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Prime Minister's Agricultural Emergency Program on Productivity Enhancement of Sugarcane (PESC)

Nutrient Indexing and Explore Efficient Integrated Nutrient Package for Optimizing Sugarcane Yield and Quality in Pakistan

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FOREWORD

This is the second crop season report generated by the Project on prime minister's gricultural emergency program on productivity enhancement of sugarcane (PESC) Nutrient Indexing and Explore Efficient Integrated Nutrient Package for Optimizing Sugarcane Yield and Quality. The results from 13 locations across the country have been reported. The report confirms the previous findings that both potash and micronutrients are effective and increased the sugarcane upto 13% and not only yield was increased but produce quality was also improved. The Project has successfully completed three years and produced enough data to justify the use of potash and micronutrients for sugarcane.

We express our sincere thanks to the PSDP Govt. of Pakistan the Secretary, Ministry of Food, Security and Research and the Chairman, Pakistan Agricultural Research Council for their active support to the project and their encouragement. The financial assistance by PSDP under Private Sector Development Fund is highly appreciated. It is gratifying to note that project has achieved its objectives considerably even though the project is only half way through.

It is hoped that the report will be a useful reference material for all those concerned with the project as well as for those interested in the introduction and promotion of potash and micronutrients in Pakistan.

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PRIME MINISTER'S AGRICULTURAL EMERGENCY PROGRAM ON PRODUCTIVITY ENHANCEMENT OF SUGARCANE (PESC)

Nutrient Indexing and Explore Efficient Integrated Nutrient Package for Optimizing Sugarcane Yield and Quality

Land Resources Research Institute (LRRI)
NARC/PARC Sub-Component-5

PROJECT BRIEF / BACKGROUND

Fertilizer use is at an advanced stage in Pakistan, with average nutrient use level being about 144.3 kg per hectare of N, P_2O_5 and K_2O which is highly imbalanced and skewed towards N as 116 kg N ha^{-1} followed by 28 kg P_2O_5 ha^{-1} and one kg K_2O ha^{-1} (NFDC, 2017). The use of K and micronutrients is almost negligible that has resulted not only in stagnation of crop yields but also hampered quality of the crop produce badly. Also soil quality is being degraded progressively due to continuous nutrient mining from soils by cropping (Akhtar and Khan, 2002). Previous studies showed that the crop yields can be enhanced significantly through balanced fertilizers application to sugarcane leading to the improvement in quality of sugar crops produce (Kumar et al., 2019). The sugarcane response to the applied potash and micronutrients especially Fe, Zn and B is variable which cannot be generalized like N and P. Rather it is more crop and site specific (Akhtar et al., 2002, 2003). Furthermore, Sugarcane is a high delta and potassium (K) demanding crop. Potassium enables sugarcane crops to take up a balanced suite of nutrients and is better able to withstand the drought conditions that periodically occur in sugarcane growing regions (Wood et al., 2004). Potassium regulates stomatal opening and closing, and thus maintains turgor pressure under unfavorable soil moisture conditions. Under salt stress, K helps to maintain ion homeostasis and to regulate the osmotic balance (Hasanuzzaman et al., 2018). K application improved overall plant growth by 19 percent over no K fertilization at harvest and a higher number of millable cane due to vigorous tillers formed in ratoon cane. An adequate supply of K not only reduced moisture stress (Wang et al., 2013) but also tolerate sugarcane to salt stress. This is because of differences in nutrient requirement of crop species, their varieties, nature of soil parent material, type and size of soil clay minerals, soil texture, etc (Awan et al., 1998). Hence, there is a need to investigate and demonstrate the role of K and micronutrient fertilizer in balance nutrient management in high yield agriculture, particularly in high K requiring crops like sugarcane grown in specific areas of Pakistan.

Objectives/Major Activities:

- Investigate the extent and severity of micronutrients and K deficiency in soils of sugarcane crop grown areas of Pakistan.
- Determine site specific micronutrients and potash fertilizer requirement for optimizing crop yield, produce quality and formulate recommendations.
- To evaluate the impact of applied nutrients on yield and quality of sugarcane crop in the main production areas in Pakistan.

Nutrient Indexing Survey Report of Major Sugarcane Growing Tendo Allah Yar District

Nutrient indexing survey of major sugarcane growing Districts of three provinces was conducted. Soil samples (0-30 and 30-45 cm depths) were collected from randomly selected sites/farmers. The sampling sites were marked on maps using geographical positioning system (GPS). Soil properly processed and analyzed considering standard procedures. The following detrminations were made for soil samples: pH, EC_e, OM, $CaCO_3$, Ca+Mg, CO_3, HCO_3, N, P, K, Zn, Fe, B and Cl.

Data were used for determining nutrient status of the surveyed area soil and was used for site specific nutrient recommendations.

Determine Site Specific Micronutrients and Potash Fertilizer Requirements:

Advisory services were provided to provincial Agricultural Extension departments by analyzing soil, plant and water samples for nutrients and other fertility/salinity related as well as to determine site specific micronutrients and potash fertilizer requirements of demonstration plot sites. It helped to use only specific crop nutrient for optimizing crop yield, produce quality and to reduce cost of production.

Explore Efficient Integrated Nutrient Package for Optimizing Sugarcane Yield and Quality:

Field Experimentation was conducted in major sugarcane growing districts of all the three provinces in collaboration with Agriculture Extension Departemnts and sugar mills in four provinces.

Educational programs and technology transfer

i) Educational programs were undertaken to disseminate available information through bringing out technical guidance for the extension workers, public and private sectors, and progressive farmers.

ii) Organizing "field days" and field demonstrations in collaboration with provincial governments.

iii) Organized training workshops, group discussions. seminars and corner meetings.

METHODOLOGY OF NUTRIENT INDEXING SURVEY

Nutrient Indexing survey was conducted to investigate the extent and severity of N, P, K, Fe, Zn and B deficiency in soils of major sugarcane growing areas in Tando Allahyar District Sindh, Pakistan. The samples were collected from thiry one sites in the selected union councils (UCs) from Tando Allahyar District. Soil sampling was done from two depths i.e. 0-30 cm and 30-45 cm form the cultivated fields and analysed for soil texture, organic matter contents, electrical conductivity, calcium plus magnesium, carbonate, bicarbonate, lime contents, chlorides, pH, N, P, K, Fe, Zn, and B. Similarly, irrigation water samples were collected used for irrigation in fields of the survey area. The collected soil samples were brought to soil and plant nutrient program's Lab. LRRI, NARC, Islamabad, dried, ground and sieved through 2 mm sieve. The processed samples were analysed for EC (), pH (), organic matter (), and $CaCO_3$ (), available N, P, K, Fe, and Zn by AB-DTPA extraction method (Soltanpour, 1985). Boron was determined colorimetrically using azomethine-H (Bingham, 1982). Similarly, irrigation water samples were analyzed for pH, electrical conductivity, Na, Ca+Mg, Cl, CO_3+HCO_3, TDS, SAR, NO_3-N, P and K in water.

RESULTS OF NUTRIENT INDEXING SURVEYS

District Tando Allahyar (Sindh)

Spatial variability of physico-chemical properties and nutrient availability in soil

A total of thirty-one (31) sites were selected for soil and water sampling for the survey of district Tando Allahyar, Sindh. Results of soil samples indicated that dominant classes in surveyed area were silty clay (29%) and silty clay loam (29%) while rest of the samples were found silty loam (25.8%), loam (9.7%), clay (3.3%) and loamy sand (3.3%). Majority of soil samples in textural class silt clay was found in sites i.e. Nasir Shah Sherawater-1, Nasir Shah Sherawater-2, Nasir Shah Deputy Goth-Farm 3, site-1, Nasir Shah Deputy Goth-Farm 3, site-2, Meer Inayat Ali Khan Talpur UC-PakSinghar, Dr. Mehmood Nawaz Shah-2, Zahid Dall Block-I , Abdul Rahim Dall, Abdul Qadoos Chachar-1 while silt clay loam soil textural class was found at Mehran Res. Farm Colony site, Haji Ali Ghulam Dall-Block-II, Asif Ali Dall, Umaid Ali Dall UC-Kumaro, Haji Shabir Memon UC-Tajpur, Azam Khan Rindh Nasarpur, Khalid Hussain and Asad Qadir Thaibo-2 areas. Similarly, silt loam class was found in soil sample of Abid Bachani-Jharki, Abdul Qadoos Chachar-2, Abdul Khaliq Kashigar UC-Town Nasarpur, M. Ramzan Meerjatt-Dasori, Ashiq Hussain- Thaibki, Qasim Khan Lund-Shahpur and Ghulam Mustafa Thaibo while, loam was recorded for soil sample of Dr. Mehmood Nawaz Shah-1, Dr. Rahila Gul Magsi and Asad Qadir Thaibo-1. The clayey soils were found in Khalid Hussain Thaibo-Aliechi and loamy sand class was recorded for Asad Qadir Thaibo-3. It was observed that majority of survey area had fine soils. Electrical conductivity of soil samples which varied between 0.28 to 6.62 dSm^{-1} and 0.22 to 5.4 dSm^{-1} with the mean values of 2.12±0.32 and 1.34±0.22 at two depths 0-30 and 30-45 cm respectively. Majority of soils (87%) were normal while 13% were categorized as saline soils in which EC ranged from 4.59 to 6.62dSm^{-1}. These soils may create problem in crop production if coupled with poor quality of irrigation water and crop management. Similarly, pH of surveyed area ranged between moderately alkaline to strongly alkaline i.e. 7.79 to 8.89 and 7.9 to 9.26 with the mean values of 8.16±0.05 and 8.23±0.05 for the respective depths. Majority of soils (90%) were moderately alkaline as the soil pH ranged from minimum of 7.86 to maximum 8.41 and 10% soils were strongly alkaline having pH ranged from 8.51 to 9.26. Generally, the availability of most of the nutrient decreased with increases in soil pH greater than pH 7.5. Organic matter (OM) contents of most of the soil varued between 0.31 to 0.63% and 0.21 to 0.53% with the average value of 0.54±0.012 and 0.39±0.013 indicating the poor OM and nutrient status of soils for the normal growth and realizing potential yield of sugarcane. The lime contents ($CaCO_3$) of the surveyed area soils lied between 6.6 to 9.1% and 4.5 to 9.6% with mean values of 7.56±0.11 and 8.61±0.19 at depths 0-30 and 30-45 cm respectively. Similarly, sodium (Na) in the soils of surveyed area varied from 30 to 1952 $mgkg^{-1}$ in 0-30 cm depth while in 18 to 2140 $mgkg^{-1}$ in 30-45 cm depth displaying mean values of 542.13±99.62 and 516±102.19. The Ca+Mg content of surveyed area varied from 2.3 to 42 $meqL^{-1}$, HCO3 as 1.33 to 8.6 $meqL^{-1}$, and Cl between 2.3 to 46 $meqL^{-1}$ with the mean values of 13.01±2.22, 2.23±0.23 and 11.65±2.32 respectively at depth 0-30 cm. In case of lower depth (30-45 cm) the Ca+Mg, HCO_3, and Cl cotents in soil varied between 1.7 to 58 $meqL^{-1}$, 1.67 to 4 $meqL^{-1}$and 1.33 to 28.3 $meqL^{-1}$ with the average values of 10.01±2.22, 2.29±0.11 and 5.82±1.11 respectively. Based on these characteristics total dissolved salt (TDS) and sodium adsorption ratio (SAR) were estimated which showed that the TDS ranged between 202 to 4766 mgL^{-1} at 0-30 cm and 155 to 3629 mgL^{-1} at 30-45 cm depths with the mean values of 1524.5±228.24 and 1002.9±159.84 respectively.

Table 1 **Physico-chemical characteristics of soil surveyed from District Tando Allahyar, (Sindh)**

Soil Property	Soil Depth*	Mean	Min.	Max.	SD	CV%	Skewness	Kurtosis	SEM
ECe (dSm^{-1})	0-30	2.12	0.28	6.62	1.77	83.36	1.32	0.74	0.32
	30-45	1.39	0.22	5.04	1.24	88.59	1.98	3.08	0.22
pH (1:1)	0-30	8.16	7.79	8.89	0.26	3.16	1.29	1.60	0.04
	30-45	8.23	7.91	9.26	0.25	3.04	2.26	7.48	0.04
OM (%)	0-30	0.54	0.31	0.63	0.07	12.64	-1.15	2.25	0.01
	30-45	0.39	0.21	0.53	0.07	19.00	-0.51	-0.19	0.01
$CaCO_3$ (%)	0-30	7.55	6.60	9.10	0.60	7.95	0.62	0.16	0.11
	30-45	8.61	4.50	9.60	1.09	7.95	-2.72	6.93	0.19
N ($mg\ kg^{-1}$)	0-30	1.16	0.57	1.88	0.30	26.04	0.38	-0.01	0.05
	30-45	1.48	0.56	4.13	0.79	53.69	1.67	2.73	0.14
P ($mg\ kg^{-1}$)	0-30	6.55	3.73	14.42	2.59	39.63	1.47	1.60	0.47
	30-45	5.59	2.87	14.45	2.62	46.83	1.71	2.70	0.47
K ($mg\ kg^{-1}$)	0-30	134.97	34.00	538.00	108.87	80.66	1.70	4.06	19.55
	30-45	138.71	42.00	364.00	79.50	57.32	1.26	0.75	14.28
B ($mg\ kg^{-1}$)	0-30	1.22	0.86	3.40	0.49	41.00	3.00	10.07	0.08
	30-45	1.16	0.82	3.49	0.53	45.51	3.25	11.12	0.09
Fe ($mg\ kg^{-1}$)	0-30	15.27	0.11	46.18	10.88	71.23	1.037	0.72	1.95
Zn ($mg\ kg^{-1}$)	0-30	0.847	0.14	3.58	0.63	74.66	2.61	9.25	0.11
Na ($mg\ kg^{-1}$)	0-30	542.13	30.00	1952.0	554.70	102.32	1.47	0.98	99.63
	30-45	516.00	18.00	2258.0	568.98	110.27	2.01	3.25	102.19
Ca+Mg	0-30	13.01	2.30	45.00	12.37	95.10	1.27	0.62	2.22
($m\ eq.L^{-1}$)	30-45	10.02	1.70	58.00	12.38	123.58	2.39	5.75	2.22
HCO_3	0-30	2.22	1.33	8.67	1.29	57.72	4.15	18.25	0.23
($m\ eq.L^{-1}$)	30-45	2.29	1.67	4.00	0.59	25.92	0.96	0.90	0.11
Cl ($m\ eq.L^{-1}$)	0-30	11.65	2.30	46.00	12.90	110.72	1.95	2.24	2.32
	30-45	5.82	1.33	28.30	6.20	106.60	2.82	7.41	1.11
SAR	0-30	11.19	1.13	76.56	14.39	128.68	3.27	11.95	2.59
	30-45	14.46	0.58	107.54	20.91	144.60	3.21	11.10	3.76
TDS (mgL^{-1})	0-30	1524.5	202.00	4766.0	1270.8	83.36	1.32	0.74	228.24
	30-45	1002.9	155.00	3629.0	889.94	88.73	1.98	3.02	159.84

***(cm)**

Similarly, SAR varied between 0.58 to 76.56 and 0.58 to 107.56 showing average values of 11.19±2.59 and 14.46±3.76. According to survey 74% soils had below 15 SAR while 26% soils had SAR ≥ 15 which indicated that almost one fourth of the soils from the surveyed area were problemematic that are sodic or saline sodic in nature. On the basis of these results pH, OM and lime contents were found least to lie in moderate range (as CV≤ 15 to ≤ 35% respectvely) while the rest of the soil characteristics i.e. EC (1:1), Na, Ca+Mg, HCO_3, Cl_2, TDS and SAR were found highely variable (CV > 35%). Plant available nitrogen (N) content in soil varied between 0.57 to 1.88 $mgkg^{-1}$ and 0.56 to 4.13 $mgkg^{-1}$ showing mean values of 1.16±0.05 and 1.48±0.14 at depths 0-30 and 30-45 cm respectively. Similarly, bio-available P in soil varied between 2.87 to 14.42 and 2.87 to 14.45 $mgkg^{-1}$ with the average values of 6.54±0.47 and 5.59±0.47, respectively at both depths.

Table 2 Generalized Guidelines for Interpretation of Soil Analysis data of Tando Allahyar, Sindh

Soil property	Soil Depth (cm)	Range	Mean	Low	Marginal	Adequate
NO_3-N	0-30	0.57-1.88	1.16	31;100%	0;0.00%	0;0.00%
	30-45	0.56-4.13	1.47	31;100%	0;0.00%	0;0.00%
PO_4-P	0-30	3.73-14.4	6.54	4;13%	22;71%	5;16%
	30-45	2.87-14.45	5.59	8;26%	18;58%	5;16%
K	0-30	34-538	134.97	12;39%	6;19%	13;42%
	30-45	42-364	138.71	1;3%	16;52%	14;45%
Zn	0-30	0.14-3.58	0.84	21;68%	10;32%	0;0.00%
	30-45	0.11-2.56	0.79	22 ;71%	9 ; 19%	0;0.00%
Fe	0-30	0.11-46.18	15.27	2;6%	5;17%	24;77%
	30-45	0.23- 53.21	13.12	0; 00%	2; 6.5%	29; 93.5
B	0-30	0.86-3.4	1.21	0;0.00%	12;39%	19;61%
	30-45	0.82-3.49	1.16	0;0.00%	18;59%	13;42%
OM (%)	0-30	0.31-0.63	0.54	31;100%	0;0.00%	0;0.00%
	30-45	0.21-0.53	0.39	31;100%	0;0.00%	0;0.00%
pH	0-30	7.79-8.89	8.15	**Strongly Acidic** 3;9.6	**Moderately Alkaline** 28;90.3%	**Strongly Alakaline** 0;0.00%
	30-45	7.91-9.26	8.22	2;6.4%	29;93.5%	0;0.00%
ECe (dS m^{-1})	0-30	0.28-6.62	2.11	(Normal) 26;83.8%		**(Saline)** 5;16.12%
	30-45	0.22-5.04	1.39	28;90.32%		3;9.67%
$CaCO_3$ (%)	0-30	6.60-9.10	7.55	Slightly Calcarious 0;0.00%	Moderatly Calcarious 28;90%	**Strongly Calacarious** 3;9.6%
	30-45	4.5-9.6	8.61	Slightly Calcarious 0;0.00%	Moderatly Calcarious 6; 19%	Strongly Calacarious 25;80.6

The K contents at 0-30 and 30-45 cm depths ranged between 34 to 538 and 42 to 364 $mgkg^{-1}$ displaying mean values of 135.9±19.55 and 138.71±14.27 respectively. Based on these results the N, P and K contents in soil it was found that total soils of the surveyed area were deficient in plant available N, 59% deficient in P and 20% adequate range and 32% marginal while 47% in adequate range for K contents. The variability in nutrient contents revealed that N at 0-30 cm depth was moderately variable whereas, N at depth 30-45 and P and K at both the depths were highly variable. The soil available micronutirents (Fe, Zn and B) showed that Zn in soil varied between 0.14 to 3.58 mg kg^{-1} while Fe as 0.11 to 46.18 mg kg^{-1} with the mean values of 0.84±0.11 and 15.27±1.95 respectively. Data showed that Zn (74%) and Fe (71%) were highly variable, and 68% samples were under low Zn availability range while 32% under marginal range and Fe as 3% under low range, 9% under marginal whereas, 87% under adequate range. Similarly, B ranged between 0.86 to 3.4 $mgkg^{-1}$ and 0.82 to 3.49 $mgkg^{-1}$ with the average values of 1.22±0.089 and 1.16±0.095 displaying 55% of the soil under adequate and 45% under marginal range plant B availability with the high variability (CV>35%).

Chemical Characteritics and Nutrient Staus of Irrigation water samples of surveyed areas

Chemical characteristics of irrigation water samples collected showed that pH of water ranged between 7.04-7.78 charcterized as all samples moderately alkaline. The EC of water samples varied between 0.46 to 3.8 $dScm^{-1}$ showing that 57% samples were under suitable limits, 14% under marginal limits while rest of the samples (28%) were not suitable for irrigation purpose because of irrigation with the water under this category may create salt problem. Similarly, bicarbonates (HCO_3) contents in all water samples of surveyed area of Tendo Allah yar ranged between 4 to 8.3$meqL^{-1}$ showing slight to moderately alkaline. Chloride contents showed severely alkaline class characters with values varying from 2.33 to 15.63 $meqL^{-1}$. The total dissolved salts (TDS) ranged between 294 to 952 mgL^{-1} with the 57% samples under suitable range, 14% marginal and 28% unsuitable of the total water samples determined, showing the one-fourth of of the water samples not fit for irrigation. The sodium absorption ratio (SAR) of water samples were recorded out of which 78% suitable and almost 21% under marginal range with the values varying from 0.17 to 11.31 (Table 3).

The nutrient status of the water samples showed that NO_3-N in water sample ranged from 0.33 to 4.79mgL^{-1}, phosphorus contents ranged between 0.91 to 1.08 mgL^{-1} potassium between 16 to 354 mgL^{-1}. Similarly, boron ranged between 0.32 to 0.71 mgL^{-1} and sodium from 6 to 574 meq^{-1}. It was concluded that 100% of the samples were under normal range in case of NO_3^-, 100% toxic according to chloride contents, 100% slight to moderate for HCO_3 and 92% toxic due to Na (Table 3 and 4).

Table 3 Chemical Characteritics and Nutrient Status of Irrigation Water

Location	pH	EC	N	P	K	B	Na	Ca+ Mg	HCO_3	Cl	TDS	SAR
		dSm^{-1}	mgL^{-1}					$meqL^{-1}$				
Nasir Shah Deputy Goth-I Sample-1	7.13	1.42	0.35	1.08	137.0	0.40	123.0	10.0	7.00	5.00	909	2.24
Nasir Shah Deputy Goth-I Sample-2	7.24	3.8	0.43	1.00	175.0	0.62	574.0	9.0	5.33	15.67	2432	11.31
Deputy Goth-II Sample-1	7.14	1.49	0.33	0.99	50.0	0.53	213.0	8.3	8.33	3.67	952	4.54
Deputy Goth-II Sample-2	7.04	1.86	0.36	0.96	64.0	0.52	305.0	7.7	7.33	4.67	1192	6.76
Saen Bakhsh	7.39	3.64	0.47	1.00	65.0	0.59	502.0	13.0	5.67	2.33	2330	8.56
Bangla	7.32	2.95	4.79	0.97	145.0	0.62	382.0	11.3	6.67	12.7	1888	6.99
Solar	7.35	3.42	2.39	0.92	110.0	0.71	474.0	7.7	6.67	15.0	2189	10.50
Dr. Rahila Gul	7.29	0.46	0.67	0.95	41.0	0.32	6.0	4.3	4.00	1.67	294	0.17
Shabir Memon	7.13	1.10	0.41	0.93	38.0	0.33	67.0	9.0	5.67	6.67	705	1.37

Location	pH	EC	N	P	K	B	Na	Ca+ Mg	HCO_3	Cl	TDS	SAR
Asad Qadir Sample-1	7.78	1.29	0.44	0.94	354.0	0.39	145.0	9.0	5.00	5.00	825	2.97
Asad Qadir Sample-2	7.34	1.66	0.69	0.91	18.0	0.43	211.0	9.3	6.00	4.67	1065	4.25
Asad Qadir Sample-3	7.46	1.05	0.37	0.91	18.0	0.38	95.0	7.0	5.33	2.33	675	2.20
Meer Inayat Ali Sample-1	7.13	1.24	0.45	1.04	16.0	0.47	132.0	8.0	4.33	3.00	796	2.87
Meer Inayat Ali Sample-2	7.13	0.94	0.48	0.91	17.0	0.41	84.0	5.0	5.00	2.67	602	2.31
Minimum	**7.04**	**0.46**	**0.33**	**0.91**	**16.0**	**0.32**	**6**	**4.3**	**4.0**	**1.67**	**294**	**0.17**
Maximum	**7.78**	**3.8**	**4.79**	**1.08**	**354.0**	**0.71**	**574**	**13**	**8.3**	**15.6**	**2432**	**11.31**
Average	**7.28**	**1.88**	**0.90**	**0.97**	**89.1**	**0.48**	**236.64**	**8.47**	**5.9**	**6.07**	**1203.86**	**4.79**

Table 4 Guidelines for the description of Chemical Characteristics and Nutrient status of Irrigation Water.

Measurement (mg kg^{-1})	**Mean**	**Minimum**	**Maximum**	**Slightly Acidic**	**Moderately Alkaline**	**Strongly Alkaline**
pH	7.27	7.04	7.78	13;93%	1;7%	0;0.00%
				Normal	**Slightly to Moderate**	**Toxic**
Na	236.64	6	574	0;0.00%	1;7%	13;93%
NO_3	0.90	0.33	4.79	14;100%	0;0.00%	0;0.00%
HCO_3	5.88	4	8.33	0;0.00%	14;100%	0;0.00%
Cl	6.07	1.67	15.67	0;0.00%	0;0.00%	14;100%
				Suitable	**Moderate**	**Unsuitable**
EC	1.88	0.46	3.8	8;57%	2;14%	4:29%
TDS	1203.86	294	2432	8;57%	1;7%	5;36%
SAR	4.78	0.17	11.31	11;79%	3;21.4%	0;0.00%

EXPLORE EFFICIENT INTEGRATED NUTRIENT PACKAGE FOR OPTIMIZING SUGARCANE YIELD AND QUALITY

MATERIALS AND METHODS

1. Site selection and soil sampling

The soil sampling was done from sugarcane fields of different selected site during 2020-2021 for the determination of macro & micronutrients and fertility status of different districts of Punjab, Sindh, Khyber Pakhtunkhwa and Balochistan. The soil samples were taken from two relative depths (0-30 and 30-45cm) using auger for their analysis through drying, grinding with wooden mortar and pestle, and then sieved through 2mm sieves.

1.1 Experimental Sites and Varieties

1) Sargodha (Jhang-59)	2) Khanpur Rahimyar Khan (CPF-252)
3) Bahawalpur (CP-77400)	4) Shaheed Benazir Abad Chak-4, (HSF-476)
5) Shaheed Benazirabad Chak-5 (CP-134)	6) Hyderabad Rural (SP-26)
7) Tando Allahyar (CP-246)	8) Khan Mahi Charsadda (CP-77400)
9) Touru Mardan (Titron)	10) Shahabaz Kalay (CP-77-400)
11) Band Korai DI. Khan (CP-77400)	12) Saddar-I, Harnai (Poona)
13) Saddar-II, Harnai (Poona)	

Soil samples were analyzed for texture, organic matter contents, electrical conductivity, chloride, pH, N, P, K, Fe, Zn, and B. On each site variety and treatments were designed according to site specific nutrient requirements. From each site the plant tissues (leaf blade and leaf sheath) were collected to determine nutrient composition as affected by applied treatments.

Plant tissues were prepared after drying in oven at 65-70°C and grinding through plant grinder. The plant tissue samples were collected for the determination of N, P, K, Fe, Zn and B concentration in leaf blade and leaf sheath separately. Also, the irrigation water samples were collected, and analysed for EC, pH, N, P and K.

2 Field Experimentation

Field experiments were conducted at different sites in September-October, 2020, sowing (Sargodha, Shahaeed BenazirAbad and Hyderabad Rural) and February-March, 2021, sowing (Khanpur, Lodhran, Shaheed Benazir Abad, Tando Jam, Touru Mardan, Khan Mahi, Shahabaz Kalay, Band Korai, DI. Khan, Saddar-I, Haranai, and Saddar-II, Harnai). Pre-plantation soil sampling was done to determine soil fertility status at different sites. The land was prepared by tractor using the mouldboard plow and ridgers etc. Planting was done manually. Farmer practice for fertilizer treatment was followed as; fertilizers P and K were applied at time of seeding while N was applied in three split dozes; at the Seeding, tillering stage and at grand growth stage. A total of thirteen (13) experiemnts were performed with varying treatments according to site specific nutrient requirement.

2.1 Fertilizer Treatments

Three field experiments conducted in sepetember sowing 2020 at Sragodha (Punjab), Shaheed Benazirabad and Hyderabad Rural (Sindh) were comprised of T_1= NP, T_2= NPK, T_3= NPK+Zn, T_4= NPK+Fe, T_5= NPK+B including biozote at Sargodha site. In February 2021 sowing there were eight field experiments on farmer fields: at Rahimyar Khan, Lodhran (Punjab), Shaheed Benazirabad, Tando Allahyar-Ratoon (Sindh), Touru and Shahabaz Kalay Mardan, Khan Mahi Charsadda (KPK) and Saddar-I and Saddar-II Harnai (Balochistan). At Rahimyar Khan and Lodhran treaments included were: T_1= NP, T_2= NPK, T_3= NPK+Zn, Fe & B, T_4= NPK+Humic Acid, T_5= NPK+Biozote.

At Shaheed Benazirabad treatements were T_1= NP, T_2= NPK, T_3= NPK+ Zn, Fe & B, T_4= NPK+Humic Acid, T_5= NPK+Biozote, T_6= NPK+BCI, T_7= NPK+Fungicide whereas, at Tando Allahyar treatments were asfallow: T_1= NP, T_2= NPK, T_3= NPK+Zn, Fe & B, T_4= NPK+Humic Acid.

In Khyber Paktun Khwa at Touru Mardan there were six treatments; T_1= NP, T_2= NPK, T_3= NPK+Zn, Fe&B, T_4= NPK+Humic Acid, T_5= NPK+Biozote, T_6= NPK+Trichoderma while, at Shahabaz Kalay Mardan the treatments were T_1= NP, T_2= NPK, T_3= NPK+Zn, Fe & B, T_4= NPK+Humic Acid, T_5= NPK+Biozote. At Khan Mahi Charsadda (Ratoon), these treatments were there were four treatments i.e., T_1= NP, T_2= NPK, T_3= NPK+Zn, Fe & B, T_4= NPK+Humic Acid. The nutrients N and P_2O_5 were applied uniformly to all experiments @ equivalent to 200 kg and P_2O_5 100 kg ha^{-1} the K_2O was applied @150 kg ha^{-1}, Zn+Fe+B= 12 kg ha^{-1} each. Similarly, biozote was applied @ rate of 2.5 kg ha^{-1}, trichoderma @ 0.5 kg ha^{-1}, BCI @ 10 litre ha^{-1}.

Plant tissue samples for determination of nutrient (N, P, K, Zn, Fe and B) status were taken at grand growth stage in the July-August. Data regarding Brix contents of sugarcane was recorded in months of November. Yield and yield component data was recorded at time of harvest from each treatment. Other quality parameters were got analyzed from different research institute and sugar mills of the relevant areas working on the sugarcane production. Data were compiled and tabulated in tables shape. The data collected so far were subjected to statistical analysis using Statistics 8 and graphs were made using Excell computer software.

2.2 Soil Physico-chemical characteristics of selected sites for field experiments in different areas of the country

The soil sampling was done from sugarcane fields during 2019-2020 for the determination of macro and micronutrients and fertility status of different districts of Punjab, Sindh and KPK. The soil samples were taken from two relative depths (0-30 and 30-45cm) by auger for analysis through drying, grinding with wooden mortar and pestle, and then sieved. These samples were analyzed for soil texture, organic matter contents, electrical conductivity, chloride, pH, N, P, K, Fe, Zn, and B. Each site has its own variety. From each site the plant tissues (leaf blade and leaf sheath) were also collected for determination of nutritional impact. The presowing soil analysis report is presented in Table 5

Table 5 Soil Physico-chemical characteristics of selected sites for field experiments in different areas of the country

Location	Depth Cm	pH	EC (µS/cm)	OM (%)	N	P	K	B	$CaCO_3$ %	Ca+Mg	HCO_3	Cl
						mgkg^{-1}					meql^{-1}	
Tando Allah	0-30	7.25	383	0.55	1.07	1.26	224	0.26	28.7	2.7	1.67	1.00
Yar	30-45	7.3	353	0.69	0.94	1.44	192	0.15	25.3	2.0	2.33	1.00
Shahbaz	0-30	7.02	561	0.48	1.23	2.92	188	0.32	33.00	4.3	1.67	1.33
Kalay	30-45	7.00	290	0.69	0.99	1.40	164	0.32	30.00	1.7	1.00	1.00
Khan Mahi	0-30	7.08	267	0.97	0.84	3.25	122	0.09	28.7	2.7	1.00	1.00
Kalay	30-45	7.40	210	0.66	0.71	1.59	150	0.13	32.00	2.3	1.67	0.67
Ijaz Harnai	0-30	8.04	658	0.80	2.05	2.75	270	0.47	6.70	1.0	1.00	0.12
Baluchistan	30-45	8.08	59	1.10	2.81	1.66	200	0.52	6.20	1.0	1.30	0.11
Zareen	0-30	8.17	606	0.40	1.31	2.39	300	0.23	6.70	1.3	1.30	0.23
Harnai	30-45	8.11	602	0.23	1.21	2.23	285	0.21	6.30	1.03	1.21	0.12
Baluchistan												
Khnan pur	0-30	7.11	968	0.66	0.72	1.52	212	0.29	27.7	4.7	2.00	1.70
Res. Sub Stn,	30-45	7.14	647	0.52	0.67	3.65	212	0.27	27.00	3.00	2.00	1.00
AARI												
Usman Saqia	0-30	8.20	300	0.38	1.39	6.34	202	0.28	22.0	3.12	30.7	0.53
Chak 13B	30-45	8.43	450	0.42	1.23	1.45	110	0.15	19.2	1.20	35.8	1.32
Sargodha												
	0-30	8.4	256	0.45	1.62	0.89	164	1.33	8.5	4.3	1.43	1.33

Mustfa Shaheed Benazirabad	30-45	8.3	437	0.52	1.33	1.42	198	1.02	9.6	4.6	2.62	1.12
Thaibo area	0-30	8.20	1.03	0.41	3.81	2.87	564	15.00	2.00	10.00	2.00	10.00
Hyderabad	30-45	8.21	1.24	0.39	2.81	7.39	276	16.67	2.00	4.33	2.00	4.33
Zulfiqar	0-30	7.41	373	0.46	1.23	1.32	214	0.25	27.2	3.30	1.67	1.06
Bhawalpur	30-45	7.23	324	0.70	10.82	1.27	179	0.19	18.3	1.10	2.42	1.23
Sajid	0-30	7.3	321	0.34	1.24	2.32	167	0.26	27	2.7	1.36	1.25
Shaheed Benazir Abad	30-45	7.14	284	0.23	0.81	1.19	155	0.24	24	1.6	1.16	1.23
Toru	0-30	7.01	461	049	1.245	2.32	178	0.22	23.0	2.3	1.36	1.23
Mardan	30-45	7.14	280	0.39	0.77	1.20	144	0.12	23.2	1.6	1.07	1.20

3 RESULTS OF FIELD EXPERIMENTATION

3.1 Suagarcane Growth Yield and Quality Characteristics as influenced by Potash, Zn, Fe, B and Biozote at Sargodha (Punjab)

The experiements performed on farmer field at Sargodha (Table 5) showed that the soil application of organic and inorganic fertilizer combinations significantly (P≤ 0.05) improved growth, yield and quality characteristics of suagarcane. Yield and quality parameter recorded at this site revealed that the highest cane yield (1083.95 mounds acre^{-1}), cane girth (9.71 cm) and cane height (236.63 cm) were recorded NPK+Fe compared to minimum in NP (farmer practice) i.e., 941.86 mounds acre^{-1}, 8.53 cm and 205.12 cm showing a resultant increase of 15%, 13.9% and 15.4% over NP applied. Similarly, Zn and B also produced 13.4 and 14.6%, 13 and 11.8% and 13.3 and 14% in cane yield, cane girth and cane height respectively, over NP. The soil applied biozote improved cane yield, cane height and cane grith that were statistically at par to different chemical fertilizers treatments. In case of cane quality to the applied treatments; brix contents increased by 12.6% over NP with applied NPK+B and NPK+Fe. Polarity, sugar recovery and purity of cane improved by 17.8%, 15% and 12% with NPK+B treatment over NP. The quality characteristics like brix (18.6%), polarity (14.88%), purity (86.02%) and sugar recovery (8.17%) recorded for N+P+Biozote which were statistically similar to the soil applied K, Fe, Zn and B addition.

Table 6 Sugarcane yield and quality traits as affected by Potash, Zn, Fe, B and Biozote under field conditions on farmer field at Sargodha (Punjab)

Treatments	cane # acre^{-1}	Caneyield (mds acre^{-1})	Cane Girth (cm)	Cane Height (cm)	Brix (%)	POL (%)	Purity (%)	Recover y (%)
NP+Biozote	56952.0a	1064.60a	9.54a	235.27a	18.6ab	14.88a	86.02a	8.17a
NP	52117.8b	941.86b	8.53b	205.12b	16.87b	13.20b	77.64b	7.34b
NPK	56899.2a	1063.16a	9.49a	225.60a	18.76a	15.03a	85.58a	8.28a
NPK+Zn	57147.6a	1067.91a	9.65a	232.57a	18.92a	15.27a	87.03a	8.19a
NPK+Fe	57394.9a	1083.95a	9.71a	236.63a	19.00a	15.32a	86.24a	8.21a
NPK+B	57258.6a	1079.49a	9.54a	233.91a	19.00a	15.55a	86.98a	8.46a
CV	NS	3.22	3.22	4.61	NS	4.69	2.50	2.69
LSD	---	61.56	0.55	9.14	---	1.26	3.85	0.39

Nutrient Composition of Suagarcane Leaf Tissues as Affected by K, Fe, Zn and B application at farmer field, Sargodha

The data presented in Table 6 revealed that the macro and micronutrients in composition of leaf tissues (leaf blade & sheath) improved with the applied potash and micronutrients under field conditions. Their concentration was improved by applying foliar sprays of Zn, Fe and B. The N contents in leaf blade ranged from 1.25 to 1.69 % and 0.71 to 0.84% in leaf sheath. The P content in leaf blade was ranged from 0. 18 to 0.29 % and in sheath ranged from 0.12 to 0.15 % while, K contents were ranged1.64 to 1.84 % in leaf blade and 1.04 to 1.96 % in leaf sheath. The Fe concentration recorded in leaf blade was 228.64 to 450.04 mg kg^{-1} while, low concentration was recorded in leaf sheath. All the macro and micronutrients application showed an increasing trend in leaf blade and sheath. The B concentration was recorded as adequate with the application of potash and foliar sprays of micronutrients, which ranged from 21.09 to 26.74 mg kg^{-1} in leaf blade and 18.90 to 21.70 mg kg^{-1} in leaf sheath.

Table 7 Macro and micro-Nutrients concentration of sugarcane leaf as affected by Potash, Zn, Fe, B and Biozote on farmer field at Sargodha (Punjab)

Treatments	N Content (g/100g)		P Content (g/100g)		K Content (g/100g)		Zn Content (mg/kg)		Fe Content (mg/kg)		B Contents (mg/kg)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP + Biozot	1.38	0.77	0.29	0.14	1.76	1.36	22.2	20.12	277.8	223.9	21.09	19.17
NP	1.25	0.71	0.18	0.12	1.68	1.04	76.9	35.84	228.6	210.2	21.09	17.88
NPK	1.53	0.82	0.21	0.15	1.72	1.52	86.4	33.92	350.5	313.9	25.85	18.90
NPK+Zn	1.69	0.79	0.25	0.15	1.64	1.96	91.3	62.2	346.6	300.4	22.82	20.43
NPK+Fe	1.57	0.84	0.25	0.14	1.84	1.44	60.4	50.48	450.0	410.7	22.82	21.43
NPK+B	1.60	0.82	0.24	0.15	1.80	1.12	58.2	41.8	367.1	342.3	26.74	21.70

Suagarcane Yield and Quality Traits as affected by Potash, Zn, Fe and B on Mustafa farm at Shaheed Benazirabad (Sindh)

Data regarding suagarcane growth, yield and quality attributes at Shaheed Benazirabad (Table 6) revealed that cane girth, cane height and cane yield recorded were 7.6 cm, 272.1 cm, and 1122.5 mounds $acre^{-1}$ in farmer oractice which effectively increased to 9 cm, 313.5 cm and 1332.8 mounds $acre^{-1}$ in treatments applied as NPK+B, NPK+Fe and NPK+Fe with the relative increase of 18.4%, 15.2% and 18.7% over farmer practice respectively. The other treatments NPK, NPK+Zn, NPK+B also remarkably increased cane height by 12.2%, 13.3% and 12.6% while cane yield by 15.3%, 17.9% and 17.5% compared to control. In response to the different treatments applied Brix, Pol and purity the maximum increase was recorded 4.8%, 13.9% and 16.6% with NPK+Zn over NP (farmer practice). As a result, the sugar recovery was improved up to 16% in response to the soil applied NPK+Fe while NPK, NPK+Zn and NPK+B showed 14.45%, 15.55% and 15.31% higher sugar recovery than that of NP (farmer practice).

Nutrient Composition of Suagarcane Leaf Tissues as Affected by Potash, Fe, Zn and B on Mustafa farm at Shaheed Benazirabad

The data (Table 8) revealed that the macro and micronutrients composition of leaf tissues (leaf blade and sheath) was affected with the use of potash and micronutrients under field conditions. Their concentration was improved by applying foliar sprays of Zn, Fe and B. The N contents in leaf blade ranged from 1.04 to 1.49 % and 0.75 to 0.83% in leaf sheath. The P content in leaf blade ranged from 0.11 to 0.14 % and in sheath it ranged from 0.12 to 0.19 %

while K content was 1.96 to 2.24 % in leaf blade and 1.40 to 2.56 % in leaf sheath. The Fe concentration in leaf blade recorded was 161.20 to 423.88 mg kg^{-1} while, its concentration was low in leaf sheath 216.12 to 386.16. The B concentration was adequate with the application of potash and foliar sprays of micronutrients, it ranged from 24.78 to 29.43 mg kg^{-1} in leaf blade and 19.22 to 25.59 mg kg^{-1} in leaf sheath.

Table 8 Sugarcane yield and quality traits as affected by Potash, Zn, Fe and B on farmer field at Mustfa farm Shaheed Benazirabad (Sindh).

Treatments	canes # $acre^{-1}$	Cane yield (mnds $acre^{-1}$)	Cane Girth (cm)	Cane Height (cm)	Brix (%)	POL (%)	Purity (%)	Recovery (%)
NP	51577.3b	1122.5b	7.6b	272.1b	18.9b	15.8b	74.4b	9.0b
NPK	58039.7a	1295.1a	8.7ab	305.4a	21.4ab	17.6ab	82.9a	10.3a
NPK+Zn	58411.3a	1323.9a	8.9a	308.4a	21.7a	18.0a	86.8a	10.4a
NPK+Fe	58064.6a	1332.8a	8.8ab	313.5a	21.6a	17.9a	88.5a	10.4a
NPK+B	57028.8a	1319.0a	9.0a	306.4a	21.4ab	17.9a	84.8a	10.4a
CV	12.38	4.51	NS	4.32	NS	NS	4.64	5.21
LSD	2537.9	108.48	---	24.48	----	---	7.29	0.98

Table 9 Macro and micro-Nutrients concentration of sugarcane leaf as affected by Potash, Zn, Fe and B on Mustafa farm at Shaheed Benazirabad (Sindh)

Treatments	N Content (g/100g)		P Content (g/100g)		K Content (g/100g)		Zn Content (mg/kg)		Fe Content (mg/kg)		B Contents (mg/kg)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP	1.14	0.75	0.14	0.12	2.22	1.64	34.2	18.4	238.04	216.1	24.78	23.36
NPK	1.18	0.83	0.11	0.14	2.24	1.64	10.2	43.48	270.64	238.28	24.81	19.23
NPK+Zn	1.49	0.81	0.10	0.13	1.96	1.40	89.08	52.2	310.04	297.12	29.43	20.61
NPK+Fe	1.45	0.79	0.13	0.13	2.18	1.72	67.28	43.68	423.88	386.16	28.63	25.59
NPK+B	1.30	0.81	0.14	0.19	2.24	2.56	24.64	26.28	161.2	266.76	29.43	22.43

Suagarcane Yield and Quality Traits as affected by Potash, Zn, Fe and B on farmer field at Thaibo area, Hyderbad

Results regarding sugarcane growth, yield and cane quality at district Hyderabad presented in Table 9 indicated that maximum cane height (247.8 cm) was observed in NPK+ micronutrients application compared to that of minimum recorded in NP treatment (217.03 cm) while cane girth of 8.81 cm was recorded in NPK+Zn treatment as compared to NP treatment (7.68cm). Similarly, the highest cane yield (1059.24 mounds $acre^{-1}$) was obtained from NPK+ Zn treatment and the lowest (926.7 mounds $acre^{-1}$) from NP treatment. The resultant increase in the respective treatments over NP (farmer practice) in cane height, girth and cane yield was 14.2%, 14.69% and 14.3%. Among different treatments effect on cane quality soil application of NPK+ foliar Fe resulted in 12.7% and 16.13% increase in brix contents and polarity respectively over the farmer practice while the sugar recovery and juice purity was 4.8% and 16.7% increase was recorded with the combine application of NPK+ Zn. Soil application NPK and foliar B also produced better quality of cane and was statistically at par to the Zn and Fe combined with K.

Table 10 Sugarcane yield and quality traits as affected by Potash, Zn, Fe and B on farmer field at Thaibo area Hyderabad (Sindh)

Treatment	Cane No acre^{-1}	Cane yield (mnds acre^{-1})	Cane Girth (cm)	Cane Height (cm)	Brix (%)	POL (%)	Purity (%)	Recovery (%)
NP	49940.19b	926.73b	7.68b	217.03b	18.50a	15.74b	75.20b	9.37b
NPK	56133.26a	1039.43a	8.54ab	243.22a	20.33a	18.07a	87.24a	10.48a
NPK+Zn	57048.61a	1059.24a	8.81a	247.89a	20.83a	18.19a	87.81a	10.76a
NPK+Fe	56558.2a	1056.72a	8.75a	247.89a	20.86a	18.28a	86.43a	10.61a
NPK+B	56250.79a	1050.69a	8.72a	247.76a	20.60a	18.25a	85.04a	10.71a
CV	--	4.03	--	--	--	--	3.03	5.04
LSD	NS	77.92	NS	NS	NS	NS	4.80	0.98

Nutrient Composition of Suagarcane Leaf Tissues as Affected by Potash, Fe, Zn and B on farmer field at Thaibo area Hyderabad

The potash and micronutrients composition of sugarcane plant tissue indicated that the N contents of leaf blade ranged between 1.23 to 1.85 mgkg^{-1} and in sheath from 0.75 to 0.90 mgkg^{-1}. The phosphorus contents of leaf blade varied from 0.10 to 0.17 mgkg^{-1} and in sheath its concentration ranged between 0.09 to 0.24 mgkg^{-1} while, K contents ranged between 1.6 to 1.88 mgkg^{-1} and 2.6 to 3.32 mgkg^{-1} in leaf blade and leaf sheath respectively. Similarly, P contents were rcorded were higher in NPK+Zn and NPK+B (0.17%) in leaf blade while in leaf sheath as 1.88 % in soil treated NPK. In case of K contents, the values varied between 1.6 to 2% and 2.6 to 3.32% in leaf blade and leaf sheath showing the highest values recorded in NPK+Fe and NPK+B respectively. The Zn, Fe and B contents in leaf blade and leaf sheath ranged between 41.56 to 67.36 mgkg^{-1} and 17.32 to 48.6 mgkg^{-1}, 300.64 to 449.56 mg kg^{-1} and 297.76 to 566.52 mg kg^{-1} and 18.25 to 32.19 mg kg^{-1} and 14.5 to 24.19 mg kg^{-1} dsiplaying the highest values recorded in the treatments like NPK+Zn, NPK+Fe and NPK+B treatemnts respectively compared to control.

Table 11 Macro and micro-Nutrients Composition of sugarcane leaf as affected by Potash, ZN, Fe and B on farmer field at Thaibo area, Hyderabad (Sindh)

Treatment	N Content (g/100g)		P Content (g/100g)		K Content (g/100g)		Zn Content (mg/kg)		Fe Content (mg/kg)		B Contents (mg/kg)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP	1.41	0.75	0.10	0.09	1.60	3.12	41.56	20.64	300.64	297.7	18.24	14.50
NPK	1.23	0.90	0.13	0.11	1.88	2.68	56.88	32.88	395.2	363.2	24.66	19.23
NPK+Zn	1.84	0.88	0.17	0.10	1.72	2.6	67.36	37.12	359.32	341.6	27.42	21.15
NPK +Fe	1.85	0.80	0.15	0.11	2.00	2.92	52.12	17.32	449.56	442.7	23.56	21.15
NPK +B	1.60	0.83	0.17	0.24	1.72	3.32	39.00	48.60	302.04	390.1	32.18	24.18

Suagarcane Growth Yield and Quality Characteristics of sugarcane as influenced by Potash, Zn, Fe, Biozot, Fungicide and Humic acid on farmer field at Bahawalpur

Data recoded at Bahawalpur for growth yield and quality characteristics of sugarcane indicated that cane height, girth, yield and quality parameters improved with the application of potash, micronutrients, Humic acid, Biozote and fungicide over NP treatment. Plant

population (number of millable canes) were maximum 51704 in NPK+micronutrient teatments followed by NP+Biozote (50037.5) whereas, the plant height was maximum (251cm) in NP+Humic Acid treatment followed by NP+Biozote (249 cm) as compared to NP (212cm) (Table 11). Similarly, the maximum cane girth (10.2cm) was observed in canes harvested from micronutrient application plot as compared to NP (8.6 cm). The highest cane yield (1238.6 mounds acre^{-1}) was obtained from applied NP+ Humic Acid treated plot which is 23% more than that of NP treatment (1006.5 mounds acre^{-1}). The cane yield also increased by 18%, 20%, 19.8% and 19% by the soil application of NPK, NPK+fungicides, NPK+ Fe+Zn+B and NP+Biozote respectively. The cane quality characteristics; brix, polarity and sugar recovery were improved effectively in all treatments however, the highest relative increase rcorded was 11.6%, 11.3% and 12% respectively in combine applied NPK+Fe+Zn+B followed by 10.5%, 8.1% and 8.2% relative increase by NPK+Fe+Zn+B+Hot Water treat-fungicide treatment over NP (farmer practice).

Nutrient Composition of Suagarcane Leaf Tissues as Affected by Organic and Inorganic Fertilization

The data presented in Table 12 indicated that the N contents in leaf blade ranged between 1.13 to 2.26% and 0.78 to 0.89 % in leaf sheath respectively. The application of K and micronutrients in combination with hotwater+fungicide treatment showed a slight increase in N contents over NP treatment. The P contents in leaf blade varied between 0.21 to 0.32% and 0.13 to 0.19% in leaf sheath while, K contents ranged from 2.0 to 2.44% and 2.06 to 2.92% in leaf blade and sheath respectively. The higher values for the P and K contents were recorded in NPK+micronutrients and NPK in leaf blade whereas, in NPK in leaf sheath showed that P and K contents increased by the application NPK and micronutrients. The Zn concentration noted ranged from 24.12 to 35.36 mgkg^{-1} in leaf blade and 15.8 to 28.2 mg kg^{-1} in leaf sheath. The Fe contents in leaf blade ranged from 24.4 to 344.48 mg kg^{-1} and 38.12 to 164.96 mg kg^{-1} in leaf sheath. Similarly, B varied between 22.86 to 28.55 mg kg^{-1} in leaf blade and 18.67 to 32.52 mg kg^{-1} in leaf sheath. The micronutrients concentration in leaf blade and leaf sheath showed that the Zn was higher in NPK+micronutrients and NPK+micronutrients and hotwater+fungicide treatement while Fe and B improved in NPK+micronutrient treatments

Suagarcane Yield and Quality Characteristics as influenced by Potash, Zn, Fe, Biozot, Fungicide and Humic acid at Khanpur

The results regarding growth, cane yield and quality attributes of sugarcane showed that the applied treatments significantly (P≤ 0.05) increased all the characteristics at Khanpur Punjab (Table 13). Results also indicated the maximum cane height (228 cm) and cane girth (6.5 cm) were recoded in the soil applied NPK+micronutrients treatment with the relative increase of 12.3% and 6.2% over control. The highest cane yield was recorded (1054.5 mounds sacre^{-1}) in soil applied NPK+ Humic acid compared to control (909.9 mounds acre^{-1}) which was 12.3% higher than that of control. Maximum number of canes (51865 acre^{-1}) were recorded in NPK over control (48491.7 acre^{-1}). Similarly, cane quality charachteristics i.e. brix contents, polarity and sugar recovery were also improved positively by 8.4%, 9.7% and 8.2% respectively in the soil applied NPK+micronutrients over the control treatment. The application of NPK + micronutrients along with hot water and fungicide treartment also showed improvement in brix, POL and sugar recovery as 8.3%, 7.04% and 5.4% respectively over NP.

Table 12 Sugarcane yield and quality traits as affected by Potash, Zn, Fe, B, Humic acid, Biozote and Fungicide on farmer field at Bhawalpur (Punjab)

Treatment	Cane No acre^{-1}	Cane yield (mnds acre^{-1})	Cane Girth (cm)	Cane Height (cm)	Brix (%)	POL (%)	Purity (%)	Recovery (%)
NP	42731.4c	1006.5b	8.6bcd	212.8b	17.1a	14.4a	80.9a	8.7b
NPK	48336.7b	1196.1a	8.9abc	217.8b	17.9a	15.4a	85.1a	9.4ab
NPK+Zn+Fe+B	51704.3	1205.8a	9.4ab	247.5a	19.0a	16.1a	88.1a	9.7a
NP+H Acid	49454.6ab	1238.6a	8.3cd	251.6a	18.4a	15.1a	83.2aa	9.2ab
NPK+Biozote	50037.5ab	1198.8a	8.1d	249.0a	17.4a	14.8a	83.5a	9.2ab
NPK+Hot H_2O +Fungicide	41733.8c	1217. 8a	9.5a	202.2b	18.9a	15.6a	83.2a	9.4ab
CV	2.92	4.48	5.04	6.79	NS	NS	NS	NS
LSD	2515.6	95.89	0.80	28.42	---	---	---	---

Table 13 Macro and micro-Nutrients concentration of sugarcane leaf as affected by Potash, Zn, Fe, B, Humic acid, Biozote and Fungicide on farmer field at Bhawalpur (Punjab)

Treatments	N Content (g/100g)		P Content (g/100g)		K Content (g/100g)		Zn Content (mg/kg)		Fe Content (mg/kg)		B Contents (mg/kg)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP	1.13	0.78	0.21	0.17	2	2.06	28.8	27.52	24.4	38.1	24.03	18.95
NPK	1.24	0.81	0.24	0.19	2.44	2.92	25.4	26.76	36.64	39.1	24.59	20.95
NPK+ Zn+Fe+B	1.54	0.83	0.32	0.14	2.16	2.72	35.36	28.24	320.8	143.0	28.55	22.67
NP+H Acid	1.45	0.85	0.25	0.14	2.28	2.88	24.12	19.04	307.08	123.8	22.86	18.67
NP+Biozote	2.20	0.88	0.23	0.13	2.30	2.44	20	15.84	324.48	157.2	24.07	20.33
NPK+HWT+ Fungicide	2.26	0.89	0.27	0.19	2.24	2.86	23.32	20.92	344.48	164.9	23.64	32.52

Nutrient Composition of Suagarcane Leaf as Affected by Conjugative use of Organic and Inorganic Fertilizer

The data presented in Table 14 indicated that the macro and micronutrients composition of leaf blade and leaf sheath improved with the application of potash, micronutrient, Humic acid, biozote and fungicide at AARI Sub station farm Khanpur (Punjab). The N contents ranged from 1.09 to 1.69 % and 0.72 to 0.91 % in leaf blade and leaf sheath respectively. The P contents in leaf blade ranged from 0.10 to 0.26 % and 0.10 to 0.19 % in leaf sheath, while K contents ranged from 1.12 to 1.32 % in leaf blade and 2.09 to 2.76 % in sheath. It was noted that macronutrients N, P and K concentration was more in leaf blade as compared to leaf sheath. The Zn concentration ranged from 19.88 to 55.2 mgkg^{-1} in leaf blade and 19.68 to 49.64 mg kg^{-1} in leaf sheath. The recorded Fe in leaf blade ranged from 316.96 to 499.04 mg kg^{-1} and 237. 08 to 337.08 mg kg^{-1} in leaf sheath. The B was ranged from 22.38 to 39.87 mg kg^{-1} in leaf blade and 19.22 to 20.88 mg kg^{-1} in leaf sheath.

Table 14 Sugarcane yield and quality traits as affected by Potash, Zn, Fe, B, Humic acid, Biozote and Fungicide on AARI sub station Farm Khanpur

Treatments	Cane No acre^{-1}	Cane yield (mnds acre^{-1})	CaneGirth (cm)	Cane Height (cm)	Brix (%)	POL (%)	Purity (%)	Recovery (%)
NP	48491a	909.9c	4.5d	203.2b	19.8a	16.3a	80.8a	9.9a
NPK	51865a	1026.3ab	5.2c	208.5b	20.8a	17.6a	86.1a	10.4a
NPK+Zn+Fe+B	51021a	1047.8a	6.5a	228.5a	21.5a	17.9a	86.3a	10.7a
NP+Humic Acid	51443a	1054.5a	6.3ab	210.8ab	20.5a	16.8a	83.6a	10.6a
NPBiozote	48070a	985.8b	5.9b	213.8ab	20.6a	16.7a	84.3a	10.2a
NPK+Fungicide	48913a	1038.1ab	6.1ab	198.5b	21.5a	17.4a	83.8a	10.5a
CV	NS	2.94	4.87	NS	NS	NS	NS	NS
LSD	---	54.08	0.51	---	---	---	---	---

Table 15 Macro and micro-Nutrients composition of sugarcane leaf as affected by Potash, Zn, Fe, B, Humic acid, Biozote and Fungicide on farmer field at AARI Khanpur

Treatment	N Content (g/100g)		P Content (%)		K Content (g/100g)		Zn Content (mg/kg)		Fe Content (mg/kg)		B Contents (mg/kg)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP	1.19	0.77	0.14	0.10	2.12	2.09	42.84	36.48	316.96	326.1	22.38	19.22
NPK	1.21	0.72	0.12	0.11	2.4	2.76	45.2	19.68	347.92	320.9	36.07	20.88
NPK+(Zn+Fe+B)	1.69	0.91	0.10	0.16	2.32	2.24	55.2	35.64	445.8	333.8	39.87	20.88
NPK+H. Acid	1.09	0.88	0.22	0.16	2.2	2.22	30.96	39.64	415.08	237.1	36.87	20.05
NP+ Biozote	1.30	0.80	0.23	0.14	2.16	2.38	19.88	39	499.04	306.9	34.00	20.88
NPK+Fungi.	1.20	0.87	0.26	0.19	2.2	2.46	29	49.64	450	314.7	32.00	20.60

Suagarcane Growth Yield and Quality Characteristics of sugarcane as affected by K, Zn, Fe, B, Humic Acid, Biozote, BCl and Fungicide at Shaheed Benazirabad (Sindh)

Effect of different treatments on sugarcane under field conditions at Shaheed Benazirabad, Sindh, significantly differed (P≤ 0.05) for growth and yield attributes of sugarcane (Table 15). Results revealed that maximum number of canes (58089) were observed in NPK+ Fungicides as compared to NP (49909). The lowest cane height was measured (257.7 cm) in NP treatment (farmer practice) which increased to 311.7 cm in soil amended with NPK+ Humic Acid treatment followed by NPK+ micronutrients (310cm). The cane girth was 8.5 cm in soil applied NP that improved to highest in NPK+fungicide (9.6cm) followed by NPK and NPK+ micronutrient (9.2 cm). The resultant increase in cane height was 20.9% and 20.3% while in cane girth was 13.6% and 9.3% over NP treatment. Similarly, cane yield was 1322.2 mounds in NPK+ micronutrient and 1317.3 mounds acre^{-1} in NPK+ Humic acid treatment as compared to 1062 mounds acre^{-1} in NP (control) treatment which was 24.4%, 24% and 23% higher with respect to the NP treatment. Although, data for quality attributes was found nonsignificant for polarity however, it increased by 9.5% in NPK +fungicide treatment while sugar recovery, brix content and purity was improved 17%, 6.3% and 4.2 % in soil applied NPK+ micronutrients over the NP treatment. The soil inoculation with biozote and BCl-bacterial inoculants also showed 11.2% and 9.2% in cane height, 18.5% and 20.8% increase in cane yield while 2.2% and 3.7%, 2% and 9.9% and 6.17%, 10.7% increase in brix contents, polarity and sugar

recovery respectively over NP practice. Results indicated that use of K could enhance growth, yield and cane quality which could be further improved by the soil applied micronutrients and humic acid.

Table 16 Sugarcane yield and quality traits as affected by K, Zn, Fe, B, H. Acid, Biozote, BCl and Fungicide on farmer field at Sajid Farm Shaheed Benazir Abad (Sindh)

Treatments	canes No acre^{-1}	Cane yield (mds acre^{-1})	Cane Girth (cm)	Cane Height (cm)	Brix (%)	POL(%)	Purity (%)	Recov. (%)
NP+Fungicide	56682.4a	1289.1a	9.6a	295.0ab	21.4a	19.3	86.1a	11.3a
NP	49909.8b	1062.1b	8.5c	257.7c	20.6a	17.6	84.9a	10.2a
NPK	58089.0a	1307.8a	9.2ab	296.2ab	21.5a	18.9	87.5a	11.8a
NPK+Zn+Fe+B	55327.2a	1322.2a	9.2b	310.2a	21.9a	19.1	88.5a	12.0a
NPK+H Acid	56626.1a	1317.3a	9.1b	311.7a	21.5a	18.4	86.6a	11.0a
NP+Biozote	55300.8a	1258.6a	8.6c	286.5ab	20.9a	18.1	86.3a	10.6a
NPK+BCl	58000.3a	1283.5a	8.6c	281.4bc	21.1a	17.9	86.0a	10.9a
CV	3.64	2.93	2.73	5.21	NS		NS	NS
LSD	3607.4	65.74	0.43	26.97	---		---	---

Nutrient Composition of Suagarcane Leaf as Affected by Organic and Inorganic Fertilizer use

The data (Table 16) revealed that the macro and micronutrients composition of leaf (blade and sheath) was affected with the use of potash and micronutrients, Humic acid, Biozote, BCl and Fungicide under field conditions at Sajid farm Shaheed Benazir Abad (Sindh). Their concentration was improved by applying foliar sprays of Zn, Fe and B. The N contents in leaf blade ranged from 1.14 to 1.51 % and 0.79 to 0.89% in leaf sheath. The P content in leaf blade was ranged from 0.14 to 0.18 % and in sheath it ranged from 0.03 to 0.13 % while K contents ranged from 1.68 to 2.56 % in leaf blade and 2.20 to 2.56 % in leaf sheath. The recorded Fe concentration in leaf blade was 220.32 to 356.68 mg kg^{-1} while, low concentration was recorded in leaf sheath 179.44 to 328.00 mg kg^{-1}. The B concentration was recorded as adequate with the application of potash and foliar sprays of micronutrients, in leaf blade it ranged from 23.02 to 29.60 mg kg^{-1} and 19.78 to 44.38 mg kg^{-1} in leaf sheath.

Suagarcane Growth Yield and Quality Traits as Affected by Potash, Zinc, Iron, Boron, Humic acid, Biozote and Tricoderma at Touru, Mardan (KPK)

The results of the experiments conduced at Touru Mardan (KPK) site (Table 17) showed that millable canes acre^{-1}, cane height, cane girth and cane yield were positively affected by different treatments applied. The minimum millable canes acre^{-1}, cane height, girth and yield recorded were 37100, 214.42 cm, 7.14 cm and 722.6 mounds acre^{-1} in NP treatment which were significantly (P≤ 0.05) increased to the maximum of 41374, 247.49 cm, 8.15 cm and 859.53 mounds acre^{-1} by the use of K in combination with micronutrients as NPK+Fe+Zn+B displaying relative increase of 11.52%, 15.43%, 14.13% and 18.95% respectively over NP. In case of K use in combination with humic acid and bioinoculants i.e. biozote and trichoderma also resulted in an increase of 11%, 10% and 10% in number of millable canes, 12%, 11.4% and 11.3% in cane height, 11.8%, 12% and 10.3% in cane girth and 17.9%, 12.4% and 11.9% in cane yield acre^{-1} over NP. In case of sugarcane quality characteristics, use of K with NP showed 12%, 15%, 12.5% and 11.6% higher brix contents, polarity, percent purity and sugar

recovery over NP treatment. These characteritics further improved showing 13.72%, 18.7%, 13.8% and 16.24% increase respectively over NP (farmer practice). Althugh, bioinoculants i.e. biozote and trichoderm showed better results however, it was found that the use of K alone and in combination with micronutrients and humic acid effectively improved sugarcane growth, yield and cane quality among different treatments used.

Table 17 Macro and micro-Nutrients concentration of sugarcane leaf as affected by Organic and inorganic fertilizers on Sajid farm at Shaheed Benazir Abad

Treatment	N Content (g/100g)		P Content (g/100g)		K Content (g/100g)		Zn Content (mg/kg)		Fe Content (mg/k\g)		B Contents (mg/kg)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP+Fungi.	1.36	0.84	0.17	0.03	2.20	2.52	31.84	33.28	300.28	179.4	25.22	19.78
NP	1.35	0.80	0.15	0.03	1.68	2.20	94.28	37.12	220.32	201.4	23.02	18.88
NPK	1.30	0.85	0.14	0.04	1.76	2.40	62.08	59.44	235.92	233.6	27.78	21.98
NPzK+Zn+Fe+B	1.40	0.79	0.16	0.05	1.72	2.56	57.72	31.36	356.68	328.4	29.60	26.66
NPK+H Acid	1.14	0.82	0.18	0.05	1.88	2.56	44.68	30.08	313.6	284.1	24.74	23.63
NPK+Biozot	1.29	0.89	0.14	0.04	1.76	2.20	37.68	32	299.24	223.3	23.37	44.38
NP+BCl	1.51	0.85	0.16	0.13	1.76	2.36	29	20.52	287.68	299.5	24.47	23.91

Table 18 Sugarcane yield and quality traits as affected by Potash, Zn, Fe, B, Humic acid, Biozote and Tricoderma on farmer field at Touru Mardan (KPK).

Treatments	canes No (acre^{-1}	Cane yield (mds acre^{-1})	Cane Girth (cm)	CaneHeight (cm)	Brix (%)	POL (%)	Purity (%)	Recovery (%)
NP	37100.1b	722.6c	7.1b	214.4b	14.7b	11.1b	78.7b	7.8b
NPK	40481.6a	832.5ab	8.0a	245.4a	16.4ab	12.8a	88.5a	8.7ab
NPK+Zn,Fe&B	41374.8a	859.5a	8.1a	247.5a	16.7a	13.2a	89.5a	9.1a
NPK+H Acid	41187.0a	851.6a	8.0a	240.2a	15.9ab	12.2ab	84.6ab	8.3ab
NPK+Biozote	40937.1a	812.3b	8.0a	238.8a	15.9ab	11.8ab	84.7ab	8.5ab
NP+Tricoder	40854.2a	809.3b	7.9ab	238.6a	15.7ab	11.9ab	83.9ab	8.3ab
CV	2.78	2.43	NS	4.51	NS	NS	NS	NS
LSD	2042.2	35.95	----	19.49	---	----	----	---

Nutrient Composition of Suagarcane Leaf as Affected by Combined use of Organic and Inorganic Fertilizers

The data presented in Table 18 showes nutrient composition of sugarcane plant in response to different treatments applied. Results showed that the N contents in leaf blade ranged from 1.34 to 1.80% and while in leaf sheath it varied between 0.69 to 0.91% with the higher values recorded in NPK+humic acid and NPK +micronutrients in leaf blade and leaf sheath respectively. The P contents varied between 0.25 to 0.53% and 0.19 to 0.39% in leaf blade and leaf sheath respectively showing a slight increase due the application of NP+Trichoderma inoculation. In case of K contents the vales ranged between 2.24 to 2.52% and 2.8 to 3.6% showing slightly higher vales in NPK+humic acid treatment. Micronutrient concentration in laef blade and leaf sheath showed that Zn ranged between 16.8 to 27.9% and 13.7 to 21.5%, Fe from 13.4 to 153.5% and 10.4 to 110.5% and B between 3.16 to 4.5 % and 3.0 to 3.23% in

leaf blade and sheath respectively. Among all the treatments higher values were recorded in the NPK+micronutrient applied treatments compared with all other treatment.

Suagarcane Growth Yield and Quality Characteristics as affected by Potash, Zn, Fe, B, Humic acid, and Biozote at Shahbaz Kalay, Mardan (KPK)

Results regarding sugarcane growth and yield (Table 19) showed that growth attributes like plant population, cane grirth, cane yield and quality characteristics including brix, polarity and sugar recovery were significantly (P≤ 0.05) affected by the treatments applied except cane height and purity during the study under field conditions at Shahabaz Kalay, Mardan KPK. Results revealed that the minimum milable canes (35467), cane yield (665.9 mounds acre^{-1}) and cane girth (7.13 cm) were recorded in control treatment (farmer practice) as compared to the maximum milable canes (40480) in soil applied NPK+Biozote while cane yield and cane girth i.e. 820.39 mounds acre^{-1} and 9.6 cm were recorded in NPK+Fe+Zn+B treated plots showing a relative increase of 14%, 23% and 34.7% respectively over NP. Also the application of potash (K) alone and combined with humic acid positively increased millable canes, cane yield and cane girth by 9-9.2%, 20.4-21.5% and 30-33.5% respectively compared to NP. Similarly, NPK+Biozote increased 22% and 23% higher cane yield and cane girth over farmer practice (contro). In case of cane quality characteristics detrmined i.e. brix, polarity and sugarc recovery were found maximum 21.74%, 34.17% and 10.92% respectively in response to the combine use of K and micronutrients showing 21.7%, 34% and 30.4% relative increase as compared to the farmer practice. The difference between K applied alone and in combination with micronutrients, humic acid and biozote was statistically at par with each other, however, use of micronutrients in combination with K as and Fe, Zn and B resulted in 4 and 3 percent increase in brix and sugar recovery compared to the sole K applied.

Table 19 Macro and Micro-Nutrients concentration of sugarcane leaf as affected by K, Zn, Fe, B, Humic acid, Biozote and Tricoderma at Touru Mardan (KPK).

Treatments	N Content (g/100g)		P Content (g/100g)		K Content (g/100g)		Zn Content (mg/kg)		Fe Content (mg/kg)		B Contents (mg/kg)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP	1.23	0.69	0.25	0.19	2.24	2.96	16.8	13.7	13.4	10.4	3.16	3.00
NPK	1.63	0.76	0.29	0.21	2.44		21.5	17.5	114.4	75.6	3.22	3.18
NPK+Zn+Fe+B	1.62	0.91	0.26	0.22	2.36	3.12	27.9	21.5	153.5	110.5	4.5	3.23
NPK+H Acid	1.80	0.74	0.46	0.25	2.52	3.60	25.5	20.0	120.5	83.5	3.22	3.18
NP+Biozote	1.59	0.72	0.47	0.28	2.32	2.8	25.6	19.6	98.5	56.5	3.23	3.19
NP+Tricoder	1.68	0.91	0.53	0.39	2.44	3.44	26.0	19.0	145.0	98.0	3.24	3.12

Table 20 Sugarcane yield and quality traits as affected by Potash, Zn, Fe, B, Humic acid, and Biozote on farmer field at Sahabaz Kalay Mardan (KPK).

Treatments	Canes No Acre^{-1}	Cane Yield Acre^{-1}	Cane Girth (cm)	Cane Heit (cm)	Brix (%)	POL (%)	Purity (%)	Recovery (%)
NP	35467.35	665.92	7.13	196.20	15.22	13.46	91.41	8.37
NPK	38751.52	802.07	9.32	216.07	17.79	17.10	93.73	10.59
NPK+Zn Fe B	39288.68	820.39	9.60	220.58	18.52	18.07	95.42	10.92
NP+Biozote	39180.00	812.43	8.77	216.83	17.84	17.15	92.37	10.63
NP+H Acid	39815.98	819.45	9.51	217.83	18.13	17.75	94.62	10.80
LSD P≤ 0.05	4085.1	85.19	1.97	NS	2.41	3.94	NS	2.43

Nutrient Composition of Suagarcane Leaf Tissues as Affected by Nutrients applied from Organic and Inorganic spources of Fertilizers

The nutrient contents in sugarcane diagnostic leaves clooected from Shahbaz Kalay, Mardan KPK, showed a slight increasing effct on nitrogen (N) contents with the K application to soil. The N contents ranged between 1.44 to 1.89 $mgkg^{-1}$ in leaf blade and 0.5 to 0.78 $mgkg^{-1}$ in sheath (Table 20). The P contents in leaf blade varied between 0.3 to 0.42 $mgkg^{-1}$ and 0.12 to 0.21 $mgkg^{-1}$ in sheath. Similarly, K contents ranged between 2.16 to 2.36 $mgkg^{-1}$ in blade and 2.72 to 2.96 mgkg-1 in sheath showing highest in the soil treated with NPK+Humic acid in leaf blade whereas, in NPK+micronutirents in leaf sheath respectively. The concentration of micronutrients affected with the applied potash and micronutrients. The micronutrients in leaf blade and leaf sheath showed that Zn contents ranged between 14.47 to 35.54 mg kg^{-1} and 12.48 to 32.48 mg kg^{-1} with the highest values recorded in NPK+micronutrients. In case of Fe the vales varied between 121.65 to 148.47 in leaf blade and 128.37 to 159.37 mg kg^{-1} with highest values recorded in NPK+micronutrients and NPK+humic acid applied soil for the leaf blade and leaf sheath respectively. The B concentration ranged between 3.11 to 3.22 $mgkg^{-1}$ in leaf blade and 3.09 to 3.23 $mgkg^{-1}$ in sheath with applied potash and micronutrients soil appliaction.

Table 21 Macro and micro-Nutrients concentration of sugarcane leaf as affected by Potash, Zn, Fe, B, Biozote and Humic Acid on farmer field at Shahabaz Kalay

Treatments	N Content (g $100g^{-1}$)		P Content (g $100g^{-1}$)		K Content (g/100g)		Zn Content (g $100g^{-1}$)		Fe Content (g $100g^{-1}$)		B Contents (g $100g^{-1}$)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP	1.77	0.64	0.36	0.14	2.16	2.72	14.47	12.48	121.6	128.4	3.16	3.09
NPK	1.77	0.50	0.38	0.14	2.24	2.88	32.47	25.47	141.6	146.5	3.11	3.11
NPK+Zn Fe B	1.89	0.63	0.38	0.12	2.28	2.96	35.54	32.48	148.4	157.7	3.16	3.11
NP+Biozot	1.89	0.72	0.39	0.17	2.32	2.88	35.38	27.48	143.4	157.4	3.20	3.23
NP+H Acid	1.44	0.78	0.42	0.21	2.36	2.84	35.48	24.47	145.6	159.4	3.22	3.23

Suagarcane Growth Yield and Quality Characteristics as affected by applied Macro and Micronutrients on farmer field at Khan Mahi, Charsadda (KPK)

The effect of different treatments applied to sugarcane under field conditions at Khan Mahi area of Charsadda to ratoon crop (Table 21) showed that cane yield, cane height, brix percentage and sugar recovery significantly ($P \leq 0.05$) improved with applied K and Micronutrients over farmer practice. Among different growth and quality characteristics, cane yield, cane height, brix and sugar recovery were found 625.9 mounds $acre^{-1}$, 221.4 cm, 14.69% and 8.01% which increased to 787.78 mounds $acre^{-1}$, 289.2 cm, 18.75% and 11.4% in soil applied mineral fertilizers as NPK+(Fe+Zn+B) with the relative increase of 25.85%, 30.6%, 27.64% and 42.6% respectively over control. The soil applied humic acid combined with K also produced better cane yield and quality. Soil application of humic acid in combination with K displayed 22.6%, 29.5%, 25.7% and 40.9% higher cane yield, cane height, brix and sugrar recovery respectively over NP (farmer practice). The overall results showed that application of micronutrients combined with K, produced highest yield and best quality cane among all treatments applied for ratoon sugarcane crop. Furthermore, the addition of micronutrient to applied K in combination with farmer practice showed 4.5%, 6.2% and 13.3% higher cane yield, brix and sugar recovery respectively compared to K combined with farmer practice.

Table 22 Sugarcane yield and quality traits as affected by Potash, Zn, Fe, B, Humic acid, on farmer field at Khan Mahi Kalay Charsadda (KPK).

Treatments	Canes # Acre^{-1}	Cane Yield Mds / acre	Cane Girth cm	Cane Heit cm	Brix %	POL %	Purity %	Recovery %
NP	39464.00	625.93	6.46	221.44	14.69	13.70	84.47	8.01
NPK	41734.93	753.40	7.87	285.56	18.47	17.11	85.74	10.07
NPK+ (Zn+Fe+B)	43159.42	787.78	8.23	289.20	18.75	18.17	85.66	11.42
NPK+H Acid	42344.47	767.20	8.11	286.71	18.47	17.66	88.06	11.28
LSD P≤ 0.05	NS	96.49	1.52	NS	4.1	4.29	NS	3.38

Nutrient Composition of Suagarcane Leaf as Affected by K, Micrnutrients and Humic Acid on farmer field at Khan Mahi, Charsadda

The data regarding nutrient contents in plant tissue of sugarcane treated with different amendments (Table 22) indicated that the N contents in leaf blade ranged between 1.46 to 1.83 mgkg^{-1} and 0.82 to 1.76 mgkg^{-1} in leaf sheath with the higher values in NP treatment at Khan Mahi site. In case of P content values varied between 0.27 to 0.56 mgkg^{-1} and 0.10 to 0.15 mgkg^{-1} with highest vale recorded in NP+humica acid and NPK+micronutrients in leaf blade and leaf sheath respectively. Similarly, K contents ranged between 2.12 to 2.28 mgkg^{-1} in leaf blade and in sheath ranged between 2.56 to 2.88 mgkg^{-1}. The Zn concentration was noted 32.5 to 40.5 mgkg^{-1} in leaf blade and 20.5 to 24.1 mgkg^{-1} in leaf sheath. The Fe in leaf blade was recorded between 168.5 to 183.7 mgkg^{-1} and 131.4 to 134.5 mgkg^{-1} in leaf sheath. The B ranged from 3.07 to 3.12 mgkg^{-1} in leaf blade and 3.08 to 3.21 mgkg^{-1} in sheath. The over all nutrient contents showed that the N ontent was higher in NP treatment, P contents in NPK+humic acid, K contents also in NPK+humic acid and NPK+micronutrients while micronutrients as NPK+ micronutrients treated soil.

Table 23 Macro and Micro-Nutrients concentration of sugarcane leaf as affected by Potash, Zn, Fe, B and Humic Acid on farmer field at Khan Mahi Charsadda (KPK)

Treatments	N Content (g/100g)		P Content (g/100g)		K Content (g/100g)		Zn Content (mg/kg)		Fe Content (mg/kg)		B Contents (mg/kg)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP	1.83	0.82	0.30	0.15	2.16	2.64	32.5	20.5	168.5	131.4	3.11	3.08
NPK	1.77	1.76	0.38	0.12	2.12	2.56	39.5	23.5	178.5	133.4	3.07	3.10
NPK+ Zn,Fe & B	1.46	0.89	0.27	0.15	2.16	2.88	40.5	24.5	183.4	134.5	3.12	3.11
NPK+ H Acid	1.83	0.59	0.56	0.10	2.28	2.68	38.5	24.1	183.7	133.5	3.10	3.21

Suagarcane Growth Yield and Quality Characteristics at Band Korai Dera Ismaeel Khan (KPK)

Data presented (Table 23) revealed that the treatments applied to the sugarcane crop under field conditions at Band Korai, Dera Ismaeel Khan KPK, significantly (P≤ 0.05) affected cane growth characteristics like milable canes, cane girth, cane height and cane yield. In farmer practice (NP) minimum millable canes were recorded i.e. 35526 which increased to maximum

40022.5 in NPK+biozote treated soil increasing by 12.6% compared to control. In case of cane yield and cane height use of K combined with micronutrients as NPK+(Fe+Zn+B) yielded the maximum 1234.5 mounds acre^{-1} and 260 cm compared to control 979.3 mounds acre^{-1} and 221.2 cm while cane girth was measured as 9.08 cm in K applied plot as compared to farmer practice (control) alone (7.32 cm). The relative increase due to use of NPK+(Fe+Zn+B) was recorded 26%, 17.6% and 24% over the respective control. The application of micronutrients over K increased 3.5% higher cane yield.

Table 24 Sugarcane yield as affected by Potash, Zn, Fe, B, Humic acid, Biozote and on farmer field at Band Korai, Dera Ismaeel Khan (KPK).

Treatments	Canes No. Acre^{-1}	Cane Yield Acre^{-1}	Cane Girth cm	Cane Heit cm
NP	35526.20	979.24	7.32	221.29
NPK	39586.59	1192.20	9.09	255.81
NPK+Fe, Zn & B	39742.44	1234.55	9.03	260.19
NPK+H Acid	39949.14	1211.53	9.09	258.10
NPK+Biozote	40022.47	1198.34	8.91	258.37
LSD P≤ 0.05	4028	49.06	1.72	16.67

Suagarcane Growth Yield and Quality Traits as affected by Potash, Zn, Fe, B and Humic Acid application on Farmer Field at Tando Allahyar (Sindh)

Effect of different treatments applied on farmer field at Tando Allah Yar to sugarcane ratoon crop under field conditions showed that cane height, girth and yield significantly (P≤ 0.05) improved by applied potash, micronutrients and humic acid as compared to NP treatment (farmer practice). The cane height, cane girth and cane yield recorded were maximum 280 cm, 8.9 cm and 1044.8 mounds acre^{-1} in NPK+ micronutrients application compared to control 223.8 cm, 7.7 cm and 900.5 mounds acre in NP traeatement. The relative increase in cane height, cane girth and cane yield due to the use of K and micronutrients in combination with NP was 25.33%, 15.4% and 16% over NP alone. The other treatments i.e. K use combination with NP and with humic acid howed 22.9% and 23.8%, 14.1% and 13.2% and 14.4% and 15% higher cane height, cane girth and cane yield compared to control. In case of the impact of applied treeatments to the cane quality, brix content, polarity, purity and sugar recovery were 8.2%, 7.2 %, 6.9%, 3.2% and 7% higher in NPK+micronutrients compared to the control while, NPK+humic acid resulted in 5.6%. 4%, 2.8% and 4.4% relative increase over NP treatment.

Table 25 Sugarcane yield and quality traits as affected by Potash, Zn, Fe, B and Humic Acid on farmer field at Tando Allah Yar (Sindh)

Treatments	Cane No acre^{-1}	Cane yield (mds/acre^{-})	Cane Girth (cm)	Cane Heit (cm)	Brix (%)	POL (%)	Purity (%)	Recovery (%)
NP	49464.9b	900.5b	7.7b	223.8b	20.1a	16.6a	84.2a	10.2a
NPK	55197.8a	1030.5a	8.8a	275.1a	21.5a	17.5a	86.2a	10.6a
NPK+Zn,Fe & B	56015.5a	1044.8a	8.9a	280.5a	21.8a	17.8a	86.9a	10.9a
NPK+H Acid	54472.2a	1036.1a	8.7a	277.1a	21.3a	17.3a	86.6a	10.5a
CV	2.26	1.16	1.35	3.82	NS	NS	NS	NS
LSD	2426.9	32.33	0.23	20.16	---	---	---	---

Nutrient Composition of Suagarcane Leaf as Affected by Potash, Zn, Fe, B and Humic Acid on Farmer field at Tendo Allayar

The data presented in Table 25 indicated that the N contents in leaf blade ranged from 0.95 to 1.25 % and 0.74 to 0.81 % in leaf sheath at Tando Allah Yar (Sindh). The application of K and micronutrients showed a slight N increase over NP treatment. The P contents were ranged from 0.10 to 0.21 % and 0.05 to 0.14 % in leaf blade and leaf sheath, respectively while K contents ranged from 1.28 to 1.96 % in leaf blade and 1.60 to 2.04 % in leaf sheath. The macronutrients N, P and K concentration was more in leaf blade as compared to leaf sheath. The Zn concentration was ranged from 17.32 to 74.28 mgkg^{-1} in leaf blade and 33.04 to 69.00 mg kg^{-1} in leaf sheath. The Fe in leaf blade ranged from 223.92 to 452.96 mgkg^{-1} and 214.52 to 350.04 mg kg^{-1} in leaf sheath. The B was ranged from 19.9 to 29. 4 mg kg^{-1} in leaf blade and 16.3 to 25.5 mg kg^{-1} in leaf sheath.

Table 26 Macro and micro-Nutrients concentration of sugarcane leaf as affected by Potash, Zn, Fe, B and Humic Acid on farmer field at Tando Allah Yar (Sindh)

Treatments	N Content (g/100g)		P Content (g/100g)		K Content (g/100g)		Zn Content (mg/kg)		Fe Content (mg/kg)		B Contents (mg/kg)	
	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf blade	Leaf sheath	Leaf Blade	Leaf Sheath	Leaf Blade	Leaf sheath	Leaf Blade	Leaf sheath
NP	0.95	0.80	0.10	0.05	1.28	1.24	17.32	33.04	223.9	214.5	19.9	13.6
NPK	1.18	0.79	0.15	0.10	1.88	1.56	25.04	34.32	230.7	235.4	24.1	20.9
NPK+Zn,Fe B	1.25	0.81	0.16	0.14	1.88	1.48	74.28	69.00	452.9	350.0	29.4	25.5
NPK+H.Acid	1.11	0.74	0.21	0.14	1.96	2.04	56	39.00	346.1	234.5	25.9	22.3

Suagarcane Growth Yield and Quality Characteristics as affected by potash, Zn, Fe, B and Fungicide on farmer field at Saddar-I Harnai Balochistan

Results regarding growth, yield and quality traits as affected by potash, Zn, Fe, B and Fungicide on farmer field at Saddar-I Harnai (Baluchistan) are presented in Table 26. The data indicated that number of canes, height, girth, yield and quality parameters were improved by the application of potash, micronutrients and fungicide over NP treatment. Data indicated that maximum cane height (230cm) and cane girth (10.2 cm) wer recorded in potash and micronutrient treatments followed by the fungicides application (220cm) as compared to NP applied plot that was 180 cm and 9.3 cm respectively while, the highest millable cane and cane yield were recorded in NPK+ fungicides (51275.9 and 1127.8 mounds acre^{-1}) compared to NP (45877 and 906.3 mounds^{-1}). The increase in cane yield was 23% and 20% by the soil applied NPK+ micronutrients and NPK application over NP. As a result of the the applied treatments cane quality was improved in term of brix contents by 6%, 2% and 7% by the soil applied K, K+micronutrients and K+micronutrients+fungicide respectively over NP treatment.

Suagarcane Growth Yield and Quality Characteristics as affected by potash, Zn, Fe, B and Fungicide on farmer field at Saddar-II Harnai Balochistan

The data recorded for Harnai, Saddar-II Balochistan (Table 27) indicated that the maximum millable canes (52621.46) and plants height (193cm) were recorded in NPK+fungicide treatments which was 18% and 14.2% higher than the respective NP treatment (44528.68 and 169 cm) while cane girth (10.03 cm) in NPK+ micronutrient application compared to NP (8.33 cm) treatment with the resultant 20.4% increase over NP. Soil applied K+Fungicides and K aslo improved cane girth by 15.1% and 7.9% as compared to control. Soil application of NPK+ Fungicide (1132.9 mounds acre^{-1}) showed 17.3% higher cane yield as compared to NP treatment (964.66 mounds acre^{-1}). The use of NPK+ micronutrients and NPK also showed better results i.e. cane yield was 16.4% and 14.7% higher respectively compared NP. In term of cane quality attribute brix contents increased by 15.1%, 11.3% and 11.9% with applied K+micronutrients, K and K+ Fungicide respectively over NP treated cane.

Table 27 Sugarcane yield and quality traits as affected by Potash, Zn, Fe, B and Fungicide on farmer field at Harnai-sadar-I (Baluchistan)

Treatments	No of canes per acre	Cane yield (mnds acre^{-1})	Cane Girth (cm)	Cane Height (cm)	Brix (%)
NP	45877.1c	906.3b	9.3b	180b	15.5a
NPK	47270.9bc	1091.5a	10.1ab	230a	16.4a
NPK+Zn+Fe+B	49845.2ab	1118.3a	10.2a	230a	15.8a
N+P+K+Fungicide	51275.9a	1127.8a	10.1a	220a	16.6a
CV	3.61	2.60	3.93	4.26	NS
LSD	3505	55.1	0.77	0.18	---

Table 28 Sugarcane yield and quality traits as affected by Potash, Zn, Fe, B and Fungicide on farmer field at Harnai-sadar II (Baluchistan).

Treatments	Canes No acre^{-1}	Cane yield (mnds acre^{-1})	Cane Girth (cm)	Cane Height (cm)	Brix (%)
NP	44528.68b	964.66b	8.33c	169a	15.77a
NPK	49915.49a	1106.53a	8.99b	174a	17.56a
NPK+(Zn+Fe+B)	51252.13a	1123.17a	10.03a	167a	18.15a
NPK+Fungicide	52621.46a	1132.49a	9.59a	193a	17.66a
CV	3.46	2.43	2.77	NS	NS
LSD	3429.3	52.42	0.51	---	---

Table 29 Generalized Guidelines for Interpretation of Soil Analysis data

Measurement	Soil Test	Low	Marginal	Adequate
		----------mg kg^{-1}----------		
Nitrate (NO_3-N)	AB-DTPA Extraction	< 11	11-20	> 20
Phosphate (PO_4-P)		< 4	4-7	> 7
Potassium (K)		< 60	60-120	> 120
Iron (Fe)		< 2.0	2.1-4.0	> 4.0
Zinc (Zn)		< 1.0	1-1.5	> 1.5
Boron (B)		<0.45	0.45-1.0	>1.0
Organic Matter		<0.86	0.86-1.29	>1.29
pH		Strongly Acidic (<5)	Moderately Alkaline (7.5-8.5)	Strongly Alkaline >8.5)
$CaCO_3$ (%)		Slightly Calcareous (0-3%)	Moderately Calcareous	Strongly Calcareous
EC			Normal (<4)	Saline (>4)

Table 30 Generalized Guidelines for the Interpretation of irrigation Water Quality Characteristic

Characteristics	slightly Acidic	Moderately alkaline	Strongly Alkaline
pH	<7.5	7.5-8.5	>8.5
	Normal	**Slight to Moderate**	**Severe / Toxic**
Na (meqL^{-1})	<3	3-9	>9
HCO3 (meqL^{-1})	<1.5	1.5-8.5	>8.5
Cl (meqL^{-1})	<1	1-1.2	>1.2
NO_3^- (mgL^{-1})	<5	5-30	>30
	Suitable		**Unsuitable**
EC(dSm^{-1})	< 1.5	1.5-2.7	> 2.7
SAR	< 7.5	7.5-15	> 15
TDS	< 1000	1000-1800	> 1800

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Pictorial Part Showing Activities of PSDP Project "Productivity Enhancement of Sugarcane " LRRI Unit 5

zChip bud seed preparation at Mehran Sugar Mill Tendo Allah Yar Sindh

Chip Bud seed cutting is in progress

Chip Bud seed cutting is in progress

Cuttings of chip bud placed in germinating trays for nursery raising

Pictorial Part Showing Activities of PSDP Project "Productivity Enhancement of Sugarcane" LRRI Unit V

chip bud germinated in trays nursery was raised for transplanting

chip bud was directly seeded for germination in fields

Chip bud nursery transplanted to field

Debating chip Bud Technology role to farmer

Farmer field day organized at Harnai, Baluchistan

Briefing importance of potash and Micronutrients role in sugarcane in Field day

Pictorial Part Showing Activities of PSDP Project "Productivity Enhancement of Sugarcane" LRRI Unit V

Visited Dr. Fateh Soomro Director Sugar and Horticultural crops Res. Inst. Thatta Sindh at is office

Discussing and interviewing sugarcane farmers during nutrient indexing survey

Visited Mr. M. Ramazan, Director Agri. Ext. Shaheed Benazir Abad Sindh

Visited Director Agri. Ext. Mardanat his office

Field Visit of Demonstration at Harnai, Balu.

Dr. Javed Briefing the insect management for sugarcane in field day at Harnai

Pictorial Part Showing Activities of PSDP Project "Productivity Enhancement of Sugarcane" LRRI Unit V

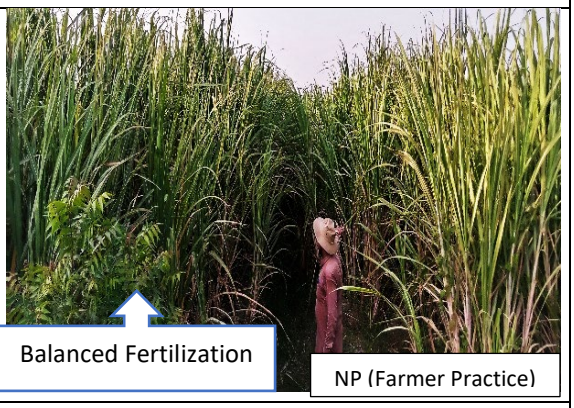
Mr. Asad Farooq SSO, CDRP, NARC Briefing and demonstrating Chip Bud Tech.to Farmer

Farmer Participant

Meeting with Dy. MD Mehran Sugar mill Tendo Allah Yar Sindh

Visited TAMAGH PARC Zonal office . Baluchistan

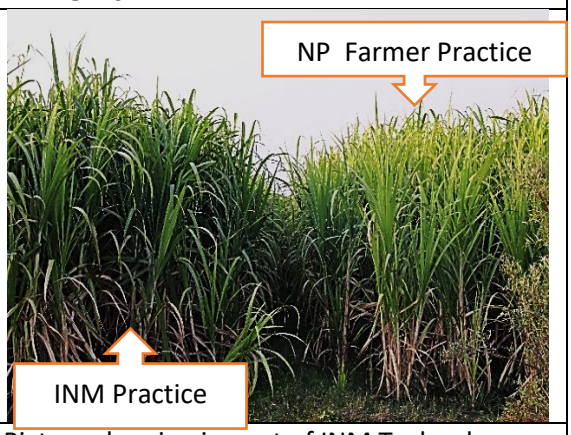
Picture with Farmer of Toru Marmer



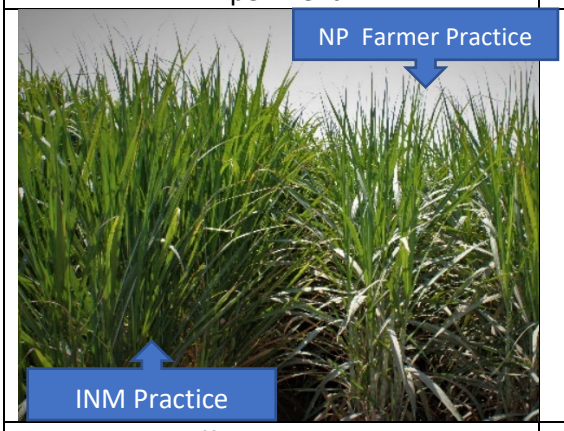
Picture showing impact of INM Technology on sugarcane

Pictorial Part Showing Activities of PSDP Project "Productivity Enhancement of Sugarcane" LRRI Unit V

ugarcane Yield Data Recordind of Harnai Experiment



Picture showing impact of INM Technology on sugarcane



Showing the difference in Farmer Practice and improved technology impact on sugarcane

Discussing potash and Micronutrient role in sugarcane with farmers of Harnai area of Baluchistan

Farmer Practice (NP)

Impact of improved practice on sugarcane (NPK+Mirnutrients)

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