FIRST YEAR FINAL REPORT ON
EVALUATION OF BIOSLURRY AS NUTRIENT SOURCE FOR SUSTAINABLE AGRICULTURE

Submitted to

Pakistan Domestic Biogas Programme, Faisalabad

By

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NEED FOR THE PROJECT

Fermented slurry, sometimes called bioslurry, as a product of anaerobic fermentation of animal excrement in the biogas digester is an excellent organic fertilizer which can make an important contribution to better crop yields and soil fertility. The fermented slurry which contains relatively high percentage of readily available nutrients can be directly applied in liquid and dried form to the plants both for basal and top dressing (Choke Mikled et al., 1994).

Multiple advantages are associated with the use of bioslurry. It increases agricultural production because of its high content of plant nutrients, growth hormones and enzymes. When the digested slurry is placed into the food chain of ruminants and birds, it leads to a sustainable increase in farm income. Besides supplying plant nutrients, organic matter plays an important role because of its beneficial effects in enhancing the cation exchange capacity (CEC), improving soils aggregation, increasing water holding capacity of the soils, stabilizing its humid content, and preventing the leaching of nutrients (Dudal and Decker, 1993). Bio-slurry has proved to be high quality organic manure because compared to Farm Yard Manure (FYM), digested slurry tends to have more plant nutrients.

The productivity of agricultural land can be increased to a remarkable extent with the use of slurry produced from biogas plant. Because of rich source of nitrogen, biogas slurry can upgrade the feeding quality of crop residues. Digested slurry, when used as fertilizer, has shown strong effects on plant tolerance to diseases such as potato wilt, late blight, cauliflower mosaic etc. thus can be used as bio-chemical pesticide. Soaking the seeds with digested slurry can induce disease resistance and faster seed germination. Similarly, foliar application of slurry has many beneficial effects on field crops, vegetables and fruits with respect to growth, quality and resistance to the diseases. (Kakri, 2001)

Bioslurry as an organic fertilizer is environment friendly has no toxic or harmful effects and can easily reduce the use of chemical fertilizers up to 50%. Nutrients from organic sources are more efficient than those from chemical sources. Bioslurry is a 100% organic fertilizer most suitable for organic farming for some high value field and horticultural crops.

In fact, not much work has been carried out on the quality of the solid output from an anaerobic digester in terms of fertilizer value. But now the application of the residue after biogas fermentation to crops has gained considerable effect of increasing crop production.

Nutrition is one of the extremely important factors which have great influence on growth, yield and quality of different crops. Optimal nutrition is pre-requisite to get maximum yield potential of various crops. Chemical fertilizers are used by the farmers to fulfill the crop nutritional requirement but, presently, chemical fertilizers are much expensive and, in certain cases, not available in time. This situation demands to explore other supplement sources of nutrients. Integrated use of organic and chemical fertilizers can reduce dependence on expensive chemical inputs. To sustain high crop yields without deterioration of soil fertility, it is important to work out optimal combination of fertilizers and manures in the cropping system (Rekhi et al., 2000).

Keeping all above in view experiments were conducted with the objectives:

- *to evaluate the effect of bioslurry as soil conditioner applied in combination with different levels of the recommended dose of chemical nitrogen on growth and yield of okra and vegetable crop.*
- *to evaluate the effect of bioslurry of different ages as soil conditioner and N nutrient source applied alone and in ratios of the recommended dose of chemical nitrogen on growth and plant growth regulators to improve the growth and yield of and yield of rice and wheat crop.*

MATERIALS AND METHODS FOR EXPERIMENT ON OKRA AS VEGETABLE

A field experiment was conducted at Experimental Area, of the Institute of Horticultural Sciences, University of Agriculture, Faisalabad to evaluate the potential of biogas slurry and compost at different levels of chemical N to improve growth and yield of okra. The experiment was laid down according to Randomized Complete Block Design (RCBD) having row to row distance 45 cm and plant to plant distance 20 cm. The following treatments were tested with three replications:

T_1 = Control (Recommended NPK @ 180: 90: 40 Kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + 100% recommended N^1

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75% of recommended N

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50% of recommended N

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK

T_6 = Compost @ 600 kg ha^{-1} + 75% of recommended N

T_7 = Compost @ 600 kg ha^{-1} + 50% of recommended N

Biogas slurry and compost each were applied at the time of seed bed preparation. According to treatment plan one third of the recommended chemical N and full dose of P & K in all plots were applied as urea, DAP and SOP at the time of seed bed preparation. Remaining chemical N was applied at flowering and fruit setting stage. After the seed bed preparation, seeds of okra will be sown on beds and recommended plant protection measures will be carried out. The crop was irrigated with canal water.

The following data were recorded:

1. Plant height
2. Number of fruit sets per plot
3. Fruit yield per plot
4. Nitrogen uptake by shoot and fruit

RESULTS OF EXPERIMENT ON OKRA AS VEGETABLE

In this experiment Bioslurry and compost were tested as soil conditioners in combination with 100, 75 and 50% of the recommended dose of chemical nitrogen to improve growth and yield of Okra. These combinations were compared with the application 100% chemical N as control.

Plant Height

The results (Table-1) showed that maximum plant height (156 cm) was recorded where compost was applied @ 600 kg/ha in combination with 100% recommended chemical N and it was statistically nonsignificant with the results obtained with the application of compost @ 600 kg/ha in combination with 75% of the recommended dose of chemical N.

The application of bioslurry in combination with chemical fertilizers also had a significant effect on plant height. There was 14, 16 and 21% in plant height with the application of bioslurry @ 600 kg/ha in combination with 100, 75 and 50% of the recommended dose of chemical N respectively.

Number of fruits per plot

The results (Table-1) revealed that maximum number of okra fruits (328) per plot were obtained where bioslurry @ 600 kg/ha was applied in combination with 50% of the recommended dose of chemical N. This increase in number of fruits per plot was 89% higher than the number of fruits achieved with the application of 100% of recommended dose of chemical N. This increase in number of fruits was followed by with the number (269, 258) recorded where bioslurry was applied in combination with 75 and 100% of recommend chemical N respectively. The maximum number of fruits recorded was nonsignficant with the number of fruits obtained with the application of compost @ 600 kg/ha in combination with 100% recommended chemical N. The results further revealed that the application of bioslurry and compost in combination with 100, 75 and 50% of recommended was superior to recommended chemical N.

Table-1: Effect of integrated use of Biogas Slurry (BGS) and compost with different levels of chemical nitrogen on growth and yield of Okra

S. No	Treatment description	Plant height		No. fruits/Plot		Fruit wt./Plot	
		Mean value	% increase over control	Mean value	% increase over control	Mean value	% increase over control
1	Control (R. NPK @ 150-120-60 kg/ha)	116 e		176 c		2910 c	
2	BGS + 100% R. N @ 150 kg/ha	132 d	14	258 b	48	4056 ab	39
3	BGS + 75% R. N @ 112.5 kg/ha	135 cd	16	269 b	55	3849 bc	32
4	BGS + 50% R. N @ 75 kg/ha	140 cd	21	328 a	89	4995 a	72
5	Compost + 100% R. N @ 150 kg/ha	156 a	34	278 b	60	4170 ab	43
6	Compost + 75% R. N @ 112.5 kg/ha	152 ab	31	238 b	37	3930 b	35
7	Compost + 50% R. N @ 75 kg/ha	144 bc	24	244 b	40	4090 ab	41

Note:

1) **Biogas slurry was applied as soil conditioner @ 600 kg/ha**
2) **100% recommended PK was applied in all treatments**

Fruit weight per plot

The maximum fruit weight (4995 g/plot) was achieved with the application of bioslurry along with 50% of recommended chemical N which was 72% higher than control where only 100% recommended chemical N was applied (Table-1). It was further observed that these results were statistically similar to the results recorded with the application of bioslurry along with 100% dose of the recommended chemical N and the application of compost along with 50 and 100% dose of the recommended chemical N.

N Concentration in Shoot:

The data depicted in Table-2 revealed that the increase in concentration of N in shoot achieved with the application of compost and bioslurry varied from 3 to 34% over control. The maximum N in shoot 1.31% was recorded where 75% of recommended N was applied through chemical fertilizer in combination with BGS @ 600 kg/ha which was 34% higher than the control where 100% N was applied through chemical fertilizer. Statistically similar results were observed where BGS was applied in combination with 100% chemical N which was followed by the treatment where compost was applied in combination with 75% chemical N which showed 13% increase over control.

P Concentration in Shoot:

The results (Table-2) revealed that maximum P contents (0.28%) were recorded by the application of compost in combination with 75% of recommended N through chemical fertilizer. This combination showed 103% increase over control where 100% of recommended N applied through chemical fertilizer. These results were statistically similar with the results achieved where compost was applied in combination with 100% of recommended N through chemical fertilizer showing 0.26% P contents which was 90% more than control.

K Concentration in Shoot:

The data given in Table-2 showed that the K contents were maximum (1.45%) in control where whole of the recommended N was applied through chemical fertilizer. But in all the treatments K contents were comparatively lower than control. Maximum decrease was observed where compost was applied in combination with 50% of the recommended N through chemical fertilizer showing 39% decrease over control.

Table-2: Effect of integrated use of Biogas Slurry (BGS), compost with different levels of chemical nitrogen on NPK contents in shoot of Okra.

S. No	Treatment description	% N in Shoot		% P in Shoot		% K in Shoot	
		Mean value	% increase over control	Mean value	% increase over control	Mean value	% increase over control
1	Control (R. NPK @ 150-120-60 kg/ha)	**0.97 cd**		**0.14 c**		**1.45 a**	
2	BGS + 100% R. N @ 150 kg/ha	**1.26 ab**	**29.00**	**0.17 bc**	**27.00**	**1.33 ab**	**-8.00**
3	BGS + 75% R. N @ 112.5 kg/ha	**1.31 a**	**34.00**	**0.17 bc**	**22.00**	**1.26 bc**	**-13.00**
4	BGS + 50% R. N @ 75 kg/ha	**0.94 d**	**-4.00**	**0.20 b**	**42.00**	**1.21 bc**	**-16.00**
5	Compost + 100% R. N @ 150 kg/ha	**1.01 cd**	**3.00**	**0.26 a**	**90.00**	**1.16 cd**	**-20.00**
6	Compost + 75% R. N @ 112.5 kg/ha	**1.10 bc**	**13.00**	**0.28 a**	**103.00**	**1.05 d**	**-27.00**
7	Compost + 50% R. N @ 75 kg/ha	**1.09 cd**	**29.00**	**0.17 bc**	**26.00**	**0.88 e**	**-39.00**

N concentration in fruit

Data regarding N in fruit (Table-3) shows that highest N contents in fruits were recorded where compost was applied in combination with 50% of recommended chemical N which showed 139% increase over control. Second best results about N in fruit were recorded where compost along with 75% of the recommended chemical N was applied and showed 103% increase over control. Statistically similar results were obtained in all remaining treatments except control.

P concentration in fruit

Table-3 shows that maximum P contents were recorded where compost was applied in combination with 50% of the recommended chemical N showing 115% increase over control where sole N was applied through chemical fertilizer. This result was followed by 68% increase over control which was obtained with the application of compost in combination with 75% recommended chemical N and this increase was found statistically similar to the application of BGS in combination with 50 and 75% chemical N and compost in combination with 75% chemical N.

K concentration in fruit

Data regarding K in fruit (Table-3) shows that highest value of K contents in fruit was achieved with the application of compost in combination with 50% chemical N and showed 84% increase over control. This increase in K content was followed by the treatment where compost was applied along with 75% recommended chemical N showing 41% increase over control. Statistically similar results were obtained with the application of BGS in combination with 50% chemical N and compost along with 100% chemical N both showed 30 and 28% increase respectively over control where sole recommended N was applied through chemical fertilizer.

Table-3: Effect of integrated use of Biogas Slurry (BGS) and compost with different levels of chemical nitrogen on NPK % contents in fruit of Okra.

S. No	Treatment description	N in Fruit (mg/plant)		P in Fruit (mg/plant)		K in Fruit (mg/plant)	
		Mean value	% increase over control	Mean value	% increase over control	Mean value	% increase over control
1	Control (R. NPK @ 150-120-60 kg/ha)	78.28 c	----------	18.040 c	----------	134.33 d	----------
2	BGS + 100% R. N @ 150 kg/ha	136.78 b	74	21.107 c	16	157.67 cd	17
3	BGS + 75% R. N @ 112.5 kg/ha	136.90 b	74	29.303 b	62	158.00 cd	17
4	BGS + 50% R. N @ 75 kg/ha	149.54 b	91	28.003 b	55	175.33 bc	30
5	Compost + 100% R. N @ 150 kg/ha	156.92 b	100	27.240 b	50	172.33 bc	28
6	Compost + 75% R. N @ 112.5 kg/ha	158.93 b	103	30.403 b	68	190.67 b	41
7	Compost + 50% R. N @ 75 kg/ha	187.47 a	139	38.967 a	115	247.33 a	84

1) **Biogas slurry was applied as soil conditioner @ 600 kg/ha**
2) **100% recommended PK was applied in all treatments**

SUMMARY

1. The application of bioslurry and compost @ 600 kg/ha as soil conditioner along with recommended chemical NPK significantly increased plant height of okra. Maximum plant height 34% higher than control was recorded with the use of compost along with 100% of recommended chemical nitrogen where as when slurry was used at the same level of chemical nitrogen, the increase in plant height over control was 14%.

2. The application of bioslurry and compost @ 600 kg/ha as soil conditioner along with recommended chemical NPK significantly increased number of fruits/ plot of okra. Maximum number of fruits 89% higher than control was recorded with the use of bioslurry along with 50% of recommended chemical nitrogen. Whereas when compost was used at the same level of chemical nitrogen, the increase in number of fruits /plot over control was 40%.

3. Similarly the application of bioslurry and compost @ 600 kg/ha as soil conditioner along with recommended chemical NPK significantly increased fruit weight/plot of okra. Maximum fruit weight/plot 72% higher than control was recorded with the use of biosurry along with 50% of recommended chemical nitrogen over control.

MATERIALS AND METHODS FOR EXPERIMENT ON POTATO

The trial on potato was carried out at experimental area of the Institute of Horticultural Sciences, University of Agriculture Faisalabad, to evaluate the potential of biogas slurry at different levels of chemical N to improve growth and yield of potato. The experiment was laid down according to Randomized Complete Block Design (RCBD). Inoculation of PGPR (plant growth promoting rhizobacteria) on tubers was done before sowing. An area of 3m x 6m was specified for each treatment. Potato v. SH-704 was sown during fourth week of October using a seed rate of 800 kg ha^{-1} with 45 cm ridge to ridge distance. Sowing was done manually by maintaining plant to plant distance of 15 cm and 1 tuber per hill was placed. Following treatments were tested:

T1 = Recommended NPK @ 250-125-125 kg/ha
T2 =R. NPK + BGS @ 600 kg/ha
T3 = 100% N as BGS
T4 =75% Chem. N + 25% N as BGS
T5 = 50% Chem. N + 50% N as BGS
T6 = 75% Chem. N + 25% N as BGS
T7 =R. NPK + PGPR
T8 = 75% Chem. N + 25% N as BGS + PGPR
T9 = BGS @ 600 kg/ha + R. NPK + PGPR
T10 = 50% N Chem. N + 50% N as BGS +PGPR
T11 = 75% Chem. N + 25% N as BGS + PGPR

The data for the following parameters were recorded:

1. Plant Height (cm)
2. Tuber yield per plant (g)
3. Tuber yield (kg/ha)
4. % N and % P in leaves
5. % N and % P in stems
6. % N and % P in tubers

RESULTS OF EXPERIMENT ON POTATO AS VEGETABLE

Plant Height

Table-4 shows that all treatments showed significant differences among all treatments. The maximum plant height 38% more than control was recorded with the application of 50% N from chemical fertilizer and50% N from BGS along with inoculation with PGPR and it was followed by T11, T5 and T6 which showed 27, 24 and 14% increase over control and these treatments differed non significantly with each other. The plant heights achieved with application of 100% N from BGS decreased significantly (-40% over control) showing that there a ready source of N was not available in that treatment.

Number of Tubers per Plant:

It was revealed from the data regarding number of tuber per plant (Table-4) that all the treatments significantly affected the number of tubers per plant. The maximum response was seen in T10 and T11 where 50 and 75% N of the recommended dose was applied through chemical fertilizer in combination with 50 and 25% N from BGS was applied respectively in combination with PGPR inoculation. The increases observed in these treatments were 108 and 96% higher over control respectively where recommended N was applied only through chemical fertilizer. The results recorded with these treatments were statistically at par with each other. Treatments where whole of recommended N was applied through BGS (T3) and where BGS and chemical fertilizer were applied in ratio 75: 25% N basis showed -29 and -8% less number of tubers per plant than control respectively. These results indicated that sole application of bioslurry did not have a positive effect on number of tubers per plant.

Tuber yield per plant (g):

It was revealed from the data regarding tuber yield per plant (Table-5) that all treatments performed significantly. The maximum tuber yield per plant (0.9775 kg) was recorded with T10 where 50% of the recommended N was applied through chemical fertilizer and remaining 50% from BGS in combination with PGPR which gave 62% higher yield per plant as compared to control where whole of the N was applied through chemical fertilizer. It was also found that it was statistically at par with T11 and T5 which showed 56 and 47% increase over control. Again

the sole application of 100% N from BGS showed a decrease in tuber yield per plant causing 5.6% decrease in tuber yield/ plant over control

Table-4: Effect of integrated use of Biogas Slurry (BGS), chemical fertilizers and plant growth promoting rhizobacteria (PGPR) on growth parameters of potato

S. No.	Treatment description	Plant Height (cm)			No. of Tubers per Plant		
		Mean value		% increase over control	Mean value		% increase over control
1	Recommended NPK	28	f	--------	8	f	---------
2	R. NPK + BGS 600 kg/ha	31.33	de	12	10	de	25
3	100% N as BGS	16.66	g	-40	5.66	g	-29
4	75% Chem. N + 25% N BGS	28.33	ef	1	7.33	f	-8
5	50% Chem. N + 50% N BGS	34.66	bc	24	13.33	b	66
6	25% Chem. N + 75% N as BGS	32	bc	14	11.33	cd	42
7	R. NPK + PGPR	26.66	cd	-5	9.66	e	21
8	75% Chem. N + 25% N as BGS + PGPR	31.66	cd	13	12.66	bc	58
9	BGS 600 kg/ha + 100% R. N + PGPR	31.66	cd	13	9.66	e	20
10	50% N Chem. N + 50% N as BGS +PGPR	38.66	a	38	16.66	a	108
11	75% Chem. N + 25% N as BGS + PGPR	35.66	ab	27	15.66	a	96

Note: 100% recommended PK was applied in all treatments

Table-5: Effect of integrated use of Biogas Slurry (BGS), chemical fertilizers and plant growth promoting rhizobacteria (PGPR) on yield parameters of potato.

S. NO.	Treatment description	Tuber Yield per Plant (kg)		Tuber Yield (kg/ha)	
		Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK	0.6000 d	----------	10890 d	----------
2	R. NPK + BGS 600 kg/ha	0.6667 cd	11.11	12100 cd	11.11
3	100% N as BGS	0.5660 d	-5.66	10273 d	-5.66
4	75% Chem. N + 25% N BGS	0.6333 d	5.55	11495 d	5.55
5	50% Chem. N + 50% N BGS	0.8840 a	47.33	16045 a	47.33
6	25% Chem. N + 75% N as BGS	0.8167 abc	36	14822 abc	36.10
7	R. NPK + PGPR	0.5947 d	-0.88	10793 d	-0.89
8	75% Chem. N + 25% N as BGS + PGPR	0.8340 ab	39	15137 ab	38.99
9	BGS 600 kg/ha + 100% Chem.N + PGPR	0.6840 bcd	14	12415 bcd	14.00
10	50% N Chem. N + 50% N as BGS +PGPR	0.9747 a	62.45	17690 a	62.44
11	75% Chem. N + 25% N as BGS + PGPR	0.9333 a	55.55	16940 a	55.55

Tuber yield (kg/ha)

The effectiveness of all the treatments on tuber yield is evident from the data of Table-5. The maximum tuber yield (17690 kg/ha) was achieved with application of 50% N from chemical fertilizer and 50% N from BGS in combination with PGPR which gave 62% higher yield than control (10890 kg/ha) where only recommended N from chemical fertilizer was applied. It was followed in descending order by application of 75% N from chemical fertilizer + 25% N from BGS + PGPR (T11), 50% N from BGS +50% N from chemical fertilizer (T5), recommended N +PGPR (T7) and 25% N from BGS+ 75% chemical fertilizer (T6) which increased tuber yield kg/ha by 55, 47, 38 and 36% respectively over control. The treatments where whole of recommended N from BGS (T3) and recommended N from chemical fertilizer in combination with PGPR (T3) showed 9 and 0.5% decrease in tuber yield over to control.

N concentration in leaves

The highest N content (3.86%) in leaves as shown in Table – 6 was observed in the treatment that received 50% N from chemical fertilizer and 50% N from BGS along with PGPR inoculation (T10). In this treatment the concentration of N in leaves was achieved 196% higher than control. The concentration of N in leaves achieved with this treatment w as followed by T11, T5 and T6 which showed 138, 84 and 56% increase over control respectively. The results also showed that the sole application of N as BGS (T3) had negative effect o N concentration of leaves as the N content of leaves recorded in that treatment was 41% less as compared to control. But the treatment where recommended N was supplemented with 600 kg BGS (T2) showed 20% increase over control while when the same combination was tested in combination with PGPR showed 35% increase over control.

Table-6: Effect of integrated use of Biogas Slurry (BGS), chemical fertilizers and plant growth promoting rhizobacteria (PGPR) on % N and % P in potato leaves

S. NO.	Treatment description	% N in Leaves		% P in leaves	
		Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK	1.30 e	----------	0.27 d	---------
2	R. NPK + BGS 600 kg/ha	1.56 e	20	0.31 c	15
3	100% N as BGS	0.76 h	-41	0.19 e	-30
4	75% Chem. N + 25% N BGS	1.01 g	-22	0.21 e	-22
5	50% Chem. N + 50% N BGS	2.40 c	84	0.36 b	33
6	25% Chem. N + 75% N as BGS	2.03 d	56	0.33 c	22
7	R. NPK + PGPR	1.60 e	23	0.28 d	4
8	75% Chem. N + 25% N as BGS + PGPR	2.10 d	61	0.33 c	22
9	BGS 600 kg/ha + 100% Chem. N + GPR	1.76 e	35	0.32 c	19
10	50% N Chem. N + 50% N as BGS	3.86 a	196	0.41 a	52
11	75% Chem. N + 25% N as BGS + PGPR	3.10 b	138	0.38 b	41

Note: 100% recommended PK was applied in all treatments

P concentration in leaves:

Table-7 shows that combined use of BGS and chemical fertilizer significantly increased the % P contents in leaves compared to the treatment where whole of the recommended N was applied either through BGS or chemical fertilizer. The maximum P content in leaves (52%) was recorded in T10 where half of the recommended N applied through chemical fertilizer and half through BGS in combination with PGPR followed by T11 and T5. T6 and T8 results were found statistically similar. The minimum P content was recorded with T3 and T4 which showed 30 and 22% decrease in P content in leaves as compared to control respectively.

N concentration in stem:

Data regarding N content in stem (Table-7) shows significant differences among all treatments. The maximum N content in stem (3.6%) was recorded by application of 50% of the recommended N from chemical fertilizer and 50% from biogas slurry in combination with plant growth promoting rhizobacteria which was 170% more than control and it was followed by T11 (75% N from chemical fertilizer + 25% N from BGS + PGPR), T5 (50% BGS + 50% chemical fertilizer) and T6 (75% BGS +2 5% chemical fertilizer) which showed 107 and 60% higher over control. The minimum N contents).73%was recorded where entire N was supplied through BGS which was 30% less than control.

P concentration in stem

Different combinations of biogas slurry and chemical fertilizer significantly affected the P content of stem (Table-7). The application of 50% of recommended N from chemical fertilizer and 50% from BGS in combination with PGPR showed maximum P content in stem (66% increase over control) followed by the treatment where 75% of recommended N applied through chemical fertilizer and 25% N from BGS along with PGPR. Treatments T3 and T4 showed negative effect on P content of stem which gave 62% lower P than control.

Table-7: Effect of integrated use of Biogas Slurry (BGS), chemical fertilizers and plant growth promoting rhizobacteria (PGPR) on % N and % P in potato stem

S. NO.	Treatment description	% N in Stem		% P in Stem	
		Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK	1.33 g	--------	0.24 f	----------
2	R. NPK + BGS 600 kg/ha	1.70 e	27	0.26 e	8
3	100% N as BGS	0.731 i	-45	0.09 g	-62
4	75% Chem. N + 25% N BGS	0.93 h	-30	0.19 g	-20
5	50% Chem. N + 50% N BGS	2.76 c	107	0.36 b	50
6	25% Chem. N + 75% N as BGS	2.13 d	60	0.33 c	37
7	R. NPK + PGPR	1.53 f	15	0.28 de	16
8	75% Chem. N + 25% N as BGS + PGPR	2.20 d	65	0.32 c	33
9	BGS 600 kg/ha + 100%. Chem. N + PGPR	1.80 e	35	0.29 d	20
10	50% N Chem. N + 50% N as BGS +PGPR	3.60 a	170	0.40 a	66
11	75% Chem. N + 25% N as BGS + PGPR	3.23 b	142	0.38 b	58

Note: 100% recommended PK was applied in all treatments

N concentration in tubers:

Different combinations of biogas slurry and chemical fertilizer significantly affected the N contents of stem (Table- 8). The application of 50% of recommended N from chemical fertilizer and 50% from BGS in combination with PGPR showed maximum N contents in stem (61% more over control) followed by T11 where 75% of recommended N was applied through chemical fertilizer and 25% from BGS along with PGPR. Treatments T2 and T4 showed negative effect on N contents in tuber which were 50 and 27% lower than control. This indicated the sole application of BGS had negative effect on N contents of tubers.

P concentration in tuber:

The data depicted the application of different combinations of biogas slurry and chemical fertilizer significantly affected the P content of stem (Table-8). The maximum P contents (36% more than control) in tubers was recorded in treatment T10 (75% N from chemical fertilizer + 25% N from BGS + PGPR) followed by T11, T5 and T8 showing 24, 11 and 8% increase over control. Minimum % P contents in tuber were observed in treatments T3 and T4 showing 17 and 12% decrease over control. Treatment where BGS was applied @ 600 kg/ha in combination with recommended N from chemical fertilizer showed 2% increase over control.

Table-8: Effect of integrated use of Biogas Slurry (BGS), chemical fertilizers and plant growth promoting rhizobacteria

S. NO.	Treatment description	% N in Tubers		% P in Tubers	
		Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK	2.60 f	----------	1.14 f	--------
2	R. NPK + BGS 600 kg/ha	1.30 h	-50	1.17 ef	2
3	100% N as BGS	3.00 e	15	0.94 g	-17
4	75% Chem. N + 25% N BGS	1.90 g	-27	1.00 g	-12
5	50% Chem. N + 50% N BGS	3.66 c	41	1.27 c	11
6	25% Chem. N + 75% N as BGS	3.30 d	27	1.23 cde	7
7	R. NPK + PGPR	2.73 f	5	1.15 f	0.8
8	75% Chem. N + 25% N as BGS + PGPR	3.33 d	28	1.23 cd	8
9	BGS 600 kg/ha + R. NPK + PGPR	3.20 de	23	1.18 def	3
10	50% N Chem. N + 50% N as BGS + PGPR	4.20 a	61	1.55 a	36
11	75% Chem. N + 25% N as BGS + PGPR	3.93 b	51	1.42 b	24

(PGPR) on % N and % P in potato tubers

Note: 100% recommended PK was applied in all treatments

SUMMARY

1) The maximum plant height was recorded with the application of 50% N from chemical fertilizer and 50% N from BGS along with inoculation with PGPR and it was 38% more than control. The application of 100% N from BGS had negative impact as 40% decrease in pant height over control was recorded with this treatment.

2) The maximum and statistically similar number of tubers per plant (109 and 96) were observed in where 50% and 75% N of the recommended dose was applied through chemical fertilizer in combination with 50% and 25% N from BGS was applied respectively in combination with PGPR inoculation respectively. Again the application of BGS as sole source of N had negative effect on number of tubers per plant showing 29% decrease over control where whole of the N was applied through chemical fertilizer.

3) The maximum tuber yield per plant (0.9775 kg) was recorded where 50% of the recommended N was applied through chemical fertilizer and remaining 50% from BGS in combination with PGPR which gave 62% higher yield per plant as compared to control where whole of the N was applied through chemical fertilizer. Again the sole application of 100% N from BGS showed a decrease in tuber yield per plant causing 5.6% decrease in tuber yield/ plant over control.

4) The maximum tuber yield (17690 kg/ha) was achieved with the application of 50% N from chemical fertilizer and 50% N from BGS in combination with PGPR which gave 62% higher yield than control (10890 kg/ha) where only recommended N from chemical fertilizer was applied. The application of whole of recommended N from BGS showed 6% decrease in tuber yield over control.

MATERIALS AND METHODS FOR EXPERIMENT ON RICE CROP

A field experiment was conducted at Research area of the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad during the year 2010, to investigate the effect of fresh and 30 days old bioslurry as soil conditioner and nutrient source applied alone and in combination with plant growth regulators (PGR) as Auxin and different levels of chemical nitrogen on rice crop cv. Super Basmati. Nursery was sown near the selected field. Fourteen treatments were arranged in Randomized Complete Block Design (RCBD) with three replications. The treatments tested were as follow:

Tr. No.	Treatment description
1	Recommended NPK @ 100-67-62 kg ha^{-1} respectively
2	R. NPK + BGS1 @ 600 kg/ha
3	R. NPK +BGS2 @ 600 kg/ha
4	R. NPK + BGS1 600 kg/ha + PGR
5	R. NPK + BGS2 600 kg/ha + PGR
6	R. NPK + PGPR
7	50% Chem. N + 50% N as BGS1
8	50% Chem. N + 50% N as BGS 2
9	75% Chem. N + 25% N as BGS1
10	75% Chem. N + 25% N as BGS 2
11	50% Chem. N + 50% N as BGS1 + PGR
12	50% Chem. N + 50% N as BGS + PGR
13	75% Chem. N + 25% N as BGS1 + PGR
14	75% Chem. N + 25% N as BGS 2 + PGR

Note: 100% recommended PK was applied in all treatments

Whole of the P & K as SSP and $K_2 SO_4$ and 1/2 of the recommended N as respectively was applied at transplanting whereas remaining N was applied 30 days after transplanting. Following observations were recorded;

1) Plant height
2) No. of tillers
3) Grain yield per plot
4) NPK contents in straw and grains

RESULTS OF EXPERIMENT ON RICE CROP

In this experiment bislurry was used as nutrient source and was applied in combination with plant growth promoting rhizobacteria and different levels of chemical nitrogen to evaluatee its effect on growth and yield of rice under field conditions.

Plant Height

The results presented in Table-9 revealed that the application of fresh and 30 days old bioslurry in combination with recommended chemical NPK enhanced plant height compared to sole application of recommend chemical NPK. This increase in plant height was further enhanced when these treatments were applied in combination with the application of plant growth regulators.

The maximum increase in plant height was observed when 50 and 75% of recommended nitrogen from chemical fertilizer 50 and 25% of recommended nitrogen from bioslurry respectively were applied along with plant growth regulators.

Number of Tillers/m^2

The data presented in Table-9 regarding tillering indicated that all the treatments significantly increased the number of tillers over control where only recommended chemical NPK was applied. Although the application of bioslurry as soil conditioner along with recommended chemical NPK increased tillering but this increase was further improved when these treatments were applied in combination with plant growth regulators.

The maximum increase in tillering was recorded with the application of recommended NPK along with bioslurry applied @ 600 kg/ha as soil conditioner and plant growth regulators; 50 and 75% of recommended nitrogen from chemical fertilizer and 50 and 25% of the recommended nitrogen from fresh and 30 days old bioslurry respectively were applied along with plant growth regulators. This increase in tillering ranged from 38 t0 44% more over control where only recommended chemical NPK was applied.

Table-9: Effect of integrated use of Bioslurry (BGS), chemical fertilizers and plant growth regulators (PGR) on growth and yield of rice under field conditions

S. No.	Treatment description	Plant Height		Number. tillers/ m^2		Paddy yield/ plot	
		Mean value	% increase over control	Mean value	%increase over control	Mean value	%increase over control
1	Recommended NPK @ 100-67-62 kg ha^{-1}	118.33 j	----------	374.3 e	---------	6.467 g	---------
2	R. NPK + BGS1 600 kg/ha	125 fgh	5	462.3 c	24	8.8 cdef	37
3	R. NPK +BGS2 600 kg/ha	123 gh	4	446.0 cd	19	8.6 def	34
4	R. NPK + BGS1 600 kg/ha + PGR	125 efg	6	537.0 a	43	9.867 ab	53
5	R. NPK + BGS2 600 kg/ha + PGR	127 cde	7	527.0 a	40	9.767 ab	51
6	R. NPK + PGR	123 hi	4	487.7 b	32	9.2 abcde	43
7	50% Chem. N + 50% N as BGS1	120 ij	2	434.0 d	16	8.4 def	30
8	50% Chem. N + 50% N as BGS 2	119.07 j	1	420.7 d	12	8.267 f	28
9	75% Chem. N + 25% N as BGS1	129 abc	9	442.0 cd	18	8.6 def	34
10	75% Chem. N + 25% N as BGS 2	127 def	7	433.7 d	18	8.3 ef	29
11	50% Chem. N + 50% N as BGS1 + PGR	130.13 ab	10	535.3 a	42	9.667 abc	50
12	50% Chem. N + 50% N as BGS2 +PGR	129 bcd	9	519.0 a	38	9.3 abcd	44
13	75% Chem. N + 25% N as BGS1 + PGR	131.17 a	11	541.7 a	44	10.10 a	56
14	75% Chem. N + 25% N as BGS 2 + PGR	130.63 ab	10	522.0 a	39	9.1 bcdef	41

Note: 100% recommended PK was applied in all treatments

Paddy Yield (kg/plot)

It was evident from the data presented in Table-9 that the application of fresh and 30 days old bioslurry applied @ 600 kg/ha as soil conditioner and as nutrient source in different ratios with chemical nitrogen had a significant effect on paddy yield over control where only recommend chemical NPK was applied. Among these treatments statistically similar paddy yield was recorded where recommended chemical N was applied in combination fresh and 30 days old bioslurry applied @ 600 kg/ha as soil conditioner and plant growth regulators; 50 and 75% of recommended nitrogen from chemical fertilizer and 50 and 25% of the recommended nitrogen from fresh bioslurry respectively and recommended chemical NPK were applied along with plant growth regulators. This increase in paddy yield achieved with these treatments ranged 43 to 56% over control where only recommended chemical NPK was applied.

N concentration in rice straw

Data regarding N content in rice straw (Table-10) after harvesting showed that maximum N (176% more than control) was recorded in treatment T13 where 75% of the recommended N was applied through chemical fertilizer and 25% N was applied from fresh biogas slurry (BGS) in combination with Auxin (PGR). The treatments T12, T13 and T14 were found statistically at par y showing 140-176% increase over control where whole of recommended N was applied through chemical fertilizer. Remaining treatments were followed in descending order as T11>T9>T10>T7>T8>T4>T5>T2. The minimum N content in straw after harvesting was recorded in T6 where whole of the recommended N was applied through chemical fertilizer in combination with PGR.

P concentration in straw

Table-10 shows that data regarding P in straw significantly increased with the integrated use of chemical fertilizer, biogas slurry and auxin. The maximum P content was recorded in T13 (75% N from CF + 25% N from fresh BGS + PGR) which showed 166% increase over control where recommended N dose was applied through chemical fertilizer. The second maximum P content (150% more over control) was analyzed in T14 where 75 percent of recommended N was applied through chemical fertilizer and 25 percent from 30 days old biogas slurry (BGS2) in combination with auxin. But the combination of 50% N from CF and 50% from fresh biogas

Table-10: Effect of integrated use of Bioslurry (BGS), chemical fertilizers and plant growth regulators (PGR) on NPK concentration in straw

S. No.	Treatment description	% N in Straw After Harvesting		% P in Straw After Harvesting		% K in Straw After Harvesting	
		Mean value	% increase over control	Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK 100-67-62	0.25 g		0.18 i		1.01 g	
2	R. NPK + BGS1 600 kg/ha	0.31 g	24	0.19 hi	6	1.17 efg	18
3	R. NPK + BGS2 600 kg/ha	0.28 g	12	0.19 hi	6	1.06 fg	10
4	R. NPK + BGS1 600 kg/ha + PGR	0.39 ef	56	0.26 f	44	1.2 def	5
5	R. NPK + BGS2 600 kg/ha + PGR	0.32 fg	28	0.24 fgh	33	1.11 fg	30
6	R. NPK + PGR	0.26 g	4	0.21 ghi	16	1.06 fg	27
7	50% Chem. N + 50% N as BGS1	0.48 cde	92	0.29 ef	61	1.32 bcde	36
8	50% Chem. N + 50% N as BGS2	0.46 de	84	0.25 fg	38	1.29 cde	33
9	75% Chem. N + 25% N as BGS1	0.52 bcd	108	0.36 cd	100	1.38 abc	45
10	75% Chem. N + 25% N as BGS2	0.49 cde	96	0.33 de	83	1.35 bcd	36
11	50% Chem. N + 50% N as BGS1 + PGR	0.57 bc	128	0.41 bc	127	1.47 ab	45
12	50% Chem. N + 50% N as BGS2 + PGR	0.60 a	140	0.38 cd	111	1.38 abc	36
13	75% Chem. N + 25% N as BGS1 + PGR	0.69 a	176	0.48 a	166	1.52 a	50
14	75% Chem. N + 25% N as BGS2 + PGR	0.60 ab	140	0.45 ab	150	1.44 abc	42

Note: 100% recommended PK was applied in all treatments

slurry (BGS1) in combination with PGR (T11) showed 127% increase over control. T12 (50% N from CF + 50% N from 30 days old BGS2 + PGR) showed 111% increase compared to control. Treatments T2 and T3 showed similar results regarding P content in straw after harvesting. They both showed 6% increase over control. Treatments T9 and T10 where 75% of recommended N dose was applied through CF and remaining 25% from fresh and 30 days old BGS respectively showed 100 and 83% increase over control where recommended N was applied only through CF. The remaining treatments were followed in descending order as T7>T4>T8>T5>T6.

K concentration in straw

Table- 10 shows that K contents in straw after harvesting were significantly increased by all treatments where biogas slurry, chemical fertilizer and PGR were used in combination. The best performed combination for K contents in straw after harvesting was that where 75% of N was applied through chemical fertilizer, and 25% through fresh biogas slurry (BGS1) in combination with PGR (T13), it showed 50% increase over control followed by T11, T14 and T12 which showed 45, 42 and 36% increase over control respectively. The treatments T14, T12 and T9 were found statistically at par. The treatments T7 and T8 where fresh, old biogas slurry and chemical fertilizer were used in 50: 50% N basis combination showed 30 and 27% increase over control. The minimum K contents were recorded in T3 and T6 showing 5% increase over control.

N concentration in grains

The maximum N contents in rice grains were recorded with the application of 75% N from chemical fertilizer and 25% N from fresh BGS2 along with PGR (T13) which showed 122% increase over control followed by treatment in which 50% recommended N was applied through chemical fertilizer and remaining through fresh BGS1 was applied in combination with PGR (T11) and it showed 107% increase over control (Table-11). When fresh BGS1 of T13 and T11 was replaced with old BGS2 (T12 and T14) showed 84 and 122% increased over control respectively. Treatments T9>T10>T7>T8>T4>T2=T5>T3 and T6 decreased in descending order showing 98, 66, 54, 35, 32, 24, 24, 22 and 20% increase over control.

Table-11: Effect of integrated use of Biogas Slurry (BGS), chemical fertilizers and plant growth regulator (PGR) on NPK contents in grain samples

S. No	Treatment description	% N in Grain		% P in Grain		% K in Grain	
		Mean value	% increase over control	Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK 100-67-62	0.53 g	---------	0.21 f	--------	0.27 c	--------
2	R. NPK + BGS1 600 kg/ha	0.66 fg	24	0.26 ef	23	0.30 bc	11
3	R. NPK + BGS2 600 kg/ha	0.65 fg	22	0.22 f	4	0.29 c	7
4	R. NPK + BGS1 600 kg/ha + PGR	0.70 fg	32	0.28 def	33	0.33 abc	22
5	R. NPK + BGS2 600 kg/ha + PGR	0.66 fg	24	0.27 def	28	0.31 bc	14
6	R. NPK + PGR	0.64 fg	20	0.24 f	14	0.31 bc	14
7	50% Chem. N + 50% N as BGS1	0.82 def	54	0.34 def	61	0.35 abc	29
8	50% Chem. N + 50% N as BGS2	0.72 ef	35	0.31 def	47	0.35 abc	29
9	75% Chem. N + 25% N as BGS1	1.05 abc	98	0.41 bcd	95	0.38 abc	40
10	75% Chem. N + 25% N as BGS2	0.88 cde	66	0.39 bcde	85	0.37 abc	37
11	50% Chem. N + 50% N as BGS1 + PGR	1.10 ab	107	0.49 ab	133	0.40 abc	48
12	50% Chem. N + 50% N as BGS2 + PGR	0.98 bcd	84	0.45 abc	114	0.39 abc	44
13	75% Chem. N + 25% N as BGS1 + PGR	1.18 a	122	0.55 a	161	0.46 a	70
14	75% Chem. N + 25% N as BGS2 + PGR	1.08 ab	103	0.51 ab	142	0.43 ab	59

Note: 100% recommended PK was applied in all treatments

P concentration in grains

The data revealed that P content in grains significantly increased with the integrated use of biogas slurry and chemical fertilizer (Table-11). The maximum P content in grain was recorded in T13 (75% N from CF + 25% N from fresh BGS1 + PGR) which showed 161% increase over control followed by T14 (75% N from CF + 25% N from 30 days old BGS2 + PGR) with 142% increase over control. The treatments T11 and T12 where 50% recommended N was applied from chemical fertilizer and 50% from fresh and old BGS in combination with PGR respectively showed 133 and 114% increase over control where recommended N was applied through chemical fertilizer. The treatments T9 and T10 where 75% of recommended N was applied through fresh and old BGS respectively in combination with 50% N from chemical fertilizer showed 95 and 85% increase over control. T4 and T5 were found statistically at par. Remaining treatments were found in descending order for P content in grain i.e. T7, T8, T2, T6 and T3.

K concentration in grains

Table-11 shows the data regarding K contents in rice grain was significantly affected by all treatments. Treatment T13 (75% N from CF + 25% N from fresh BGS1 + PGR) showed maximum K contents in grains that was 70% more than control where chemical fertilizer used. It was followed by T14, T11, T12, T9 and T10 showing 59, 48, 44, 40 and 37% increase over control respectively. Treatments T7 and T8 showed same value for % K contents in grain (29 % more than control).

SUMMARY

1. All the treatments significantly affected the plant height of rice over control where only recommended chemical NPK fertilizers were applied. Maximum plant height was achieved with the application of 50% and 75% of recommended nitrogen from chemical fertilizer 50% and 25% of recommended nitrogen from bioslurry respectively along with PGR..

2. There was 24% increase in tillering with the application of fresh bioslurry along with recommended chemical NPK. The use of different proportions of nitrogen from chemical fertilizer and bioslurry significantly increased the tillering and it was further enhanced when these treatments were applied along with plant growth regulators. Statistically similar results were observed when 50% & 75% of the recommended N from chemical fertilizer and 50% & 25% of the recommended N from bislurry was applied along with PGR. The maximum increase number of tillers recorded with these treatments was 44% higher than control.

3. There was 37 and 34% increase in paddy yield over control when fresh and 30 days old bioslurry respectively was applied @ 600 kg/ha as soil conditioner in combination with recommended chemical N. When these treatments were applied along with plant growth regulators, the paddy yield increased to 53 and 51% respectively over control where only recommended chemical NPK fertilizers were applied.

4. When bioslurry was applied in different proportions on the basis of N with chemical fertilizer it gave higher paddy yield which ranged from 28 to 43% as compared to control and the application of bioslurry as soil conditioner along with recommended chemical NPK fertilizers. When these different ration of chemical and bioslurry N were applied along with plant growth regulators, the paddy yield was further enhanced ranging from 41 to 56% over control. Maximum paddy yield 56% higher than control was achieved with the application of 75% N from chemical fertilizer and 25% N from fresh bioslurry along with plant growth regulators. Although when 50% increase in grain yield was recorded with the application of 50% N from chemical fertilizer and 50% N from fresh bioslurry along with plant growth regulators.

MATERIALS AND METHODS FOR EXPERIMENT ON WHEAT CROP:

A wheat trial was carried out at farmer's field in Tehsil Harroonabad District Bahawalnagar. Recommended doses of P and K as DAP and K_2SO_4 were applied at the time of sowing. Plots were prepared for each treatment and bio slurry was applied according to treatment plan. Urea was applied in three splits. All splits were applied with 1st, 2nd and 3rd irrigations respectively. The crop was irrigated with canal water. The experiment was laid out according to randomized complete block design using the following treatments:

T1	Recommended N (control)
T2	75% N from fertilizer + 25% N from biogas slurry
T3	50% N from fertilizer + 50% N from biogas slurry
T4	25% N from fertilizer + 75% N from biogas slurry
T5	100% N from biogas slurry

Note: 100% recommended PK was applied in all treatments

RESULTS OF EXPERIMENT ON WHEAT CONDUCTED AT FARMER'S FIELD

Plant height

Table-12 shows that the plant height was significantly increased with the combined use of biogas slurry and chemical fertilizer (urea). The maximum plant height was obtained with T3 where 50% of recommended N was supplied through chemical fertilizers and the remaining 50% from biogas slurry. This treatment caused 6% increase over control followed by T2 (75% N from fertilizer + 25% N from biogas slurry) and T4 (25% N from fertilizer + 75% N from biogas slurry) with 3 and 0.2% increase over control. T3 was statistically at par with T2. There was non-significant difference between T4 and T5. The results also revealed that the sole application of bioslurry as N source had negative effect on plant height of wheat.

Number of tillers per m^{-2}

Combined use of biogas slurry and chemical fertilizer significantly increased number of tillers m^{-2}. (Table- 13). The highest number of tillers (533) was recorded with T3 (50% N from chemical fertilizer + 50% N from biogas slurry) which was 56% more than control and it was statistically non significant with T2 (75% N from chemical fertilizer + 25% N from biogas slurry).The application of 25% of recommended N from chemical fertilizer and 75% N from biogas slurry produced 448 number of tiller/ m^{-2} and the increase was 31% more over control. The minimum number of tillers (-30%) were recorded with T5 where whole of the recommended nitrogen was supplied through biogas slurry.

1000 Grain Weight (g):

According to Table-13 the highest 1000 grain weight (49% higher over control) was recorded with treatment T3 (50% N from chemical fertilizer + 50% N from biogas slurry) followed by T2 (75% CF + 25% BGS) and T4 (25% CF + 75% BGS) with 19 and 11% increase over control. The minimum 1000 grain weight was recorded by applying 100% N through biogas slurry showing a negative effect of sole application of biogas slurry.

Table-12: Effect of integrated use of Biogas Slurry (BGS) and chemical fertilizers on growth and yield of wheat

S. NO.	Treatment description	Plant Height (cm)		No. of Tillers (m^{-2})		1000 Grain Weight (g)	
		Mean value	% increase over control	Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK	86.96 b	--------	340 c	---------	24.8 bc	--------
2	75% Chem. N + 25% N as BGS	89.45 ab	3	483 ab	42	29.7 ab	19
3	50% Chem. N + 50% N BGS	92.11 a	6	533 a	56	37.06 a	49
4	25% Chem. N + 75% N BGS	87.13 b	0.2	448 b	31	27.34 bc	10.6
5	100% N as BGS	85.95 b	-1	237 d	-30	21.9 c	-11

Note: 100% recommended PK was applied in all treatments

Straw Yield (t/ha)

Table-13 shows the data regarding straw yield and revealed that maximum straw yield 9.58 t/ha was observed with T3 (50% N from chemical fertilizer + 50% N from biogas slurry) which was 32% increase over control and it was followed by T2 (75% N from chemical fertilizer + 25% N from biogas slurry) and T4 (25% N from fertilizer + 75% N from biogas slurry). It was further noticed that these treatment differed non significantly with each other. The lowest straw yield (6.34 t/ha) was recorded where bioslurry was applied as sole source of N (T5) and caused a 12% decrease over control.

Grain Yield (t/ha)

The data presented in Table-13 shows that the grain yield was significantly increased as a result of integrated use of chemical fertilizers and biogas slurry. The maximum grain yield (4,59 t/ha) was also with the application of 50% of recommended N from chemical fertilizer and the remaining from biogas slurry (T3)and it was followed by T2 (75% N from fertilizer + 25% N from biogas slurry) and T4 (25% N from fertilizer + 75% N from biogas slurry) by recording 34 and 19% increase over control. The sole application of bioslurry as N source again prodecd a negative effect on grain yield and caused 25% decline in grain yield over control.

N concentration in straw

Table-14 shows that maximum N contents in straw (0.29%) were recorded by applying 50% N from biogas slurry and 50% N from chemical fertilizer which showed 81.25% increase over control. It was followed by treatments T2 and T3 showing 25 and 12.5% increase over control but found statistically non-significant. Treatment T5 showed same % N contents in straw (0.16) that were obtained by applying recommended chemical NPK (control).

P concentration in straw

Table-14 shows that % P contents in straw were increased by 48.14% over control where biogas slurry and chemical fertilizer were used in 50: 50% N basis combinations (T3) followed by T2 (75% Chem. N + 25% N as BGS) showing 18.51% increase over control. Treatments T4 and T5 showed -14.81 and -22.22% decrease over control.

Table-13: Effect of integrated use of Biogas Slurry (BGS) and chemical fertilizers on yield of wheat

S. NO.	Treatment description	Straw Yield (t/ha)		Grain Yield (t/ha)	
		Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK	7.22 c	-------	2.72 c	-------
2	75% Chem. N + 25% N as BGS	9.02 ab	24.93	3.65 b	34
3	50% Chem. N + 50% N BGS	9.58 a	32	4.59 a	68
4	25% Chem. N + 75% N BGS	8.52 ab	18	3.26 bc	19
5	100% N as BGS	6.34 bc	-12	2.04 d	-25

Note: 100% recommended PK was applied in all treatments

Table-14: Effect of integrated use of Biogas Slurry (BGS) and chemical fertilizers on wheat % NPK in Straw:

Trt. NO.	Treatment description	% N in Wheat Straw		% P in Wheat Straw		% K in Wheat Straw	
		Mean value	% increase over control	Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK	0.16 b	----------	0.2733 bc	----------	3.32 c	----------
2	75% Chem. N + 25% N as BGS	0.20 ab	25	0.3233 ab	18.51852	3.8767 ab	16.56627
3	50% Chem. N + 50% N BGS	0.29 a	81.25	0.4067 a	48.14815	4.1133 a	23.79518
4	25% Chem. N + 75% N BGS	0.18 ab	12.5	0.2300 bc	-14.8148	3.5933 bc	8.13253
5	100% N as BGS	0.16 b	0	0.2133 c	-22.2222	3.2067 c	-3.61446

Note: 100% recommended PK was applied in all treatments

K concentration in straw

Data regarding % K contents in straw (Table-14) shows that maximum % K contents were recorded in T3 (50% Chem. N + 50% N BGS) showing 23.79% increase over control followed by T2 and T4 with 23.79 and 8.13% increase over control. Treatment T5 and T1 (control) were found statistically similar.

N concentration in grains

Combined use of biogas slurry and chemical fertilizer significantly increased the % N contents in grains. Maximum % N contents in grains (Table-15) were observed by applying 50% N from chemical fertilizer and 50% N from biogas slurry which showed 78.12% increase over control. Treatments T2 and T4 were found statistically similar and showed 39.06 and 14.06% increase over control.

P concentration in grains

Table-15 shows that the plant height was significantly increased by combined use of biogas slurry and chemical fertilizer (urea). Maximum % P contents were obtained with T3 showing 36.97% increase over control followed by T2 (75% N from fertilizer + 25% N from biogas slurry) and T4 (25% N from fertilizer + 75% N from biogas slurry) with 33.61 and 23.52% increase over control. T3 was statistically on par with T2. Minimum % P contents (-29.41% less than control) were observed with T5 (100% N from biogas slurry).

K concentration in grains

According to Table-15 the highest % K contents in grains 49.43% increase over control were recorded with treatment T3 (50% N from fertilizer + 50% N from biogas slurry) followed by T2 (75% CF + 25% BGS) and T4 (25% CF + 75% BGS) with 28.72 and 17.02% increase over control. The minimum % K contents were recorded by applying 100% N through biogas slurry.

Table-15: Effect of integrated use of Biogas Slurry (BGS) and chemical fertilizers on wheat % NPK in grains

Trt. NO.	Treatment description	% N in Wheat Grain		% P in Wheat Grain		% K in Wheat Grain	
		Mean value	% increase over control	Mean value	% increase over control	Mean value	% increase over control
1	Recommended NPK	0.6433 b	----------	1.1967 bc	----------	0.9433 b	----------
2	75% Chem. N + 25% N as BGS	0.8900 ab	39.0625	1.5900 ab	33.61345	1.2100 ab	28.7234
3	50% Chem. N + 50% N BGS	1.1467 a	78.125	1.6300 a	36.97479	1.2733 a	35.10638
4	25% Chem. N + 75% N BGS	0.7333 ab	14.0625	1.4700 ab	23.52941	1.1067 ab	17.02128
5	100% N as BGS	0.4867 b	-25	0.8467 c	-29.4118	0.6567 c	-30.8511

Note: 100% recommended PK was applied in all treatments

SUMMARY

1) The maximum plant height 6% increase over control was obtained with the application of 50% of recommended N through chemical fertilizers and the remaining 50% from biogas slurry. It was also observed that the sole application of biogas slurry as N source had negative effect on plant height of wheat.

2) Combined use of biogas slurry and chemical fertilizer significantly increased number of tillers m^{-2} and the highest number of tillers (533) was recorded with the use of 50% N from chemical fertilizer and 50% N from biogas slurry which was 56% more than control and it was statistically non significant where 75% N from chemical fertilizer and 25% N from biogas slurry was applied. The supply of 100% recommended nitrogen from biogas slurry caused 30% decrease in number of tillers per m^{-2}.

3) The highest 1000 grain weight (49% higher over control) was recorded with the use of 50% N from chemical fertilizer and 50% N from biogas slurry. The sole application of biogas slurry for the supply of 100% of recommended N exhibited a negative effect on 1000 grain weight.

4) Like other growth and yield parameters the maximum grain yield (4,59 t/ha) was also achieved with the application of 50% of recommended N from chemical fertilizer and the remaining 50% N from BGS which produced 68% higher grain yield over control. The sole application of bioslurry as N source again produced a negative effect on grain yield and caused 25% decline over control.

INTERIM RECOMMENDATIONS

1. The use of bio slurry in combination with chemical fertilizers for improving yield of okra was better than compost used in combination with bio slurry.

2. The preliminary studies showed that the use of 50% of recommended nitrogen from biogas slurry and d 50% from chemical fertilizer was the best combination for improving growth and yield of rice, potato and wheat. Further increase in yield was recorded when this combination was used in combination with PGPR or PGR. Therefore these combinations may be used for improving growth and yield of these crops

3. The preliminary study on okra also showed that the use of bio slurry @600 kg/ha as soil conditioner can also improve the yield of okra.

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