0.05	0.07	0.08	0.05	0.06
CV (%)	8.5	10.5	10.1	12.3	9.9	7.7	11.1	8.4	8.4	9.5	7.2	8.6
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

potassium content (0.69%) was documented with M_2 treatment and it was closely followed by M_3 and both were comparable with each other and exhibited significant superiority over control. This may be due to addition of organic manures that facilitates availability of plant nutrients directly to plants through solubilising effect on fixed forms thereby more nutrients available for absorption by plants thus more nutrient content in plants.

Banerjee *et al*. (2018) also reported that higher potassium content in cane plants was observed with application of biofertilizers along with inorganic fertilizers than application of only inorganics.

The data presented in Table 4.22 revealed that various sub plot treatments had exerted significant effect on potassium content at all the growth stages. At 60 DAP, the application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting (S_5) exerted remarkable influence in increasing potassium content. However, it was statistically on par with 125% STBNK alone applied at 45 days interval (S_6), 100% STBNK applied at 30 days interval + additional 25% RDK one month before harvesting (S_3) and 100% STBNK alone applied at 45 days interval (S_4). The least potassium content was observed with plots receiving lower dose of fertilizers *i.e.*, S_2 and S_1 during first year of experimentation and in pooled data. Similar trend of treatmental performance continued with regard to potassium content at 120 DAP during 2020-21 and in pooled data.

While during 2020-21, the higher potassium content (0.95%) was observed with S_5 and S_6 treatments and were statistically comparable with S_3 and S_4 treatments. At 120 DAP during 2019-20 similar trend of treatmental performance observed with regard to potassium content.

At 180 DAP, application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting (S_5) recorded significantly higher potassium content over S_2 and S_1 treatments and found on par with S_6, S_3 and S_4 during 2019-20 and 2020-21 and with S_6 and S_3 in pooled data. Conspicuously, lower potassium content was noticed with S_2 and S_1 treatments which might be due to low availability of K with less fertilizer applied plots. Higher potassium content with the execution of 125% STBNK might be due more available K under these treatments. These results corroborates with the findings of Madhuri *et al*. (2011) and Kadarwati (2020).

At harvest, the higher potassium content (0.70%) was registered with S_3, S_5 and S_6 treatments and was comparable with S_4 treatment (0.68%) during 2019-20. Whereas in the second year of experimentation, higher potassium content of 0.70% was observed with S_5 and S_6 treatments and was comparable with S_3 and S_4 treatments. In pooled data, S_5 recorded significantly higher potassium content over S_1 and S_2 treatments and found on par with S_6, S_3 and S_4 treatments. The conspicuously lower potassium content was observed with lower dose of fertilizers *i.e*., S_2 and S_1 during both the years of experimentation and in pooled data.

The potassium content of whole cane did not differ significantly due to interaction between organic sources and time and dose of nitrogen and potassium application at all the growth stages during 2019-20, 2020-21 and in pooled data.

4.4.6 Potassium Uptake (kg ha^{-1})

A perusal of the data in Table 4.23 and Fig. 4.16 revealed that differences in potassium uptake was significantly altered by different organic sources studied in the experiment at different stages and at harvest except at 60 DAP.

Potassium uptake by whole cane plant was higher (80.9, 61.9 and 71.4 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) in biofertilizer applied treatment (80.5, 60.6 and 70.6 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) and found comparable with trash mulching (M_3) and both inturn superior to control at 120 DAP. The differences in potassium uptake of seedcane recorded at 180 DAP and at the time of harvest were also followed the similar trend during both the years of experimentation and in pooled data. During the process of decomposition of trash by decomposers various chelating compounds are released which improved nutrient availability might be the possible reason for higher nutrient uptake by seed crop (Bhalerao *et al*., 2006 and Babu, 2009b).

The doses and time of nitrogen and potassium application had exerted significant influence on potassium uptake at all the growth stages. Among all the treatments, at 60 DAP, the higher potassium uptake was displayed with 125% STBNK applied at planting, 30, 60, 90, 120 DAP + additional 25% recommended K one month before harvesting (S_5). However treatments S_5, S_6, S_3 and S_4 were comparable. Lower potassium uptake was recorded with application of 75% STBNK at planting, 45, 90, 135 and 180 DAP followed by75% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% recommended K one month before harvesting.

Higher potassium uptake (89.5, 67.1 and 78.3 kg ha^{-1} durig 2019-20, 2020-21 and in pooled data, respectively) was recorded with S_5 treatment and maintained parity with S_6 (84.9 kg ha^{-1}) and S_3 (80.8 kg ha^{-1}) during 2019-20 and with only S_6 (61.4 and 73.2 kg ha^{-1}) during 2020-21 and in pooled data. The treatment S_3 was followed by S_4 and both was found statistically on par with each other. The least potassium uptake was observed in S_2 (60.7, 48.7 and 54.7 kg ha^{-1} during 2019-20, 2020-21 and in pooled data) treatment at 120 DAP. Similar trend was noticed at harvest during both the years and also in pooled data as that observed at 120 DAP during 2019-20.

At 180 DAP, during the first year similar trend of treatmental influence on potassium uptake was exhibited as that noticed at 120 DAP during 2019-20. In the second year of investigation and in pooled data, treatment S_5 registered higher potassium uptake (198.7 and 207.2 kg ha^{-1} during 2020-21 and in pooled data, respectively) and found significantly superior to all other treatments except S_6 (189.2 and 196.9 kg ha^{-1} during 2020-21 and in pooled data, respectively) and S_3 (186.8 and 192.7 kg ha^{-1} during 2020-21 and in pooled data, respectively). This could be attributed to application of nutrients in high dose increased the N, P and K contents in cane plants by providing balanced

Table 4.23. Potassium uptake (kg ha^{-1}) at different growth stages of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest	60 DAP	120 DAP	180 DAP	At harvest
Organic sources												
M_1	19.0	65.6	155.0	157.9	13.7	49.2	136.0	147.2	16.4	57.4	145.5	152.6
M_2	20.5	80.9	205.8	208.2	14.8	61.9	183.6	194.3	17.7	71.4	194.7	201.3
M_3	20.2	80.5	191.9	204.5	14.6	60.6	173.2	187.1	17.4	70.6	182.6	195.8
SEm±	0.68	2.65	6.05	6.53	0.42	1.88	6.11	4.96	0.50	2.02	5.98	4.68
CD (p = 0.05)	NS	10.4	23.7	25.7	NS	7.4	24.0	19.5	NS	7.9	23.5	18.4
CV (%)	14.6	14.9	13.9	14.6	12.4	13.9	15.8	11.9	12.4	12.9	14.6	10.8
Time and dose of N & K application												
S_1	17.5	63.9	158.5	164.6	12.8	51.7	132.1	149.0	15.2	57.9	145.3	156.8
S_2	16.8	60.7	143.6	158.3	12.5	48.7	116.5	141.5	14.7	54.7	130.1	149.9
S_3	21.0	80.8	198.6	206.4	15.2	58.9	186.8	190.8	18.1	69.9	192.7	198.6
S_4	20.0	74.0	184.3	189.0	14.4	55.7	162.4	176.7	17.2	64.9	173.4	182.9
S_5	22.4	89.5	215.7	216.0	15.9	67.1	198.7	202.6	19.2	78.3	207.2	209.3
S_6	21.8	84.9	204.6	206.9	15.5	61.4	189.2	196.7	18.7	73.2	196.9	201.8
SEm±	0.94	3.68	7.91	9.24	0.53	2.65	6.30	6.13	0.70	2.39	6.08	6.55
CD (p = 0.05)	2.7	10.6	22.9	26.7	1.5	7.7	18.2	17.7	2.0	6.9	17.6	18.9
CV (%)	14.2	14.6	12.9	14.6	11.1	13.9	11.5	10.4	12.2	10.8	10.5	10.7
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

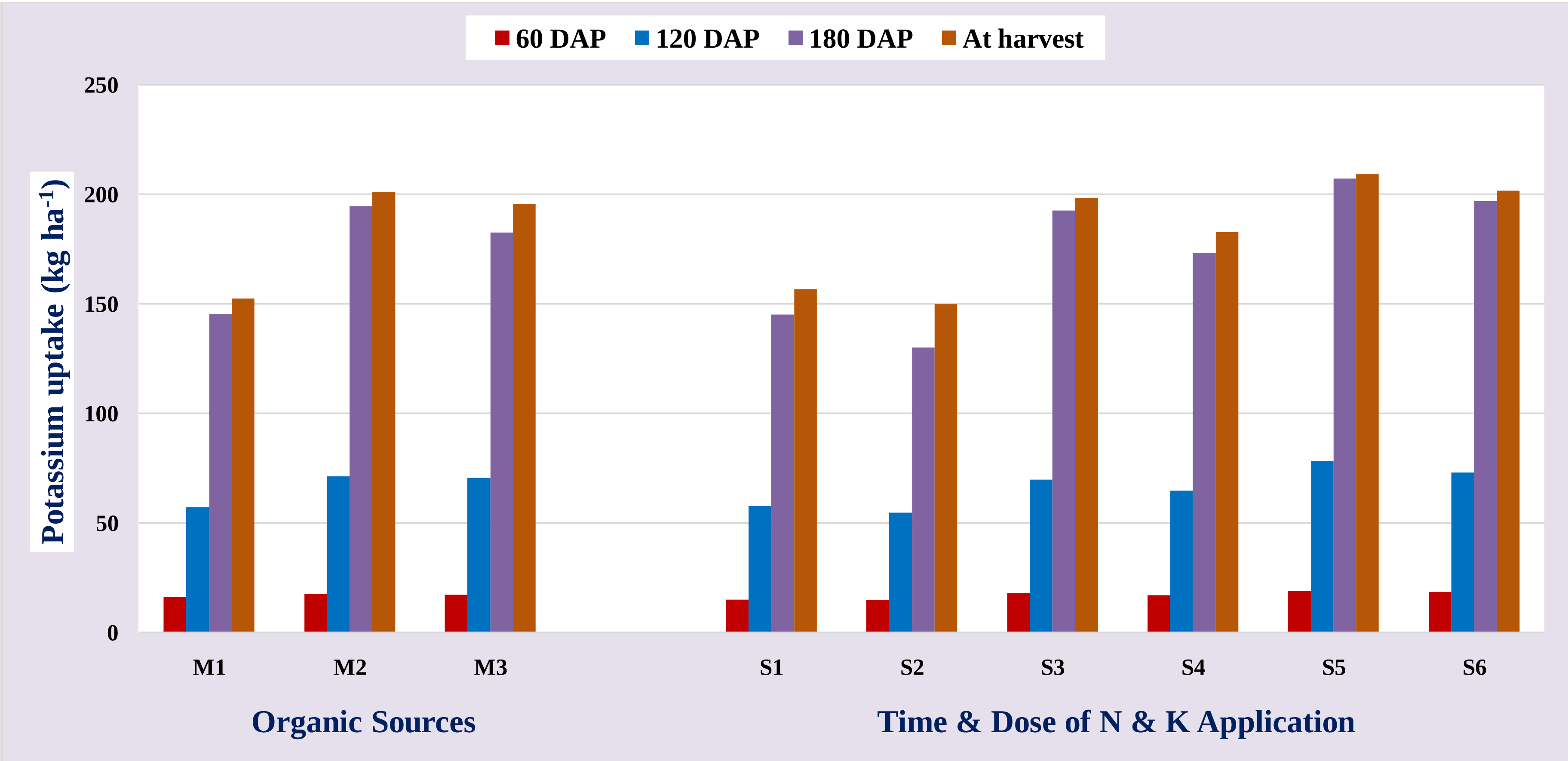

Fig. 4.16. Potassium uptake (kg ha^{-1}) at different growth stages of sugarcane seed crop as influenced by biological nutrient management in pooled data

nutrition to plant which improved photosynthetic activity thereby profuse shoot and root growth owing to high drymatter accumulation. Since the nutrient removal is a function of drymatter and nutrient concentration, the increased drymatter together with high N, P and K contents resulted in great removal of N, P and K. The least potassium uptake was observed in S_2 followed by S_1 treatments during both the years of study and in pooled data. The current findings are in accordance with Tiwari *et al*. (2000), Kumar (2012), Umesh *et al*. (2013) and Meena and Kumar (2015).

The organic sources and application of nitrogen and potassium in different doses and time failed to interact significantly in influencing potassium uptake at all the stages of crop growth during 2019-20, 2020-21 and also in pooled data.

4.5 EFFECT OF ORGANIC SOURCES AND TIME AND DOSE OF NITROGEN AND POTASSIUM APPLICATION ON NUTRIENT AVAILABILITY AFTER HARVEST OF SEEDCANE

4.5.1 Nitrogen (kg ha^{-1})

Nitrogen availability in soil was significantly influenced by both the organic sources and application of various levels and time of nitrogen and potassium while, their interaction did not differ significantly (Table 4.24).

In the first year of experimentation, among main plot treatments, application of biofertilizer mixture *i*.e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} recorded higher nitrogen availability (189.9 kg ha^{-1}) in soil, which was on par with trash mulching (186.4 kg ha^{-1}). The lower soil available nitrogen was recorded with control, which is significantly inferior to all other treatments. Similar trend was noticed during the second year of study and in pooled data. Bhalerao *et al*. (2006), Saini *et al*. (2006), Shankaraiah (2007), Soundarrajan *et al*. (2007), Nazirkar *et al*. (2010), Banerjee *et al*. (2018) and Lakshmi *et al*. (2019) also reported similar results.

The improved N availability in soil with the addition of biofertilizers and trash mulching might be due to FYM integrated biofertilizers release organic acids which solubilise the soil nutrient reserve besides ameliorating effect of trash rich in nutrient content fortified with lignified compounds present in organic manures are responsible for slow release of nutrients thereby reduced losses and build up of soil N pool (Tyagi *et al*., 2011).

Application of 125% STBNK applied at 30 days interval + additional 25% RDK one month before harvesting (S_5) exhibited significantly higher nitrogen availability (194.8, 184.4 and 189.6 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) over 75% STBNK applied at 45 days interval (S_2) followed by 75% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting (S_1). However, S_5 treatment was on par with the application of 125% STBNK alone at 45 days interval, 100% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting and 100% STBNK alone applied at 45 days interval. Conspicuously, lower nitrogen availability was associated with S_2 followed by S_1. These results are in tune with the findings of Mathew and Varughese (2007), Shankaraiah (2007) and Kumar and Kumar (2020).

Increase in N fertilizer level assured increased availability of N to the sugarcane in adequate amount and leftover in soil in considerable amount after fulfilling the sugarcane needs that ultimately increased the post harvest availability of N in soil (Kumar, 2012).

4.5.2 Phosphorus (kg ha^{-1})

The perusal of data (Table 4.24) on phosphorus availability in soil after harvest of crop indicated that both organic sources and time and dose of nitrogen and potassium application had significant influence on phosphorus availability while the interaction failed to exert significant effect on phosphorus availability during the both the years of study and also in pooled data.

Table 4.24. NPK availability (kg ha^{-1}) in soil after harvest of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20			2020-21			Pooled data		
	N	P	K	N	P	K	N	P	K
Organic sources									
M_1	173.0	65.0	191.2	161.0	60.3	190.8	167.0	62.6	191.0
M_2	189.9	76.1	217.3	182.3	69.2	212.8	186.1	72.6	215.1
M_3	186.4	73.5	216.0	180.7	66.3	209.0	183.6	69.9	212.5
SEm±	3.19	2.14	4.79	4.31	1.44	4.47	3.37	1.66	3.87
CD (p = 0.05)	12.5	8.4	18.8	16.9	5.7	17.5	13.2	6.5	15.2
CV (%)	7.4	12.7	9.8	10.5	9.4	9.3	8.0	10.3	8.0
Time and dose of N & K application									
S_1	173.0	66.1	200.4	165.9	60.9	195.2	169.4	63.5	197.8
S_2	169.5	65.6	196.1	161.4	60.6	189.3	165.4	63.1	192.7
S_3	184.4	74.1	213.0	180.1	67.7	208.7	182.3	70.9	210.9
S_4	183.0	73.9	203.5	177.6	66.5	204.3	180.3	70.2	203.9
S_5	194.8	75.3	222.5	184.4	68.6	218.0	189.6	71.9	220.3
S_6	194.1	74.2	213.5	178.6	67.4	209.9	186.3	70.8	211.7
SEm±	6.57	2.67	6.17	5.29	2.03	6.28	5.72	1.88	5.40
CD (p = 0.05)	19.0	7.7	17.8	15.3	5.9	18.1	16.5	5.4	15.6
CV (%)	10.8	11.2	8.9	9.1	9.3	9.2	9.6	8.3	7.9
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1- No Biofertilizers, M_2- Biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} & VAM @ 12.5 kg ha^{-1}, M_3- Trash mulching with bio-decomposer (A & B), S_1 -75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_2 - 75% STBNK at planting, 45, 90, 135 & 180 DAP, S_3 - 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_4 - 100% STBNK at planting, 45, 90, 135 & 180 DAP, S_5 - 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, S_6 - 125% STBNK at planting, 45, 90, 135 & 180 DAP.

Post harvest phosphorus availability was higher with the application of *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} (76.1, 69.2 and 72.6 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) and showed on par with trash mulching with bio-decomposers and both displayed significant superiority over control. The possible reason for high available phosphorus was due to increased PSB activity in the rhizosphere owing to PSB application which constitutes increased P solubilisation resulting in more available P in soil at appropriate growth stages (Sundara *et al*., 2002). Present findings are in conformity with Bhalerao *et al*. (2006), Saini *et al*. (2006), Soundarrajan *et al*. (2007), Nazirkar *et al*. (2010), Banerjee *et al*. (2018) and Lakshmi *et al*. (2019).

Irrespective of year of the study, soil available phosphorus after harvest markedly increased in 125% STBNK applied at 30 days interval + additional 25% RDK (75.3, 68.6 and 71.9 kg ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively). This could be due to high fertilizer addition leaving more residual nutrients in soil besides nutrient uptake by crop, which was however statistically on par with 125% STBNK applied at 45 days interval, 100% STBNK at planting, 30, 60, 90, 120 DAP + extra 25% recommended K one month before harvesting and 100% STBNK alone applied at 45 days interval. The addition of 75% STBNK alone at 45 days interval registered distinctly lower available phosphorus in soil and was closely followed by 75% STBNK at 30 days interval along with 25% additional RDK applied one month before harvesting. Our results depicted in the present study corroborates with earlier findings of Mathew and Varughese (2007) and Kumar (2012).

4.5.3 Potassium (kg ha^{-1})

Close observation of the data presented in Table 4.24 indicated that the potassium availability was differed significantly due to organic sources and time and dose of nitrogen and potassium application as well. Potassium availability not influenced by the interaction between these two during 2019-20, 2020-21 and in pooled data.

Potassium availability also followed a similar trend as observed in availabile nitrogen and phosphorus. Among various organic sources, application of biofertilizer mixture *i*.e., *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} increased the availability of potassium (217.3 kg ha^{-1}) however it was comparable with trash mulching with bio-decomposers (216.0 kg ha^{-1}) and both shows significant superiority over control during 2019-20. Similar trend was observed during 2020-21 and in pooled data as well. The present findings are supported by Bhalerao *et al*. (2006), Saini *et al*. (2006), Soundarrajan *et al*. (2007), Nazirkar *et al*. (2010) and Banerjee *et al*. (2018).

More post harvest availability of soil K with organic sources of nutrients could be ascribed to improved soil physical conditions and enhances microbial activity besides supplying nutrients which inturn lead to increased nutrient availability in soil.

Increased available potassium (222.5 kg ha^{-1}) was manifested with application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting. However, it maintained parity with 125% STBNK alone applied at planting, 45, 90, 135 and 180 DAP, 100% STBNK applied at planting, 30, 60, 90, 120 DAP + additional 25% recommended K one month before harvesting during 2019-20 and in pooled data and with application of 100% STBNK alone at planting, 45, 90, 135 and 180 DAP treatment also during 2020-21. The lower potassium availability was documented with 75% STBNK applied at planting, 45, 90, 135 and 180 DAP followed by the 75% STBNK applied at planting, 30, 60, 90, 120 DAP + additional 25% recommended K one month before harvesting. Application of higher level of K fertilizers could be the reason for higher residual K in soil after harvest of seed crop. Similar results were also reported in earlier studies conducted by Tiwari *et al*. (2000), Mathew and Varughese (2007), Kumar (2012) and Kadarwati (2020).

4.6 EFFECT OF ORGANIC SOURCES AND TIME AND DOSE OF NITROGEN AND POTASSIUM APPLICATION ON ECONOMICS OF SEEDCANE

4.6.1 Gross Returns (Rs. ha^{-1})

Gross returns is a dependent variable related with market value of the produce. Data related to gross returns furnished under Table 4.25 and Fig. 4.17 proved that higher gross returns (Rs. 2,44,483, 2,28,050 and 2,36,267 ha^{-1}, respectively) was observed with the application of biofertilizers which could be owing to higher yield. However, it was found to be on par with trash mulching and both the treatments exhibited significant superiority over control (M_1) during both the years of experimentation and in pooled data. These results are corroborating with the findings of Bhalerao *et al*. (2006) and Tyagi *et al*. (2011).

A significant influence of application of different doses and time of nitrogen and potassium was observed on gross returns. In the first year, second year and in pooled data, application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting registered higher gross returns (Rs. 2,51,933, 2,38,200 and 2,45,067 ha^{-1}, respectively) and was statistically comparable with the application of 125% STBNK at planting, 45, 90, 135 and 180 DAP and 100% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% recommended dose of K one month before harvesting. The next best treatment was 100% STBNK applied at planting, 45, 90, 135 and 180 DAP. Higher gross returns might be due to increased yield attributes and yield with the adequate supply of nitrogen and potassium at 125% STBNK. Lower gross returns was noticed with 75% STBNK applied at planting, 45, 90, 135 and 180 DAP which was significantly lower than all other treatments except with application of 75% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting. Similar trend of effects has also been advocated by Gupta *et al*. (2006), Virdia *et al*. (2009), Dev *et al*. (2012), Sarala *et al*. (2012) and Meena and Kumar (2015). The interaction between organic sources and

Table 4.25. Cost of cultivation (Rs. ha^{-1}), gross returns (Rs. ha^{-1}), net returns (Rs. ha^{-1}) and BCR in sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Treatments	2019-20				2020-21				Pooled data			
	Cost of cultivation	Gross returns	Net returns	BCR	Cost of cultivation	Gross returns	Net returns	BCR	Cost of cultivation	Gross returns	Net returns	BCR
Organic sources												
M_1	154179	219200	65021	1.42	156409	207100	50691	1.32	155294	213150	57856	1.38
M_2	157095	244483	87392	1.56	159321	228050	68729	1.43	158208	236267	78061	1.50
M_3	156541	239100	82721	1.53	158610	225150	66541	1.42	157576	232125	74631	1.48
SEm±	-	5018.6	2459.1	0.02	-	4223.0	2267.7	0.02	-	4632.7	1531.3	0.02
CD (p = 0.05)	-	19705	9656	0.09	-	16582	8904	0.08	-	18190	6013	0.08
CV (%)	-	9.1	13.3	6.39	-	8.1	15.5	6.4	-	8.7	9.3	6.2
Time and dose of N & K application												
S_1	153529	218967	65438	1.42	155759	202533	46774	1.30	154644	210750	56106	1.36
S_2	152959	209800	56841	1.37	155189	195333	40144	1.26	154074	202567	48493	1.32
S_3	156169	245467	89298	1.57	158399	230800	72401	1.46	157284	238133	80849	1.52
S_4	155599	233100	77501	1.50	157829	219500	61671	1.39	156714	226300	69586	1.45
S_5	158806	251933	93127	1.59	161036	238200	77164	1.48	159921	245067	85146	1.54
S_6	158236	246300	88064	1.56	160466	234233	73767	1.46	159351	240267	80916	1.51
SEm±	-	5677.3	2999.1	0.03	-	5361.6	3068.3	0.03	-	5309.1	2110.2	0.03
CD (p = 0.05)	-	16397	8662	0.08	-	15485	8862	0.08	-	15334	6095	0.08
CV (%)	-	7.3	11.5	5.87	-	7.3	14.8	6.3	-	7.0	9.0	5.7
Interaction	-	NS	S	NS	-	NS	S	NS	-	NS	S	NS

Table 4.25a. Interaction between organic sources, time and dose of nitrogen and potassium application on net returns (Rs. ha^{-1}) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Time and dose of nitrogen and potassium application	Organic Sources (2019-20)			Mean	Organic Sources (2020-21)			Mean	Organic Sources (Pooled data)			Mean
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
S_1	39075	82263	74975	65438	20845	61633	57845	46774	29960	71948	66410	56106
S_2	29045	74333	67145	56841	11915	54503	54015	40144	20480	64418	60580	48493
S_3	86235	92123	89535	89298	69805	74493	72905	72401	78020	83308	81220	80849
S_4	62805	85993	83705	77501	54875	65463	64675	61671	58840	75728	74190	69586
S_5	88398	98086	92898	93127	75568	80356	75568	77164	81983	89221	84233	85146
S_6	84568	91556	88068	88064	71138	75926	74238	73767	77853	83741	81153	80916
Mean	65021	87392	82721		50691	68729	66541		57856	78061	74631	
	SEm±	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**		**SEm±**	**CD (p = 0.05)**	**CV (%)**	
Organic Sources (M)	2459.1	9656	13.3		2267.7	8904	15.5		1531.3	6013	9.3	
Time and dose of nitrogen & potassium application (S)	2999.1	8662	11.5		3068.3	8862	14.8		2110.2	6095	9.0	
Interaction												
M*S	5194.7	15003			5314.4	15349			3654.9	10556		
S*M	5484.9	17464			5395.7	17059			3687.2	11643		

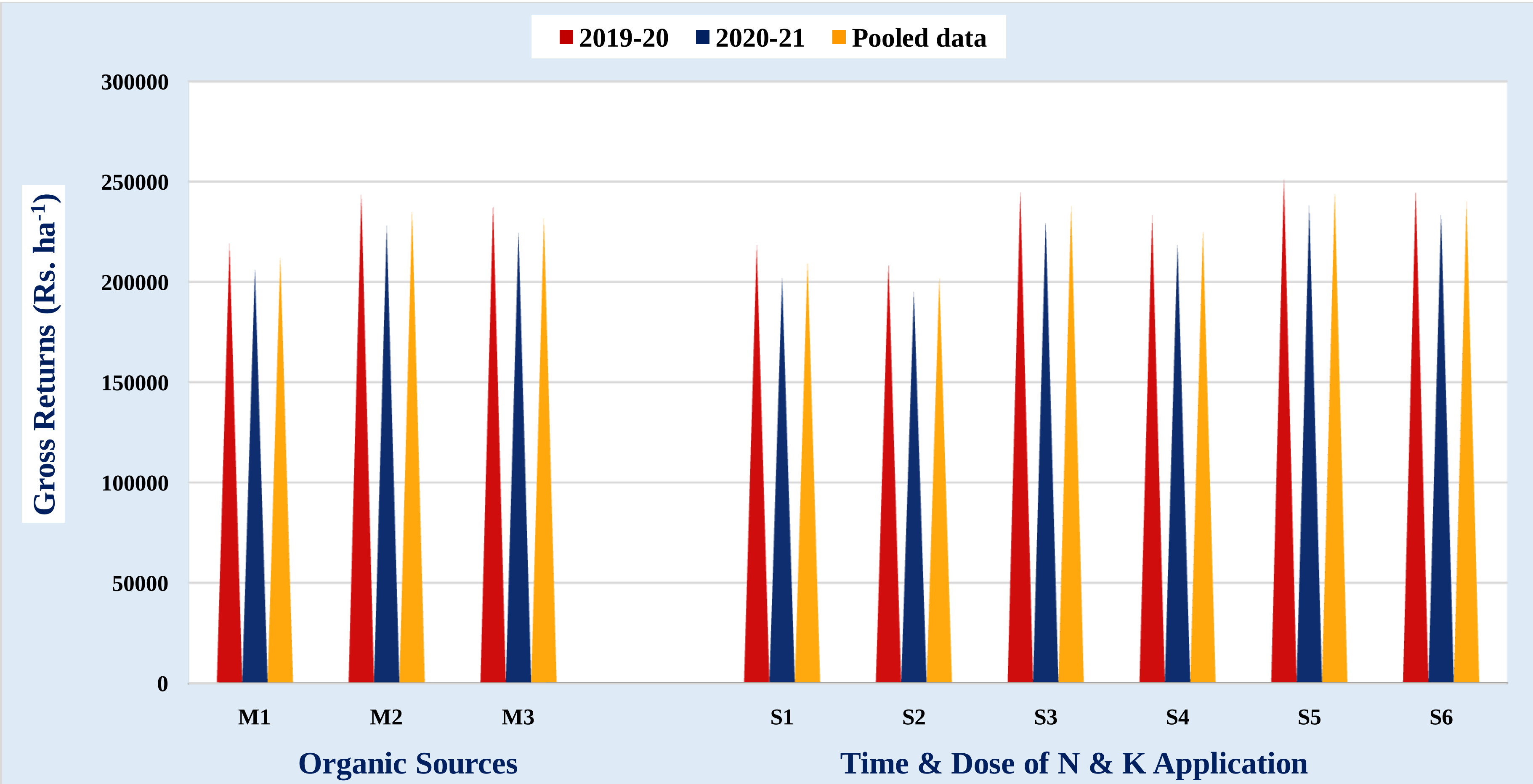

Fig. 4.17. **Gross returns (Rs. ha^{-1}) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data**

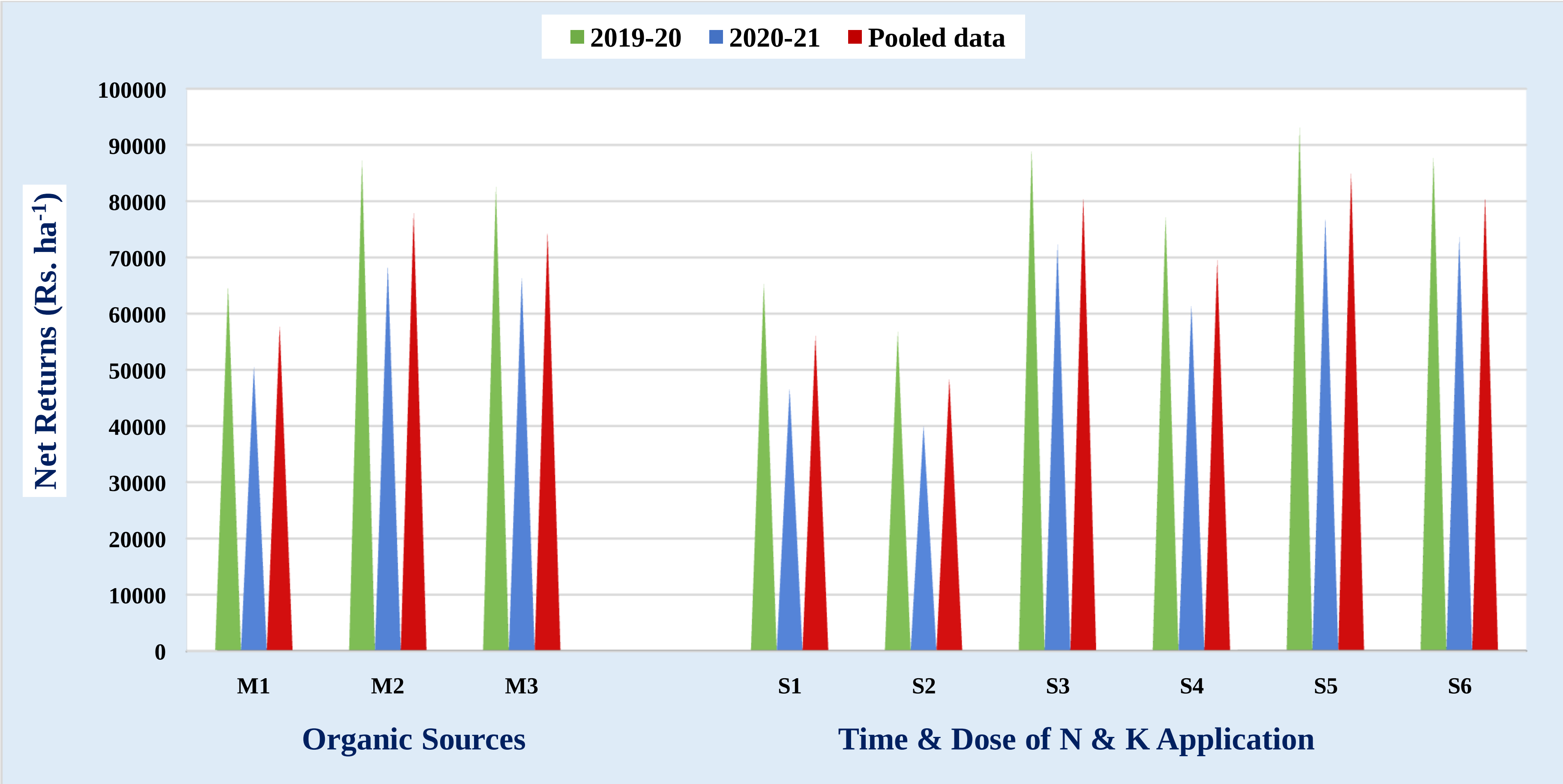

Fig. 4.18. Net returns (Rs. ha^{-1}) of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

time and dose of nitrogen and potassium application did not differ in influencing gross returns.

4.6.2 Net Returns (Rs. ha^{-1})

The data pertaining to net returns presented in Table 4.25 and Fig. 4.18 showed that organic sources were having a significant influence on net returns during both the years of study and also in pooled data. Biofertilizer application recorded the maximum net returns (Rs. 87,392, 68,729 and 78,061 ha^{-1} during 2019-20, 2020-21 and in pooled data, respectively) and it was followed by trash mulching with bio-decomposer and both were found superior to control. The steady supply of nutrients through organics favoured higher growth, yield attributes and yield which ultimately resulted in higher net returns. The results confirm the findings of Singh (2002), Bhalerao *et al*. (2006), Thakur *et al*. (2010), Tyagi *et al*. (2011) and Patel and Chaudhari (2018).

Among different levels and time of N and K application, appreciably increased net returns were obtained with application of 125% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting. However, it was comparable with application of 125% STBNK at 45 days interval and 100% STBNK at 30 days interval + 25% recommended K one month before harvesting (S_3). Lower net returns were accrued with 75% STBNK applied at 45 days interval and found significantly inferior to all other treatments except with the application of 75% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting uring both the years but not in pooled data. The more tiller population, more number of stalks and subsequently higher seedcane yield under adequate nutrient supply lead to high yield and inturn the higher net returns. These results are in consonance with the earlier findings of Ramesh *et al*. (2002), Gupta *et al*. (2006), Dev *et al*. (2012), Kumar (2012), Sarala *et al*. (2012), Meena and Kumar (2015) and Kumar and Kumar (2020).

The interaction between organic sources and time and dose of nitrogen and potassium application significantly influenced the net returns during both the years of experimentation and in pooled data (Table 4.25a).

At all the main plot levels, application of 125% STBNK at 30 days interval + additional dose of 25% RDK (S_5) registered higher net returns. However, it was statistically comparable with S_3 and S_6 treatments at M_1 level and S_3, S_6 and S_4 treatments at M_3 level and M_2 level during 2019-20 and 2020-21 while, in pooled data S_5 was on par with S_3 and S_6 treatments at all the main plot levels. S_2 treatment recorded lower net returns but maintained parity with S_1 at all the main plot treatments.

At S_1, S_2 and S_4 levels, M_2 treatment exhibited higher net returns and comparable with M_3 treatment and the lower net returns were observed with M_1. Whereas at S_3, S_5 and S_6 levels, M_1, M_2 and M_3 were comparable among themselves.

4.6.3 Benefit Cost Ratio

The data on BC ratio of seedcane crop as affected by different organic sources and time and dose of nitrogen and potassium application is furnished in Table 4.25 and depicted in Fig. 4.19 indicated that significant differences among main plot and sub plot treatments while, the interaction did not differ significantly.

The higher BC ratio (1.56, 1.43 and 1.50, respectively) was registered with biofertilizer applied treatment but it was statistically comparable with trash mulching with bio-decomposers (1.53, 1.42 and 1.48). The control treatment recorded significantly lower BC ratio as compared to M_2 and M_3 treatments during both the years of study and also in pooled data. The current results are in line with the earlier findings of Singh (2002), Bhalerao *et al*. (2006), Thakur *et al*. (2010), Singh *et al*. (2016) and Patel and Chaudhari (2018).

Application of 125% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting (S_5) recorded the higher BC ratio (1.59, 1.48 and 1.54, respectively) but it was on par with 100% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting and 125% STBNK applied at 45 days interval treatments. BC ratio was lower with S_2 treatment which was comparable with S_1 treatment during 2019-20, 202-21 and also in pooled data. The higher gross returns owing to higher cane yield could generate high BC ratio with application of biofertilizers and supply of 125% STBNK + additional RDK. The results projected in the present study were in accordance with findings of Ramesh *et al*. (2002), Gupta *et al*. (2006), Dev *et al*. (2012), Kumar (2012), Sarala *et al*. (2012), Meena and Kumar (2015) and Kumar and Kumar (2020).

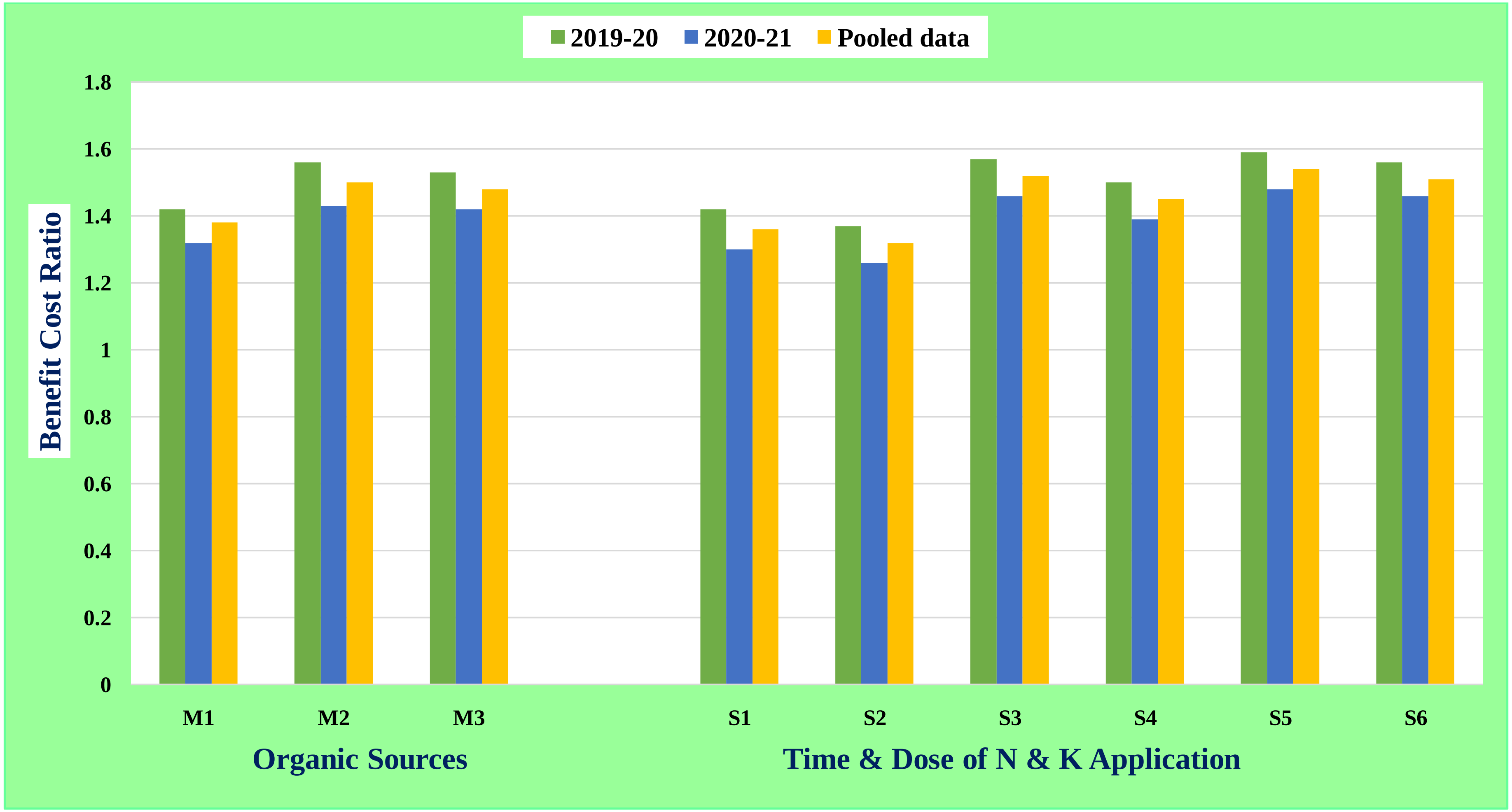

Fig. 4.19. Benefit Cost Ratio of sugarcane seed crop as influenced by biological nutrient management during 2019-20, 2020-21 and pooled data

Chapter – V

Summary and Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

The salient findings of the investigation on **"Biological Nutrient Management for Enhancing Yield and Quality of Seedcane"** are summarized in this chapter. The experiment was conducted at the Regional Agricultural Research Station, Anakapalle for two consecutive seasons of 2019-20 and 2020-21.

The experiment was laid out in a split-plot design with three replications. The treatments consisting of organic sources as main plots *viz*., control, biofertilizer mixture (*Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1}), trash mulching with bio-decomposers; levels and time of nitrogen and potassium application *viz*., 75% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, 75% STBNK at planting, 45, 90, 135 & 180 DAP, 100% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, 100% STBNK at planting, 45, 90, 135 & 180 DAP, 125% STBNK at planting, 30, 60, 90, 120 DAP + 25% recommended K one month before harvesting, 125% STBNK at planting, 45, 90, 135 & 180 DAP were allotted to sub plots.

Germination percentage was not significantly influenced either by organic sources or levels and time of nitrogen and potassium given to seed crop of sugarcane.

The maximum plant height at 120, 180 DAP and at harvest was recorded with the application of *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} which was on par with trash mulching with bio-decomposers and both these treatments were found significantly superior to control. Among various sub plot treatments, taller plants were recorded at all the growth stages with 125% STBNK applied at planting, 30, 60, 90, 120 DAP + 25% additional dose of recommended K one month before harvesting (S_5) which was on a par with 100% STBNK applied at planting, 30, 60, 90, 120

DAP + 25% additional dose of recommended K one month before harvesting (S_3) and both were found significantly superior to application of 75% STBNK applied at planting, 30, 60, 90, 120 DAP + 25% additional dose of recommended K one month before harvesting (S_1) and 75% STBNK applied at planting, 45, 90, 135 and 180 DAP (S_2) treatments.

Number of tillers ha^{-1} at 120 DAP and shoot population at 180 DAP were significantly influenced by application of biofertilizers (M_2) and trash mulching (M_3) over control. Among various levels and time of nitrogen and potassium application, more number of tillers or shoots were registered with 125% STBNK applied at 30 days interval + additional dose of 25% recommended potassium applied one month before harvesting and it was comparable with S_6 and S_3 treatments.

Application of biofertilizers showed remarkable performance in increasing the drymatter production at 120, 180 DAP and at harvest and it was comparable with trash mulching. With respect to sub plot treatments higher drymatter accrual was observed with 125% STBNK and maintained parity with 100% STBNK + additional dose of 25% recommended K (S_3), whereas, distinctly lower drymatter production was found with 75% STBNK applied treatments. The interaction between organic sources and time and dose of N and K application on drymatter production was found to be significant only at 180 DAP. The combined effect of biofertilizer with 125% STBNK applied at 30 days interval + additional dose of 25 % recommended K (M_2S_5) one month before harvesting produced higher drymatter production and the lower drymatter accumulation was noticed with M_1S_2.

Yield attributes of seedcane *viz*., stalk population, cane length, diameter, single cane weight and 100 three bud sett weight were significantly influenced by both organic sources and time and dose of N and K application, but number of internodes did not differ significantly either with main plot or sub plot treatments.

Stalk population, cane length, diameter, single cane weight and 100 three bud sett weight were maximum with the application of biofertilizers (M_2) and was comparable with trash mulching with bio-decomposers and found significantly superior to control. Among different sub plot treatments, the higher yield attributing characters were recorded with the application of 125% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting, but it was found statistically comparable with 125% STBNK applied at 45 days interval and application of 100% STBNK at planting, 30, 60, 90, 120 DAP + additional dose of 25% recommended K one month before harvesting. The lower yield attributing characters were registered with application of 75% STBNK alone at 45 days interval followed by addition of 75% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting.

A significant increase in seedcane yield was recorded with application of biofertilizers or trash mulching over control. Among sub plot treatments, the higher cane yield was obtained with 125% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting which was significantly superior to rest of the treatments except for the treatments 125% STBNK alone applied at 45 days interval and 100% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting. The interaction between organic sources and different doses and time of N and K application had significant effect on seedcane yield. The higher seedcane yield was registered with M_2S_5 treatment combination. While, lower seedcane yield was noticed with M_1S_2 and M_1S_1 treatments. However, application of less fertilizer dose along with biofertilizers (M_2S_1), trash mulching (M_3S_1) was found on a par with that of application of 125 % STBNK + additional dose of 25 % recommended K (M_1S_5).

Different organic sources did not influence the quality parameters of seedcane *viz*., moisture percentage, reducing sugars percentage, brix percentage, sucrose percentage and germinability of setts obtained from seedcane after harvest and seedling vigour index. With regard to sub plot treatments, only moisture percentage, reducing sugars percentage, germinability of setts obtained from seedcane after harvest and seedling vigour were significantly affected but not brix and sucrose percentage.

The seedcane grown with the application of 125% STBNK alone at 45 days interval recorded significantly higher moisture percentage, reducing sugars percentage and germinability of setts obtained from seedcane after harvest and seedling vigour over lower dose of fertilizer applied plots (S_1 and S_2). However, it was statistically comparable with 125% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting, 100% STBNK alone applied at 45 days interval and 100% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting.

It was found that various organic sources used in the current study had significant influence on nitrogen, phosphorus content of whole plant only at 180 DAP and at harvest whereas, potassium content varied at harvest only. The higher N, P and K contents were observed with application of *Azospirillum*, PSB, KRB each @ 1250 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} and with trash mulching (M_3).

At all the growth stages, time and dose of N and K application significantly influenced the N, P and K contents. Application of 125% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting (S_5) perceptibly increased the N, P and K contents. However, 125% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting, 125% STBNK applied at 45 days interval, 100% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting were comparable among themselves. Significantly lower nitrogen content was observed with 75% STBNK alone applied at 45 days interval followed by 75% STBNK applied at 30 days interval + additional dose of 25% recommended one month before harvesting.

The uptake of N, P and K by seedcane was significantly influenced by organic sources at all the growth stages except at 60 DAP. Nitrogen, phosphorus and potassium uptake by whole plant was higher in biofertilizer applied treatment (M_2) and found comparable with trash mulching (M_3) and both inturn showed significant superiority over control.

Contemplating the data on nutrient uptake at various stages of crop growth indicated that the nitrogen uptake was significantly influenced by different timings and doses of nitrogen and potassium application at all the growth stages. The N, P and K uptakes by whole cane was higher in S_5 treatment, which was significantly superior to other treatments and statistically on par with S_6 and S_3 treatments. The interaction effect significantly influenced the nitrogen uptake at 180 DAP and phosphorus uptake at harvest. The higher N and P uptake by whole cane was registered with M_2S_5 treatment combination. Whereas, the lower N and P uptake was noticed with M_1S_2 and M_1S_1 treatments.

The maximum gross returns, net returns and BC ratio were observed with biofertilizer applied plot (M_2) and trash mulching with bio-decomposer (M_3). With regard to sub plot treatments, application of 125% STBNK at 30 days interval + additional dose of 25% recommended K one month before harvesting recorded higher gross returns, net returns and BC ratio and was statistically comparable with the application of 125% STBNK at 45 days interval and 100% STBNK at 30 days interval + additional 25% RDK one month before harvesting. The significantly lower gross returns, net returns and BC ratio were observed with 75% STBNK applied at planting, 45, 90, 135 and 180 DAP which was statistically on par with the application of 75% STBNK at planting, 30, 60, 90, 120 DAP + additional 25% RDK one month before harvesting. The interaction between organic sources and time and dose of N and K application had significant influence on net returns. The combined effect of biofertilizer with 125% STBNK applied at 30 days interval + additional 25% RDK one month before harvesting (M_2S_5) gave higher net returns and the lower was noticed with M_1S_2 treatment combination.

Conclusions

Based on the results obtained in the present investigation, it can be concluded that:

- Application of biofertilizers or trash mulching with bio-decomposers along with 125% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting showed a significant response on growth, yield attributing characters and yield of seedcane and it was comparable with 100% STBNK applied at 30 days interval + additional dose of 25% recommended potassium one month before harvesting.
- Application of 125% STBNK applied at 45 days interval improved the quality parameters of seedcane and significantly superior to 75 % STBNK.
- Combined application of biofertilizers or trash mulching along with 125% STBNK or 100% STBNK applied at 30 days interval + additional dose of 25% recommended K one month before harvesting recorded higher N, P and K content as well as uptake by seed crop of sugarcane.
- The gross returns, net returns and benefit cost ratio were higher with the application of biofertilizers or trash mulching along with125% STBNK applied at 45 days interval and it was comparable with 100% STBNK applied at 30 days interval + additional dose of 25% recommended potassium one month before harvesting.
- Application of biofertilizers or trash mulching with bio-decomposers along with 125% STBNK applied at 45 days interval improved the quality of seedcane in terms of sett moisture percentage, reducing sugars percentage and resulted in higher germination per cent and seedling vigour which may account for higher plant stand and cane yield of succeeding commercial crop.

Finally, it can be concluded from the two years study that application of biofertilizer mixture or trash mulching with bio-decomposers and 100% STBNK applied at 30 days interval + additional dose of 25% recommended potassium one month before harvesting was found to be optimum for improving yield and quality of sugarcane seed crop on sandy clay soils of North Coastal Zone.

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*** Original not seen**

Note: The pattern of Literature Cited presented above is in accordance with the guidelines for thesis presentation, Acharya N. G. Ranga Agricultural University, Guntur.

Appendices

APPENDIX - I

CALENDAR OF OPERATIONS

S. No.	Particulars of field operations performed	2019-20	2020-21
1.	Ploughing the land with mould board plough	01.07.19	22.06.20
2.	Working with tractor drawn rotovator for fine tilth	08.07.19	23.06.20
3.	Working with cultivator	09.07.19	24.06.20
4.	Levelling the field	10.07.19	24.06.20
5.	Forming furrows	11.07.19	25.06.20
6.	Forming cross channels and rectification	12.07.19	26.06.20
7.	Layout of the experiment	12.07.19	26.06.20
8.	Basal fertilizer application as per treatments	13.07.19	30.06.20
9.	Planting with furrow irrigation	14.07.19	01.07.20
10.	Trash mulching as per treatments	16.07.19	03.07.20
11.	Application of bio-decomposers	17.07.19	04.07.20
12.	Soil application of phosphorus solubilizing bacteria, *Azospirillum*, potassium releasing bacteria & VAM	17.07.19	04.07.20
13.	Irrigation	20.07.19 & 22.07.19	25.07.20
14.	Gap filling	08.08.19	26.07.20
15.	Spraying of monocrotophos	12.08.19	29.07.20
16.	Spraying of 2,4-D & Metribuzin	13.08.19	30.07.20
17.	Top dressing of fertilizers as per treatments	13.08.19	31.07.20
18.	Irrigation	18.08.19 & 19.08.19	-
19.	Top dressing of fertilizers as per treatments	28.08.19	15.08.20
20.	Irrigation	29.08.19 & 30.08.19	-
21.	Spraying of chlorpyriphos	09.09.19	-
22.	Weeding and hoeing	11.09.19	29.08.20
23.	Top dressing of fertilizers as per treatments	12.09.19	30.08.20
24.	Irrigation	-	01.09.20 & 02.09.20

S. No.	Particulars of field operations performed	2019-20	2020-21
25.	Spraying of Nativo	21.09.19	-
26.	Hand weeding	11.10.19	28.09.20
27.	Top dressing of fertilizers as per treatments	12.10.19	29.09.20
28.	Removal of excess water	-	17.10.20
29.	Foliar spraying of 19-19-19	-	22.10.20
30.	Earthing up	10.11.19	28.10.20
31.	Top dressing of fertilizers as per treatments	11.11.19	29.10.20
32.	Irrigation	12.11.19 & 13.11.19	-
33.	Soil drenching with COC & streptocyclin	-	30.10.20
34.	Soil drenching with COC & streptocyclin	-	04.11.20
35.	Spraying of Mancozeb & Rogor	21.11.19	08.11.20
36.	Soil drenching with COC & streptocyclin	-	09.11.20
37.	Foliar spraying of 13-0-45	-	11.11.20
38.	Top dressing of fertilizers as per treatments	26.11.19	13.11.20
39.	Irrigation	27.11.19 & 28.11.19	20.11.20 & 21.11.20
40.	Trash twist propping	10.12.19	27.11.20
41.	Irrigation	11.12.19 & 12.12.19	10.12.20 & 11 12.20
42.	Spraying of Mancozeb & Rogor	21.12.19	08.12.20
43.	Irrigation	07.01.20 & 08.01.20	23.12.20 & 24.12.20
44.	Top dressing of fertilizers as per treatments	10.01.20	28.12.20
45.	Irrigation	27.01.20	02.01.21 & 03.01.21
46.	Irrigation	-	27.01.21 & 28.01.21
47.	Harvesting	12.02.20	01.02.21

APPENDIX – II

COST OF INPUTS AND PRICE OF OUTPUT

S.No.	Input/output	Cost (Rs.)
INPUT COST		
1.	Seedcane	2800 t^{-1}
2.	Labour wage	200 $head^{-1}$
3.	Urea	5.9 kg^{-1}
4.	SSP	8.4 kg^{-1}
5.	MOP	19 kg^{-1}
6.	*Azospirillum*	300 l^{-1}
7.	PSB	300 l^{-1}
8.	KRB	300 l^{-1}
9.	VAM	35 kg^{-1}
10.	Monocrotophos	500 l^{-1}
11.	2,4-D	120 kg^{-1}
12.	Metribuzin	1850 kg^{-1}
13.	Chlorpyriphos	300 l^{-1}
14.	Nativo	9000 kg^{-1}
15.	COC	680 kg^{-1}
16.	Streptocycline	2400 kg^{-1}
17.	Mancozeb	560 kg^{-1}
18.	Rogor	560 kg^{-1}
OUTPUT PRICE		
19.	Seedcane	3000 t^{-1}

Plate 1. A General view of the sugarcane seed crop during 2019-20

Plate 2. A General view of the sugarcane seed crop during 2020-21