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Comparisons of Different Types of Organic Manures Integrated in Diverse Ratios with Inorganic N-Fertilizer in Terms of Maize Yield and Productivity

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Abstract

In modern agriculture, the integration of organic and inorganic fertilizers has been proved as the best technique to maximize the nutrient availability to crops for longer period of time and to minimize the essential nutrients loss from rhizosphere soil. However, most of the researchers and farmers are uninformed of that which is the best fertilizer integration ratio and what type of organic manure should be used for obtaining good fertile soil and economical crop yield. In response of the above question the present research experiment was carried out in Kharif season 2018 at Cereal Crop Research Institute (CCRI), Nowshera, KPK, Pakistan to investigate the performance of maize crop in response to different types of organic manures integrated with inorganic nitrogen fertilizer in distinct ratios based on % nitrogen (N). Total 9 treatments were used in the experiment such as T_1 (Control=100% N from Urea), T_2 (50% N from SSB+50% N from Urea), T3 (50% N from SCB+50% N from Urea), T4 (50% N from PL+50% N from Urea), T5 (50% N from FYM+50% N from Urea), T6 (25% N from SSB+75% N from Urea), T7 (25% N from SCB+75% N from Urea), T8 (25% N from PL+75% N from Urea) and T9 (25% N from FYM+75% N from Urea). The outcomes of the experiment revealed that all the treatments have significantly affected the kernel yield, plant height, 100 kernel weight, and ear length while the number of kernel rows was non-significant. Treatments having 1:1 combination (T_2, T_3, T_4, T_5) have far better results as compared to 3:1 ratio combination (T_6, T_7, T_8, T_9) and 1:0 ratio combinations (T_1). Among 1:1 treatment the overall performance of treatment T_2 (50% N from Soyabean Straw Biochar (SSB)+50% N from urea) was best of all increasing the kernel yield, plant height, 100 kernel weight, ear length and kernel rows per cob up to 54.5%, 15.2%, 16%, 17.7% and 8.1% respectively more than any other treatment. Hence the integration of Soya Bean Straw Biochar with urea in 1:1 based on % N is advised for maximum yield and better growth performance of maize. Such a study on different cereal and leguminous crops under different soil and climatic conditions are recommended for vast spread application and authorization of results.

Keywords: Maize; Soyabean straw biochar; Sugarcane bagasse; Poultry litter; Farmyard manure; Urea; Kernel yield

Abbreviations: SSB: Soyabean Straw Biochar; SCB: Sugarcane Bagasse; CCRI: Cereal Crop Research Institute; PL: Poultry Litter; LSD: Least Significance Difference; ANOVA: Analysis Of Variance

Introduction

Maize botanically called as *Zea mays L.* is the 3rd most growing cereal crop in Pakistan after wheat and rice [1]. It is a nutritional source of food for humans, feed for animals and raw material for several agro-based industries. It belongs to the cereal crop family which require an adequate amount of essential nutrients due to its ability high growth rate and producing large biomass yield [2]. The nature of Pakistani soils comes in category of alkaline calcareous soils in which maize crops suffer from nitrogen

deficiency [3]. Various other factors that will affect the nitrogen availability are temperature, moisture content, pH of the soil and amount of clay minerals in the soil. Nitrogen is the most essential nutrient required for plant growth and is usually absorbed by plants in form of nitrate [4] and it constitutes about 1.7%-5.8% of dry weight of many plants. It is also the important component of many nucleic acids, organic acids, and many proteinaceous compounds, apart from this its plays a vital role in synthesis of chlorophyll, photosynthesis process and carbon dioxide (CO_2) assimilation [5]. Nitrogen also has synergistic relationships with other nutrients like phosphorous, potassium and calcium and deficiency of nitrogen in soil will result the plants to suffer from other nutrients deficiency [6]. The major loss of nitrogen in Pakistani soils occurs through leaching due to its mobile nature in soils. Integration of organic and inorganic is the best possible way to reduce nitrogen loss through leaching and to increase its availability to crops for longer period of time [7].

Nowadays, the combined application of organic and inorganic fertilizers has been a favorable method for farmers to enhance their crop yield and production growth. However, most of the researchers and farmers are unaware of that which is the best fertilizer integration ratio and what type of organic manure should be used for obtaining good fertile soil and economical crop yield. The present study was planned to investigate the comparison between various types of organic manures for obtaining best performance of maize crop in terms of yield and productivity and to evaluate what is the best integration ratio between organic manures with inorganic nitrogen fertilizers for economical maize yield and various other yield attributes of maize crop in agro-climatic conditions of Nowshera, KPK, Pakistan.

Materials and Methods

The field experiment entitled "Comparisons of different types of organic manures supplemented in diverse ratios with inorganic N fertilizer in terms of maize yield and productivity" was carried out at Cereal Crop Research Institute (CCRI), Nowshera, KPK, Pakistan in Kharif season 2018. Maize variety (BS-01) is used as a test crop. A total of 9 treatments were used and each treatment was replicated five times thus making 45 experimental units. Each of the plot sizes was 12 m^2 (4 m × 3 m). The experimental units were designed according to Randomize Complete Block design. The treatment combination is shown in **Table 1**.

Table 1: Treatment combination of the present experiment.

Treatments	% N from Organic manure	% N from Urea	Urea: Organic manure (based on % N)	Required amount of N (kg/ha)
T1 (Control)	0	100%	1:0	120
T2	50% N from SSB	50%	1:1	120
T3	50% N from SCB	50%	1:1	120
T4	50% N from PL	50%	1:1	120
T5	50% N from FYM	50%	1:1	120
T6	25% N from SSB	75%	3:1	120
T7	25% N from SCB	75%	3:1	120
T8	25% N from PL	75%	3:1	120
T9	25% N from FYM	75%	3:1	120

N: Nitrogen; SSB: Soyabean Straw Biochar; SCB: Sugarcane Bagasse; PL: Poultry Litter; FYM: Farm Yard Manure

Basal dosage 90 kg/ha and 60 kg/ha of phosphorus and potassium respectively were applied to each plot prior to 1 week before the sowing. Different types of organic manures were also applied to specified plots before 1 week of sowing whereas urea was applied in split doses at time of sowing and first irrigation. The composite soil sample was collected from field before the initiation of the experiment and was processed and analyzed for soil texture by method of Gee et al. [8], pH of soil by method of Mclean [9], Electrical Conductivity (EC) by method proposed by Black [10], organic matter content by method of Nelson and Sommers [11], total nitrogen by method of Bremener and Mulveney [12], extractable phosphorus and potassium by method proposed by Soltanpur [13] in the laboratory in order to evaluate the physical and chemical properties of the experimental location and its data is shown in the **Table 2**. It shows that the soil was slightly alkaline, non-saline, silt loam in texture and was deficient in organic matter, total nitrogen, extractable phosphorus, and potassium. The samples were also taken from various types of organic manures used in the experiment and were analyzed for different chemical properties and its data is shown in **Table 3**.

The data of the following parameters are recorded during the experiment:

1. Plant height (cm)
2. Ear length (cm)
3. Number of rows of kernel per each cob
4. Weight of hundred kernels (g)
5. Kernel yield (kg/ha)

Plant height (cm)

The data of the plant height of the maize was calculated at full maturity phase of the crop. From each experimental unit, 10 random plants were selected and their heights were measured in centimeters with the help of graduated scale with one end of the scale at ground and the other end at auricle of the flag leaf. After that average of the calculated data was taken.

Ear length (cm)

Data on length of the ear is also calculated with help of graduated scale. From each experimental unit, 10 random plants were

selected and their ear lengths were measured in centimeters with one end of the graduated scale at ground and the other end at node having the uppermost primary ear. After that average of the calculated data was taken.

Number of rows of kernel per each cob

Data of kernel rows per ear is calculated by randomly taking ten cobs from each plot and the grain rows each cob was counted and then its mean was taken.

Weight of hundred kernels (g)

Data of 100 kernels weight is measured in grams with the help of an electric balance. 100 kernels were counted from various cobs of each experimental unit and their weight is measured in grams with sensitive electric balance.

Kernel yield (kg/ha)

Data of grain or kernel yield is calculated by harvesting 5 central rows of each plot. The cobs were shredded and their grains were collected and were measured in kilograms with help of electric balance. The final grain yield in kilograms per hectares is calculated by the following formula:

$$\text{Kernal yield (kgha}^{-1}) = \frac{\text{Yield of Kernels per rows}}{\text{R-R space(m)} \times \text{row size(m)} \times \text{number of rows}} \times 10{,}000\text{m}^2$$

Statistical analysis

ANOVA (Analysis of Variance) procedures appropriate for RCB design was used for statistical analysis of the data. Least Significance Difference (LSD) test at 0.05 probability level was used to compare the means when the F-values were significant [14]. The data was then also analyzed by computer software program STATISTICS 10.1.

Results

Mean values of plant height, ear length, number of kernels rows per cob, weight of 100 maize kernels and kernel yield is shown in **Table 4** shows that various types of organic manures supplemented with urea in dynamic ratios have significantly affected the kernel yield and various yield attributes of maize except number of kernel rows per each cob which is non-significant. In case of plant height, maximum plant height (170.1 cm) was examined for T_2 receiving Soyabean Straw Biochar (SSB)+Urea in 1:1 ratio significantly tailed by (168.2 cm) given by T_3 receiving 1:1 ratio of Sugarcane Bagasse (SCB)+Urea. While the minimum plant height of 147.7 cm was recorded for T_1 treatment control receiving only 100% Urea. The same phenomenon is reflected in **Figure 1** which shows that treatment T_2 (Urea+SSB applied in 1:1 ratio) has increased the plant height up to 15.2% followed by treatment T_3 (Urea+SCB applied in 1:1 ratio) which has increased the plant height up to 13.9% over control treatment. In case of ear length parameter maximum value (22.4 cm) was calculated for T_4 receiving 1:1 ratio of Poultry Litter (PL) and Urea successfully followed by results (21.6 cm) from T_2 receiving SSB+Urea in 1:1 while the minimum ear length of 18.1 was recorded for T_1 treatment control receiving only 100% Urea. In case of number of kernel rows per cob, maximum kernel rows (16.0) was investigated for T_2 receiving SSB+Urea in 1:1

Table 2: Physical and chemical properties of experimental site.

Physical and Chemical Property	Value and Unit
Soil Texture	Silty Loam
pH	7.75
Electrical conductivity	2.17 dSm^{-1}
Organic matter	0.81%
Bulk density	1.23%
Total Nitrogen	0.46%
Extractable Phosphorous	3.73 kg/ha
Extractable Potassium	91.65 kg/ha

Table 3: Chemical properties of different types of organic manures used in the experiment.

Chemical Property	Different types of organic manures			
	SSB	**SCB**	**PL**	**FYM**
pH	7.9	7.68	7.6	7.2
Electrical conductivity (dsm^{-1})	2.86	3.11	3.08	2.66
Organic carbon (%)	43.7	28.3	35.1	28.9
CN ratio	29.3	25.7	22.2	32.6
Total Nitrogen (%)	1.14	1.1	1.58	0.86
Total Phosphorous (%)	0.74	0.7	2.12	1.14
Total Potassium (%)	1.58	1.48	1.34	1.2

Table 4: Plant height, ear length, rows of kernel cob^{-1}, hundred kernel weight and kernel yield as affected by treatments having various organic manures and inorganic fertilizers integrated in different ratios.

Treatments	Plant height (cm)	Ear length (cm)	Rows of kernel cob^{-1} --	Hundred seed weight (g)	Kernel Yield (kg/ha)
T1=Control (100% N from Urea)	147.7e	18.1d	14.8	35.9d	3315.6f
T2=50% N from SSB+50% N from Urea	170.1a	21.6ab	16	41.1a	5123.7a
T3=50% N from SCB+50% N from Urea	168.2ab	20.4b	15.3	40.0ab	4728.3b
T4=50% N from PL+50% N from Urea	167.0ab	22.4a	15.7	39.0bc	4928.9ab
T5=50% N from FYM+50% N from Urea	165.3b	20.8b	15	38.7	4648.0bc
T6=25% N from SSB+75% N from Urea	162.1bc	21.1ab	14.9	39.7abc	4002.7c
T7=25% N from SCB+75% N from Urea	160.9cd	21.5ab	14.9	39.0bc	3935.4cd
T8=25% N from PL+75% N from Urea	161.8cd	19.5bc	15.2	38.3c	3749.0cde
T9=25% N from FYM+75% N from Urea	161.5cd	19.0bc	14.8	36.6cd	3625.3de
LSD	4.57***	1.48*	1.41 NS	2.77*	387.56***

NS (Non-significant) if p>0.05; *if p ≤ 0.05; **if p ≤ 0.01; ***if p ≤ 0.001
SSB: Soyabean Straw Biochar; SCB: Sugarcane Bagasse; PL: Poultry Litter; FYM: Farm Yard Manure; LSD: Last Significant Difference

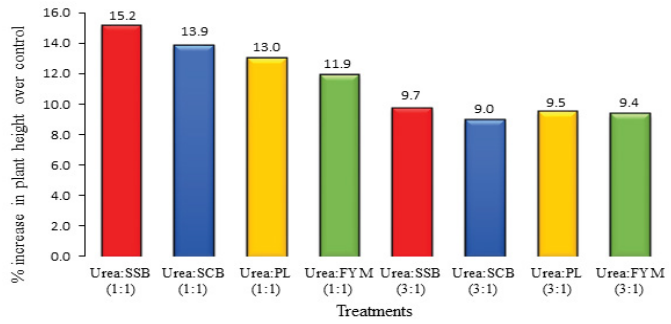

Figure 1 Percent increase in plant height of maize by treatments having various organic manures and inorganic fertilizers integrated in different ratios.

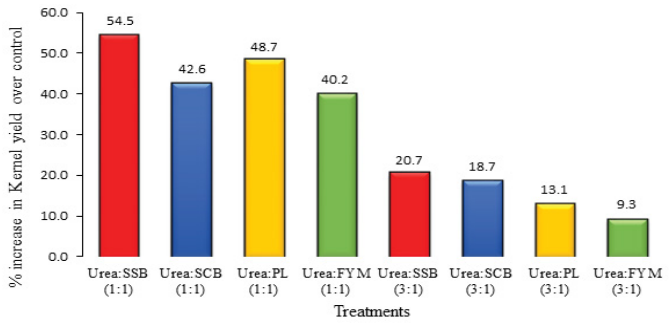

Figure 2 Percent increase in kernel yield of maize by treatments having various organic manures and inorganic fertilizers integrated in different ratios.

significantly tailed by (15.7) given by T_4 receiving 1:1 (PL+Urea). While the kernel rows of 14.8 were recorded for T_1 treatment control receiving only 100% urea. However, the number rows of kernel were not significantly affected by combination of urea with different organic manures in diverse ratios.

Weight of 100 maize kernels was significantly influenced by the different treatments used in the experiment. Maximum values (41.1 g) are obtained for treatment T_2 getting 50% N from SSB+50% N from urea, significantly tailed by (39.7 g) treatment T_6 receiving 25% N from SSB+75% N from urea (applied in 1:3), while minimum 100 kernel weight of 35.9 g was obtained from T_1 control treatment. Similarly, the like plant height and 100 kernel weight, the maximum kernel yield (5123.7 kg/ha) was examined for treatment T_2 receiving 50% N from SSB+50% N from Urea (1:1), significantly followed kernel yield (4928.9 kg/ha) given by treatment T_4 receiving 50% N from PL+50% N whereas minimum kernel yield (3315.6 kg/ha) was recorded for T_1 control treatment receiving 100% N from Urea (1:0). The same phenomenon is also represented in **Figure 2** which shows that treatment T_2 (Urea+SSB applied in 1:1 ratio) has increased the kernel yield (kg/ha) up to 54.5% followed by treatment T_4 (Urea+PL applied in 1:1 ratio) which has increased the kernel yield up to 48.7% over control treatment T_1 gaining alone urea.

Discussion

By comparing the results of kernel yield and various yield traits of maize significantly affected by organic manures applied to the field in distinct ratios with urea. The treatments having 1:1 combination (T_2, T_3, T_4 and T_5) have far better results as compared to 3:1 ratio combination (T_6, T_7, T_8 and T_9) and 1:0 ratio combination (T_1). Among 1:1 treatment the overall performance of treatment T_2 (50% N from Soyabean Straw Biochar (SSB)+50% N from Urea) was best increasing the kernel yield up to 54.5% more than any other treatment. The above data is strongly correlated with the findings of Maha [15] who suggested that combine application of inorganic fertilizers and Soyabean Straw Biochar will significantly influence the production of cereal crops. Presumably it may be due to better mineralization of nitrogen and other nutrients offered by Soyabean Straw Biochar. Due to enhanced microbial activity, plant residues biochar plays a vital role in enhancing the solubilization of nutrients present in the soil and manures by releasing different types of organic acids such as formic, carbonic and citric acids during decomposition process [16], resulting into increasing essential nutrients availability to plants and reducing its losses from rhizosphere [17,18]. The function of biochar is that it immobilizes the nutrients by chelation process and then slowly released the nutrients to the plant in different growth phases. The synergistic relation nitrogen with phosphorous and other nutrients [6] plays a vital role in its uptake resulting in vigorous roots, shoots, and healthy grains development. Due to mobile nature of nitrogen, it moves to the grains after its uptake resulting in enhanced kernel weight and yield. The above results lie in par with [19,20] who reported that combination of biochar with inorganic fertilizers had a significant effect on maize yield and development [21,22] also received positive response from plant yield when they applied organic manures in combination with inorganic fertilizers.

Conclusion

From the present study, it is concluded that all the treatments receiving integration of organic and inorganic fertilizers in diverse ratios have significantly affected the kernel yield, plant height, 100 kernel weight, and ear length while the number of kernel rows was non-significant. Maximum values of plant height (170 cm), 100 kernel weight (41.1 g), kernel rows per cob (16.0) and kernel yield (5123.7 kg/ha) was given by treatment T_2 (Soyabean Straw Biochar (SSB)+Urea applied in 1:1) whereas maximum value for ear length was obtained from treatment T_4 (Poultry Litter (PL)+Urea applied in 1:1).

Treatments having 1:1 combination has far better results as compared to 3:1 ratio and control. Among 1:1 treatment the overall performance of treatment T2 (50% N from soya bean straw biochar (SSB)+50% N from urea) was best of all increasing the kernel yield, plant height, 100 kernel weight, ear length and kernel rows per cob up to 54.5%, 15.2%, 16%, 17.7% and 8.1% respectively more than any other treatment. Hence integration of Soyabean Straw Biochar with urea in 1:1 based on % N is recommended for maximum yield and better growth performance of maize grown under agro-climatic conditions of District Nowshera, Pakistan.

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