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Effect of NPK levels and city compost on soil chemical and biological properties, yield and quality of wheat (*Triticum aestivum* L.) under system of wheat intensification (SWI)

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Abstract
A field experiment was conducted on medium black calcareous soil at Junagadh (Gujarat) during *rabi* season of 2019-20 to study the effect of NPK levels and city compost on soil chemical and biological properties, yield and quality of wheat (*Triticum aestivum* L.) under and system of wheat intensification (SWI). Total twelve treatment combinations, consisting of three system of sowing (S_1: normal practice at 22.5 cm, S_2: SWI at 20 cm × 20 cm and S_3: SWI at 25 cm × 25 cm) were assigned to main plot and four fertility levels (F_1: city compost 10 t/ha, F_2: 50% RDF + city compost 5 t/ha, F_3: 75% RDF + city compost 5 t/ha and F_4: 100% RDF) were allotted to sub plots in a split plot design with three replications. The results revealed that sowing of wheat under SWI recorded significantly higher values of protein yield (562.63 kg/ha) and total fungal, bacterial as well as *Azotobacter* count in soil. SWI at 20 cm × 20 cm produced significantly maximum grain yield (5070 kg/ha) and straw yield (8289 kg/ha). Application of 75% RDF (90-45-45 kg N- P_2O_5- K_2O/ha) + city compost 5 t/ha enhanced almost all the quality parameters *viz*., protein, gluten and fiber content in grain, protein yield, available N, P and K as well as organic carbon content in soil after harvest and soil microbial population *viz.*, total fungal, bacterial, actinomycetes, *Azotobacter*, PSB and KSB count in soil, and resultantly gave higher grain yield (5975 kg/ha) and straw yield (8344 kg/ha).

Keywords: Wheat, NPK, city compost, system of wheat intensification (SWI), soil properties, yield and quality

1. Introduction

Wheat is also called as 'King of Cereals'. It is the third most produced cereal after maize and rice in the world. It is the second most important crop grown in India after rice, both in terms of area and production. Mexican Dwarf Wheat (*Triticum aestivum* L.) presently grown in India everywhere is called common bread wheat and belongs to *Dinkale* series (Hexaploid, 2n = 6x = 42), it was evolved by Dr. N. E. Borlaug at CIMMYT, Mexico. Its origin is South West Asia. Wheat is a C_3 plant, thermo sensitive cool season crop, self-pollinated and long day plant (LDP). The preeminence of bread wheat in baking industry is mainly due to the presence of a unique viscoelastic gluten protein complex that makes it the best cereal grain suitable for the manufacture of leavened bread. Wheat is harvested in the world at different times of the year. It can be grown on a variety of soils (sandy loam to clay soil) but clay loam soil is most suitable (Hossain *et al*., 2006) [12]. In Gujarat, comparatively lower productivity of wheat is due to several constraints like low soil fertility, moisture stress due to low water holding capacity of soil, lack of irrigation facilities, lack of required soil depth, imbalanced use of fertilizers, no or very low use of organic manures and lack of knowledge of modern agro techniques.

Plant nutrient management is one of the key components of intensive agriculture. Intensive agriculture involves the dwarf varieties of wheat having great potential but due to exhaustive nature they require more nutrients and have posed a great threat to long-term sustainability of crop production. The farmers are using high analyzed inorganic fertilizers to get higher yield of wheat. But continuous and uncontrolled use of these chemical fertilizers lead to environmental pollution and ultimately deteriorate the soil health or physical, chemical and biological properties. The organic carbon status of soil is depleted year by year due to less supply of organic matter. Furthermore, the availability of fertilizer at higher economic price is another problem for the country.

Under these circumstances one should not depend on single source of plant nutrients like chemical fertilizers. The need of the ours is to evolve an integrated plant nutrient supply system comprising balanced use of chemical fertilizers, organic manures and biofertilizers. Nowadays, composted municipal solid waste (MSW) known as 'city compost' is being popular in agriculture as a soil conditioner and fertilizer. City compost is enriched with certain strains of bacteria, algae or fungi, as a single or composite culture. They produce hormones and anti-metabolites which promote root growth. They decompose organic matter and help in mineralization in soil. Beneficial microorganisms help in nutrient acquisition by plants through fixation of nitrogen, solubilization and mobilization of other nutrients. It also improves the yield, stabilize C:N ratio, improve structure, bulk density and water holding capacity of soil. Use of city compost in agriculture promotes '*Swachh Bharat Mission*' to create a clean India.

System of wheat intensification (SWI) popularly known '*Sri Vidhi Gehun*' is a methodology for wheat cultivation. Its root goes in system of rice intensification (SRI) principle being practiced in paddy. SWI is mainly based on the two principles of crop production: principle of root development and principle of intensive care. Method of sowing play very important role providing for the proper space required by plant for efficient utilization of air, water, solar energy and nutrients, which altogether improve the crop yield and quality of the produce. In India, farming has traditionally been family based small holdings. The average size of an operational holding has been steadily declining in the country. The system of wheat intensification (SWI), based on low-tech methods, may be more labor-intensive than traditional techniques, but it requires less seeds, water, pesticide and fertilizer. Yield obtained in SWI is double than that of obtained conventional methods (Abraham *et al*., 2014) [2]. System of wheat intensification technique has high potential in providing higher yields, increase productivity which ultimately contributes to the household level food security of marginal farmers. Keeping above points in view, a field experiment was conducted to study the effect of NPK levels and city compost on soil chemical and biological properties, yield and quality of wheat (*Triticum aestivum* L.) under and system of wheat intensification (SWI).

2. Materials and Methods

A field experiment was conducted on a medium black calcareous soil at College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) in *rabi* season of 2019-20. The experimental soil was clayey in texture and slightly alkaline in reaction with $pH_{2.5}$ 8.0 and $EC_{2.5}$ 0.43 dS/m. The soil was low in organic carbon content (0.45%). The soil was low in available nitrogen (242 kg/ha) and medium in available phosphorus (33.15 kg/ha) and potassium (230 kg/ha).

Total twelve treatment combinations, consisting of three system of sowing [S_1: normal practice at 22.5 cm, S_2: SWI at 20 cm × 20 cm and S_3: SWI at 25 cm × 25 cm] were assigned to main plot and four fertility levels [F_1: city compost 10 t/ha, F_2: 50% RDF (60-30-30 kg N- P_2O_5- K_2O/ha) + city compost 5 t/ha, F_3: 75% RDF (90-45-45 kg N- P_2O_5- K_2O/ha) + city compost 5 t/ha and F_4: 100% RDF (120-60-60 kg N- P_2O_5- K_2O/ha)] were allotted to sub plots in a split plot design with three replications.

The wheat variety 'Gujarat Junagadh Wheat 463' (GJW 463) was sown on November 07, 2019 at the rate of 120 kg/ha at row spacing 22.5 cm in respect of normal sowing. However, under system of wheat intensification (SWI) two to three seeds per hill (20-25 kg/ha) were sown as per row-to-row and plant-to-plant spacing of the treatments. General depth of sowing was 4-5 cm from the soil surface.

SWI cultivation is a system rather than a technology in which different seed treatment techniques are adopted. For 10 kg seed treatment, 20 litres of water heated, up to 60 °C in an earthen vessel then seeds were poured in the hot water. Floating seeds were removed from the hot water, 2.25 kg vermicompost, 1100 g jaggery and 4 litre cow urine were added and kept for 8 hours. Separate seed mixture from the solution and treated with 2 g of Bavistin powder per kg seed. Treated seeds were kept in wet jute bag for 8-10 hours, which are then dried in shade for about an hour. Two seeds of wheat were dibbled in the field at a depth of 5 cm by maintaining different spacings *i.e.* 20 cm x 20 cm & 25 cm x 25 cm.

Nutrient application was done as per the treatment. KRIBHCO (Krishak Bharati Cooperative Limited) enriched city compost was used. The compost was already enriched with specific strains of N fixers, PSB and cellulolytic microorganisms. City compost was applied one day before sowing and incorporated into the top 20-25 cm soil manually. Nitrogen, phosphorus and potassium was applied through Urea (46% N), Single super phosphate (16% P_2O_5) and Muriate of potash (60% K_2O). 1/3 of nitrogen and full dose of phosphorus and potash is applied at sowing and rest 2/3 of nitrogen is applied in two equal spilts at 25 and 45 days after sowing. The crop was harvested at physiological maturity on March 06, 2020. Grain and straw yield were recorded from the net plot area and converted into kg per hectare base.

Protein content in grain was determined as suggested by Gassi *et al.*, 1973 [10]. Gluten content in grain was determined by NIR spectroscopy instrument (Haraszi *et al*., 2011) [11]. Fibre content in grain was determined by fiber thermal instrument (Prosky, 1990) [20]. The protein yield was computed by using the following formula:

$$\text{Protein yield (kg/ha)} \; \frac{\text{Protein content in grain (\%)} \times \text{grain yield (kg/ha)}}{100}$$

Soil available nitrogen was determined by alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [28]. Soil available phosphorus was determined by Olsen's method (Olsen *et al*., 1954) [19]. Soil available potassium was determined by flame photometer method (Jackson, 1974) [14]. Soil organic carbon content determined by chromic acid oxidation method (Walkley and Black, 1934) [31].

The soil microbial analysis was carried out by using serial dilution method (Aneja, 2005) [6]. Microbial count in soil was done by general colony formation unit count per gram (cfu/g). Microbial count of total fungus, bacteria, actinomycetes, *Azotobacter*, PSB and KSB population in the soil samples were made by the plate count method as described by Ismail and Yup (1994) [13]. Fungal growth study was done by using Potato Dextrose Agar (PDA) media. Bacterial study was done by using Nutrient Agar (NA) media. Actinomycetes count study was done using Rose Bengal Agar (RBA) media. *Azotobacter* count study was done by using Ashby's mannitol media. PSB count study was done using Pikovaskaya's Agar media. KSB count study was done using glucose, yeast extract, calcium carbonate (GYC) media.

3. Results and Discussion

3.1 Effect of system of sowing

3.1.1 Effect on post-harvest nutrient status of soil

The data furnished in Table 1 indicated that soil fertility status after harvest of wheat was not significantly influenced due to different system of sowing. After harvest of crop available soil nutrients *viz.*, nitrogen, phosphorus and potassium status as well as organic carbon content were slightly increased by improved rooting, root exudates and litter fall under SWI over normal practice but cannot reach the levels of significant due to the losses of decomposed materials and immobilization with wider C: N ratio. Similar results were also reported by Dhar *et al*. (2016) [9].

3.1.2 Effect on quality parameters and yield

The data presented in Table 2 revealed that different system of sowing did not impart their significant influence on quality parameters *viz.*, protein, gluten and fiber content in grain. An assessment of data showed that sowing of wheat under SWI at 20 cm × 20 cm recorded significantly higher protein yield (562.63 kg/ha) and it was remained statistically at par with SWI at 25 cm × 25 cm. Whereas, significantly the lowest protein yield (400.45 kg/ha) was recorded under normal practice at 22.5 cm. Higher protein yield under SWI at 20 cm × 20 cm may be due to moderate plant population, resulting in availability of more nitrogen per plant and higher yield per unit area over SWI at 25 cm × 25 cm and normal practice at 22.5 cm.

The data presented in Table 2 revealed that grain yield and straw yield of wheat were significantly influenced by different system of sowing. Highest grain yield (5070 kg/ha) and straw yield (8289 kg/ha) were recorded under SWI at 20 cm × 20 cm. Grain yield and straw yield of wheat increased significantly from SWI at 25 cm × 25 cm to SWI at 20 cm × 20 cm. This was mainly due to the fact that wider spacing under SWI at 25 cm × 25 cm could not compensate the drastic decrease in plant population and effective tillers resulting in severe decrease in number of ear head per unit area. The higher yields under SWI was due to adequate supply of resources which contributed towards higher dry matter accumulation and better partitioning of photosynthates resulting in higher yield traits and ultimately the yield. This was in conformity with the finding of Suryawanshi *et al*. (2013) [29], Singh *et al.* (2016) [26] and Singh *et. al.* (2018) [27].

3.1.3 Effect on soil microbial count

Among the soil microbial population studied (Table 3) total fungal, bacterial and *Azotobacter* count at 60 DAS and at harvest were significantly increased under SWI at 25 cm × 25 cm which was statistically comparable with SWI at 20 cm × 20 cm. This can be due to seed treatment techniques are adopted under SWI using vermicompost, jaggery and cow urine which contains plant growth regulator that promote root growth and also favorable for soil microorganisms. With the improved aeration and light transmission condition, soil microbial population were significantly increased under SWI as compared to normal practice at 22.5 cm. These results are in accordance with the findings of Namdeo and Sharma (2020) [18].

3.2 Effect of fertility levels

3.2.1 Effect on post-harvest nutrient status of soil

Results on soil fertility status after harvest of wheat crop as influenced by different levels of NPK & city compost presented in Table 1 showed that available nitrogen (285.82 kg/ha), phosphorus (43.01 kg/ha) and potassium (299.64 kg/ha) were significantly higher with application of 75% RDF + city compost 5 t/ha. The improvement in nitrogen, phosphorus and potassium status of the soil with integrated use of chemical fertilizers and city compost might be due to increased physico-chemical and biological properties of the soil. One thing was also noticed that increased uptake of nutrients by wheat crop due to combined use of chemical fertilizers and city compost did not decreased available soil nutrients as compared to sole treatments of city compost and 100% RDF. This might be due to subsequent decomposition of city compost in soil released the plant nutrients slowly throughout the crop growth and thus improved supply of nutrients and reduced nutrients losses. Data presented in Table 1 revealed that varying levels of NPK & city compost exerted their significant effect on organic carbon content in soil after harvest. Wheat fertilized with city compost 10 t/ha significantly improved organic carbon content (0.84%) in soil, which was found statistically at par with application of 50% RDF + city compost 5 t/ha and 75% RDF + city compost 5 t/ha. This might be due to use of city compost as a source of organic fertilizer in combination with chemical fertilizers. City compost added huge amount of organic matter to soil and itself act as an excellent source of organic carbon and various nutrients. The results confirm the findings of Shiralipour *et al.* (1992) [24], Bhandari *et al.* (2002) [8], Yuksel (2004) [32], Banwasi and Bajpai (2006) [7], Tabassum *et al.* (2010) [30], Scotti *et al*. (2016) [22] and Meena *et al*. (2016) [17].

3.2.2 Effect on quality parameters and yield

Data mentioned in Table 2 revealed that different levels of NPK & city compost exhibited their significant influence on protein, gluten and fiber content in grain. Significantly higher protein (11.67%), gluten (8.54%) and fiber (6.07%) content in grain were recorded when wheat was fertilized with 75% RDF + city compost 5 t/ha, which were found statistically at par with application of 50% RDF + city compost 5 t/ha. Significantly the highest protein yield (697.22 kg/ha) was also recorded under 75% RDF + city compost 5 t/ha. The improvement in nitrogen, phosphorus and potassium status of the soil with integrated use of chemical fertilizers along with city compost, enabled the crop for efficient metabolism of absorbed nutrients and carbon dioxide from the soil and atmosphere, respectively. Generally, nitrogen plays a major role in the metabolism of the crop plants. It enters into the structure of chlorophyll, amino acids, amides, alkaloids, protein and protoplasm of the plant parts, such as leaves and grains and ultimately improved the quality parameters of wheat crop. The findings are in close conformity with the results reported by Abedi *et al.* (2010) [1], Amin *et al.* (2011) [5] and Jat *et al.* (2013) [15]. The data furnished in Table 2 indicated that application of 75% RDF + city compost 5 t/ha to wheat produced significantly higher grain yield (5975 kg/ha) and straw yield (8344 kg/ha). Whereas, for straw yield, treatments 75% RDF + city compost 5 t/ha and 50% RDF + city compost 5 t/ha were found statistically at par. Integrated use of chemical fertilizers with city compost supplied nutrients in balanced quantity throughout the various growth stages might have enabled the plants to assimilate sufficient photosynthetic product and thus increased the yield. The results obtained in present study are in close agreement with those reported by Ram *et al*. (2005) [21], Akhtar *et al*. (2007) [3], Sefidkoohi *et al.* (2012) [23] and Aktar *et al.* (2018) [4].

Table 1: Effect of different system of sowing and fertility levels on nutrient status and organic carbon content of soil after harvest of wheat

Treatments	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)	Organic carbon (%)
System of sowing- (S)				
S_1- Normal practice at 22.5 cm	232.61	34.20	250.84	0.72
S_2- SWI at 20 cm × 20 cm	234.38	35.30	254.33	0.73
S_3- SWI at 25 cm × 25 cm	239.43	37.84	264.62	0.75
S.Em.±	7.69	0.98	10.10	0.03
C.D. at 5%	NS	NS	NS	NS
C.V.%	11.31	9.51	13.64	12.69
NPK & city compost- (F)				
F_1- City compost 10 t/ha	184.55	27.19	212.24	0.84
F_2- 50% RDF + City compost 5 t/ha	264.81	39.41	277.76	0.80
F_3- 75% RDF + City compost 5 t/ha	285.82	43.01	299.64	0.80
F_4- 100% RDF	206.70	33.51	236.75	0.49
S.Em.±	6.24	0.73	4.79	0.02
C.D. at 5%	18.53	2.18	14.22	0.05
C.V.%	7.95	6.14	5.60	6.39
Interaction (S X F)				
S.Em.±	10.80	1.27	8.29	0.03
C.D. at 5%	NS	NS	NS	NS

3.2.3 Effect on soil microbial count

The data furnished in Table 3 revealed that soil microbial population at 60 DAS and at harvest were significantly affected due to different levels of NPK & city compost. Significantly maximum total fungal, bacterial, actinomycetes, *Azotobacter*, PSB and KSB count in soil were recorded with the application of city compost 10 t/ha, which were found statistically at par with application of 50% RDF + city compost 5 t/ha and 75% RDF + city compost 5 t/ha. In contrast, significantly the lowest soil microbial counts were recorded with 100% RDF. KRIBHCO city compost was already enriched with specific strains of N fixers, PSB and cellulolytic microorganisms. The microbial population increased under the integrated use of city compost with chemical fertilizers due to increased physico-chemical and biological properties of the soil. With the improved aeration and other soil properties, soil microbial population were significantly increased because city compost also adds sufficient amount of humic substances to soil, which keeps the soil pH within favourable range. This component of city compost was also responsible to increase the efficiency of microbial activity by producing amino acids, growth promoting substances, antibiotics, *etc*. These results corroborate with the findings of Kavitha and Subramanian (2007) [16], Shyamala and Belagali (2014) [25] and Meena *et al*. (2016) [17].

3.3 Interaction effect

The interaction effect between levels of NPK & city compost and system of sowing was found non-significant for all the parameters studied.

Table 2: Effect of different system of sowing and fertility levels on quality parameters and yield of wheat

Treatments	Protein content in grain (%)	Gluten content in grain (%)	Fiber content in grain (%)	Protein yield (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)
System of sowing- (S)						
S_1- Normal practice at 22.5 cm	10.11	7.25	5.20	400.45	3870	6815
S_2- SWI at 20 cm × 20 cm	10.80	8.03	5.80	562.63	5070	8289
S_3- SWI at 25 cm × 25 cm	10.78	8.23	5.97	502.91	4537	7434
S.Em.±	0.45	0.26	0.24	23.22	135	204
C.D. at 5%	NS	NS	NS	91.16	529	801
C.V.%	14.81	11.50	14.43	16.46	10.39	9.40
NPK & city compost- (F)						
F_1- City compost 10 t/ha	8.77	7.10	5.19	225.97	2574	5857
F_2- 50% RDF + City compost 5 t/ha	11.19	8.16	5.99	568.07	5050	8174
F_3- 75% RDF + City compost 5 t/ha	11.67	8.54	6.07	697.22	5975	8344
F_4- 100% RDF	10.63	7.54	5.38	463.40	4370	7677
S.Em.±	0.33	0.23	0.22	18.81	124	158
C.D. at 5%	0.98	0.69	0.66	55.88	370	470
C.V.%	9.38	8.89	11.86	11.55	8.31	6.32
Interaction (S X F)						
S.Em.±	0.57	0.40	0.39	32.58	215	274
C.D. at 5%	NS	NS	NS	NS	NS	NS

Table 3: Effect of different system of sowing and fertility levels on soil microbial count (Total microbial count)

Treatments	Fungal count at (× 10^4 cfu/g soil)		Bacterial count at (× 10^6 cfu/g soil)		Actinomycetes count at (× 10^5 cfu/g soil)		*Azotobacter* count at (× 10^4 cfu/g soil)		PSB count at (× 10^4 cfu/g soil)		KSB count at (× 10^4 cfu/g soil)	
	60 DAS	Harvest	60 DAS	Harvest	60 DAS	Harvest	60 DAS	Harvest	60 DAS	Harvest	60 DAS	Harvest
System of sowing- (S)												
S_1- Normal practice at 22.5 cm	16.48	14.55	34.19	44.05	5.08	6.37	5.02	7.47	4.80	6.16	2.42	6.07
S_2- SWI at 20 cm × 20 cm	21.59	16.88	40.44	53.50	5.48	6.64	5.46	8.19	5.10	6.60	2.75	6.93
S_3- SWI at 25 cm × 25 cm	23.31	19.26	44.72	57.72	5.83	7.00	6.12	8.69	5.24	6.81	2.88	7.40
S.Em.±	0.60	0.87	1.67	1.81	0.29	0.34	0.20	0.23	0.22	0.27	0.12	0.39
C.D. at 5%	2.35	3.40	6.55	7.10	NS	NS	0.80	0.92	NS	NS	NS	NS
C.V.%	10.15	17.77	14.52	12.11	18.51	17.44	12.83	9.97	15.15	14.09	15.93	19.91
NPK & city compost- (F)												
F_1- City compost 10 t/ha	26.27	22.08	51.04	66.97	6.60	7.71	6.57	9.63	6.37	8.03	3.14	8.36
F_2- 50% RDF + City compost 5 t/ha	24.96	20.08	48.25	63.97	5.93	7.14	6.20	9.06	5.95	7.81	2.91	7.98
F_3- 75% RDF + City compost 5 t/ha	24.71	19.57	48.06	62.83	5.80	7.06	6.16	9.03	5.93	7.74	2.89	7.73
F_4- 100% RDF	5.90	5.86	11.77	13.26	3.50	4.77	3.21	4.73	1.93	2.51	1.80	3.13
S.Em.±	0.54	0.85	1.01	1.40	0.27	0.22	0.14	0.21	0.15	0.11	0.09	0.22
C.D. at 5%	1.60	2.51	2.99	4.15	0.81	0.67	0.42	0.61	0.45	0.34	0.26	0.65
C.V.%	7.92	15.01	7.59	8.10	14.91	10.11	7.62	7.63	8.91	5.24	9.62	9.68
Interaction (S X F)												
S.Em.±	0.94	1.46	1.74	2.42	0.47	0.39	0.24	0.36	0.26	0.20	0.15	0.38
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

4. Conclusion
On the basis of the results obtained from the present one year field experimentation, it could be concluded that higher yield and quality of wheat can be obtained by the application of 75% RDF (90-45-45 kg N- P_2O_5- K_2O/ha) + city compost 5 t/ha under system of wheat intensification at 20 cm × 20 cm, which also maintain soil health of medium black calcareous soil.

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