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Benefit Cost Ratio of Buds Chips Planting and its Effects on Yield and Quality of Sugarcane

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Abstract

Background: High price and poor quality of seed material is a great concern to Farmers. Sugarcane seed is 20% of total cost of production. Cane Growers used setts having 2-3 buds with 8-10 t ha^{-1} cane stalk as Seed. The large quantity of seed carriages a great problematic in handling, transport, seed treatment for diseases, storage , viability of buds and their germination. The use of bud chips is less bulky, easily handling in seed treatment, storage and transportation.

Methods: In this view, a research experiment was designed at Sugarcane Research Institute, Faisalabad during 2016 and 2017, to study the feasibility of bud chips as an alternate to conventional planting in sugarcane crop. The experiment was planted with sugarcane variety CPF-252 in randomized complete block design with split plot arrangement having three replications.

Results: The results of study revealed that setts planting on 15 April gave maximum cane (61 t ha^{-1}) and sugar yield (7.15 t ha^{-1}). While bud chips sown on 15 April produced higher yield. The benefit cost ratio (BCR) was high in bud chips planting (1.63) than setts planting of sugarcane.

Conclusion: The study concludes that bud chip planting on 15 April is an improved technique with greater potential to provide disease free seed, improve the yield with minimum quantity of seed than conventional planting.

Introduction

In sugarcane production, good, healthy and disease seed is the prime aspect for the establishing good crop stand and it accounts 20% of the total production cost [1]. In Pakistan, conventionally, sugarcane is grown by using three budded setts. In which high seed rate of 8-10 tons ha^{-1} are being used because end to end, dual row planting, parallel along the furrow to compensate poor germination of buds owing to damage during handling and transport in field [2] .

One substitute method to reduce the seed rate, cost of production with better seed quality is the use of bud chip planting in sugarcane crop. This technology as a principle in the Sustainable Sugarcane Initiative involves use of less seed, less water and optimal utilization of land to attain more yields and income per unit area [3].

In this improved technology of sugarcane sowing, cane bud with small material of the root band is removed, growing them in soil media and finally transplanting the raised seedlings into the main field after attaining the proper age. There is only 40 to 55% germination in setts planting. While bud chips sowing showed more than 83% germination [4] and will save 70-80% seed weight of planting material. The remaining cane can be well used for preparing juice and sugar. It will provide quality seed to farmers at affordable price. Bud chips could be one of the most viable and economical method in reducing the cost of sugarcane production and improve the quality of seed cane [5].

Bud chips Seedlings have to face transplanting shocks during shifting in field, thus reducing number of plants and tillers. Research is needed to find out and develop the age of cane for nursery, age of nursery for transplant, fertilizer necessities of Nursery, quality and size of pots / seedling trays, composition of soil media, seed treatment, time of raising nursery and transplant, plant to plant and row to row distance during field transplant. So that high viability of seedlings produced from bud chips cane be attained and transplanting shocks will be minimized [6].

The age of seedling from bud chips were studied in various experiments and it was found that bud chips with age of 35-40 days in summer and 70-90 days in winter will become seedlings ready to transplant in the main field. Bud chips seedling with age less than 40 days showed high mortality rate due to transplanting shock [6]. Research using bud chips depicts that intra-row spacing (P-P) ranging from 0.75 m and inter-row spacing (R-R) of 1.2 m can be used for transplanting of bud chips seedling. In this planting geometry, plant population will also be maintained with highest girth of cane, more tillering and lesser number of weeds flora [1, 6].

In an experiment, it was noted that bud chip planting technique recorded 39.7 % higher cane yield, higher tillers per plant (17.3) and number of mill-able canes per clump (14.2) and survival 93.2% than farmer's practice of conventional method of setts planting. This technique produced gross return of Rs. 190080/- ha^{-1}, over conventional method [7].

Keeping in view the importance on the use of bud chips as planting material with the aim of improving the cane yield with reduced cost of production, the present study was designed to determine the effect of bud chips planting technique on yield, quality and economics of Sugarcane.

Methods

The experiment was laid out in Randomized Complete Block Design with split plot arrangement having a net plot size of 8 m x 8.4 m at Sugarcane Research Institute, Faisalabad, Pakistan during the year 2016 and 2017. The experiment was replicated thrice. Sugarcane Variety CPF-252 was planted. The factor planting time was kept in main plot and factor seed type was kept in split plot. Bud chips were sown in seedling trays with 50 cells each tray on 01 February during years under study. There were six treatments in the experiment i.e. Transplanting bud chips seedling in field on 15 April, 1 May, 15 May each year & conventional Triple budded setts (TBS) were also planted on same dates. The seedlings were transplanted at 1.5 feet P-P distance in 4 feet apart rows. The experiment was harvested on 20 January 2017 and 10 January 2018. Physio-chemical analysis of soil of growth media for raising of bud chips and experimental site was done before sowing. For this purpose, composite soil samples were collected from site at a depth of 15-30 cm. Soil analysis was carried out at the Soil and Water Testing Laboratory for Research-AARI, Faisalabad and is given in Table 1. Weather data of the experimental location for both crop seasons is presented in Table 2.

Preparation of the bud chips

Bud chips were removed from eight months old seed canes with inter-node length of 15-18 cm. the canes should be healthy, free from disease and pest infestation. Stalks were cut, de-trashed and the sugarcane bud chipper machine was used to remove bud chips from the cane stalks.

Experimental procedure

The soil media for the growth of bud chips were prepared at Sugarcane Research Institute, Farm, Faisalabad. The cells of Plastic seedling tray were partially filled with the well decomposed growth / soil media and the buds were placed in slanting position facing upwards and covered completely with the soil media. The weight of soil filled is 70 g per cell in seedling tray. The tray size is 45 x 20 cm having 50 cells. Later the trays were placed in Fuzz area at Farm and covered completely with a black polythene sheet. The bud chips trays were remained covered for 30 days to hasten bud chips germination. Irrigation water was showered two to three times in a day with hand sprinkler depending upon the weather conditions. The data of germinated buds is enlisted in Table-3.

Preparation of soil media

The media was prepared by mixing of berseem Fodder, decomposed animal dung and silt (3:1:1). One bag of urea (50 kg) was also added to enhance decomposition process. Then water was sprinkled daily and mixed thoroughly. The growth media was prepared in 5 months. The analysis report is presented in Table-1.

Crop husbandry

Four feet apart trenches were made by sugarcane ridger designed by SRI, Faisalabad. Urea, DAP (Di-ammonium Phosphate), SOP (Sulphate of Potash) fertilizer was used as source of NPK @ 168:112:112 kg per ha. Phosphorus and Potash was applied in full dose at the time of planting of experiment. Nitrogen fertilizer in the form of Urea was applied in three equal splitting at 45, 80, 120 dates after planting (DAP). Granular Insecticide application of Vertako (Thiamethoxam + Chlorantraniliprole) was also done @ 10 kg ha^{-1} at the time sowing of crop and 10 kg ha^{-1} at earthing up 90-100 days after planting (DAP) to protect from Borers. Light irrigation applied after planting to ensure better germination of buds and seedlings. One dose of Gang-V (atrazine + mesotrione) @ 2500 mL ha^{-1} and Sunstar Gold (Ethoxysulfuron) @50 g ha^{-1} was applied at 30 DAP to keep crop free from all types of weeds. Two inter cultures were employed and earthing up after complete application of all inputs made at 120 DAP. Overall, 16 irrigations (100 mm each) was applied to crop in addition to rainfall during the entire crop season.

Germination percentage

The germination of buds was observed at 30 Days age of seedlings. The total number of buds germinates were counted in relation to total bud chips sown in seedling trays.

Germination Percentage= (Total bud chips emerged / Total number of buds sown) x 100

Crop harvesting

The crop was harvested after achieving maturity in the month of January each year under study. The whole plot was harvested, topped, trashed, roped to make bundles manually to record stripped cane yield for each experimental unit by floor weighing balance. Observations on germination was recorded at 70 DAP by counting all germinant in each plot to work out germination % and tillers per plant were counted at 110 DAP to calculate tillers per plant by using following formula:

Tillers per plant: (total tillers – total germinant) / total germinant

The cane thickness was measured with Vernier caliper and cane length was measured by meter rod from 10 randomly selected plants from each plot and then averaged. Mill able canes and stripped cane yield was recorded at harvesting of crop on whole plant basis. For this purposes, each plot was cut, stripped, topped, counted and weighed on floor balance to calculate data on plot basis and then converted into hectare.

Each composite sample of ten randomly selected cane were subjected to extract juice by cane crusher with extraction capacity of 70% at Sugarcane Technology Laboratory, Faisalabad. The brix was recorded by brix hydrometer. The brix hydrometer was standardized at 20℃. The POL% was calculated by Horns dry lead sub-acetate method of sucrose analysis [8]. The Australian commercial cane sugar formula was used to assess (CCS%) commercial sugarcane.

CCS%=3P/2{1-(F+5)/100}-B/2{1-(F+3)/100}

Where P stands for POL%, F for fiber % and B for brix % of first extracted juice.

Sugar yield was obtained by using following formula:

Sugar Yield: Commercial Cane Sugar % / 100 x stripped cane yield

Statistical analysis

During course of study, the data were collected and subjected to statistical analysis employing Statistix 8.1 and all means were compared by using Least Significant Difference Test (LSD) [9].

Results

Buds viability

The data presented in Table-3 depicts that 700 bud chips were sown in seedling trays. Out of which 545 bud chips germinated. It shows 78% buds viability. At sowing time, healthy, disease and pest free buds were selected but 22% bud chips did not germinate.

Effect of sowing dates on yield and quality of Sugarcane

If we see on statistical analysis of data in Table 4, it shows that sowing dates had no significant effect on germination, tillers per plant, diameter and sugar recovery. However, it showed significant effects on cane height, number of cane, cane yield, sugar yield. Highest cane yield (67.38 ha^{-1}) and sugar yield (8.15 t ha^{-1}) was achieved in treatment where sowing was done on 15 April.

Effect of Seed type on yield and quality of Sugarcane

The data in Table 5, unveiled the facts that seed type had no significant effect on germination, tillers per plant, diameter and sugar recovery. Out of seedlings that were shifted in field, only 40.25% were succeeded to survive in field and became millable canes and 60% mortality were occurred due to transplanting shock. Seed types had significant effects on cane height, number of cane, cane yield, sugar yield. Highest cane yield (61 ha^{-1}) and sugar yield (7.15 t ha^{-1}) was achieved in treatment where setts was sown.

Effect of Seed type and sowing dates interaction on yield and quality of Sugarcane

In table 6, it was revealed that interactive effect of seed type and sowing dates had no significant effects on Sugar recovery but significantly affected germination and tillers per plant, height, cane diameter, number of cane, cane yield and sugar yield. Highest germination percentage (52.25%) was seen where buds were sown on 15 April. Lowest germination percentage 26% was seen where setts sown on 15 May.

As regarding with tillers per plant. Highest number of tillers 3.14 per plant was reported in Treatment in which buds were sown on 15 April. Minimum tillers 1.18 per plant was reported where setts sown on 15 May. Height and diameter of cane are important yield contributing factors in sugarcane crop. Maximum Height 6.23 feet was achieved in setts sown on 15 April. Lowest height

Year	Detail	EC m S/cm	Soil pH	Organic Matter %	Available potassium PPM	Available Phosphorus PPM	Saturation %	Texture
2016	Growth media	0.88	7.8	1.12	220	9.30	34	Loam
2017		1.16	7.8	1.05	200	8.60	32	Loam
2016	Experimental site	2.02	7.6	0.89	156	7.82	35	Loam
2017		2.18	7.5	0.97	149	6.98	37	Loam

Table 1: Physio-chemical analyses of soil and growing media for sugarcane cultivation

Year	2016	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2016	Temperature (°C)	12.5	16.3	21.6	28.5	33.1	34.9	32.1	31.5	31.2	27.2	20.3	16.5
	Relative Humidity %	64.0	64.5	64.5	66.5	52.0	49.0	54.0	66.5	69.5	61.5	63.5	64
	Rainfall (mm)	12.2	5.8	78.0	6.1	41.0	41.5	154.5	66.1	5.8	2.0	0.0	0.0
2017	Temperature (°C)	12.9	16.8	20.7	29.3	33.5	33.5	33.7	33.4	30.5	27.1	18.0	14.4
	Relative Humidity %	72.0	53.0	49.5	30.6	29.8	44.5	70.0	68.9	67.7	68.2	84.6	69.3
	Rainfall (mm)	11.5	4.1	16.2	28.3	10.1	41.6	117.2	66.0	35.6	0.0	1.5	4.2

Source: Observatory of plant physiology section, AARI, Faisalabad

Table 2: Weather data during both years of experiment

Year	Date of sowing	No. of buds sown	Buds germinates	Germination %
2016	04-02-2016	700	530	76%
2017	01-02-2017	700	560	80%
Average		700	545	78%

Table 3: Germination of bud chips

Sowing time	Germination (%)	Tiller / plant	Height/ plant (ft)	Diameter (cm)	Thousand canes/ha	Cane yield (t/ ha)	Sugar yield t/ha	Sugar Recovery (%)
15 April	42.00	1.81	4.98 a	3.98	75.50 a	67.38 a	8.15 a	12.12
1 May	40.63	2.28	4.45 b	5.77	68.75 b	57.86 b	6.83 b	11.75
15 May	32.75	1.67	4.39 b	3.80	58.75 c	46.13 c	5.07 c	11.00
LSD 0.05	**NS**	**NS**	**0.19**	**NS**	**1.64**	**2.49**	**0.45**	**NS**

Table 4: Effect of sowing time on yield and quality of sugarcane

Seed Type	Germination/survival %	Tiller / Plant	Height/ Plant (Feet)	Diameter (cm)	Thousd. canes/ha	Cane Yield T/ ha	Sugar Yield T/ha	Sugar recovery
Bud chips	40.25	2.18	4.09 B	5.80	65.75 B	53.25 B	6.21 B	11.50
Setts	36.67	1.66	5.12 A	3.23	69.58 A	61.00 A	7.15 A	11.75
LSD	NS	NS	0.33	NS	0.31	2.39	0.38	NS

Table 5: Effect of seed type on yield and quality of sugarcane

Treatment	Seed Type	Sowing Time	Germination / survival %	Tiller / plant	Height/ plant (Ft)	Diameter (cm)	No. of canes 1000 / ha	Cane yield t/ ha	Sugar yield t/ha	Sugar recovery
T1	SETTS	15-April	31.50 c	1.26 b	6.23 a	2.15 bc	89 a	85.25 a	10.23 a	12
T2	BUDS	15-April	52.50 a	3.14 a	3.73 c	2.90 a	62 d	49.50 d	6.06 d	12.25
T3	BUDS	1-May	49.75 a	2.37 ab	3.03 d	2.53 ab	58.25 e	44.50 e	5.11 e	11.5
T4	SETTS	1-May	31.50 c	1.43 ab	5.85 ab	1.90 c	79.25 b	71.25 c	8.55 b	12
T5	BUDS	15-May	39.50 b	2.16 ab	3.03 d	2.20 bc	50 f	30.00 f	3.31 f	11
T6	SETTS	15-May	26.00 d	1.18 b	5.75 b	1.93 c	67.50 c	62.25 c	6.84 c	11
		LSD 0.05	**5.147**	**0.4673**	**0.3893**	**0.4673**	**1.9207**	**3.6786**	**0.6347**	**N.S**

Table 6: Effect of seed type and sowing dates on yield and quality of sugarcane

Parameters	Quantity	Parameters	Quantity
No. Of Canes	47	Weight of Bud Chips / ha	2.5 Ton
Weight Of Canes	416 Kg	Weight of Seed In Setts Planting / ha	10.5 Ton
No Of Bud Chips Obtained	700	Seed Saving In Bud Chips Sowing /ha.	8 Ton
Weight of buds	16 kg	Seed Saving	76%
Weight Of Remaining Cane	400 Kg	Cost of seed in Setts planting / acre @ Rs. 220/40 Kg	Rs. 24200/-
Per Bud Chip Weight	16 Kg	Cost of seed in Setts planting / ha	Rs. 60500/-
Weight Of Bud Chips /Ac	1050 Kg	Cost of seed in bud chips planting / ha	Rs. 14438/-
		Saving of cost in seed / ha	Rs. 46063/-

Table 7A: Economics of bud chips planting in sugarcane

Seed Type	Sugarcane yield (T/ ha)	Cost of producation per acre (Rs.)	Cost of producation per ha (Rs.)	Gross income per ha (Rs.)	Profit per ha (Rs.)	Benefit Cost ratio (BCR)
Setts	61.00	90016	225040	335500	110460	1.49
Bud chips	53.25	71591	178977	292875	113898	1.64

Table 7B: Economics of bud chips planting in sugarcane

3.03 feet was seen in treatment where buds were sown on 15 May. Height of bud chips transplanted seedling was found maximum 3.73 feet in 15 April.

Number of millable canes was found highest 89 thousand per ha in setts sown on 15 April. While minimum canes were 50 thousand per ha in treatment with buds sown on 15 May. As regards the cane and sugar yield, setts planted on 15 April produced maximum cane yield (85.25 t ha^{-1}) and sugar yield of 10.23 t ha^{-1}. Among bud chip planting, maximum cane yield (49.50 t ha^{-1}) and sugar yield (6.06 t ha^{-1}) attained where bud chips seedling sown on 15 April did not respond better on 1 May and 15 May.

Economics of bud chips and sett planting

In table 7, a comparative economics was calculated of bud chips and sett planting in sugarcane. Highest benefit cost ratio of 1.64 was found in bud chips planting than setts planting (1.49). Because 76% seed was saved in bud chips. It reduces the cost of production to Rs.71591/- per ha in contrast to setts planting having cost of production of Rs. 90016/- per ha.

Discussion

Buds viability

At sowing time, healthy, disease and pest free buds were selected but 22% bud chips did not germinate because during the month of February, 2016, 2017, temperature was 16.3 ^{o}C, 16.8 ^{o}C and during march 2016, 2017, temperature was 21.6 ^{o}C, 20.7 ^{o}C. and frost was occurred in first week of February which affect eyes of bud chips. All these factors produced 78% buds viability [10]

Effect of sowing dates on yield and quality of Sugarcane

Sowing dates had no significant effect on germination, tillers per plant, diameter and sugar recovery. But it showed significant effects on cane height, number of cane, cane yield, sugar yield. Highest cane yield (67.38 ha^{-1}) and sugar yield (8.15 t ha^{-1}) was achieved in treatment where sowing was done on 15 April. This is because number of height and number of tillers was also high on 15 April. Similarly, Sugar yield was high due to high cane yield and sugar recovery on same date [10].

Effect of Seed type on yield and quality of Sugarcane

Seed types had no significant effect on germination, tillers per plant, diameter and sugar recovery. Out of seedlings that were shifted in field, only 40.25% were succeeded to survive in field and became millable canes and 60% mortality were occurred due to transplanting shock. Seed types had significant effects on cane height, number of cane, cane yield, sugar yield. Highest cane yield (61 ha^{-1}) and sugar yield (7.15 t ha^{-1}) was achieved in treatment where setts was sown. Because cane height and number of tillers was seen high in setts planting. Similarly, high sugar yield was due to higher cane yield and sugar recovery on setts planting than bud chip sowing [11].

Effect of Seed type and sowing dates interaction on yield and quality of Sugarcane

The interactive effect of seed type and sowing dates had no significant effects on Sugar recovery but significantly affected germination and tillers per plant, height, cane diameter, number of cane, cane yield and sugar yield. Highest germination percentage (52.25%) was seen where buds were sown on 15 April. Lowest germination percentage 26% was seen where setts sown on 15 May. The reason behind low germination is due to high Temperature that results in mortality in eyes of triple buded setts [6,7] in which he said that increase in temperature effects the viability of eyes of setts.

As regarding with tillers per plant. Highest number of tillers 3.14 per plant was reported in Treatment in which buds were sown on 15 April. Minimum tillers 1.18 per plant was reported where setts sown on 15 May. This is because the survival of seedling was also high in this treatment [12].

Height and diameter of cane are important yield contributing factors in sugarcane crop. Maximum Height 6.23 feet was achieved in setts sown on 15 April. Lowest height 3.03 feet was seen in treatment where buds were sown on 15 May. Height of bud chips transplanted seedling was found maximum 3.73 feet in 15 April. This might be due to transplanting shock that have to bear by every buds chips seedling during transplanting and low quantity of 70 g of growth media in the cells of seedling trays [12].

Number of millable canes was found highest 89 thousand per ha in setts sown on 15 April. While minimum canes were 50 thousand per ha in treatment with buds sown on 15 May. This is due to increase in temperature in the month of May. High temperature reduces the tillering capacity of plants [13].

As regards the cane and sugar yield, setts planted on 15 April produced maximum cane yield (85.25 t ha^{-1}) and sugar yield of 10.23 t ha^{-1}. Because other yield contributing parameters were also attained maximum quantity in this treatment. Among bud chip planting, maximum cane yield (49.50 t ha^{-1}) and sugar yield (6.06 t ha^{-1}) attained where bud chips seedling sown on 15 April and did not respond better on 1 May and 15 May due to increase in temperature as reported [4].

Economics of bud chips and sett planting

Highest benefit cost ratio of 1.64 was found in bud chips planting than setts planting (1.49). Because 76% seed was saved in bud chips and was used in crushing and milling. It reduces the cost of production to Rs.71591/- per ha in contrast to setts planting having cost of production of Rs. 90016/- per ha. This reduction in cost of production leads to more income and ultimately more BCR than setts planting in sugarcane.

It is concluded from the study that setts planted on 15 April produced more cane and sugar yield than bud chips while bud chips transplanted on 15 April gave higher cane and sugar yield with more BCR of 1.64 than setts planting of Sugarcane and saving 76% cane seed saves that may be used for crushing in Sugar and Jaggery production. Bud chips planting have many benefits but it

is not alternate to setts planting to achieve potential yield in farmer field.

Competing interest

All the authors declare that they have no competing interest that can affect the current study.

Authors' Contribution

Abdul Khaliq design and conduct the experiment, Arshad Mahmood summarize the results of paper, Hafiz Bashir Ahmad and Muhammad Rizwan Khursheed review the paper, Muhammad Ashfaq Nadeem write the introduction portion, Naeem Ahmad provide the technical and administrative support to complete the research and Rashad ul sher review the study.

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