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Effect of Planting Materials and Integrated Nutrient Management on Yield of Sugarcane Seed Crop

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A field experiment was conducted at Sugarcane Research Station, Cuddalore during *special season* of 2017 - 18 (July - February) to select an appropriate planting material of sugarcane seed crop and to ascertain the effective integrated nutrient management package to enhance the productivity of the same. The sugarcane variety used was CoC 25. The experiment was laid out in split plot design and the treatments were replicated thrice. The treatments comprised of three different sugarcane planting materials *viz*., double budded setts (S_1) , single bud setts (S_2) and chip bud seedlings (S_3) were allocated to the main plots and four integrated nutrient management practices *viz.,* 100 per cent recommended dose of NPK (N_1), 75 per cent of recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp (N_2), 75 per cent of recommended NPK + *insitu* incorporation of sunnhemp + foliar spraying of sugarcane booster (N_3), 75 per cent of recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp + foliar spraying of sugarcane booster (N_4) were accommodated in sub plots. Planting of chip bud seedlings recorded higher establishment percentage (87.01), plant height (229.46 cm), tiller population (113.01 '000 ha^{-1}), dry matter production (85.87 t ha^{-1}), single cane weight (1.80 kg/cane), seed cane yield (98.32 t ha^{-1}), gross return (Rs. 2,94,962 / ha), net return (Rs. 1,83,040) and B:C ratio (2.63). Among integrated nutrient management practices, application of 75 per cent of recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp + foliar spraying of sugarcane booster resulted in higher establishment percentage (78.20), plant height (217.06 cm), tiller population (105.45 '000 ha^{-1}), dry matter production (86.77 t ha^{-1}), single cane weight (1.59 kg/cane), seed cane yield (88.71t ha^{-1}), gross return (Rs. 2,66,138 / ha) net return (Rs. 1,56,819) and B:C ratio (2.42).

Key words: Sugarcane, Planting materials, Integrated Nutrient Management, Seed cane yield.

Sugarcane, the second predominant agro-industry based crop of India is being cultivated in about 4.94 million hectares with an annual production of 348 million tonnes, contributing around 7.5 per cent to the total agricultural productivity of the country (Indian Institute of Sugarcane Research, 2016). Though, India is a major producer as well as the consumer of sugar in the world, the demand for sugar and other sweetening agents are in augmenting trend and it is estimated that by 2030 AD, India requires nearly 33 million tonnes of white sugar for domestic consumption alone. With an average sugar recovery of 10.7 per cent, around 520 million tonnes of sugarcane have to be produced and it would enhance the sugarcane productivity to the tune of 110 tonnes ha^{-1}. However, while considering the present level of sugarcane and sugar production, India would hardly not able to meet the 75 per cent of the projected requirements. Hence, appropriate crop management strategies have to gear up to meet out the emerging new challenges of higher cane and sugar production.

To increase the profitability of sugar sector, a persistent need is required to enhance the crop productivity efficiency with minimized cost of cultivation through adoption of viable agronomic practices wherein the selection of good quality planting material is of almost essential. Unlike the sugarcane crop meant for crystalline sugar production, significant emphasis have also to be given for the increased production of cane shoots to realize increased quantum of seed canes from an unit area. This could be achieved through adoption of viable nutrient nourishment strategy during the early stages of crop growth, since the seed crop of sugarcane is harvested at the age of 6 to 7 months old.

Despite a huge producer of crop biomass, the recently released sugarcane cultivars are highly nutrient responsive and its demand for nutrient inputs are higher. Hence, the conventional level of organic and inorganic nutrient prescriptions needs to be revalidated to exploit its maximum genetic yield potential. On other hand, indiscriminate prescription of inorganic fertilizer alone in long run deteriorates soil health resulting in drastic reduction of cane yield. Hence, balanced use of organic and inorganic inputs is essential to maintain a good soil physical and chemical environment. Further, the present escalated cost of inorganic chemical fertilizers and its practical limitations in their availability at right time and right quantity necessitate an imperative need

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to formulate an effective and appropriate integrated nutrient management package comprising organic and inorganic components to obtain consistent sugarcane yield (Gopalasundaram *et al.,* 2011).

Considering the Organic input integration, application of biofertilizers and green manures for sugarcane have proved to be a potential strategy to prevent and to ameliorate the negative effects of excessive fertilization on soil degradation and yield declination. Intercropping of green manure and its *insitu* incorporation along the sides of the cane rows helps in building up of the organic content of the soil and also the uptake of applied nutrients by the crop (Bokhtiar and Sakurai, 2007).

Material and Methods

The experiment was conducted during *special season* (2017-18) in split plot design with three replications at Sugarcane Research Station, Cuddalore. The experimental site is geographically situated in the north eastern agro-climatic zone of Tamil Nadu at 11.46' N latitude 79.48' E longitude and at an altitude of 4.6 m above MSL. The soil of the experimental field was sandy loam in texture with neutral in reaction. The soil was medium in available phosphorus (18 kg ha^{-1}) and low in organic carbon (0.38 per cent), available nitrogen (175 kg ha^{-1}) and available potassium (182 kg ha^{-1}). The sugarcane variety used for planting was Co C 25.

The experimental trial was comprised of three different sugarcane planting materials *viz*., double budded setts (S_1) , single bud setts (S_2) and chip bud seedlings (S_3) were allocated to the main plots and four integrated nutrient management practices *viz.,* 100 per cent recommended dose of NPK (N_1), 75 per cent of recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp (N_2), 75 per cent of recommended NPK + *insitu* incorporation of sunnhemp + foliar spraying of sugarcane booster (N_3), 75 per cent of recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp + foliar spraying of sugarcane booster (N_4) were accommodated in sub plots.

The experimental field was initially disc ploughed once and twice with tractor mounted cultivator and to brought out the field soil to a fine tilth condition. Farm yard manure was applied @ 12.5 t ha^{-1} at the time of last ploughing, incorporated and levelled. The ridges and furrows were formed at 120 cm apart uniformly using tractor drawn ridger. The experimental plots were provided with irrigation and drainage channels. *Azophos* at the rate of 10 kg ha^{-1} along with 50 kg ha^{-1} of decomposed FYM was applied along the furrows before planting for the respective plots as per the treatment schedule. Three different types of planting materials *viz.,* double budded setts, single bud setts and chip bud seedlings were used for this study. The seven month old nursery cane was used for the preparation of two budded setts and single bud setts. Regarding the chip bud seedlings, a separate portray nursery crop was raised one month before the planting of double budded and single budded setts in the main field. For planting, 55,550 two budded setts, 27,778 single bud setts and 27,778 chip bud seedlings per hectare were used. All type of sugarcane setts were planted horizontally in the furrows while the single bud and chip bud seedlings were planted with a spacing of 120cm x 30cm, the double budded setts was planted with a spacing of 120cm x 15cm.

The prescribed quantity of fertilizers were applied according to the treatments while the entire quantity of P_2O_5 was applied as basal in the form of single super phosphate, nitrogen in the form of urea and potassium as muriate of potash were applied in three equal splits on 30, 60 and 90 DAP. The recommended quantity of sunnhemp seeds @ 10 kg ha^{-1} were sown on the ridges in 3 lines with the spacing of 30 cm between the rows and 10 cm between the plant of sunnhemp on 5^{th} day after cane planting. The intercropped sunnhemp were *insitu* incorporated in the allocated plots on 45 DAP. Foliar spraying of sugarcane booster was done @ 1.0, 1.5, and 2 kg $acre^{-1}$ as per the treatment schedule respectively on 45, 60 and 75 DAP to the demarked treatment plots.

Observations on growth characters *viz*., Establishment percentage (45 DAP), plant height, tiller population and Dry Matter Production (DMP), single cane weight and seed cane yield were recorded at the time of harvest. Establishment per cent was recorded on 45 DAP and expressed in percentage, taken into account the number of buds/ seedlings established in main field to the total number of buds planted. The vigour and growth of the cane was measured in terms of plant height. In selected representative sugarcane plants, the plant height measurement were recorded from the ground level to top end of the leaf and the mean values were expressed in cm. Tiller population was recorded from the respective canes and expressed in tillers ha^{-1}. For DMP estimation, five random plants were destructively sampled from border rows of each plot, shade dried and then oven dried at 60° to get a constant weight and the weight were recorded and expressed in t ha^{-1}.The total weight of five sample canes were recorded and the mean was arrived and expressed in kg per cane.

The matured sugarcanes were harvested from the net plot area for each treatment and were weighed and expressed in t ha^{-1}. Gross return was computed by multiplying the yield in respective treatments with the unit market price of the produce and expressed as Rs. ha^{-1}.The net income for each treatment was obtained by subtracting the cost of cultivation from gross income obtained from each treatment, then expressed in Rs. ha^{-1}.The experimental data were subjected to statistical analysis using standard procedures (Gomez and Gomez, 1984).

Results and Discussion

Establishment percentage

The enumerated data on the establishment percentage (45 DAP) showed significant variations with regard to the sugarcane planting materials used and the varied integrated nutrient management strategies are furnished in Table 1.

Planting of chip bud seedlings recorded higher establishment percentage of 87.01 whereas single bud setts planting resulted in lower establishment per cent of 70.51.

Table.1. Effect of planting material and integrated nutrient management on establishment percentage (45 DAP) and growth attributes of sugarcane at harvest

Treatments	Establishment (%)				Plant height (cm)				Tiller population ('000 ha^{-1})				Dry matter production (t ha^{-1})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	72.77	70.24	88.65	77.22	195.36	187.52	229.68	204.19	98.33	82.56	112.35	97.75	82.36	72.35	88.92	81.21
N_2	73.25	71.21	86.25	76.90	182.35	174.25	218.56	191.72	91.25	68.57	106.89	88.90	77.21	69.56	80.21	75.66
N_3	71.37	69.35	85.25	75.32	189.65	181.25	223.26	198.05	94.89	71.56	109.56	92.00	80.21	70.12	82.12	77.48
N_4	75.47	71.25	87.89	78.20	207.56	197.26	246.35	217.06	102.12	90.98	123.25	105.45	86.54	81.56	92.21	86.77
Mean	73.22	70.51	87.01		193.73	185.07	229.46		96.65	78.42	113.01		81.58	73.40	85.87	
	Establishment (%)				Plant height (cm)				Tiller population ('000 ha^{-1})				Dry matter production (t ha^{-1})			
	S	N	S xN	N x S	S	N	S xN	N x S	S	N	S xN	N x S	S	N	S xN	N x S
SE d	2.41	1.6	2.95	4.11	5.38	4.21	9.35	10.88	2.65	1.78	4.54	5.21	2.01	1.67	3.74	4.33
CD (p=0.05)	5.68	NS	NS	NS	12.69	9.81	17.21	20.01	6.25	4.16	8.36	9.58	4.75	3.89	6.88	7.96

Main plot : S_1 – Double budded setts; S_2 – Single bud setts; S_3 – Chip budded seedlings; Sub plot : N_1 – 100 % recommended NPK; N_2 – 75 % recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp; N_3 – 75 % recommended NPK + *Azophos* + foliar spraying of sugarcane booster; N_4 – 75 % recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp + foliar spraying of sugarcane booster.

This might be due to the care given during scooping of buds from the cane shoots and are placed in pro trays filled with appropriate rooting medium of cocopith inside the shade nets during chip bud seedlings preparation. while application of adequate moisture to every buds might have utilized the congenial situation of surplus nutrients and moisture for its effective absorption of inputs for better root proliferation, growth and subsequent establishment compared to other type of sugarcane planting materials resulted with even germination and establishment of buds. On other hand, the exposure of two or single budded setts to the environment and the delay in emergence of sett roots would have resulted with poor establishment in the main field (Patnaik *et al.,* 2016).

Table 2. Effect of planting material and integrated nutrient management on single cane weight (kg) and seed cane yield (t ha^{-1}) of sugarcane at harvest

Treatments	Single cane weight (kg)				Seed cane yield (t ha^{-1})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	1.55	1.15	1.82	1.51	83.58	61.92	101.11	82.20
N_2	1.35	0.95	1.69	1.33	73.00	52.79	90.85	72.21
N_3	1.46	1.07	1.75	1.43	80.65	55.81	95.31	77.26
N_4	1.63	1.18	1.95	1.59	91.90	68.23	105.99	88.71
Mean	1.50	1.09	1.80		82.28	59.69	98.32	
	Single cane weight (kg)				Seed cane yield (t ha^{-1})			
	S	N	S x N	N x S	S	N	S x N	N x S
SE d	0.04	0.02	0.07	0.08	0.6	1.05	1.69	1.83
CD (p=0.05)	0.1	0.06	0.13	0.15	1.67	2.22	3.71	3.85

Main plot : S_1 – Double budded setts; S_2 – Single bud setts; S_3 – Chip budded seedlings; Sub plot : N_1 – 100 % recommended NPK; N_2 – 75 % recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp; N_3 – 75 % recommended NPK + *Azophos* + foliar spraying of sugarcane booster; N_4 – 75 % recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp + foliar spraying of sugarcane booster.

Even though, the integrated nutrient management practices did not show any significant differences on establishment percentage, application of 75 per cent recommended NPK in combination with *Azophos* along with *insitu* incorporation of sunnhemp and foliar spraying of sugarcane booster recorded higher establishment percentage of 78.20 in main field.

Regarding interactions, the carefully raised chip bud seedlings in protrays under environmentally safe conditions prevailing in the shade net altogether with appropriate rooting medium for the seedlings provided with the ample availability of major nutrients under 100 per cent recommended NPK application have resulted with enhanced sugarcane establishment (Mohamed Owais Ahmed Galal, 2016).

Growth attributes

Planting materials and integrated nutrient management practices significantly influenced the plant height, tiller population and dry matter production (DMP) of sugarcane seed crop (Table 1). Higher plant height 229.46 cm, tiller population of 113.01('000 ha^{-1}) and dry matter production of 85.87 t ha^{-1} were obtained on planting of chip bud seedlings followed by double budded setts and lower plant height (185.07 cm), tiller population (78.42

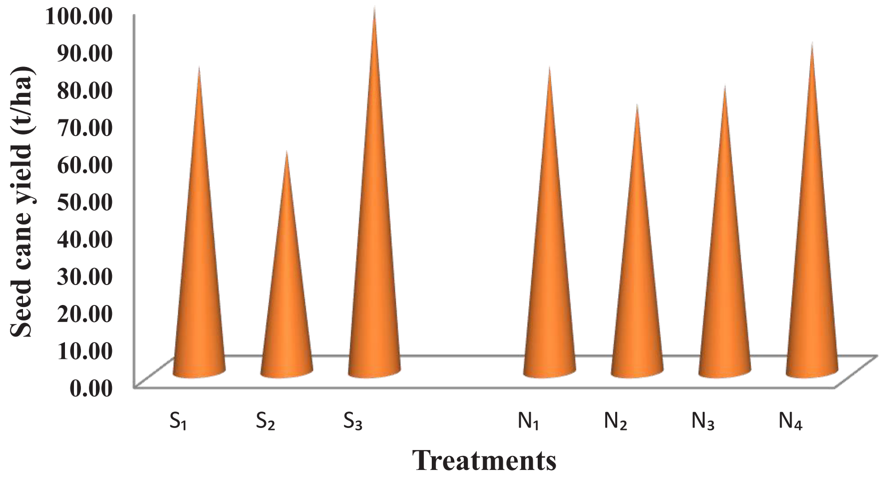

Fig.1. Effect of planting materials and integrated nutrient management on seed cane yield (t ha^{-1}) of sugarcane

'000 ha^{-1}) and DMP (73.40 t ha^{-1}) were reported under single bud setts planting. Despite its well established root system the effective absorption of nutrients and moisture increased the plant height, higher number of tillers m^{-2} with the planting of chip bud seedlings might be due to the abundant light interception, aeration and lesser plant competition prevailed with interplant spacings would have offer congenial environment for each seedling for effective utilization of above resources for metabolic activities

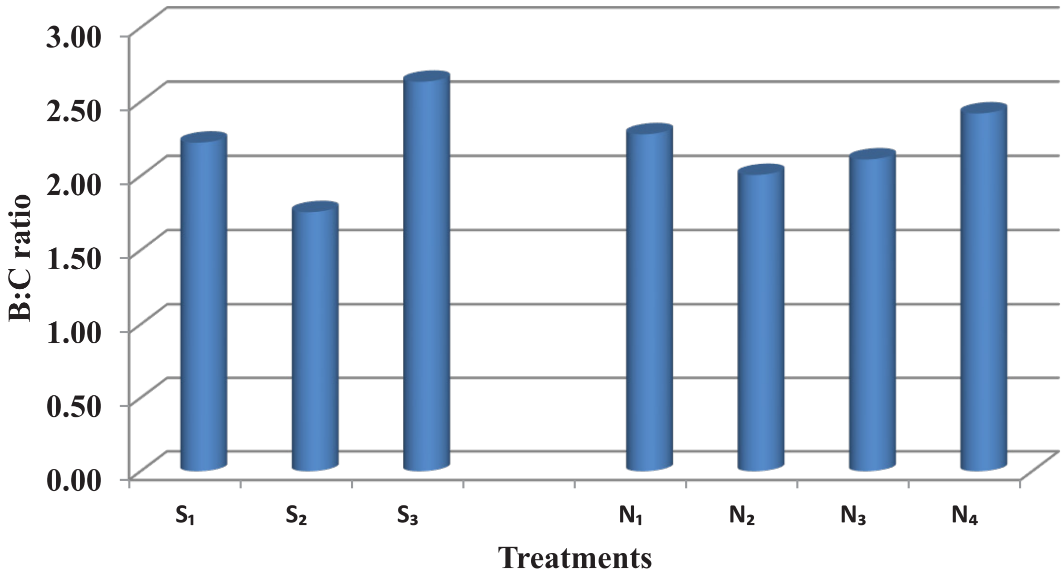

Fig.2. Effect of planting materials and integrated nutrient management on benefit cost ratio of sugarcane

of sugarcane compared to conventional method. In addition, with appreciable increments in the values of both the plant height and tiller numbers would have contributed increased values of crop biomass in terms of DMP (Loganandhan *et al.,* 2013).

Regarding the integrated nutrient management practices, the combined application of 75 per cent recommended NPK, *Azophos* and *insitu* incorporation of sunnhemp followed by sugarcane booster (N_4) registered higher plant height of 217.06 cm, tiller population of 105.45 '000 ha^{-1}, dry matter production of 86.77 t ha^{-1}. Lower value of plant height (191.72 cm), tiller population (88.90 '000 ha) and dry matter production (75.66 t ha^{-1}) was recorded with the application of 75 per cent recommended NPK along with *Azophos* and *insitu* incorporation of sunnhemp (N_2). Though the recommended quantity of NPK was reduced by 25 per cent, the growth parameters of sugarcane at all the stages were significantly improved under 75 per cent recommended dose of NPK + *Azophos* + *insitu* incorporation of sunnhemp on 45 DAP + foliar spray of sugarcane booster. The results are in accordance with the findings of Shankar (2015). Under such comfortable available nutrient status the crop would have results in effective utilization for varied metabolic process, for production of effective source components *viz.* enhanced plant height, more tiller per unit area and the total leaf area. During nitrogen fixation and phosphorous solubilisation the respective microbial populations might also secreted enormous amount of growth accelerating hormones and enzymes which would have also contributes for the increased values of plant height, tiller production and leaf area enlargement. Since the micro nutrients and the growth promoting components needs of sugarcane is being taken care of by the foliar application of sugarcane booster at the early stages of crop would have also contributed positive impact on crop growth and subsequent establishment.

Regarding the treatment combinations, chip bud ssedlings planting along with 75 per cent recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp + foliar spraying of sugarcane booster (S_3N_4) recorded higher values of the above growth characteristics. The salient enhancement with respect to plant height, tiller production and leaf area etc., due to profused production of leaf primordia with sugarcane chip budded seedlings for effective utilization of available input resources and the abundant availability of growth promoting pre-requisites *viz.,* essential macronutrients addition from inorganic sources, substitution from the beneficial microbial activity, decomposition and mineralization of green manure biomass and foliar feeding of micro-nutrients, growth hormones and enzymes from the sugarcane booster might have collectively resulted upon enhanced values of the above growth parameters.

Yield parameter and yield

The yield parameter of sugarcane crop *viz.,* single cane weight (1.80 kg / cane) and seed cane yield (98.32 t ha^{-1}) were significantly higher with chip budded seedlings planting compared to other types of seed cane plantings (Table 2.). Adequate care and nourished seedling under shade net have been transplanted to main field with initial crop vigour and with profuse root biomass for effective absorption of nutrients and moisture for crop utilization. In addition, the appropriate spacing maintained within the acquainted seedling rows might have intercepted solar radiation at its potential for enhanced photosynthates productivity at the source region i.e. enlarged leaf area of increased individual leaves and its effective translocation and subsequent storage in the cane stalk, the sink. On other hand the low initial crop vigour in main field with inadequate rooting biomass and the existence of competition among the seed cane buds for inputs acquainted with the double budded and single bud setts might have resulted with lesser values of both the source and sink attributes of sugarcane (Patnaik *et al*., 2016 and Mohanty *et al.,* 2014).

Table 3. Effect of planting material and integrated nutrient management on economic returns of sugarcane

Treatments	Gross return (Rs. ha^{-1})				Net return (Rs. ha^{-1})				B:C ratio			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	250740	185760	303345	246615	140610	84630	192215	139152	2.28	1.84	2.73	2.28
N_2	219000	158394	272568	216654	109114	57508	161682	109435	1.99	1.57	2.46	2.01
N_3	241968	167448	285951	231789	130282	64762	173265	122770	2.17	1.63	2.54	2.11
N_4	275724	204705	317985	266138	163738	101719	204999	156819	2.46	1.99	2.81	2.42
Mean	246858	179077	294962		135936	77155	183040		2.22	1.76	2.63	

Main plot : S_1 – Double budded setts; S_2 – Single bud setts; S_3 – Chip budded seedlings ; Sub plot : N_1 – 100 % recommended NPK; N_2 – 75 % recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp; N_3 – 75 % recommended NPK + *Azophos* + foliar spraying of sugarcane booster; N_4 – 75 % recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp + foliar spraying of sugarcane booster.

While considering the sub plot treatments, N_4 recorded higher single cane weight (1.59 kg / cane) and seed cane yield (88.71 t ha^{-1}). This might be due to the biofertilizer application followed by decomposition and mineralisation of *insitu* incorporated sunnhemp would have substantially improved the physio-chemical properties of soil in addition to additional partitioning of nutrients from the decomposed green manure biomass. Nitrogen being the integral constituent of chlorophyll decides the rate of photosynthesis and crop growth. While phosphorous is responsible for adequate root production and its prolification, potassium as a prime constituent of varied enzymes involved in effective translocation of photosynthates from source to sink attributes. Hence, the optimal availability of the essential major nutrients altogether with the addition of micro-nutrients responsible for catalytic involvement in varied physiological process of plant system from the foliar spraying of sugarcane booster augmented the photosynthetic assimilates translocation from source regions to the cane stalks, the ultimate sink of seed cane crop.

The enlisted positive influences of the above individual treatments on seed cane productivity might have combinedly contributed for increased seed cane production with S_3N_4 (Planting of chip bud seedlings along with the application of 75 per cent recommended NPK + *Azophos* + *in situ* incorporation of sunnhemp + foliar feeding of sugarcane booster) treatment combinations.

Economics

Among the different sugarcane planting materials evaluated, chip bud seedlings planting registered the maximum economic returns in terms of net income (Rs.1,83,040 ha^{-1}) and B:C ratio of 2.63 (Table 3.).

Although the input cost on chip bud seedlings involves high cost, the beneficial aspects of chip budded seedling on establishment and productivity in terms of seed cane yield are much higher and it could have ultimately reflected on high economic income in terms of net monetary returns and B:C ratio.

Among the sub plot, 75 per cent of recommended NPK + *Azophos* + *insitu* incorporation of sunnhemp + foliar feeding of sugarcane booster (N_4) enforced higher economic return. However, the addition of above inputs might have combinedly contributed for higher productivity of seed cane and subsequently on higher net income (Rs. 1,56,819 ha $^{-1}$) and B:C ratio (2.42). The declining trend of seed cane yield with the other integrated nutrient management practices might be the actual reason for reduction in low economic out turn with the other integrated nutrient management treatments.

Conclusion

Considering the above evaluated treatment combinations, to realize maximum sugarcane seed cane productivity, the planting of chip bud seedlings may be advocated along with the integrated application of 75 per cent recommended dose of NPK + *Azophos* + *insitu* incorporation of sunnhemp in combination with foliar spraying of sugarcane booster which would also enhanced monetary returns.

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