Effect of inorganic Fertilizers and Biogas slurry on Content and Uptake of NPK in Wheat Grown Under Sodic Vertisols

ABSTRACT

Conjoint use of inorganic and organic amendments can be a pragmatic solution for improving soil physico-chemical and biological properties and sustaining crop productivity. Keeping in this view a pot experiment was conducted during rabi season of 2015-16 in net house of AICRP on Management of Salt Affected soils and use of Saline Water in Agriculture, College of Agriculture, Indore to study the effect of recommended doses of fertilizer and biogas slurry on uptake and content of NPK in wheat grown under sodic Vertisols. The treatment comprised of T0-Control, T1-100% RDF, T2- 100% RDF + 750 kg BGS ha^{-1}, T3-75% RDF + 750 kg BGS ha^{-1}, T4- 50% RDF + 750 kg BGS ha^{-1}, T5- 100% RDF + 1000 kg BGS ha^{-1}, T6-75% RDF + 1000 kg BGS ha^{-1}, T7-50% RDF + 1000 kg BGS ha^{-1}, T8-100% RDF + 1250 kg BGS ha^{-1}, T9-75% RDF+ 1250 kg BGS ha^{-1}, T10-50% RDF+ 1250 kg BGS ha^{-1} were laid in completely randomized design with 3 replications. Results showed that the treatment T9 (75% RDF+1250 kg BGS ha^{-1}) gave maximum dry matter production (0.205, 0.434 and 0.821 g plant-1), N content (2.39, 1.58 and 1.36%), P content (0.41, 0.30 and 0.24%) and K content (1.24, 0.68 and 1.68%) at 30, 60 and 90 DAS. Maximum uptake of N (1.20 and 0.72 g pot^{-1}), P (0.132 and 0.119 g pot^{-1}) and K (0.237 and 1.08 g pot^{-1}) by grain and straw of wheat respectively, were found with the application of T9 (75% RDF+1250 kg BGS ha^{-1}). Thus, it may be concluded that integrated application of 75% RDF+1250 kg BGS ha^{-1} not only increases dry matter production but also content and uptake by wheat.

Key words- Biogas slurry, Recommended Doses of Fertilizer, Sodic (Alkali), Vertisols.

1. INTRODUCTION

"It is estimated that out of 329 M ha total geographical area of India. The area under agriculture is 179.9 M ha and 120.4 M ha area is degraded through one or more degradation type, which in turn is affecting the country's productive resource base. The alkali soils in general are characterised by high soil pH, high exchange sodium percent, low organic carbon, poor filtration and poor fertility status. These soils are dominated by sodium carbonate and sodium bicarbonate salts" [5]. "To improve sodic soil, a substantial percentage of the exchangeable sodium needs to be removed by calcium ions. This reaction can be quickly accomplished using chemical soil amendments, such as gypsum. These soils first require calcium additions to correct sodium, followed by leaching to remove salts. However, adding industrial acids to soils is an expensive alternative for near-subsistence farmers in developing countries. Thus, alternative and readily available acidic substances such as manure can also help dissolve calcium compounds in soils" [19].

"The addition of organic amendments in sodic soils binds fine particles together into large water-stable aggregates, increasing porosity and thus improving the soil physical properties" [62]. "Fertilization with organic matter can be expected to improve salt-affected soils, regarding their chemical and physicochemical characteristics by decreasing the exchangeable Na^+ content and improve their physical properties by increasing the aggregate stability" [13]. "Additionally, remediating saline–sodic soils with organic amendments is a cheaper and more sustainable alternative to inorganic materials" [44].

"Among the many organic fertilizers existing, biogas slurry has not been fully utilized as a fertilizer yet it has great potential of improving soil productivity and crop yield through nutrient supply" [50]. "Biogas slurry is rich in nutrients and trace elements and can be used as a kind of high-quality organic fertilizer that is generally applied directly or combined with other fertilizer" [39, 10] "Organic wastes in cattle cow dung and agricultural wastes added to the biogas digester are converted to inorganic form during decomposition, making them more available for uptake by the plants thus contributing to improved crop yields and soil fertility" [33]. "Digestates from organic matter such as animal slurry reportedly contains more mineral nitrogen as compared to the undigested ones" [40]. "In comparison to traditional compost, BGS is an easily available form of compost and is also reported to have stronger plant growth-promoting activities than raw slurries" [56, 57]. Nutrient profile of BGS As compared to cow manure, Mdlambuzi et al. [35] found "0.65%, 0.133%, and 0.10% higher values of N, P, and K content (% wt) in BGS respectively". Jared et al. [29] recorded "higher levels of Ca, Mg, Fe, Mn, and Zn in slurry compost as compared to BGS. The high concentration of nitrogen in the bio-slurry is attributed to the conversion of organic compounds during anaerobic decomposition to readily available Ammonium-Nitrogen". "This is an indication that the bioslurry is a better organic fertilizer than the other commonly used organic fertilizers as soil amendments. Previous studies have shown that appropriate use of biogas slurry can increase soil nutrients, enhance crop nutritional quality, reduce greenhouse gas emissions, decrease crop disease and have other benefits" [53, 59]. "It seems that there is a consensus on the ability of biogas slurry to improve the physical and biological quality of soil besides providing both macro and micro-nutrients to crops and vegetables" [60]. "At the same time, it prevents adverse environmental impacts of waste disposal. Proper utilization of biogas slurry can reduce dependency of many farmers on increasing expensive chemical fertilizers as it contains 20-30% more nutrients than mostly used organic fertilizers such as cow dung, farmyard manure and compost" [3, 63]. "Sufficient supply of nutrients from soil and fertilizers at early growth stages is of great importance for optimum crop yield. Dry matter and nutrient accumulation in the growing season are the main factors in the determination of seed yield and nutrient use efficiency" [32]. "For fertilizer recommendations and synchronization of nutrient supply with crop nutrient demand, it is essential to determine the total nutrient requirements and the temporal pattern of uptake during the growing season" [1]. Keeping in this view the aimed of research was to study the effect of biogas slurry and recommended doses of fertilizer on yield and chemical composition of wheat" and to find out the optimal ratio of chemical fertilizer and biogas slurry to dissolve biogass slurry and reduce the chemical fertilizer application.

2. MATERIAL AND METHODS

A pot experiment was conducted during *rabi* seasons of 2015-16 in the net house of Salt Affected Soils Project, College of Agriculture, Indore. The bulk surface soil (0-15 cm) was collected from Salinity Research Farm, Barwaha, district Khargone, Madhya Pradesh. The bulk soil was air dried, crushed with wooden roller and lot was thoroughly mixed before filling of pots.

The experimental soil (Typic Haplustert- sodic phase) had following characteristics: texture clayey, pHs 8.42, ECe 1.26 dSm^{-1}, organic carbon 0.36 %, available N 190, P 10.3 and K 335 kg ha^{-1}. The exchangeable Ca, Mg and Na were 16.01, 5.60 and 17.17 (c mol (P^{+}) kg^{-1}), respectively. The CEC and ESP of soil were 39.6 (c mol (P^{+}) kg^{-1}) and 43.23, respectively.

The biogas slurry was obtained from Dairy Biogas Plant, College of Agriculture, Indore. The biogas slurry thus obtained was dried in an oven at $55^{o}C$ and subjected to the chemical analysis. The physic-chemical properties of biogas slurry are given in Table 1. The treatment comprised of T0-Control, T1-100% RDF, T2-100% RDF + 750 kg BGS ha^{-1}, T3-

75% RDF+ 750 kg BGS ha^{-1}, T4-50% RDF + 750 kg BGS ha^{-1}, T5-100% RDF + 1000 kg BGS ha^{-1}, T6-75% RDF+ 1000 kg BGS ha^{-1}, T7-50% RDF + 1000 kg BGS ha^{-1}, T8-100% RDF + 1250 kg BGS ha^{-1}, T9-75% RDF+ 1250 kg BGS ha^{-1}, T10-50% RDF+ 1250 kg BGS ha^{-1} were tried in Completely Randomized Design with 3 replications.

Table 1. Characteristics of biogas slurry (BGS) used in experiment

Moisture (%)	pH (1:5)	EC (dSm^{-1})	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)
88	6.98	.93	1.60	1.55	1.00	1.60	0.50

For this study, China clay pots with a capacity of about 30 kg were employed. The 15 kg of prepared soil were placed inside the containers. In accordance with the procedures, the full dosages of biogas slurry (BGS) were applied to the top 15 cm of soil to moisten it. The pots were then left in place for 15 days. Half of the nitrogen from each RDF was applied at seeding after 15 days and the remaining half was applied in two equal portions at 22 and 45 days following sowing. When wheat was sown, the entire P and K dose of each RDF was administered as basal. Urea, single super phosphate, and muriate were used to administer nitrogen, phosphorus, and potassium.

Urea, triple super phosphate, and potash muriate, the recommended NPK doses of 120, 90, and 60 kg ha1 were applied during fertilization. The urea was broadcast in three split doses: 1/3 before sowing, 1/3 at tillering, and 1/3 throughout the wheat crop's flowering phases. The total P and K fertilizers were applied at the time of field preparation. Wheat seeds (var. HI 1077) were shown in pots with deionized water serving as irrigation fluid. After 8 days of seeding, the seedlings were thinned, and 5 plants were preserved in each container. When the plants were mature enough to be harvested, the yield of grain and straw was measured.

For dry matter in wheat, five plants were first cut from the ground level, air-dried and then oven-dried at 65^{0}C for 48 hours and weighed. Plant samples (grain and straw) were oven dried at 60^{o}C. Total nitrogen in plant samples was determined by micro-Kjeldahl method as outlined by Jackson (1973). Phosphorus and potassium were determined in wet digested samples by Vanado- molybdo phosphoric acid yellow colour method (Chapman and Pratt, 1961) and flame photometer method, respectively. Nutrient uptake in wheat grain and straw was calculated by multiplied nutrient concentration in grain or straw (%) to grain or straw yield (g pot^{-1}).

3. RESULTS AND DISCUSSION

3.1 Dry weight at different growth stages

Data showed that (Table 1) all the treatment were found significant over control. Different combination of BGS and RDF were found significant over alone RDF. The minimum dry weight plant^{-1} (0.106, 0.291 and 0.546g plant^{-1}, respectively) was obtained with control and the maximum values (0.214, 0.448 and 0.854 g plant^{-1}) were obtained with T8 (100% RDF+ 1250 kg BGS ha^{-1}). However, the dry weight plant^{-1} in treatments T8 and T9- 75% RDF+ 1250 kg BGS ha^{-1} (0.205, 0.434 and 0.821 g plant^{-1}, respectively) were statistically similar to each other in all periods of recording at 30, 60 and 90 DAS. T8 and T9 showed significant enhancements of 64.61, 24.79 and 19.27% and 57.69, 20.89 and 14.66%, respectively over T1-RDF (0.130, 0.359, 0.716 g plant^{-1}, respectively). Biomass accumulation rate increased with time, reaching a maximum at later stage [32]. “Treatment with 100% and 75% dosage of fertilizer had a more significant number of total dry weight compared with 50% dosage” [60]. Similar results was also reported by Mdlambuzi et al. [36] who stated that “the increase of dry matter yield with the increasing rate of the BGS could be explained by higher uptake of NPK. The higher biomass accumulation was a result of increased N availability and uptake of other nutrients”. Islam et al., [28] also reported that “the higher nutrients increased maize growth and development, leading to higher dry matter yields". The digestion process (biogas production) is believed to convert organically bound nutrients into more readily available forms (11). Several researchers [60, 63] have observed comparatively better results of BGS and RDF than those obtained from chemical fertilizers treatment alone. Total dry matter yield subsequently increased with the increment of higher doses of inorganic N when combined with bioslurry [49]. This is similar to other research comparing plant biomass production under digestate treatments vs mineral fertilizers [4, 55, 45].

3.2 Nitrogen content at different growth stages

Table 1 showed that all the combination of RDF and BGS were found significant over control. The T8 (100% RDF+ 1250 kg BGS ha^{-1}) displayed the significantly higher N content in dry matter of wheat (2.42, 1.61 and 1.39%, respectively) which was found statistically similar with T9- 75% RDF+ 1250 kg BGS ha^{-1} (2.39,1.58 and 1.36%, respectively) at 30, 60 and 90 DAS. T8 and T9 were also found significant over all remaining treatment at 30, 60 and 90 DAS. T2 (100% RDF + 750 kg BGS ha^{-1}) and T5 (100% RDF + 1000 kg BGS ha^{-1}) were also found significant over T1 (100% RDF). The recorded improvements due to T8 and T9 were 8.52, 17.51 & 19.82% and 7.17, 15.32 and 17.24%, respectively than that of T1 (100% RDF) at respective growth stages. A positive change in nutrient dynamics was noted with treatment application. In general improvement in soil nitrogen, phosphorus and potassium were observed when bioslurry was applied. Bioslurry contains higher amounts of nitrogen which is readily mineralized and becomes plant available. Therefore, the application of bioslurry is related to higher nitrate availability [41]. Haque et al. [23] found that bioslurry increased the availability of nitrogen in soils. He also reported that the application of bioslurry in soil not only increased NO_3-N content of soil but also increased its plant uptake when applied in integration with mineral nitrogen fertilizers. "During manure digestion, about half of the carbon is released as methane and carbon dioxide (biogas) and changes in the C:N ratio occur due to the fact that carbon is absorbed by the resulting biomethane, part of the organic nitrogen is released as ammonium so when it is applied to fields, ammonium can directly be utilized by crops. Resulting forms are much easier to be assimilated by plants, as nitrogen is converted to NH4+. High NH4+ content is easily accessible to plants" [33, 20, 14]. "Furthermore, biogas slurry contains abundant available N, P and K, which are important nutrients for plants. It has been reported that the supply of N from digested slurry exerts a direct influence on the yield during the growing season" [30]. Thus biogas slurry as an effective substitute for chemical fertilization [61].

3.3 Phosphorous content at different growth stages

The data (Table 1) revealed that phosphorus content in dry matter of wheat was significantly increased with the application of T8 (100% RDF+ 1250 kg BGS ha^{-1}) over T1 (100% RDF) at 30, 60 and 90 DAS, respectively but it did not differ significantly with T9 (75% RDF+ 1250 kg BGS ha^{-1}). The highest phosphorus content (0.43, 0.32 and 0.26%, respectively) in dry matter of wheat with the increment of 65.38, 100 and 73.33% in T8 at 30, 60 and 90 DAS, respectively. T9 treatments significantly increased P content (0.41, 0.30 and 0.24%, respectively) with the increment of 65.38, 100 and 73.33%, respectively in comparison to T1. Bachmann et al. [9] reported that digestates resulted in higher P uptake. The digestates can, therefore, be considered a suitable P source for plants. These results confirmed previous outcomes of an experiment with maize and amaranth [6] significant amounts of easily assimilable minerals were introduced with the digestate mass [43,47**],** which probably had an impact on increasing their content in the biomass**.** The P concentration rapidly increased by increasing the BS addition [7]. Thus, the BS contains labile and highly soluble P forms [8], which are quickly mineralized to release the easily bioavailable P form [9]. Moreover, BS could also stimulate microbial activity with an enhancement in the available P released from soil P pool [42]. Likewise, Haase et al. [22] reported that BS increased the fraction of plant-available inorganic phosphate which ultimately increase P content in plant. Delin and Nyberg

[17] reported a significantly higher P content in plant tissue following BGS application compared to the control.

3.4 Potassium content at different growth stages

Data presented in table 1 showed that application of T8 (100% RDF+ 1250 kg BGS ha^{-1}) achieved higher K content followed by T9 (75% RDF+ 1250 kg BGS ha^{-1}). T8 (1.26, 0.71 and 1.72%, respectively and T9 (1.24, 0.68 and 1.68%, respectively) found significant over all treatments. T8 and T9 has increments of 17.75, 39.21 & 13.09% and 15.88, 33.33 and 11.25% respectively, over T1 (100% RDF) at 30, 60 and 90 DAS. The lowest value in T0 (control) were 1.02, 0.44 and 1.42%, respectively at respective growth stages. “The greater accumulation of accessible phosphorus and potassium after biogas slurry application” [52]. “The potassium concentrations were similar in the BS and CF treatments (T8 and T9) and were substantially higher than in the alone chemical fertlizers. This might be explained by high concentrations of potassium in biogas slurry treatments. Bioslurries supplied greater amount of nutrients compared to their respective original state of soil which influenced nutrient uptake of the test crop” [24]. “The lower C and higher nutrient content resulted in lower C/N, C/P, C/K, and C/S ratio, which indicated possibility of higher nutrient supply by the organic manure like CD slurries” [23]. Sharma et al. [48] opined that “bioslurry is an efficient source of organic manure with higher ability to deliver nutrients, especially N to crops”. Shahbaz et al. [49] reported that “changes in soil nutrient reserves and alterations in root systems under different sources of N, P, K, and S supply, including organic sources, might have a direct bearing on the nutrient availability and uptake by crops especially wheat and rice”. Haque et al. [23] also found that “cowdung bioslurry had higher N, P, K, and S content compared to chemical fertilizers. He also found that bioslurry is recommended as a substitute of 24–32% N, 52–91% P, 18–24% K and 50–73% S which ultimately increased availability of nutrients”.

3.5 Nitrogen uptake by grain and straw

Application of different combination of RDF with BGS were found significant over control (Table 2). The application of T8 (100% RDF+ 1250 kg BGS ha^{-1}) significantly enhanced the nitrogen uptake by grain (1.27 g pot^{-1}) and straw (0.77 g pot^{-1}) of wheat by 54.4 and 70.06%, respectively over T1 (100% RDF) but it was statistically at par with T9 (75% RDF + 1250 kg BGS ha^{-1}). However, uptake of N (1.20 and 0.72 g pot^{-1}) found with T9, which was “The results of this study indicated biogas slurry as an effective substitute for chemical fertilization. A previous study evaluated the utilization ratio of NH4-N in biogas slurry and reported that more than 90% of the applied NH4- N could be used, which indicated an immediate increase in the amount of soil NH4-N” [53]. “Several researchers reported that an appropriate fertilizer doses and a proper ratio of biogas slurry and chemical fertilizer could offer nutrients for crop growth in a timely manner and reduce carbon and nitrogen losses caused by leaching and gas emissions consequently increasing nutrient uptake by wheat. These results agreed with results reported by many researchers” [2, 12, 26,63, 31].

3.6 Phosphorus uptake by grain and straw

Table 2 showed that the application of T8 (100% RDF+ 1250 kg BGS ha^{-1}) treatment has higher uptake of P by grain (0.147 g pot^{-1}) and straw (0.134 g pot^{-1}) than T1- 100% RDF (0.047 and 0.044 g pot^{-1}, respectively) and at par with T9 (75% RDF+ 1250 kg BGS ha^{-1}). The uptake improvements due to T8 were 112.7 and 104.54%, respectively over 100% RDF. Application of T9 (0.132 g pot^{-1} in grain and 0.119 g pot^{-1} in straw) significantly enhanced 212.76 and 180.85% uptake of P by grain and straw, respectively over T1 (100% RDF). There are relatively few studies directly investigating the effects of digestate on phosphorus

(P) availability and uptake, and the majority of those that do compare it with undigested materials, rather than with mineral fertilizers. While there is some suggestion of increased P availability from digestates as compared with raw manures [34, 4], there are some that suggest there is no effect of digestates on P availability as compared with manures [8,10]. Our results supported by Bachmann et al. [8] who showed that applying BGS did not only increase the plant available P but also the uptake by plants was improve with respect to the control, which is consistent with findings by Delin [18]. Application of biogas slurry at 30 t/ha level with 100% and 75% dosage of inorganic fertilizer had the same ability [60]. C/N ratio plays an essential role in making the nutrients available for the plants. It is often stated that degradation processes during digestion will improve phosphorus (P) plant availability [37, 46, 34].

3.7 Uptake of potassium by grain and straw

Application of different combination of RDF with BGS were found significant over control (Table 2). Maximum value found in T8 (100% RDF+ 1250 kg BGS ha^{-1}) and lowest value found in control. Application of T8 (100% RDF+ 1250 kg BGS ha^{-1}) and T9 (75% RDF+ 1250 kg BGS ha^{-1}) found significant over all treatments and at par each other with the values of 0.257 & 1.14 g pot^{-1} and 0.237 & 1.08 g pot^{-1}, respectively in grain and straw of wheat. The enhancement of uptake of K due to T8 113.47 & 56.16% and 106.08 and 47.94% in grain and straw respectively. Yu et al. [63] showed a significant increase in available K content in biogas slurry compared to control. Tambone et al. [54] assessed "the variation in K concentration levels between BGS and compost treated soils, results indicated that K concentration are generally higher in BGS than compost. In a related study where Haraldsen et al. [25] compared the efficiency of different organic amendments including BGS when applied at 80 kg N/ha. Results showed that BGS supplemented significantly higher amounts of K than any other treatment. There is a general trend that BGS supplements significant quantities of K, which then emphasizes more suitability in BGS for supplementing K. Biogas slurry had a high organic matter by 2.89%". "The nitrogen, phosphorus, and potassium contained in it helped to improve the effectiveness of fertilizing" [60]. significant amounts of easily assimilable minerals were introduced with the digestate mass [47, 43] which probably had an impact on increasing their content in the biomass of wheat.

4. CONCLUSION

In the present investigation it has been found that there was no significant difference between the application of T8 (100% RDF+1250 kg BGS ha^{-1}) and T9 (75% RDF+1250 kg BGS ha^{-1}) for all the parameters studied therefore the treatment T9 that is 75% RDF+1250 kg BGS ha^{-1} may be suitable option for growing wheat crop under sodic Vertisols as it saved the 25% recommended doses of fertilizer.

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Table 2. Effect of chemical fertilizers on Total N,P and K content at 30, 60 and 90 DAS

Treatments	Dry weight g pot-^{1}			Total N content (%)			Total) P content (%)			Total K content (%)		
	30	**60**	**90**	**30**	**60**	**90**	**30**	**60**	**90**	**30**	**60**	**90**
T0	0.106	0.291	0.546	2.18	1.27	1.08	0.21	0.12	0.10	1.02	0.44	1.42
T1	**0.130**	**0.359**	**0.716**	**2.23**	**1.37**	**1.16**	**0.26**	**0.16**	**0.15**	**1.07**	**0.51**	**1.51**
T2	0.174	0.375	0.758	2.31	1.48	1.28	0.34	0.23	0.19	1.17	0.60	1.63
T3	0.162	0.367	0.738	2.28	1.45	1.25	0.32	0.21	0.17	1.14	0.59	1.59
T4	0.137	0.351	0.721	2.25	1.39	1.18	0.27	0.17	0.15	1.08	0.52	1.55
T5	0.185	0.381	0.767	2.32	1.50	1.30	0.36	0.25	0.20	1.18	0.63	1.65
T6	0.172	0.370	0.744	2.29	1.47	1.27	0.33	0.22	0.18	1.16	0.58	1.62
T7	0.142	0.362	0.731	2.27	1.40	1.20	0.29	0.18	0.16	1.11	0.53	1.53
T8	**0.214**	**0.448**	**0.854**	**2.42**	**1.61**	**1.39**	**0.43**	**0.32**	**0.26**	**1.26**	**0.71**	**1.72**
T9	**0.205**	**0.434**	**0.821**	**2.39**	**1.58**	**1.36**	**0.41**	**0.30**	**0.24**	**1.24**	**0.68**	**1.68**
T10	0.171	0.388	0.755	2.32	1.49	1.27	0.34	0.24	0.17	1.16	0.60	1.57
SE(m) ±	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.01**	**0.02**	**0.02**	**0.02**
CD at 5%	**0.03**	**0.05**	**0.05**	**0.07**	**0.07**	**0.05**	**0.04**	**0.03**	**0.04**	**0.05**	**0.07**	**0.07**

T0-Control, T1-100% RDF, T2-100% RDF + 750 kg BGS ha^{-1}, T3-75% RDF+ 750 kg BGS ha^{-1}, T4-50% RDF + 750 kg BGS ha^{-1}, T5-100% RDF + 1000 kg BGS ha^{-1}, T6-75% RDF+ 1000 kg BGS ha^{-1}, T7-50% RDF + 1000 kg BGS ha^{-1}, T8-100% RDF + 1250 kg BGS ha^{-1}, T9-75% RDF+ 1250 kg BGS ha^{-1}, T10-50% RDF+ 1250 kg BGS ha^{-1}

Table 3. Effect of chemical fertilizers on dry weight and uptake of N,P and K by grain and straw

T0-Control, T1-100% RDF, T2-100% RDF + 750 kg BGS ha^{-1}, T3-75% RDF+ 750 kg BGS

Treatments	Uptake by Grain (g pot^{-1})			Uptake by Straw (g pot^{-1})		
	N	**P**	**K**	**N**	**P**	**K**
T0	0.57	0.024	0.068	0.31	0.023	0.55
T1	**0.82**	**0.047**	**0.115**	**0.43**	**0.044**	**0.73**
T2	1.06	0.092	0.180	0.59	0.081	0.97
T3	0.95	0.076	0.156	0.54	0.066	0.88
T4	0.86	0.053	0.124	0.45	0.049	0.77
T5	1.08	0.096	0.193	0.62	0.088	0.96
T6	1.01	0.083	0.167	0.55	0.072	0.90
T7	0.89	0.058	0.131	0.47	0.054	0.80
T8	**1.27**	**0.147**	**0.257**	**0.77**	**0.134**	**1.14**
T9	**1.20**	**0.132**	**0.237**	**0.72**	**0.119**	**1.08**
T10	1.04	0.095	0.174	0.58	0.076	0.94
SE(m) ±	**0.03**	**0.006**	**0.003**	**0.03**	**0.005**	**0.04**
CD at 5%	**0.07**	**0.019**	**0.010**	**0.08**	**0.013**	**0.11**

ha^{-1}, T4-50% RDF + 750 kg BGS ha^{-1}, T5-100% RDF + 1000 kg BGS ha^{-1}, T6-75% RDF+ 1000 kg

BGS ha^{-1}, T7-50% RDF + 1000 kg BGS ha^{-1}, T8-100% RDF + 1250 kg BGS ha^{-1}, T9-75% RDF+ 1250 kg BGS ha^{-1}, T10-50% RDF+ 1250 kg BGS ha^{-1}